3.1.1 Grants received from Government and non-governmental agencies for research projects, endowments, Chairs in the institution during the last five years (INR in Lakhs)

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BRNS- IPR PROJECT

National Fusion Programme

Development of Level Sensor for Lead-Lithium Loop System

Project Sanction No. 39/14/03/2017-BRNS

Principal Investigator : Dr K K Rajan

Principal Collaborator : Dr Rajendra Prasad Bhattacharyay

Co-Principal Investigator : Dr B Aruna

Report Submitted to Institute for Plasma Research towards Total Fulfillment of Collaborative Research Project under

Board of Research in Nuclear Science

by

Viswajyothi College of Engineering and Technology, Vazhakulam, Kerala

August 2019

Declaration

We hereby declare that the report on Board of Research in Nuclear Science (BRNS) funded research project, entitled "Development of Level Sensor for Lead- Lithium Loop System ", is a record of original work carried out under the supervision of Dr. K K Rajan, Principal Investigator of the project at Viswajyothi College of Engineering and Technology (VJCET), Muvattupuzha, Kerala in collaboration with Institute for Plasma Research (IPR), Ahmadabad, Gujarat.

Principal Investigator **Head of Institution**

List of Papers presented in Symposia/ Conference

1. K.K Rajan[1], B.Aruna[1], A.Venugopal[1], S. Verma[2], P. R. Pedada[2], R. Bhattacharyay[2], "Development Of Level Sensor for Lead Lithium Loop System", NFP-PFRC Vision Meeting 2018, at Nirma University, Ahmedabad, Gujarat [1] Viswajyothi College of Engineering and Technology, Vazhakulam, Kerala, India- 686670,[2] Institute for Plasma Research, Gandhinagar, Gujarat, India-382428.

2. K K Rajan[1], B Aruna[1], S Anju[1],S. Verma[2], P. R. Pedada[2], R. Bhattacharyay[2], "Development of Level Sensor for Lead Lithium Loop System", Third IEEE International Conference on Electrical, Computer and Communication Technologies, ICECCT 2019, at SVS College of Engineering, Coimbatore, 642109 [1]Viswajyothi College of Engineering and Technology, Vazhakulam, Kerala, India- 686670, [2]Institute for Plasma Research, Gandhinagar, Gujarat, India-382428

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I place on record my thanks to Mr. Akhil Venugopal and Ms. Anju S, Junior Research Fellows appointed for this project for their contribution towards the completion of this research work.

Dr. K K Rajan

Brief report on BRNS funded Project

1. Sanction Number**:39/14/03/2017-BRNS**
2. Mode of Execution: ~~MoU / CRP /~~ **RP** ~~/ YSRA~~
3. Date of Start: **09.08.2017**
4. Date of Completion: **09.08.2019**
5. Total Amount Sanctioned (in Lakhs): **33,08,500/- (Rupees thirty three lakh eight thousand five hundred only)**
6. Amount Received (in Lakhs with date): **29,85,347/-(Rupees twenty nine lakh eighty five thousand five three hundred and thirty seven only)**
7. Category: ~~Facility Development /~~ **Product Development** ~~/ Technology Demonstration/ Applied Research/ Conceptual/Exploratory/ Survey/Others~~
8. Title: " **Development of Level Sensor for Lead- Lithium Loop System"**
9. Name of PI & Affiliation: **Dr. K K Rajan , Prof. EEE, Viswajyothi College of Engineering and Technology, Vazhakulam, Muvattupuzha, Kerala**
10. Name of CI & Affiliation: **Dr. B. Aruna , Prof. EEE, Viswajyothi College of Engineering and Technology, Vazhakulam, Muvattupuzha, Kerala**
11. Name of PC & Affiliation **:Dr. Rajendraprasad Bhattacharyay, IPR, Ahmedabad, Gujarat**
12. Name of major Equipment procured and their cost :
    - **Personal Computer - Rs. 41800/-**
    - **Waveform Generator - Rs. 99,023.24/-**
    - **Digital Multimeter - Rs.59,469.64/-**
    - **Sample Probe and Electronics - Rs. 12,95,640/-**
    - **Aluminium Blocks - Rs.47,200/-**
13. Present working status of the Equipment**:**
    - **Personal Computer - Operational at VJCET**
    - **Waveform Generator - Operational at VJCET**
    - **Digital Multimeter - Operational at VJCET**

- **Sample Probe and Electronics - Operational at IPR**
- **Aluminium Blocks - Operational at VJCET**

14. Details of the High cost consumables used: **Stainless Steel Blocks – Rs. 90,000/-**

15. Number of Journal Publications with impact factor (attach list as Annex- I): **0**

16. Number of symposia/conference presentations: **2**

17. Number of staff trained under this project: **2**

18. List of Objectives as mentioned in original proposal:

- Deciding on the number of probes based on process, safety and functional requirements and sizing of them based on geometrical configuration of the lead lithium system at IPR – **Accomplished**
- Detailed design and specification of the probes considering an ambient DC magnetic field of 200 Gauss – **Accomplished**
- Manufacturing of a sample probe with the help of an Indian industry – **Accomplished**
- Evaluation of sensitivity of the probe through finite element analysis at various process conditions and establishing the relation between level and output signal – **Accomplished**
- Design of electronic circuit required for input source, output signal processing and temperature compensation – **Accomplished**
- Integrated testing of probe and electronics – **Accomplished**
- Delivery of sample probe and its electronics to IPR for testing in lead lithium loop system – **Accomplished**
- Delivery of design and specifications documents to IPR – **Accomplished**

Accomplishments of the projects in 3 to 4 bullets

- A mutual induction type level sensor has been proposed for the level measurement of Pb-Li eutectic alloy.
- Sensitivity evaluation of probe has been carried out using FEMM model

- Manufactured a sample probe and its electronics with the help of an Indian industry and tested in aluminium and stainless steel medium
- Proposed and designed a suitable method for temperature compensation and its validation is conducted in SS medium.

Summary

Lead-Lithium (Pb-Li) eutectic alloy is considered as the coolant in Indian Lead-Lithium ceramic breeder blanket. This liquid metal alloy is circulated through the blanket modules of fusion reactors at operating temperatures around 450^{o}C. The Lead- Lithium system which supplies the alloy to the blanket module is operating at high temperature and needs redundant level measuring sensors along with other diagnostic devices. The high operating temperature, high chemically active nature of Pb-Li alloy and its reaction with air make its instrumentation difficult over conventional instrumentation. Since Lead Lithium is a good conductor of electricity, mutual inductance type continuous level sensors is the best choice.

Design and development of the level sensor has been taken up based on the experience of mutual inductance level sensor used in sodium systems. Viswajyothi college of Engineering and Technology (VJCET) in collaboration with IPR, Ahmedabad has taken up a BRNS funded research project to develop a MI type Level Sensor for Lead Lithium Loop System.

A detailed study on conceptual design, specifications, modeling and simulation using Finite Element Method Magnetics (FEMM), study on skin depth and temperature compensation of sensor output were carried out at PI's Institution. A sample probe and electronics had been manufactured with the help on an industry and experimental validation of the level probe using aluminium blocks and solid aluminum blocks in place of Lead-Lithium alloy were carried out.

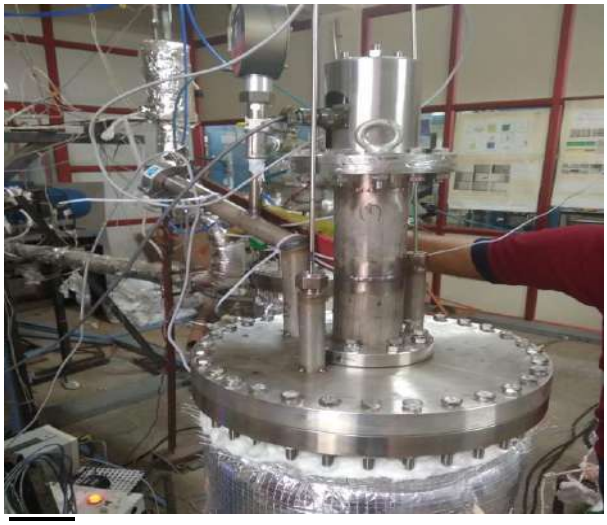
The level sensor comprises of a primary and secondary winding, where primary is excited by a constant AC current source at a fixed frequency and the induced voltage at secondary side is calibrated against the level of liquid metal. The secondary voltage of the probe varies as a function of level of Pb-Li as well as the temperature of the liquid metal. In order to find the exact level of the liquid metal the effect of temperature change on the secondary voltage must be eliminated. A temperature compensation method had been suggested for the sensor output and its experimental validation had been conducted in SS medium.

The probe and its electronics has been delivered to IPR Ahmadabad after testing and validation of probe and electronics in Lead Lithium medium at Pb-Li test facility at IPR.

Probe winding assembly

Level Probe Electronics

Level Probe testing setup with SS Blocks at VJCET



Testing of Level Probe performance at IPR

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CHAPTER-1

INTRODUCTION

Fusion reactors are considered as the source of power for the future as it completely eliminates carbon dioxide emission and its radioactive waste products are mostly be very short-lived compared to those produced by Conventional Nuclear Fission Reactors. Lead Lithium (Pb-Li) eutectic alloy is considered as the coolant in lead lithium ceramic breeder (LLCB) test blanket module (TBM) of fusion reactors. Alloy of this particular composition is selected as lithium is required to breed tritium by the high-energy neutron reaction and lead is needed to multiply the number of neutrons. Moreover, an alloy of lithium and lead can bring down the melting point of lead substantially and as a liquid metal, this alloy will act as an efficient coolant. Lead lithium alloy is circulated through the blanket modules of fusion reactors and the operating temperature is around 500°C. The extreme operating temperature conditions and high chemical reactivity of this liquid metal makes its instrumentation a difficult task. The major sensors required for Lead-Lithium alloy are Flow, Level, Pressure, Temperature and Leak detectors. Viswajyothi College of Engineering has taken up a BRNS project to develop a level sensor for the Lead Lithium system. The sensor development will be based on level sensor developed at IGCAR, Kalpakkam for liquid sodium level measurement. This document gives technical details of all activities carried out under this collaborative project.

1.1 Working Principle of Mutual Inductance Type Level Sensor

The level sensor consists of two strips of SS316 which are welded to form a cruciform shaped section/bobbin. Primary and secondary windings made of mineral insulated cable with copper conductor are wound around the active length in bifilar fashion. The probe shall be placed inside the pocket (a single seamless pipe made of Stainless steel) which protects it from direct contact with lead-lithium or its vapour. The Level sensor is immersed in Lead-Lithium Eutectic alloy under working conditions. The primary winding of the sensor is excited using a constant current and constant high frequency voltage source. The induced voltage in secondary is inversely proportional to the level of the Pb-Li alloy in the tank. Higher the level of Pb-Li alloy, lower will be the secondary induced voltage. The factor which influence this action is the eddy current induced in the molten alloy. Higher the eddy current density, the more prominent will be the reduction in secondary voltage. The secondary voltage induced depends on the festivity of the surrounding medium. So the induced voltage will be different for different surrounding medium and it depends on the electrical resistivity of the medium.

1.2 Activities involved in this Research Project

A mutual induction type level sensor had been developed at Viswajyothi College of Engineering and Technology in collaboration with IPR Ahmedabad as a part of BRNS funded project in order to measure the level of Pb-Li eutectic alloy in tanks and capacities. A study on various properties of Pb-Li, conceptual design, detailed design modeling estimation of sensitivity of probe, skin depth analysis etc. has been carried out prior to probe manufacturing. Detailed technical specifications were prepared and a sample level probe and its electronics has been manufactured with the help of an industry. The basic working principle of MI type level sensor is that, the secondary voltage of the probe varies as a function of level of liquid metal. But the secondary voltage of the probe varies not only as a function of level of Pb-Li as well as the temperature of the liquid metal. To determine the exact level of the liquid metal a temperature compensation technique has been designed and was validated in SS medium. After undergone various tests in Aluminium and Stainless steel medium the probe has been delivered to IPR Ahmedabad for further testing and analysis in Pb-Li medium.

1.3 Research Document Organization

The probe material which comes into contact with Pb-Li is selected as Stainless Steel AISI 316, hence it is essential to know the behavior of this material and its properties before employing it for this purpose. Hence a detailed study has been conducted to determine various properties of Stainless steel and Pb-Li eutectic alloy. Chapter 2 covers the studies carried out on various properties of Stainless steel and Lead- Lithium alloy. Chapter 3 deals with the conceptual design of lead lithium system continuous level probes and its dimensions for various capacities in IPR facilities. Since the Pb-Li liquid metal exhibits high electrical conductivity a continuous level sensor based on principle of Mutual Induction is proposed. Preliminary design of this Level sensor based on the requirements at IPR is included in this chapter. Chapter 4 contains details of design, analysis and sensitivity estimation of the level probe using FEMM model.Chapter 5 includes a study on the results of analysis carried out on skin depth analysis of the probe. Determining this dimension is enabling us to predict the minimum radius of the tank for satisfactory operations of the probe and also allows the prediction of radius of the metal blocks which needs to be purchased for testing of the probe before testing in the actual Pb-Li medium. Chapter 6 of the research work deals with the detailed design and technical specification of the probe for manufacturing. This specification covers the general requirements of Mutual inductance type continuous Lead-Lithium level probes and associated electronics. Chapter 7

deals with the manufacturing and quality control details of the probe. Chapter 8 includes the performance evaluation of manufactured probe under normal temperature conditions using aluminium and stainless steel blocks as substitute for Pb-Li. Chapter 9 discusses the need for temperature compensation for the manufactured probe and proposes a best suited method and its experimental validation in SS medium. Chapter 10 deals with the performance evaluation of Level Probe in Pb-Li medium at IPR and Chapter 11 summarizes the research work held at Viswajyothi College of Engineering and Technology as a part of BRNS-IPR collaborative research project in order to develop a MI type continuous level sensor for Lead-Lithium loop system.

CHAPTER-2

PROPERTIES OF STAINLESS STEEL AISI 316 AND LEAD LITHIUM ALLOY

2.1 Introduction

In this research it is important to study the physical properties of Lithium Lead eutectic alloy (17% Li-83% Pb- atomic percentage) as an initial step towards the development of the level sensor. The material for level probe pocket which is coming in to contact with the lead lithium alloy is selected as stainless steel AISI 316. Properties of both these materials were taken from literature and are given in tabular form for ready reference[6].

2.2 Properties Of Lead Lithium Alloy

The properties of Lead Lithium alloy were obtained using the relations given in literature[7]. Table 3.1 gives the value of electrical resistivity, density and viscosity of Lead Lithium alloy at different temperatures in the range of interest in steps of 5°C. It may be noted that for some of the properties the temperature range mentioned in the literature does not cover the range of interest, in that case same co-relation has been extended to required temperature

2.2.1 Electrical Resistivity

Equation for electrical resistivity of lead lithium alloy is given by the equation[7]:

$$\rho_{el\ l} = 102.3 \times 10^{-8} + 0.0426 \times 10^{-8}\ T$$

In the temperature range $508 < T < 933$ K, where $[\rho] = \Omega m$, $[T] = K$

The uncertainty reported in the recommended value of Lead Lithium Alloy resistivity is of the order of $\pm$ 5%.

2.2.2 Density

The evaluation of the density of the liquid eutectic was performed using the equation:

$$\rho = 10.45(1 - 161 \times 10^{-6}\ T),\ [T] = K$$

2.2.3 Viscosity

The viscosity of the eutectic alloy was estimated using the equation:

$$\eta = 0.187 \exp(l1640/RT) \times 10^{-3}\ Pas$$

Table 2.1: Properties of Lead Lithium Eutectic Alloy				
Sl. No	Temperature (K)	Resistivity, (10^{-8} Ωm)	Density, (kg/m^3)	Viscosity, (10^{-3}Pa.s)
1	510	124.026	9591.951	2.911
2	515	124.239	9583.538	2.834
3	520	124.452	9575.126	2.761
4	525	124.665	9566.714	2.691
5	530	124.878	9558.302	2.625
6	535	125.091	9549.889	2.561
7	540	125.304	9541.477	2.499
8	545	125.517	9533.065	2.441
9	550	125.730	9524.653	2.384
10	555	125.943	9516.240	2.330
11	560	126.156	9507.828	2.278
12	565	126.369	9499.416	2.228
13	570	126.582	9491.004	2.180
14	575	126.795	9482.591	2.134
15	580	127.008	9474.179	2.090
16	585	127.221	9465.767	2.047

17	590	127.434	9457.355	2.006
18	595	127.647	9448.942	1.967
19	600	127.860	9440.530	1.928
20	605	128.073	9432.118	1.892
21	610	128.286	9423.706	1.856
22	615	128.499	9415.293	1.822
23	620	128.712	9406.881	1.789
24	625	128.925	9398.469	1.757
25	630	129.138	9390.057	1.726
26	635	129.351	9381.644	1.696
27	640	129.564	9373.232	1.667
28	645	129.777	9364.820	1.639
29	650	129.990	9356.408	1.612
30	655	130.203	9347.995	1.585
31	660	130.416	9339.583	1.560
32	665	130.629	9331.171	1.535
33	670	130.842	9322.759	1.511
34	675	131.055	9314.346	1.488
35	680	131.268	9305.934	1.465
36	685	131.481	9297.522	1.444
37	690	131.694	9289.101	1.422

38	695	131.907	9280.697	1.402
39	700	132.120	9272.285	1.382
40	705	132.333	9263.873	1.363
41	710	132.546	9255.461	1.343
42	715	132.759	9247.048	1.325
43	720	132.972	9238.636	1.307
44	725	133.185	9230.224	1.290
45	730	133.398	9221.812	1.273
46	735	133.611	9213.399	1.256
47	740	133.824	9204.987	1.240
48	745	134.037	9196.575	1.225
49	750	134.250	9188.163	1.209
50	755	134.463	9179.750	1.194
51	760	134.676	9171.338	1.180
52	765	134.889	9162.926	1.166
53	770	135.102	9154.514	1.152
54	775	135.315	9146.101	1.139
55	780	135.528	9137.689	1.125
56	785	135.741	9129.277	1.113
57	790	135.954	9120.865	1.100
58	795	136.167	9112.452	1.088

59	800	136.38	9104.040	1.076
60	805	136.593	9095.628	1.064
61	810	136.806	9087.216	1.053
62	815	137.019	9078.803	1.042
63	820	137.232	9070.391	1.031
64	825	137.445	9061.979	1.020
65	830	137.658	9053.567	1.010
66	835	137.871	9045.154	1.000
67	840	138.084	9036.742	0.990
68	845	138.297	9028.330	0.980
69	850	138.510	9019.918	0.971
70	855	138.723	9011.505	0.962
71	860	138.936	9003.093	0.952
72	865	139.149	8994.681	0.943
73	870	139.362	8986.269	0.934
74	875	139.575	8977.856	0.926
75	880	139.788	8969.444	0.918
76	885	140.001	8961.032	0.910
77	890	140.214	8952.620	0.902
78	895	140.427	8944.207	0.894
79	900	140.640	8935.795	0.886

2.3 Properties of Stainless Steel AISI 316

2.3.1 Electrical Resistivity

The electrical resistivity of stainless steel AISI 316 tabulated in literature [8] is extrapolated. Table 3.2 gives the value of resistivity at different temperatures in the range of interest in steps of 5°C. The uncertainty reported in the recommended value of SS resistivity is of the order of $\pm$ 5%.

2.3.2 Thermal conductivity

The thermal conductivity of stainless steel AISI 316 is calculated in the range of interest in steps of 5 °C by extrapolating the values tabulated in literature [8]. The uncertainty in the recommended values of thermal conductivity is of the order of $\pm$ 5%.

Table 2. 2 :Properties SS AISI 316

Sl. No	Temperature (K)	Electrical Resistivity ($10^{-8}\Omega$ m)	Thermal Conductivity ($W\ m^{-1}K^{-1}$)
1	273	75.400	12.970
2	275	75.570	13.005
3	280	75.995	13.092
4	285	76.420	13.179
5	290	76.845	13.266
6	295	77.270	13.353
7	300	77.700	13.440
8	305	78.080	13.528
9	310	78.460	13.616

10	315	78.840	13.704
11	320	79.220	13.792
12	325	79.600	13.880
13	330	79.980	13.968
14	335	80.360	14.056
15	340	80.740	14.144
16	345	81.120	14.232
17	350	81.500	14.320
18	355	81.870	14.404
19	360	82.240	14.488
20	365	82.610	14.656
21	370	82.980	14.656
22	375	83.350	14.740
23	380	83.720	14.824
24	385	84.090	14.908
25	390	84.460	14.992
26	395	84.830	15.076
27	400	85.200	15.160
28	405	85.525	15.242
29	410	85.850	15.324
30	415	86.175	15.406

31	420	86.500	15.488
32	425	86.825	15.570
33	430	87.150	15.652
34	435	87.475	15.734
35	440	87.800	15.816
36	445	88.125	15.898
37	450	88.450	15.980
38	455	88.775	16.062
39	460	89.100	16.144
40	465	89.425	16.226
41	470	89.750	16.308
42	475	90.075	16.390
43	480	90.400	16.472
44	485	90.725	16.554
45	490	91.050	16.636
46	495	91.375	16.718
47	500	91.700	16.800
48	505	92.000	16.878
49	510	92.300	16.956
50	515	92.600	17.034
51	520	92.900	17.112

52	525	93.200	17.190
53	530	93.500	17.268
54	535	93.800	17.346
55	540	94.100	17.424
56	545	94.400	17.502
57	550	94.700	17.580
58	555	95.000	17.658
59	560	95.300	17.736
60	565	95.600	17.814
61	570	95.900	17.892
62	575	96.200	17.970
63	580	96.500	18.048
64	585	96.800	18.126
65	590	97.100	18.204
66	595	97.400	18.282
67	600	97.700	18.360
68	605	97.970	18.436
69	610	98.240	18.511
70	615	98.510	18.587
71	620	98.780	18.662
72	625	99.050	18.738

73	630	99.320	18.813
74	635	99.590	18.889
75	640	99.860	18.964
76	645	100.130	19.040
77	650	100.400	19.115
78	655	100.670	19.191
79	660	100.940	19.266
80	665	101.210	19.342
81	670	101.480	19.417
82	675	101.750	19.493
83	680	102.020	19.568
84	685	102.290	19.644
85	690	102.560	19.719
86	695	102.830	19.795
87	700	103.100	19.870
88	705	103.345	19.946
89	710	103.590	20.022
90	715	103.835	20.098
91	720	104.080	20.174
92	725	104.325	20.250
93	730	104.570	20.326

94	735	104.815	20.402
95	740	105.060	20.478
96	745	105.305	20.554
97	750	105.550	20.630
98	755	105.795	20.706
99	760	106.040	20.782
100	765	106.285	20.858
101	770	106.530	20.934
102	775	106.775	21.010
103	780	107.020	21.086
104	785	107.265	21.162
105	790	107.510	21.238
106	795	107.755	21.314
107	800	108.000	21.390
108	805	108.205	21.460
109	810	108.410	21.530
110	815	108.410	21.600
111	820	108.615	21.670
112	825	109.025	21.740
113	830	109.230	21.810
114	835	109.435	21.880

115	840	109.640	21.950
116	845	109.845	22.020
117	850	110.050	22.090
118	855	110.255	22.160
119	860	110.460	22.230
120	865	110.665	22.300
121	870	110.870	22.370
122	875	111.075	22.440
123	880	111.280	22.510
124	885	111.485	22.580
125	890	111.690	22.650
126	895	111.895	22.720
127	900	112.100	22.790

2.4 Conclusion

Important properties of lead lithium eutectic alloy and stainless steel AISI 316 based on standard literature relevant to the design of the level sensor are brought out in this chapter for ready use. As the next step of the research and development the conceptual design of the level probe was taken up.

CHAPTER-3

CONCEPTUAL DESIGN OF LEAD LITHIUM SYSTEM CONTINUOUS LEVEL PROBES AND ITS DIMENSIONS FOR VARIOUS CAPACITIES IN IPR FACILITIES

3.1 Introduction

A detailed study was carried out on the number of level probes required for the Pb-Li MHD experiment loop, Pb-Li MHD experiment loop sump tank, Pb-Li diagnostic loop and Pb-Li Production system being constructed at IPR. The number of probes required for each system was arrived at based on process, functional requirements and safety. Sizing of the probes on each tank/ vessel based on geometrical configuration of the system was obtained. This chapter gives conceptual design details of the probe, the number of continuous level probes required, dimensions of the level probe, and construction material used for different parts of the probe[9].

3.2 Conceptual Design of the Probe and Probe Dimensions

Conceptual design of the probe has been performed. The schematic diagram of MI type continuous level sensor is shown in Fig.4.1. The figure clearly illustrates the basic components of MI type sensor[10]. The primary winding of the sensor is excited using a constant current, constant high frequency voltage source. The induced emf in the secondary is a measure of the mutual inductance between the two windings. In a level sensor, the mutual inductance varies as a function of the level of liquid metal surrounding the sensor. As the level increases, the secondary emf suffers higher voltage drops. This occurs due to the weakening of primary field fluxes due to the demagnetizing flux produced by the eddy currents in the eutectic alloy. In such cases, the secondary emf can be related as a direct measure of the level of eutectic alloy. This variation is measured using a high sensitivity electronic circuit to determine the level of the eutectic alloy. In addition, temperature plays a crucial role in the magnitude of induced secondary voltages. This happens because; the resistivity of the eutectic alloy varies with temperature. Hence the magnitude of eddy-current in this region is also affected by temperature and thereby the MI type level sensor requires temperature compensation. Usually, temperature compensation is provided by connecting a suitable resistance parallel to the secondary winding. The magnitude of this resistance is determined either experimentally or by simulation, and then verified by experimental means.

This design is based on the experimental level probe design carried out in IGCAR for sodium system . The similar design is planned to be used in Lead-Lithium Eutectic alloy, with modifications in sensor components and in the electronic chassis to compensate the effect of change in material from sodium to lead-lithium. This is necessary because, Pb-Li has increased electrical resistivity compared to sodium. Modifications, including improving number of turns in coil and optimizing the dimensions may be adopted to achieve desired sensitivity of the probe in lead-lithium. These aspects will be studied in detail during modeling and simulation of the probe.

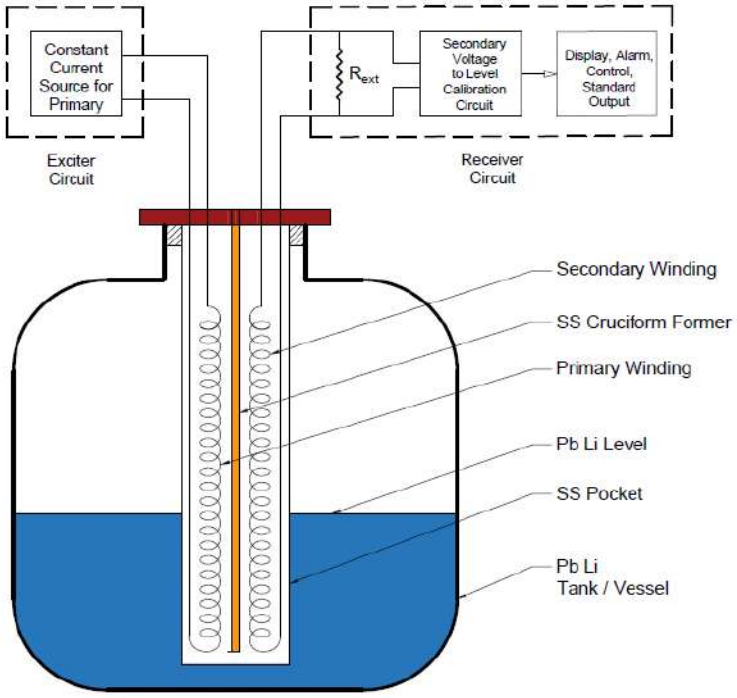


Fig.3.1: Schematic of MI type continuous Level Sensor.

The Probe consists of a primary and secondary winding which is alternatively wound on the cruciform bobbin. Mineral insulated (MgO) , SS sheathed high quality copper conductor cables are used for winding in order to withstand the high operating temperature of liquid metal. The probe is placed inside a pocket made up of stainless steel material and the pocket with probe is introduced in the tank containing Lead-Lithium eutectic alloy. The primary is excited by a high frequency (2.5 kHz, 120mA) AC source. This will produce a flux and a secondary voltage.

When the level of Pb-Li alloy inside the tank is zero[11],

$$E_{20} \propto \Phi_1 \propto I_{10} \qquad \text{(Eqn. 3.1)}$$

E_{20} – Secondary voltage for zero level

Φ_1 - Main flux due to primary current

I_{10} – Primary current

When the level of Pb-Li rises inside the tank, eddy currents are produced in the liquid metal alloy depending upon the conductivity and level of the metal alloy and the flux produced by this eddy current opposes the main flux and weakens it and thereby reduces the secondary output voltage.

$E_2 \propto \Phi_1 - \Phi_2$

$\Phi_2 \propto I_{eddy} \alpha L$

$$L \propto (E_{20} - E_2) \qquad \text{(Eqn. 3.2)}$$

E_2 – Secondary voltage at level

L– Level of Pb-Li alloy

Φ_2 - Reverse flux due to eddy current

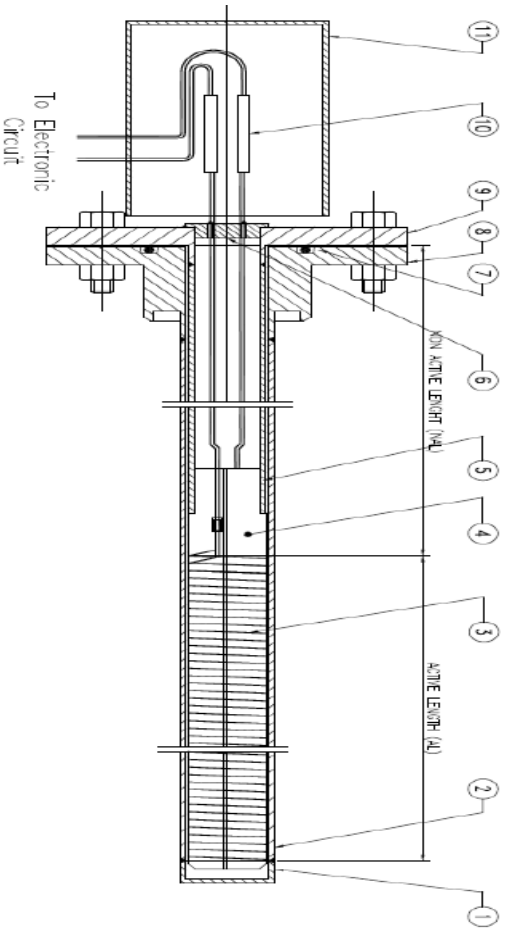
I_{eddy} –Eddy current in Pb-Li alloy

The level of Pb-Li inside the tank determines the magnitude of the reverse flux. As the level of liquid metal increases the more will be the reverse flux and less will be secondary voltage output of the sensor. The level rise of metal alloy is calibrated against this reduction of secondary voltage in order to determine the exact level of Pb-Li liquid metal inside the vessel.

Design

Due to the increased resistivity and higher operating temperatures of Pb-Li eutectic alloy as compared to sodium [12] many modifications were done in sensor components and its electronic chassis compared to the MICLP used for liquid sodium level measurement.

The level probe assembly consists of a pocket and probe. The pocket assembly consists of pocket closure cup, pocket of single seamless pipe made of stainless steel (SS316). The pipe shall be of extruded construction so that the bend or curvature does not exceed ±1 mm per meter length of the pocket.



1 Pocket Closure Cup

2 Pocket

3 Mineral Insulated Cable

4 Bobbin/ Former

5 Bobbin Support Tube

6 Cable Penetration

7 Gasket/O ring

8 Pocket Flange

9 Top Flange

10 Cable Termination

11 Terminal Box

Fig 3.2: CAD drawing showing Pb-Li level probe/sensor Assembly.

The probe shall be placed inside the pocket which protects it from direct contact with Lead-Lithium or its vapour and shall be held in position by bolting its flange to the flange of the pocket. The clearance between the probe and the pocket should be as minimal as possible, only to the extent of allowing easy removal and insertion.

The electronics of probe shall have two independent modules.

- An Exciter module
- A Receiver module.

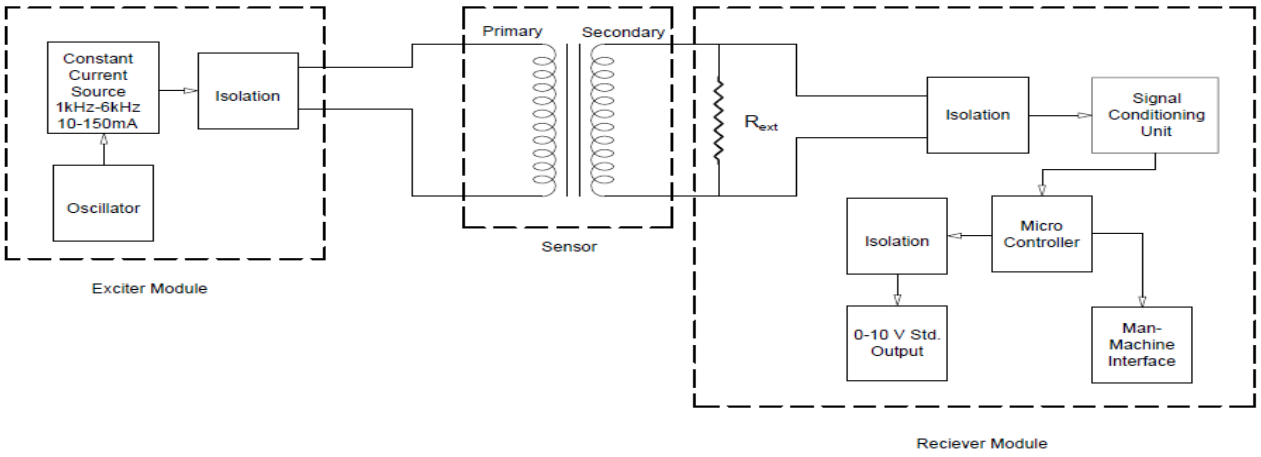


Fig 3.3 : Block diagram of Electronics Unit of Pb-Li level sensor

The source module feeds the primary winding of the probe with constant current and frequency. It consists of a sinusoidal oscillator (Frequency range: 1 kHz to 6 kHz) and constant current circuit (10 to 150 mA). The isolated AC signal of secondary winding is processed by the receiver module. The receiver module also has a trip module and a display module

The Basic design parameters are the active and non-active length of the probe. Regardless of the size of the tank, a general design of the probe is selected. All dimensions other than active length (AL) and non-active length (NAL) will be same for all the probes[13].

Table 3.1: Table of Components

Item No.	Qty	Description	Material	Remarks
1	1	Pocket Closure Cup	SS 316	Cylindrical, Closed at Bottom
2	1	Pocket	SS 316	Cylindrical Tube
3	1	M I Cable (2 COILS)	1 mm DIA SS, Sheathed MgO Insulated, 0.30 mm DIA Copper	Free Length Depends on AL And NAL
4	1	Bobbin	SS 316	
5	1	Bobbin Support Tube	SS 316	Cylindrical Tube

6	1	Cable Penetration	SS 316	
7	1	Gasket	Metallic	Round
8	1	Pocket Flange	SS 316	Round
9	1	Top Flange	SS 316	Round
10	4	Cable Termination	SS 304	
11	1	Terminal Box	SS 304	Cylindrical

3.3 Selection of Sample Level Probe for Fabrication

The level probe is required to be designed, developed , and fabricated for only one tank as per the objectives of the project. IPR has suggested to develop the level sensor probe for the Pb-Li diagnostic loop (tank 3), of which active and non-active length are mentioned is shown in Fig. 3.4 [12] .

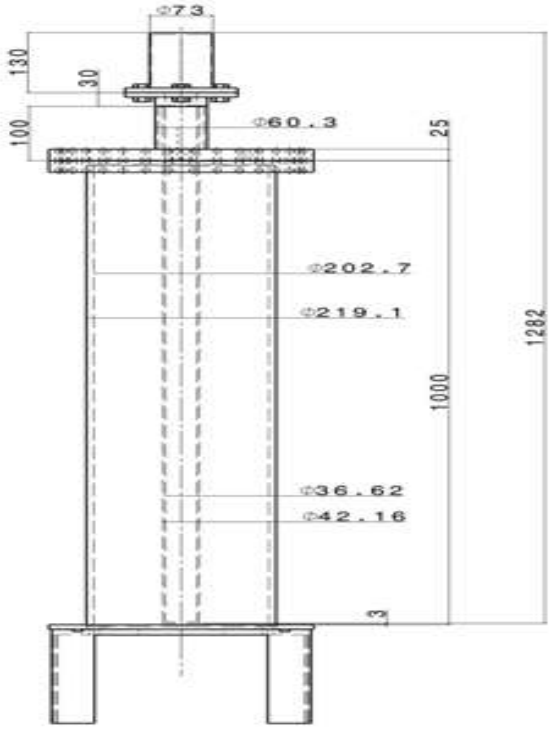


Fig.3.4: Level probe with tank dimensions.

3.4 Level Sensors for Various Tanks and Vessels

3.4.1 Pb-Li MHD Experiment Loop Dump Tank

The tank has a total height of 436mm and level to be measured up to a height of 387mm. The suggested probe for this tank is to have an active length 380 mm and non-active length of 189 mm. For this tank, which has already been manufactured an additional piece is required that could fit on to the flange on top of the tank. The level probe will be mounted on the additional piece.

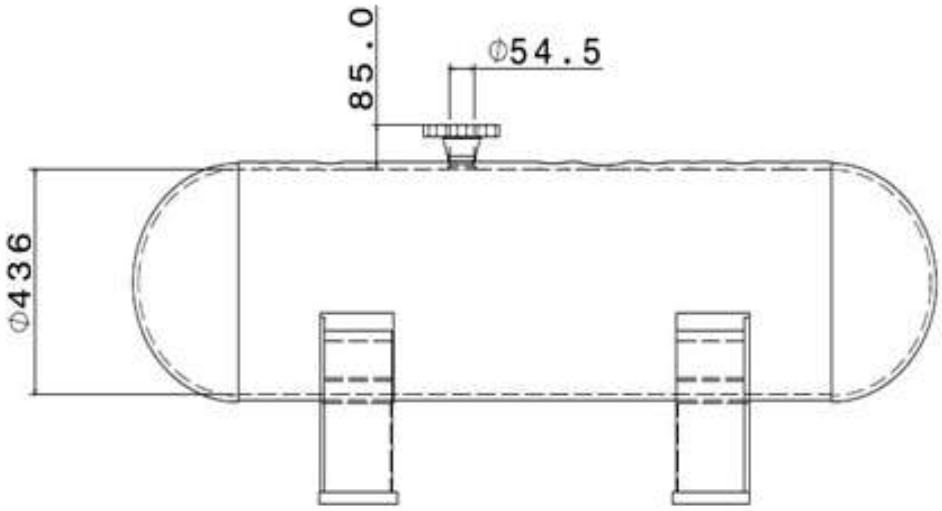


Fig. 3.5: Dump Tank of MHD Loop with Level Probe Mounting Flange

3.4.2 Pb-Li MHD Experiment Loop Sump Tank

The tank has a total height of 340 mm and level to be measured up to a height of 235 mm. The suggested probe for this tank has an active length of 228 mm and non-active length of 352 mm. Here, the probe is welded to the nozzle of the tank.

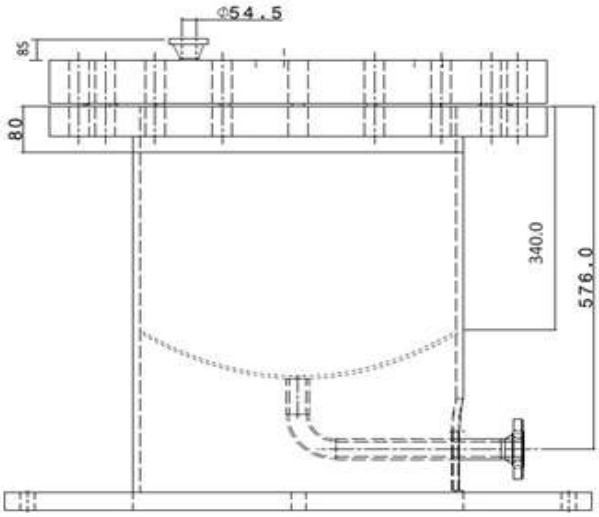


Fig. 3.6: Pb-Li MHD experiment loop sump tank with Level Probe Mounting Flange

3.4.3 Pb-Li diagnostic loop

The tank has a total height of 1000 mm and level to be measured up to height of 895 mm. The suggested probe for this tank has an active length of 888 mm and non-active length of 305 mm. Here, the probe is welded to the nozzle of the tank.

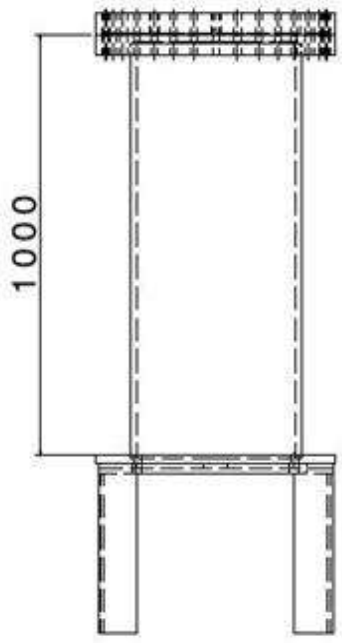


Fig. 3.7: Pb-Li Diagnostic Loop Dump Tank

3.4.4 Pb-Li Production System Dump Tank

The tank has a total height of 900 mm and level to be measured up to a height of 805 mm. The suggested probe for this tank has an active length of 798 mm and non-active length of 286 mm. Here, the probe is welded to the nozzle of the tank.

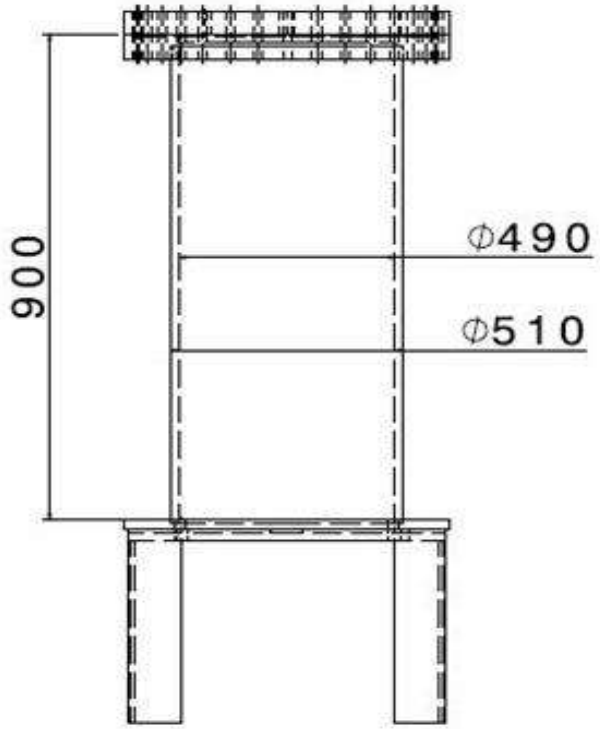


Fig. 3.8: Pb-Li Production System Dump Tank

After detailed study, the requirements of continuous level sensor in following four tanks/ vessels are identified. Based on functional and process requirement dimensions of each probes were finalized and tabulated in Table 3.2.

Table 3.2: IPR Li -Pb System Level Probe AL and NAL estimation

Sl. No	Name of the Experiment	Process fluid	Name of Tank	Total length/ height of Tank (mm)	Tank shell/flange thickness	Height of the nozzle above the tank (mm)	Distance Between Probe Flange and Nozzle Weld (mm)	NAL (mm	AL of probe (mm)
1	Pb-Li MHD experiment loop	Pb-Li	Dump tank (Ref. Fig.3.5)	436	0*	85* + 30**	30	189	380
2	Pb-Li MHD experiment loop sump tank	Pb-Li	Sump tank (Ref. Fig.3.6)	340	72	150	30	352	228
3	Pb-Li diagnostic loop	Pb-Li	Dump tank (Ref. Fig.3.7)	1000	25	150	30	305	888
4	Pb-Li Production system	Pb	Lead tank (Ref. Fig.3.8)	900	16	150	30	286	798

* The height of the nozzle includes thickness of the tank.

** An additional flange is to be fabricated and bolted to the flange on the IPR tank.

A nozzle of height 150 mm is required over the tank for welding the probe to the tank.NAL as per Fig. 1 is = NAL suggested by IPR + Tank shell/flange thickness + Height of the nozzle above the tank + Distance between Nozzle Weld and Probe Flange.

Important factors to be noted are,

a. The inactive length of the bobbin at the bottom is only 3 mm.
b. The distance between the tip of the bobbin to the bottom of the probe pocket including the gap inside the pocket and thickness of pocket closure cup is 6mm.
c. The overall clearance from the bottom of the tank to the probe pocket bottom is 3mm.

According to the design, blank length level that cannot be measured at the bottom end of the probe will be nearly 12 mm in all the tanks[13].

3.5 Conclusion

This document gives the conceptual design details of the probe. Number of probes required in lead lithium system at IPR, Ahmadabad is finalized. Active length and non-active length of each probe is finalized. As per objective of the project, a sample probe with an active length of 888mm and non-active length of 305mm for Pb-Li diagnostic Loop has to be designed, fabricated and tested. Deliverables identified in the projects proposal such as conceptual design of the probe, decision on number of probes, dimension of the probe etc, are finalized and the deliverables are met. The following chapter deals with the sensitivity estimation of selected sample probe using FEMM modeling before finalizing the model for manufacturing.

CHAPTER- 4
SENSITIVITY ESTIMATION OF THE MI TYPE LEVEL PROBE USING FINITE ELEMENT ANALYSIS

4.1 Introduction

Before, proceeding for manufacturing of the probe, it is necessary to assess the sensitivity of the probe at actual operating conditions of Lead-Lithium environment and confirm that the targeted sensitivity of minimum 5μV/mm can be achieved. Estimation of secondary voltage output and sensitivity of the probe by analytical methods using fundamental equations are very difficult and may not yield accurate results as the system is very complex. The most appropriate method is simulating the required process environment in a finite element software to carry out the computations and obtain the results. This chapter deals with Pb-Li MI type Level sensor modelling, simulation and analysis of the result obtained.

4.2 Performance of Probe

The MI type Pb-Li level sensor works on the principle of Mutual Induction between the primary and secondary coils of the sensor which varies inversely with increase in level of Pb-Li eutectic alloy in the Pb-Li tank. The dimensions of the probe to be designed, manufactured and tested were fixed as 888 mm of active length and 305 mm of non-active length. The detailed dimensions are discussed in later sections of this document.

Sensitivity for a typical sensor is the relationship indicating variation of output signal for unit change in input. In other words, it is the ratio between the small change in electrical output to a small change in physical input. Here the input is level in mm, and the output is voltage in μV. Achieving adequate sensitivity of the probe is a major challenge in the design of MI type level sensor for the Pb-Li system. This is mainly because the resistivity of Pb-Li eutectic alloy is much higher (4 to 5 times) than that of sodium. Hence, the sensitivity of Pb-Li probe at actual process condition has to be verified by modelling and simulation[14].

Another performance parameter of the level probe is % output variation of secondary output voltage expressed in percentage for 100% change in level.

$$\% \text{ Output Variation} = \frac{\text{Zero level Secondary voltage} - \text{Full level Secondary voltage}}{\text{Zero level Secondary Voltage}} \times 100$$

4.3. Sensitivity Estimation

To estimate the sensitivity of the probe accurately, it is required to model the probe based on actual dimensions. However where there is limitation in modelling the actual dimensions certain approximations are made. After modelling, the actual process environment was simulated and secondary voltages of the probe at various levels were estimated.

Finite element analysis is a suitable method for estimating the probe output voltage for various Lead-Lithium Levels. Finite Element Method (FEM) or Finite Element Analysis (FEA) is a method of solving complex physics and engineering problems.

The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain. To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses calculus of variations to approximate a solution by minimizing an associated error function.

For preliminary analysis and estimation of output voltages, we are using Finite Element Method Magnetics (FEMM) software. FEMM is an open source platform capable of performing 2D models of practical problems. It can support only a limited number of physics processes. The advantage of using FEMM is that it can readily take into account the basic Magnetic and Electric properties of materials. Certain assumptions are used to model the three dimensional probe using FEMM which will be discussed in detail in later section. FEMM is capable of projecting 3D models of 2D figures by assuming either planar symmetry or axis symmetry.

The basic steps in Finite element analysis using FEMM are:

- Observing the entity to be modelled and studying its nature and associated physics.
- Deducing a suitable two dimensional equivalent for the actual 3D object.

- Reproduce the 2D equivalent on the FEMM workspace.
- Assign properties of components and make necessary changes in property window to suit changes in process environment or create new materials when suitable material is not available.
- Create mesh of suitable size. In most cases the software will assign the mesh automatically. In this model also mesh has been assigned automatically by the software.
- Compute the result using solver.
- Observe the required result in the result window.

Using FEMM model, it is possible to assess expected voltage output and sensitivity of the Lead-Lithium Level probe.

4.4. Assumptions Used for Modelling

FEMM has limited capabilities when it comes to 3D modelling[15]. Certain assumptions are used to make it convenient to model. However the effect of these assumptions on the output will be negligible.

These assumptions are:

- The probe is considered to be axis symmetric about a central axis.
- The cruciform bobbin inside the bifilar winding is not possible to be included in an axis symmetric modelling. Hence it is considered to be a hollow cylinder with thickness as half that of the cruciform bobbin, and mean radius equal to the geometrical mean radius of the cruciform structure. This is a pessimistic approach in modelling the bobbin.

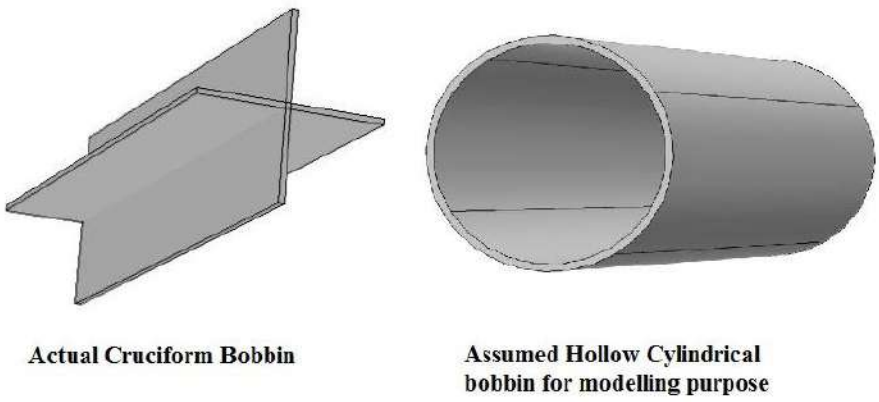


Fig 4.1: Actual Bobbin and Modelled Bobbin of the Probe.

- The windings are approximated to be circular.
- The boundaries for the 2D model are also assumed.
- Since the FEMM cannot include heating effects and thermal properties of materials, a material block is considered to be at a uniform temperature. So electrical resistivity of both SS and Pb-Li are considered as uniform within the block.

4.5. Dimensions Used for Modelling

All dimensions of the probe are finalized based on the preliminary design, functional requirement and feasibility of manufacturing. For FEMM modelling dimensions are taken from the central axis of the probe since the probe model considered is axis symmetric. The main components and their dimensions considered for modelling are given below. And these dimensions are selected based on the proven design adopted for sodium system level sensors at IGCAR.

- Bobbin: The bobbin is cruciform in shape with a width of 32mm, and 1mm thick. It has slots of 2mm depth at 2.5mm pitch for the primary and secondary windings. The material used is SS316. Since this geometry cannot be modelled in the axis symmetric method, the bobbin is assumed to be a hollow cylinder of thickness 0.5mm and diameter 16mm (mean value of 32 mm and 0 mm). In this assumption, the eddy current path in the bobbin is modelled approximately.

- MI cable: The MI cable has an overall diameter of 1 mm. The MI cable consists of three different layers. The innermost core is the conducting layer made of copper of diameter 0.3 mm. The middle layer is Magnesia (MgO) which serves as an insulation. The outer layer is Stainless steel sheath of thickness 0.1mm. The conductor is placed at a distance of 14mm from the axis to account for the slots in the actual cruciform bobbin.

- Pocket: The pocket is made of SS316 of ID 36.62mm and OD 42.16mm. The same dimensions are used in modelling also.

- Bulk Lead Lithium and Argon: This volume of Pb-Li in the tank is modelled with the lateral boundary at a distance of 100mm (towards right end) from the symmetry axis. The bottom boundary is taken as the bottom boundary of the Lead lithium tank. The top boundary is taken at a distance of 20mm above the active length. This length was chosen based on a preliminary judgement to account for the flux path inside the chamber. This length was found appropriate by evaluating the model. The region is either partially or completely filled with Pb-Li and the rest of the portion by argon depending on the level for which the probe is modelled.

- Lead Lithium tank: The Pb-Li tank is assumed to be sufficiently large to accommodate the flux path generated by the coil. So, only the bottom end of the tank is modelled which is kept merely at a distance of 3 mm from the pocket closure cup. The thickness of the tank is taken as 8.4mm. (Assumed from tank data provided by IPR).

The regions A, B & C marked in the above figure are respectively the top, middle and bottom regions of the active length region of the probe. The figures 5.2, 5.3 and 5.4 are respectively the enlarged view of A, B & C. The figures are axis symmetric showing only right hand side of the axis.

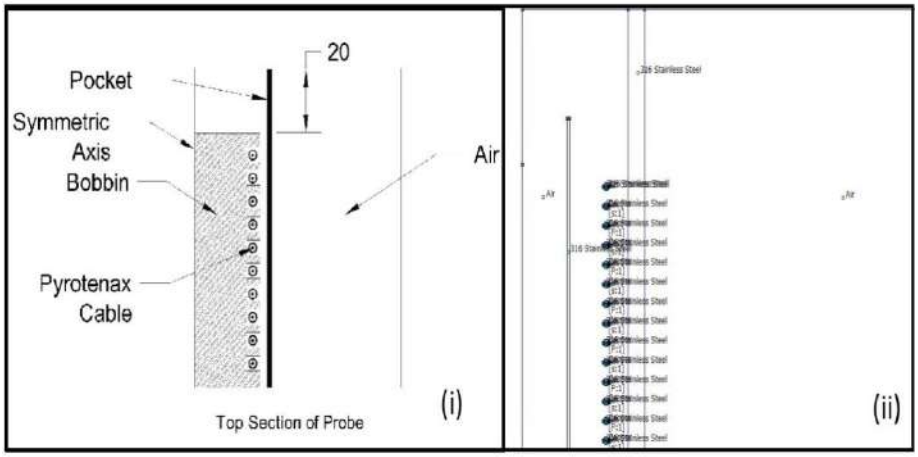


Fig 4.2: Top Section ‘A’ of the probe; (i) CAD drawing, (ii) FEMM Model.

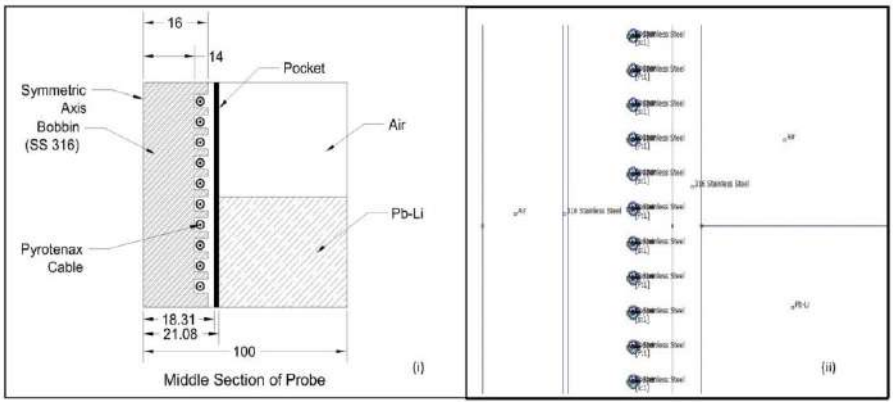


Fig 4.3 Middle Section 'B' of the probe; (i) CAD drawing, (ii) FEMM Model.

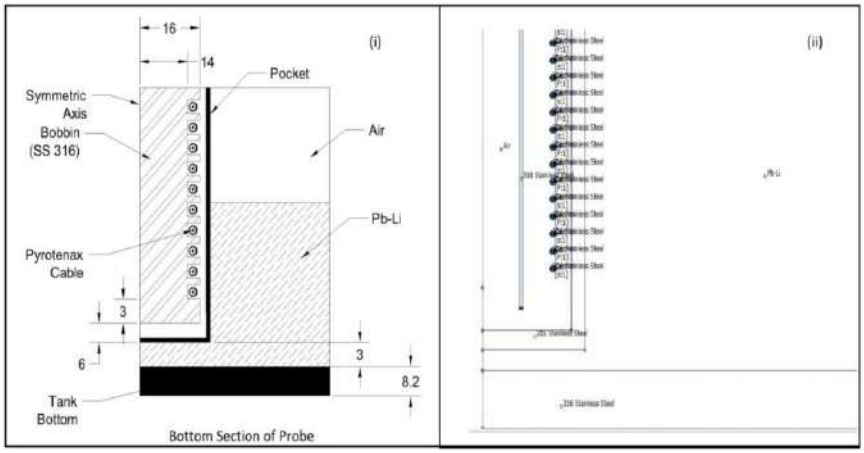


Fig 4.4: Bottom Section 'C' of the probe; (i) CAD drawing, (ii) FEMM Model.

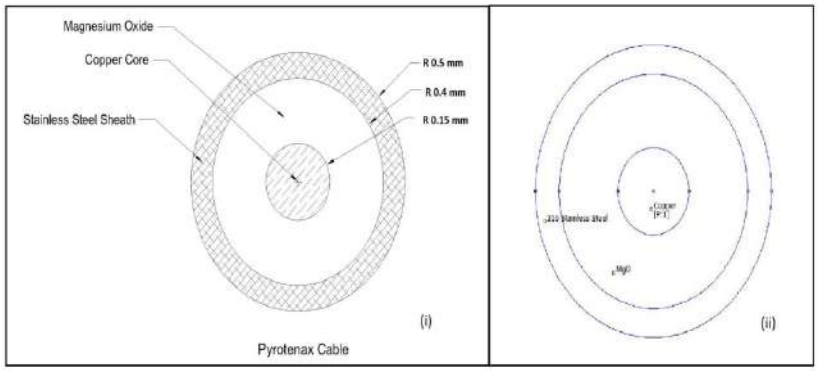


Fig 4.5: Cross sectional view of cable; (i) CAD drawing, (ii) FEMM Model.

The important feature to be noted here is that the FEMM model of the probe does not show the bobbin as cruciform. It is shown as a hollow cylinder with dimensions as specified earlier in this section and also it is axis symmetric.

4.6. Results

The models are evaluated at a constant primary current of 120 mA and at a frequency of 2.5 kHz against various defined Aluminium, Stainless steel and Pb-Li levels. The secondary output voltages were noted and the sensitivity was estimated. The secondary output voltages against various levels and the probe sensitivity is given in Table 4.1. In modeling the temperature of aluminium and stainless steel is fixed as room temperature whereas the temperature of Pb-Li is fixed as 452^0C

Table 4.1: Estimated Level Probe Output and Sensitivity

Current = 120mA		**Frequency = 2.5KHz**	
Level of Liquid Metal (**%** of active length)	**Sec. Volt. for Al** (mV)	**Sec. Volt for SS** (mV)	**Sec. Volt for Pb-Li** (mV)
0	44.723	44.723	44.723
25	40.952	41.552	41.936
50	36.309	38.833	39.066
75	31.173	35.799	36.175
100	27.351	32.588	34.345
Sensitivity (µV/mm)	-19.382	-13.665	-11.686
% Output Variation	38.843	27.134	23.21

*Probe active length is 888 mm.

The sensitivity of the probe is found to be -11.686 µ V/mm for Pb-Li. Negative sign indicates that the voltage reduces when level increases. Percentage output variation is 23.21%.

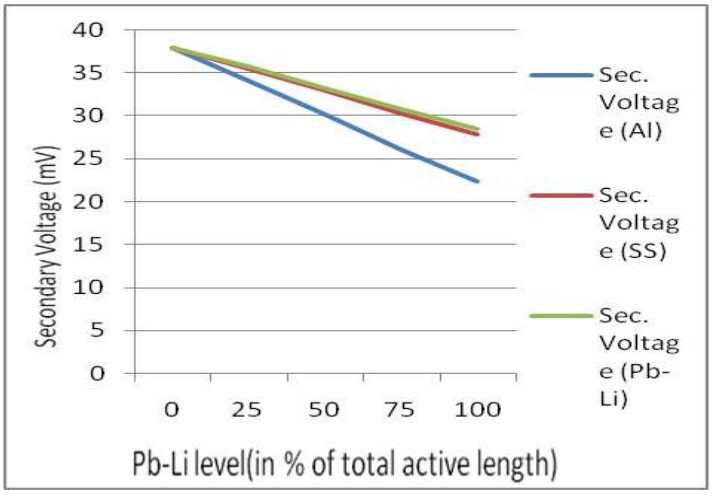


Fig 4.6: The graphical plot of the secondary voltage output vs. level for Al, SS and Pb-Li

4.7. Conclusion

The secondary voltage shows the variation of the probe output for a change of 25% of active length in each step. The total active length of probe is 888 mm as mentioned. So, 25% step is actually 222 mm. The calculated sensitivity is greater than 10µV/mm for aluminium, stainless steel and Lead Lithium, which is much higher than the minimum required sensitivity of 5µV/mm. Hence, the probe dimensions and materials used are found suitable and verified through modelling.

Percentage output variation for Pb-Li is 24.84 % which is a good value for a probe of 888 mm active length. This is acceptable for the given design. Since, the probe is giving adequate sensitivity it is planned to manufacture a probe of this design for further evaluation and testing. Before taking up the manufacture of the probe and electronics it was decided to determine the skin depth and predict the size of metallic block for dry testing of MI type level sensor.

CHAPTER-5

DETERMINATION OF SKIN DEPTH AND PREDICTION OF SIZE OF METALLIC BLOCK FOR DRY TESTING OF MI TYPE LEVEL SENSOR

5.1 Introduction

The Level sensor is immersed in Lead-Lithium Eutectic alloy under working conditions. The primary winding of the sensor is excited using a constant current and constant high frequency voltage source. The induced voltage in secondary is inversely proportional to the level of the Pb-Li alloy in the tank. Higher the level of Pb-Li alloy, lower will be the secondary induced voltage. The factor which influence this action is the eddy current induced in the molten alloy. Higher the eddy current density, the more prominent will be the reduction in secondary voltage. The skin effect of the alloy must be considered to determine the eddy current density inside the alloy. The eddy current density reduces exponentially in the outward direction from the surface of the level probe pocket. The distance from the surface of the pocket at which the eddy current density is 1/e times (37%) of eddy current density at the surface of the pocket is known as skin depth of the conductor. In most cases, more than 98% of the eddy current will be contained in a region equivalent to 4 times the skin depth.

Determining this depth will enable us to predict the minimum radius of the tank/vessel for satisfactory operations of the probe. It also allows to predict the radius of the solid conductive metal blocks which needs to be used for dry testing of the probe before testing in the actual Pb-Li medium. Therefore, skin depth is an important parameter that has to be taken in to account for an MI type Level sensor.

The major objectives of this document are:

- To predict the depth of eddy current penetration in Aluminium, stainless steel (SS) and Lead Lithium alloy and assess the radius and thereby the minimum size of the Lead-Lithium vessel/ tank for satisfactory performance of the level probe.
- To predict the minimum size of the Aluminium and SS metallic blocks to be used for dry testing of the MI type Level Sensor.

5.2 Skin Depth

A magnetic wave falling over the surface of a conducting medium tries to penetrate into the medium. Depending upon the parameters, particularly conductivity, the wave is able to enter into the

medium only up to a certain depth before it gets weakened completely. Skin Depth is a parameter which describes the depth up to which the wave is allowed to enter into the medium or is also known as the *depth of penetration.*

The major factor which influences skin depth of a conducting material is the resistivity of the material. Higher the resistivity, the more will be the skin depth of the material.

The following methods were used for prediction of the skin depth:

- Analytical method by using skin depth equation.
- Graphical Method by using FEMM model.

The results from both these methods are tabulated and compared and required minimum radius of metal block and Pb-Li tank is arrived at.

The materials for which skin depth is calculated are:

a) Aluminium
b) Stainless Steel 304
c) Pb-Li Alloy

5.2.1 Analytical Method

Skin depth (δ) [16] is given by the equation [6.1]:

$$\delta = \sqrt{\frac{2\rho}{\omega\mu}}$$

Where

μ = Permeability of the material $\cong \mu_r = 4\pi * 10^{-6}$ H/m

ρ = Resistivity of the material

ω = Angular frequency (2πf)

For each of the materials the skin depth is determined using the above equation. The Aluminium and Stainless Steel are evaluated at room temperature (25°C), and the Pb-Li is evaluated at the

operating temperature (452°C). Resistivity of Pb-Li for various temperatures is mentioned in previous chapters . The operating frequency is fixed at f=2500 Hz.

Table 5.1 : Resistivity and skin depth through Analytical Method.

SI. No.	Material	Resistivity (Ωm)	Skin depth(δ) (in mm)	Minimum radius = 4δ (mm)
1.	Aluminium	2.82×10^{-8}	1.69	6.76
2.	Stainless steel 304	72×10^{-8}	8.54	34.16
3.	Pb-Li Eutectic alloy	133.2×10^{-8}	11.62	46.48

5.2.2 Graphical Method

The FEMM modelling of the level probe was carried out for sensitivity estimation of the MI type Level Probe initially. In the Finite Element Analysis it was assumed that the model probe is axial symmetric The same model is used for estimating the eddy current density in the surrounding medium. The graphical method utilizes the plot of distance vs eddy current density. The graph plotted here shows the magnitude of eddy current in Y-axis and the distance from the central symmetrical axis used for modelling in X-axis .The following is the plot of Distance vs Eddy current density for Lead-Lithium alloy.

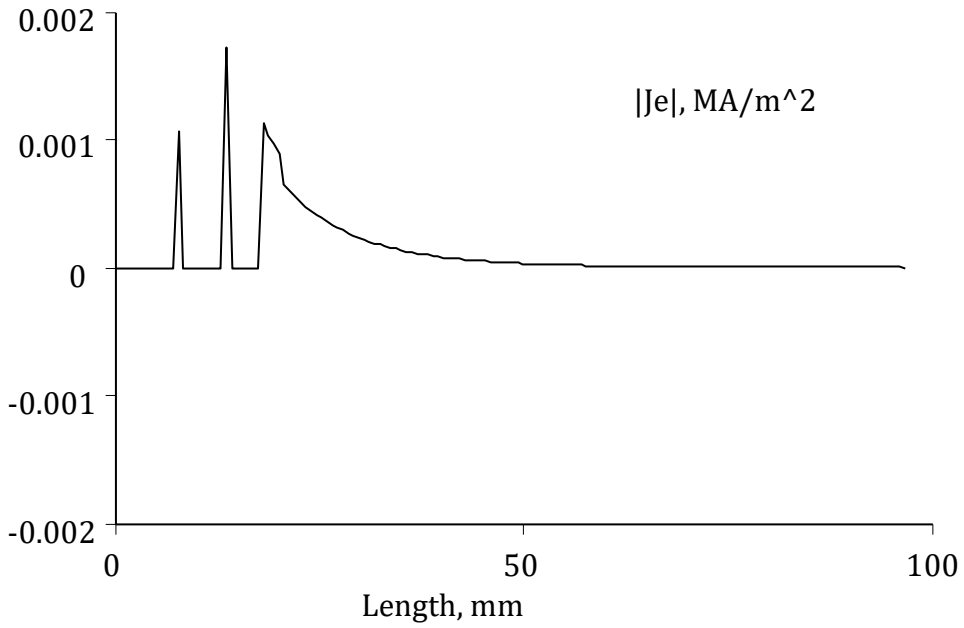


Fig. 5.1: Typical plot of Eddy Current vs distance for Lead-Lithium alloy.

The first two peaks in the plot (Fig 6.1) shows the eddy current distribution in the former/bobbin and MI copper conductor of the probe respectively and the third and final peak represents eddy current distribution in liquid metal of which the level is to be measured. Distance at which current extinguishes to nearly 2% of the value from the surface of the pocket is obtained from the plot and is taken as the minimum radius. Skin depth will be approximately 1/4th of this distance. A typical plot of eddy current vs distance for lead lithium alloy is shown in Fig 3. Similarly plots and skin depth were also obtained for aluminium and stainless steel. The tabulated results are shown in table 6.2.

Table 5.2 : Resistivity and skin depth through Graphical Method.

SI. No	Material	Minimum radius From graph (2% value) (in mm)	Skin depth(δ) Approx. (in mm)
1.	Aluminium	13	3.25
2.	Stainless steel 304	37	9.25
3.	Pb-Li Eutectic alloy.	50	12.50

5.3 Deciding Dimensions of Test Block

The minimum required dimensions for the test block and Pb-Li tank can be determined from these data. The highest value of skin depth from the two methods is taken. This value will be used for calculation of minimum dimensions of Aluminium, SS304 block and Pb-Li tank. Table 5.3 shows the minimum required dimensions of test blocks, the Pb-Li tank, and the actual dimensions. The actual dimensions are very much higher than minimum dimensions to account for any error in predetermined values.

Table 5.3 : Comparison of predetermined dimension with actual dimensions.

Sl. No.	Material	Predetermined dimension (minimum radial thickness)	Actual dimension (radial thickness utilized in experimental testing)
1.	Aluminium	13	20*
2.	Stainless steel 304	37	45*
3.	Pb-Li alloy	50	90**

* Radial thickness of test block to be purchased.

** Radial gap inside Pb-Li diagnostic loop tank (data provided by IPR).

Hence, the diameter of the tank is sufficient enough to accommodate the eddy currents generated inside the lead lithium eutectic alloy.

5.4 Finalizing Dimension of Test Blocks

The dimensions of test blocks are decided based on the data of radial thickness from Table 5.3. Table 5.4 shows the complete dimensions of test blocks. The test blocks are hollow cylinders of the above mentioned materials. The height of the block is chosen as 100 mm for the ease of handling. In this case, the increase in level for the addition of each piece will be exactly 100 mm. Inner diameter depends on the size of the probe and outer diameter on skin depth/ radial thickness[17].

Table 5.4 : Finalized dimensions of Blocks to be purchased for dry testing of probes.

SI. No.	Material	Inner Diameter (I.D) (mm)	Outer Diameter (O.D) (mm)	Height (mm)
1.	SS 304	44	134	100
2.	Aluminium	44	84	100

Isometric View **Top View & Front View**

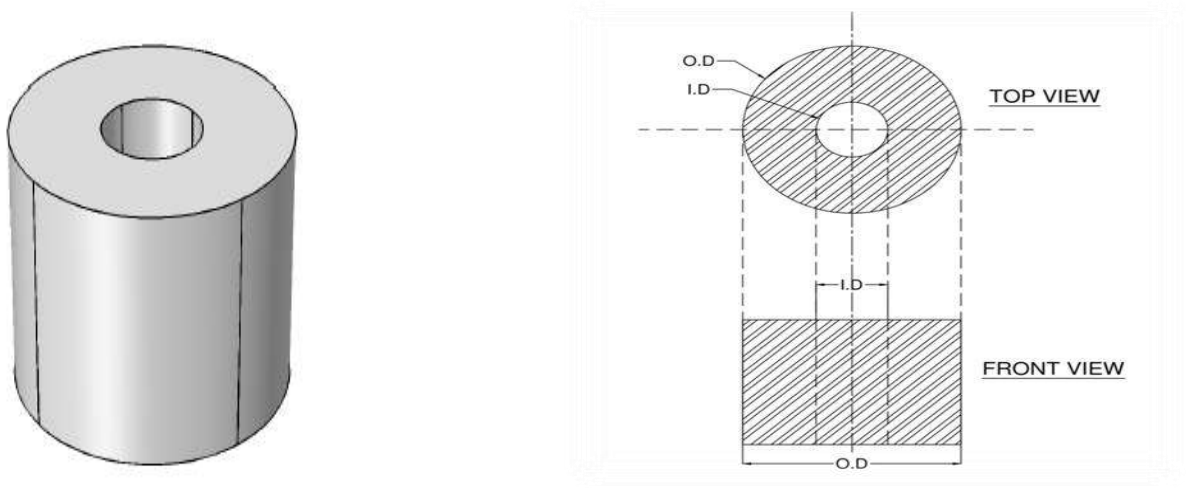


Fig. 5.2: Isometric, Top and Front view of blocks for dry testing.

5.5 Conclusion

This chapter gives the skin depth analysis of the MI type level probe for Pb-Li Loop system. The parameters including current, frequency and sensitivity of the probe are as per the design in the previous chapters. Depth of eddy current penetration in Aluminium, stainless steel (SS) and Lead Lithium alloy was determined by analytical method and FEMM modelling. Based on that minimum size of the Lead-Lithium vessel/ tank for satisfactory performance of the level probe and the minimum size of the Aluminium and SS metallic blocks required for dry testing of the MI type Level Sensor were decided.

CHAPTER-6

TECHNICAL SPECIFICATIONS FOR MUTUAL INDUCTANCE TYPE CONTINUOUS LEVEL SENSOR FOR LEAD LITHIUM SYSTEM

6.1 Name of Item : MUTUAL INDUCTANCE TYPE CONTINUOUS LEAD –LITHIUM LEVEL PROBES AND ELECTRONICS

6.2 Specifications and Quantity

6.2.1 Scope

This specification covers the general requirements of Mutual inductance type continuous Lead-Lithium level probes and associated electronics [18].

6.2.2 Requirements

Continuous level probe and electronic chassis are required for Experimental and demonstration purpose. It is required that the probes and the electronic chassis shall be fabricated, tested and supplied by same firm.

6.2.2.a M I type Continuous level probes Quantity Required: 01 No.

Sl No.	Active length in mm	Non-Active length
1	888	305

6.2.2.b Electronic chassis Required for continuous level probe Quantity Required: 01 No.

6.2.3 Process operating condition

Fluid : Lead Lithium Eutectic alloy

Temperature range : 300 - 550°C

6.2.4 Reference Drawings

For MI Continuous Level probes: Refer Fig.7.1 for MILP assembly drawing

6.3 Specification For MI Type Continuous Level Probes

6.3.1 Level Probe Assembly

The level probe assembly consists of a pocket and probe.

6.3.2 Pocket

The pocket assembly consists of pocket closure cup, pocket of a single seamless pipe made of stainless steel (SS316). The pocket assembly is shown in the assembly drawing (Fig.6.1). The pipe shall be extruded so that the bend or curvature does not exceed ±1 mm per meter length of the pocket. The internal/external diameters and wall thickness of the pocket are as follows

External diameter : 42.16 mm

Internal diameter : 36.62 mm

Wall thickness : 2.77 mm

At the upper end of the pocket, a pocket flange (Item no.8) shall be machined from solid round which provides for fixing the level probe. All the parts which are likely to come in contact with lead-lithium or its vapour shall be made of stainless steel (SS316). The overall length of the probe shall be to meet the requirements of the active length and non-active length .The weld joints shall be tested for Liquid Penetrant Examination, Radiographic test and Helium leak test. The overall construction of the pocket shall have clean internal and external surfaces, free from scratches and all other defects.

6.3.3 Leak tightness

After assembling the pocket, the leak rate should not exceed 10^{-8} Pa m^3/second of Helium. The pocket should withstand an external pressure of 1000kPa at 873 K.

6.3.4 Probe

The probe consists of

-Sensing element

-Supporting tube

-Supporting flange

-Terminal box

The probe shall be placed inside the pocket which protects it from direct contact with lead-lithium or its vapour and shall be held in position by bolting its flange to the flange of the pocket. It shall well fit into the pocket. The clearance between the probe and the pocket shall be as minimum as possible only to the extent of allowing easy removal and insertion.

6.3.4.a Sensing Element

The sensitive portion of the probe is made of two bobbin strips of SS316 as shown in Item No.4 in the assembly drawing. The two bobbin strips are welded to form an uniform (cross) shaped section as shown in view-A. Primary and secondary windings are wound around over the active length in bifilar fashion. The primary and secondary windings are wound with 1 mm dia. mineral insulated cable with copper conductor core, SS sheathed and magnesium oxide insulation. The bobbin assembly consists of bobbin support tube, cable penetration flange and probe flange are shown in the assembly drawing. The insulation resistance between the windings and electrical ground shall be > 100 MΩ at 20°C and the value of insulation resistance shall be > 1 MΩ at 550°C. The voltage for insulation resistance measurement shall be I00V DC.

6.3.4.b Mineral Insulated cable specifications

Cable diameter : 1 mm

Sheath material : SS316L

No. of core : 1

Core material : Copper

Core diameter : 0.33mm

MgO content in Insulation : >96%

Impurity content in the Insulation (Max) :

Boron plus cadmium – 30 ppm

Sulphur – 50 ppm

Carbon – 300 ppm

6.3.4.c Terminal Box

The terminal box, support screws, connector support, cold end termination and eye bolts are

shown in the assembly drawing. All the terminals of the windings shall be extended by cables with cold end pot and terminated in a terminal box at the upper part of the probe. The cables shall be suitable for operation at elevated temperatures. Within the terminal box, all the terminals shall be clearly marked. The cable entry to the terminal box shall be through leak tight cable glands. MS circular connector (6 pin) shall be used for terminal connector.

6.3.4.d Electronics

The specification covers the general requirement of Mutual Inductance type lead-lithium continuous Level probe Electronic Chassis. The supplier shall submit the schematic circuit drawings, layouts, size of PCB for approval. The supplier shall mention about the ventilation requirements.

Each chassis shall have two independent chains.

-an input chain

-an output chain.

The input chain feeds the primary winding of the probe with constant current and constant frequency. The output chain consists of receiver circuit. The isolated AC signal of secondary winding is processed by this circuit.

6.3.4.e Chassis

The chassis shall be 19" rack mountable instrument case with plug-in module construction. The Front view of electronics chassis is shown in Fig.6.3 and the rear view is shown in Fig.6.4.

The chassis shall have the following modules:

-Mains ON /OFF module

-Exciter module

-Receiver module

-Trip circuit module

-Display module

i) Mains ON/OFF Module

The module shall have on its front panel the following:

-a switch for connecting the instrument power supply

-an indicating lamp to show that the unit is connected to power supply

ii) Exciter Module

The module shall have sinusoidal oscillator and constant current drive circuit.

iii) Sinusoidal Oscillator

Type : Hardware based Direct Digital Synthesizer

Clock : Crystal oscillator

Frequency range : 1kHz to 10kHz

Frequency stability : better than 15 ppm rc

Frequency setting : By key pad and microcontroller in steps of 1Hz

Total harmonic distortion : Less than 0.05%

Output Amplitude : Variable up to 10V AC

Amplitude Stability : better than l00 micro Volt/ °C at the output

iv) Constant current circuit

Type : Low side sense with PI control algorithm

Output : Isolated with Integrated Power Amplifier

Output current : 80 to 200mA rms, isolated.

Frequency : As set by the sinusoidal oscillator

Load resistance : 100 Ohms max.

Current stability as

function of load : better than ±0.1% Current stability as a

function of temperature : ±0.1% ambient temperature from 0 to 50°C

Total harmonic distortion : less than 0.2%

Push button switches shall be provided to increase / decrease the probe current at the front panel.

v) Receiver Module

The module shall have isolated input AC signal amplifier and isolated DC output.

Input signal : AC signal, 5 mV to 100 mV rms.

Input impedance : $\geq 10^5$ ohms at the frequency of 2.750 kHz

Band width : Lower 3 db point - less than 2 kHz Upper 3 db point - greater than 3 kHz

Output : 0 -10V DC, isolated.

Linearity : ±0.2% of full scale

Stability : It is a function of temperature.

±0.01% for the frequency range of I kHz to 5 kHz for an ambient temperature from 10°C to 50°C

Gain selection switches shall be at front.

vi) Trip Module

The module shall have 2 set points viz. Low set point and High set point with LED indication.

No. of contacts : 3 C/O contacts for high and low set point

Contact rating : 240 V, 5 A (non-inductive load) Indication

Test push buttons to simulate the low and high trip signal, independent switches for low and high set points selection for setting, LED indication and trim pots shall be available on front panel.

vii) Display Module

Digital metering shall be provided to display the lead-lithium level in mm.

Display : 20X4 line backlit alphanumeric LCD and a 4 key keypad

Parameters to be displayed : Primary current, Voltage, Frequency and Level in mm.

Resolution of level : 1 mm

Communication : LAN

viii) Rear panel

Input : 240 V AC, ±10%, 50 Hz, single phase through EMI/RFI filters.

Probe Connector : 6 pin Amphenol male connector (mating connector shall be supplied)

Terminal strip connector : To measure the probe outputs and for trip contacts.

Current measuring terminals : shall be provided with short link.

ix) Environment

Temperature : 283 - 323 K (10- 50°C)

Relative humidity : up to 98%, non-condensing

6.4 Materials and workmanship

Materials, processes and standard parts which are not specifically designated herein and which are necessary for the fulfilment of this specification shall be of good commercial quality and in accordance with the practice pertinent to the manufacture of system of similar nature. The components used shall be inherently moisture and fungus resistant or shall be made so by suitable

treatments. Workmanship shall be in accordance with the high grade commercial practice adequate to ensure satisfactory operation.

6.5 Material test

All materials designated in conformance with a standard shall be tested as required by the standard. The materials should be checked for required tests such as chemical composition and tensile test etc., and test certificates should be produced for approval.

6.6 Inspection and testing

Before dispatch of equipment the supplier shall perform all inspection and testing specified herein to ensure that materials and workmanship are of the degree of excellence as required by this specification and operational requirements are fully met. The inspection and testing shall be done in a manner satisfactory to and subject to the approval of the purchaser. The purchaser reserves the right to ask for or conducted by the parties other than the supplier, any additional inspection and testing deemed necessary by him.

6.6.1 Tests for the probe assembly

All the Mutual inductance type continuous level probes covered by the specifications shall undergo the following tests at the manufacturer's premises.

6.6.2 Dimensional check

The dimensions of the probes and pockets shall be checked for the following.

- Internal and external diameters of the pocket.
- The maximum bend in the pocket.
- The overall length of the assembly.
- The length of the active length portion.
- The length of the non-active length portion.

The bend in the length of the pocket shall be tested by introducing a dummy pipe over the complete length of the pocket.

6.6.3 Leak Tightness test

The pocket shall be tested for leak tightness under vacuum with Helium. The maximum

leak rate shall not be greater than 10^{-8} Pa m^3/second of Helium.

6.6.4 Electrical test

The electrical continuity of each winding and their connections to the terminal connector shall be checked. The resistance of each winding shall be measured.

6.6.5 Insulation test

The insulation resistance shall be measured between the windings and between each winding and the ground. The voltage for insulation resistance measurement shall be 100 V DC. It shall be greater than 100MΩ at 20ºC and greater than 1MΩ at 600 ºC.

6.6.6 Assembly test

After these tests, the probe shall be introduced into the pocket vertically without allowing the sensitive part to undergo rotation. Proper assembly of the probe into the pocket shall be ensured.

6.6.7 Tests for Electronics

Frequency stability, current stability, linearity, accuracy of adjustments, insulation resistance between signal leads and between signal leads and ground. All the individual modules of electronic chassis should be checked. It shall be checked for environmental qualification as per IS 9000.

6.6.8 Tests for Level indication

The supplier shall demonstrate the proper operation of the electronics in conjunction with the probe assembly for all the levels. The probe shall be mounted in the pocket and wired to Electronics. The influence of Pb-Li level on the output signal for all the levels shall be simulated by allowing the probe assembly to enter an SS block of sufficient thickness.

6.6.9 Inspection or Test failure

In the event of any failure of the probes the supplier shall notify the purchaser or his authorized representative and obtain permission from the purchaser before repair. Re-inspection and retest shall be conducted on the repaired probe.

6.6.10 Acceptance Test

The purchaser or his authorized representative reserve the right to do inspection and testing as per the provision of the specifications within a reasonable time after the arrival of the equipments at their ultimate destination. The equipment shall not be deemed accepted until after the said inspection and testing is completed. Equipments not confirming to this specification shall be rejected and the purchasers inspector's decision shall be final.

The level probes offered shall undergo tests at the designated labs for certification. The cost includes all the testing for each probe, material analysis weld dye penetration, radiography and Helium test. Test certificates shall be provided with the probes.

6.7 Packing

The equipments and components shall be protected and packed adequately and effectively so as not to suffer corrosion deterioration or damage of any sort during shipment and storage at site under shade protected from rain and sun for a period of 12 months. Packing shall be done keeping in view the character of equipment, conditions of climate, storage, handling and transportation the consignment is likely to undergo before reaching the destination. Level probe and pocket shall be packed properly with suitable supports. It should not bend during handling and transportation.

Packing list shall show package numbers, kind of packages, content, dimensions and net and gross weight of each package. If different items are in package the net weight of each item shall be specified. The shipment of the equipment shall not be affected until and unless clearance is obtained from the purchaser or his authorized representative.

The supplier shall arrange specially hired vehicle for direct delivery at site. The shipping Vehicle shall have adequate capacity and shall have valid permit for shipment. Clearance from the purchaser's representative shall be obtained before shipping. The supplier has the responsibility for the safe shipments of all parts to the site, safe delivery and unloading at site.

The package shall be stenciled in bold character with indelible paint protected with shellac to indicate shipping mark, package numbers, dimensions and gross weight, purchase order number, purchaser's address and suppliers address.

6.8 Eligibility Criteria:

- Offers from the manufactures / authorized dealers of manufacturers only will be considered.
- Along with offer, sketch of the MILP showing relevant dimensions should be submitted.

- In case the offer is received from the authorized dealer, inspection and testing will be carried out only at the manufacturer's works.
- The firms should have all the testing facilities to carry out all the tests specified in the specifications and proof of availability of test facility should be submitted.
- Along with the offer the firms should enclose the previous executed supply list of MI type level probe supplied for Lead – Lithium application for the past three years.
- The offers submitted by the firms without meeting all the above requirements will be summarily rejected.

6.9 Guarantee

Supplier shall give a guarantee against any defect in design materials and workmanship for a minimum period of 12 months from the date of installation or 18 months from the date of shipment whichever is earlier.

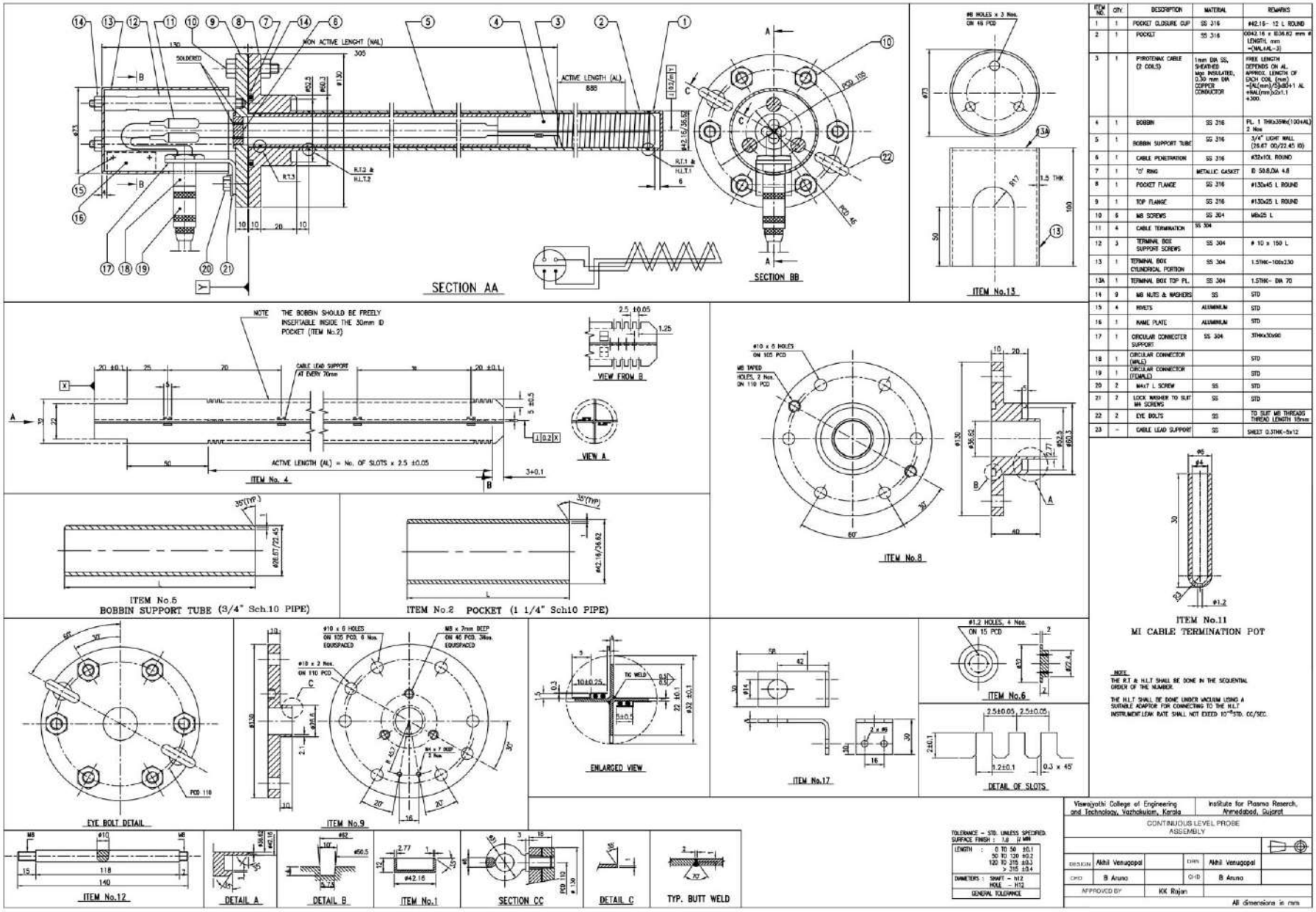


Fig.6.1: MI Type Continuous Level Probe Assembly drawing

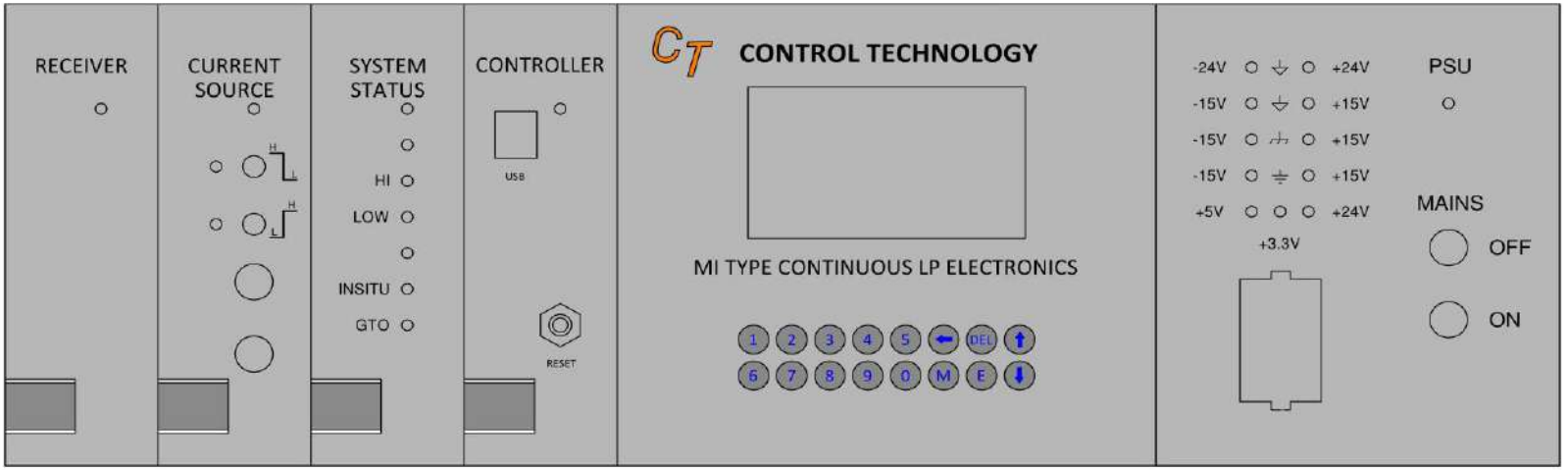


Fig.6.2. Front View of Continuous Level Probe Electronic Chassis

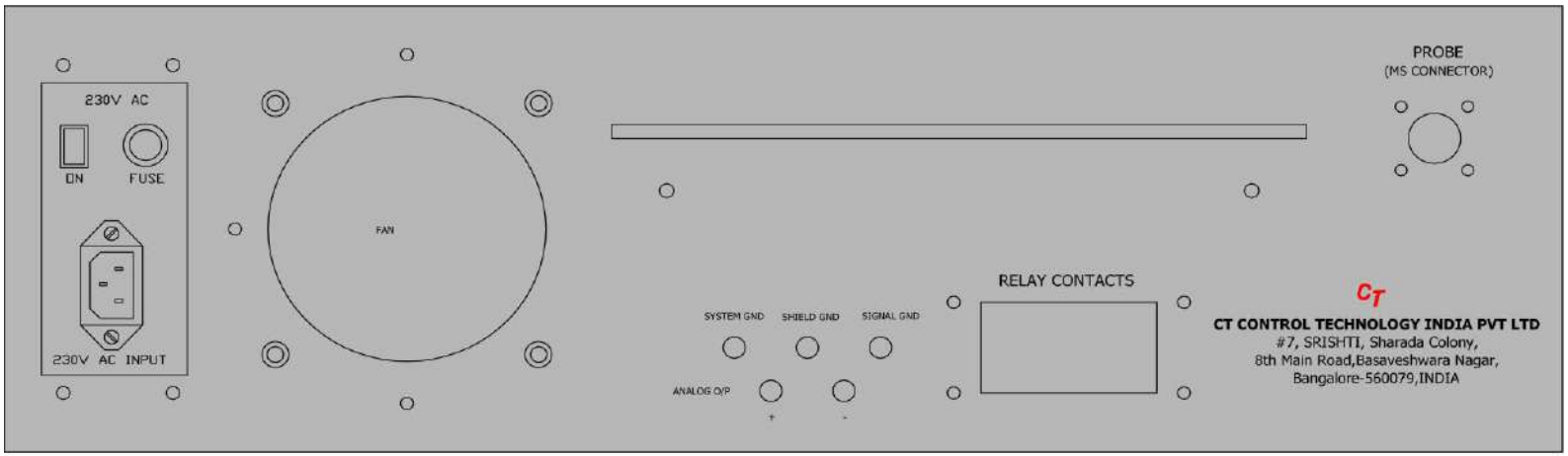


Fig.6.3. Rear View of Continuous Level Probe Electronic Chassis

CHAPTER - 7

MANUFACTURING AND QUALITY CONTROL

7.1 Introduction

Following the specifications and drawings the probe had been manufactured by an Indian Industry and has undergone a series of tests before the final acceptance. The first series of test includes material testing, liquid penetration examination, radiographic inspection etc. The test reports for various tests undergone is submitted as separate document.

7.2 Manufacturing of the probe

Fig 7.1 Probe winding assembly

Fig 7.2 Electronics for the Level Sensor

7.3 Quality Conformance Test and Inspection Reports

Sl No.	Description	Conclusion
1	Material Test Report	Acceptable on comparison with spec.
2	Liquid Penetration Examination Report	Acceptable
3	Radiographic Inspection Report with FILIMS	Acceptable
4	Helium Leak Test Report	Acceptable
5	Pickling & Passivation Report	Found ok, Acceptable
6	Welding Process Specification	-
7	Procedures for Radiographic Examination of Welds	-
8	Procedure for Helium Leak test	-
9	Procedure for Liquid Penetrant examination of Welds	-
10	Procedure for surface treatment	-
11	Acceptance test procedure & report	Acceptable
12	Functional test Report 1	Acceptable
13	Burn-in test report	Acceptable
14	Functional test report - 2	Acceptable
15	Bare PCB test report	Acceptable

7.4 Conclusion

The Final acceptance of the probe by VJCET has been made only after the evaluation of all the test reports for the quality assurance of the probe. The performance evaluation of the probe in Aluminium and Stainless steel medium in place of Lead-Lithium were carried out at VJCET and the report and its analysis has been discussed in next chapter.

CHAPTER -8

TESTING OF LEVEL PROBES AND ITS ELECTRONICS

8.1 Introduction

Level probe and Electronics manufactured as per specification has to be tested to confirm its performance. Testing of the probe and electronics has to be carried out in actual operating medium and at different operating temperature. This will be done at IPR when the system is ready. In order to make a preliminary assessment and to establish the feasibility of functioning of the probe and electronics tests were conducted with solid aluminum blocks and stainless steel blocks as the medium. The size of the blocks were selected based on skin depth studies carried out earlier. The performance of the probe varies mainly with the resistivity of the medium. Advantage of conducting the test with aluminum and stainless steel block is that the test can be conducted at room temperature at atmospheric conditions. In order to meet the requisite sensitivity the primary current has been increased from 100mA to 120mA

The value of resistivity of Aluminum, SS and lead lithium are given in the table. As the performances of the probe only depends on the resistivity of the medium the physical state of the medium does not matter.

Table 8.1 : Resistivity of Aluminum, SS and lead lithium

SI. No.	Material	Resistivity (Ωm)	Temperature
1.	Aluminium	2.82×10^{-8}	RT
2.	Stainless steel 304	72×10^{-8}	RT
3.	Pb-Li Eutectic alloy	133.2×10^{-8}	500˚ C

- The primary current is constant at 120mA with a permissible error of $\pm$0.1 mA.

- The fluctuations in measured secondary voltage against a level is minimized and is within the range of 3µV (difference between maximum and minimum)
- The resolution of probe is found to be 1mm.

Following are the steps involved in testing of the probe

- Warming of the Electronics for one hour, after switching on the power supply to electronics chassis and powering the probe.
- Setting of active length of the probe
- Setting of operating frequency as 2.5 kHz
- Setting of operating current as 120 mA
- Zero and span setting (Keep the system in respective level for half an hour before setting the level)
- Calibration of the probe by varying the height of the SS/ Aluminum block

8.2 Test Results

8.2.1 Sensitivity

Table 8.2 gives the test result of Level Probe in Aluminium medium at room temperature and the sensitivity of Probe in Aluminium medium is found to be -9.64µV/mm.

Table 8.2 : Observation in Aluminium medium at RT

Current = 120mA		Frequency = 2.5kHz		
True level (mm)	Measured Sec Voltage(mV)	Measured Level (mm)	Error in mm	Error in % of span
0	32.898	0	0	0.00
88	32.007	92	4	0.45
188	30.959	201	13	1.46
288	29.936	307	19	2.14
388	28.926	412	24	2.70
488	27.938	514	26	2.93
588	26.953	616	28	3.15
688	26.004	714	26	2.93
788	25.076	810	22	2.48
888	24.337	888	0	0.00

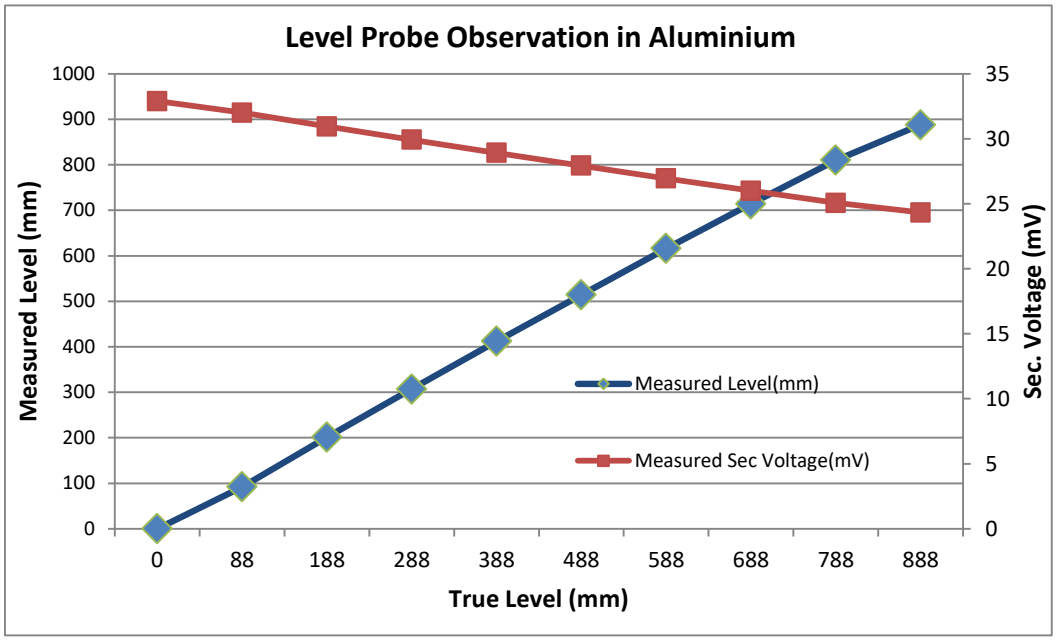


Fig. 8.1: Level probe Reading at RT in Aluminum Medium

Table 8.3 is the observation of Level probe in SS medium at RT and the sensitivity of probe in this medium is found to be **- 6.53µV/mm**

Table 8.3: Observation in Stainless Steel medium at RT

Current = 120mA			Frequency = 2.5kHz	
True level (mm)	Measured Sec Voltage(mV)	Measured Level(mm)	Error in mm	Error in %
0	32.888	0	0	0.00
88	32.301	88	0	0.00
188	31.602	197	9	1.01
288	30.916	302	14	1.58
388	30.228	408	20	2.25
488	29.562	510	22	2.48
588	28.888	614	26	2.93
688	28.23	715	27	3.04
788	27.679	815	27	3.04
888	27.094	888	0	0.00

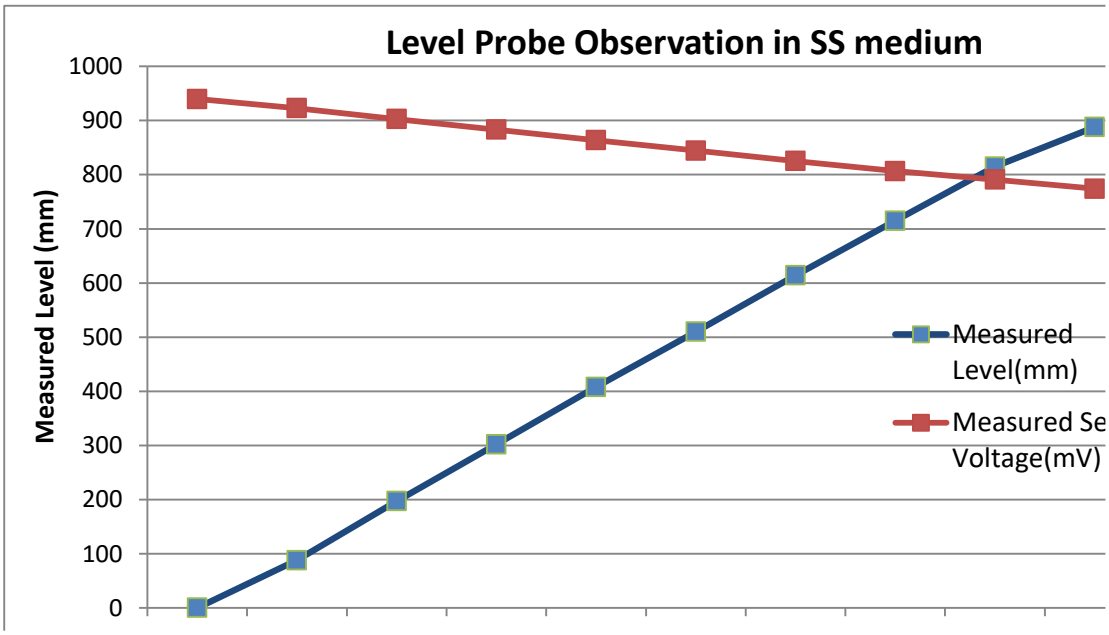


Fig. 8.2 : Level probe Reading at RT in SS Medium

9.2.2 Probe Characteristics

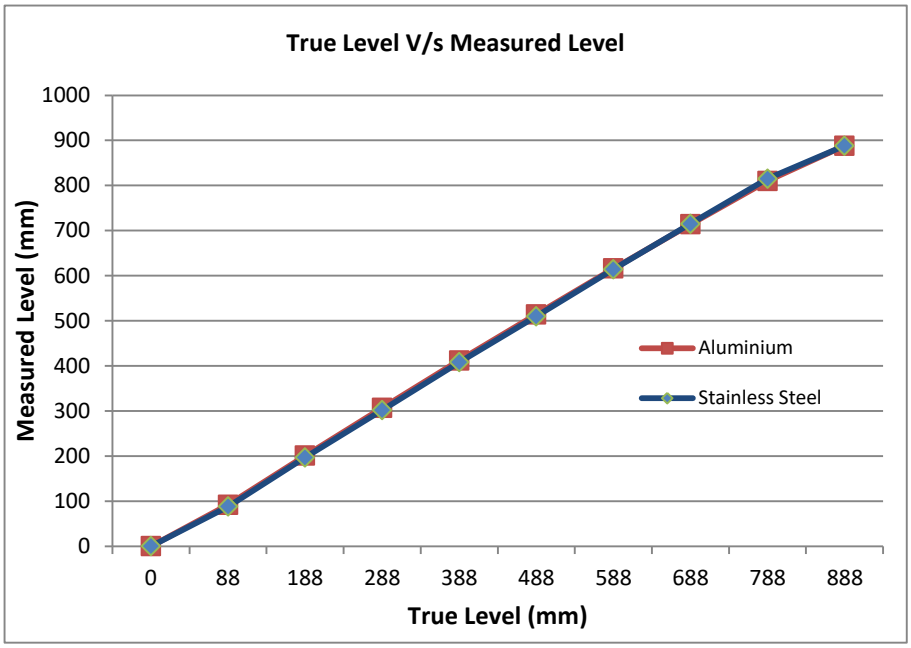


Fig .8.3 : Level probe Characteristics

Table 8.4 : Error in Level Readings						
True level (mm)	Level reading in SS	Error in mm for SS	Error % for SS	Level reading in Al	Error in mm for Al	Error % for Al
0	0	0	0	0	0	0
88	88	0	0	92	4	0.45
188	197	9	1.01	201	13	1.46
288	302	14	1.58	307	19	2.14
388	408	20	2.25	412	24	2.70
488	510	22	2.48	514	26	2.93
588	614	26	2.93	616	28	3.15
688	715	27	3.04	714	26	2.93
788	815	27	3.04	810	22	2.48
888	888	0	0	888	0	0

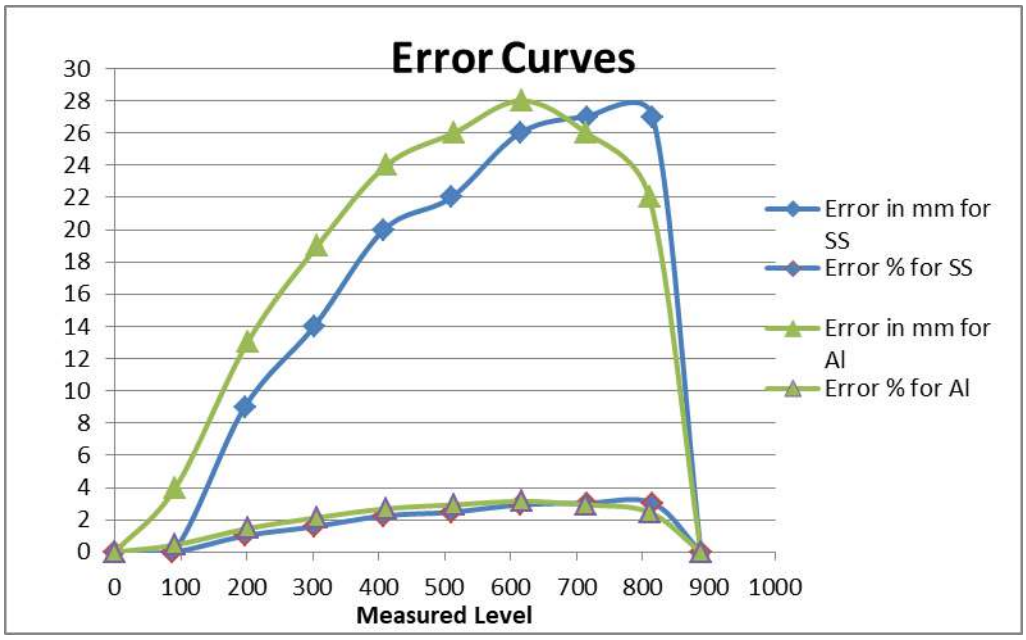


Fig. 8.4 : Error in level probe reading

8.2.2 DC Analogue Output

In addition to the level display provided in the front panel of the electronic chassis , the rear panel has a provision to deliver 0-10V DC isolated analogue output proportional to the lead Lithium Level. This output is verified from zero level to full level in SS medium and is found to have a linear variation corresponding to the level change.

8.2.3 Relay Output Verification

The relay contacts terminated on the rear panel uses a 15 pin universal Lock and Mate connector. Details of connection Pins are illustrated in User Manual . The Good To Operate indication, a low level trigger and a high level trigger output is obtained from the rear panel connector. The outputs of all these relays were verified and are accurate.

8.2.4 LAN Output

The Moxa LAN interface provided in the front panel helps in monitoring the system through a PC. In user mode through USB primary current, frequency, level and all system setting parameters are send to PC in a Hexadecimal packet of 36 bytes. The LAN Data format of the Packet is illustrated in User Manual and IEEE754 format can be used for conversion of Floating point hex to decimal Values. A separate software has been also developed for conversion of the primary current, frequency, and level in to decimal format.

8.3 Summary

Probe sensitivity in SS at room temperature is found to 6.53 micro volt per mm. A slightly lower value of sensitivity is expected in lead lithium alloy and is expected to be close to 5 micro volt per mm which is the target sensitivity. From the test result it is observed the probe characteristic and the pattern of error in readings is same for SS and Aluminium and will remain same for lead lithium too. The correction on level readings or actual level corresponding to any reading can be obtained by means of a look up table prepared based on test results. Non linearity observed in the characteristic of the probe is around 3 % and is close to the reported value of mutual type level probes manufactured for liquid sodium. The observed non- linearity is due to manufacturing tolerance of level probe parts and thickness variations in probe pocket.

CHAPTER -9

TEMPERATURE COMPENSATION FOR LEVEL SENSORS

9.1 Introduction

The voltage output of level probe is depending on the level of the medium and also the temperature of the medium. This is because of the variation of resistivity of the medium due to temperature variations. In order to read the level accurately at all temperatures a temperature compensation has to applied to the level probe output. When temperature of the medium increases the resistivity of the medium increases. Increase in resistivity causes a reduction in eddy current. Reduction in eddy current lead to lesser weakening of main flux due to medium and the higher voltage is induced in the secondary winding of the probe. High voltage output will display as lower level in the probe reading. The temperature compensation is achieved by connecting an external resistance Rext parallel to the secondary winding. For experimental verification of temperature compensation a high temperature test set up is made to vary the temperature of stainless steel blocks upto the value of 300 C. The value of Rext is determined experimentally. The effect of temperature and the effectiveness of temperature compensation is demonstrated in SS medium. This chapter gives the need for temperature compensation, the methodology followed for temperature compensation and its experimental demonstration with SS blocks upto a temperature of 300 C.

9.2 Theory of temperature compensation

Temperature plays a crucial role in the magnitude of induced secondary voltages because the resistivity of the eutectic alloy varies with temperature. Hence the magnitude of eddy-current in this region is also affected by temperature and thereby the MI type level sensor requires temperature compensation. In order to find the exact level of the liquid metal the effect of temperature change on the secondary voltage must be eliminated. The temperature compensation for MI type level probe is difficult due to following reasons [19]

- The variation of conductivity of Pb-Li, stainless steel and copper with temperature is different.
- The temperature coefficient of probe at different levels of Pb-Li is different.
- The effect of cover gas temperature has to be considered at partial levels.
- The change in secondary voltage with rise in temperature is nonlinear.

9.2.1 Temperature Compensation by Electronic method

One method of temperature compensation is by measuring the primary voltage variation, which is the measure of average temperature of the probe. In this method temperature compensation is achieved through electronics. The procedure is to experimentally determine a coefficient in mV/mm/^{0}C and is fed back to the system for the correction in accordance with this. The error contribution of this method is very high. So a different simpler method has to be adopted in order to achieve the temperature compensation with minimal error.

9.2.1 Temperature Compensation by Electrical method

This method utilizes the internal resistance variation of the coil with temperature and uses variation of internal resistance as a correction factor to compensate temperature effect. In the case of any given level, the internal resistance of the secondary coil increases with temperature. In practice, temperature compensation is provided by connecting a suitable resistance in parallel to the secondary winding. The magnitude of this resistance is determined either experimentally or by simulation, and then verified by experimental means. By connecting an external resistance, R_{ext}, there is a current flow such that the voltage drop within the internal resistance of the probe compensates the increase in the voltage induced within the secondary.

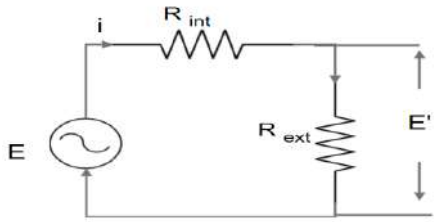


Fig 9.1 : Internal circuit for secondary winding with temp. compensation resistance.

The equation for external resistance for zero change in secondary voltage due to temperature change is obtained as follows[20]

$$R_{ext} = \frac{V \times \Delta r}{\Delta V} - r$$

Where R_{ext} : is the external resistance estimated

V: Secondary voltage

r : is the internal resistance of the secondary

Δ r : is the change internal resistance

ΔV : is the change in secondary voltage

Using the above mentioned equation the value of external resistance which is to be connected to secondary winding in order to compensate for the change in temperature is obtained.

9.3 Experimental set up

Before testing in Pb-Li medium the effect of temperature and the effectiveness of temperature compensation is demonstrated in SS medium. For that the SS blocks where stacked above an insulating surface and are wounded by heater coils of 1KW capacity. K type thermocouples of 3mm diameter were introduced by drilling narrow holes on SS block surface upto a depth of 1inch from outer surface of blocks. Mineral wool insulation with aluminium cladding were used to prevent the heat loss. The thermocouple output was fed to a temperature controller cum indicator. The heater cable input was controlled using temperature controller along with ON/OFF relay. A temperature from room temperature to 350^0C was able to be maintained with a precision of $\pm$ 1^0C. The probe is introduced into the setup for high temperature performance evaluations and the photographs of setup is shown below.

Fig 9.2 Experimental setup for high temperature setting of Probe

9.4 Effect of Temperature on Probe Output

The probe is introduced completely in to the high temperature experimental setup without any compensation for the temperature variation and a study on the effect of temperature variation (room temperature to 300^0C) on a particular level and error in various levels at a particular temperature has been carried out to know exact effect of temperature before designing the compensation.

9.5 Determination of External Resistance

The level probe will be initially validated using Stainless Steel blocks before using for lead lithium eutectic alloy. Proper heating arrangements were made in order to bring the SS block from its minimum operating temperature of 29^0C (room temperature) to its maximum operating temperature of 300^0C.

1. Adjust the excitation frequency to 2.5 kHz and primary current to 120mA.
2. Insert the probe completely in to the heating setup at room temperature and allow it to stabilize for 15 minutes. Note the values of voltage across primary and secondary winding.
3. Bring the probe to zero level of SS block and take primary and secondary voltages. Note the zero level readings correspond to minimum operating temperature.
4. Repeat step 2 and 3 for maximum operating temperature by stabilizing the heating set up at 300^0C.

Using obtained data calculate the value for Rext and choose the average value as value of the external temperature compensator resistor. This obtained Rext is connected in parallel to secondary and thereby provides temperature compensation to the level sensor

Table 9.1 : Determination of Rext for Temp. Compensation

Frequency = 2500Hz				**Primary Current = 120mA**					
Level (mm)	**At 28^0C**			**At 300^0C**			**Δ r** (r_{300}- r_{28})	**Δ V** (V_{300}- V_{28})	**Rext (Ω)** $\frac{V_{300} * \Delta r}{\Delta V} - r_{300}$
	V pri (V)	**Ri r_{28} (Ω)**	**V sec V_{28} (mV)**	**V pri (V)**	**Ri r_{300} (Ω)**	**V sec V_{300} (mV)**			
Zero	0.599	4.99	32.888	0.836	6.97	33.628	1.98	0.74	83.007
Full	0.602	5.01	27.089	1.044	8.7	28.558	3.69	1.469	63.035
							Average Rext (Ω)		**73.021**

The calculated average resistance from the experimental result is connected in parallel to the secondary winding and then readings were taken for various level at different temperature and are compared with initial readings without any compensation.

9.6 Effect of Temperature Compensation on Probe Output

Table 9.2 : Variation of Level with Temp. Rise

Temperature	Without Rext	With Rext
25	888	888
35	882	884
45	875	881
55	868	878
65	860	877
75	854	876
85	846	876
95	839	875
105	832	875
115	825	875
125	817	874
135	810	874
145	803	873
155	795	872
165	788	872
175	780	871
185	772	870
195	763	869
205	755	869
215	746	868
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235	728	866
245	720	864
255	711	863
265	702	862
275	693	861
285	680	859
300	668	859

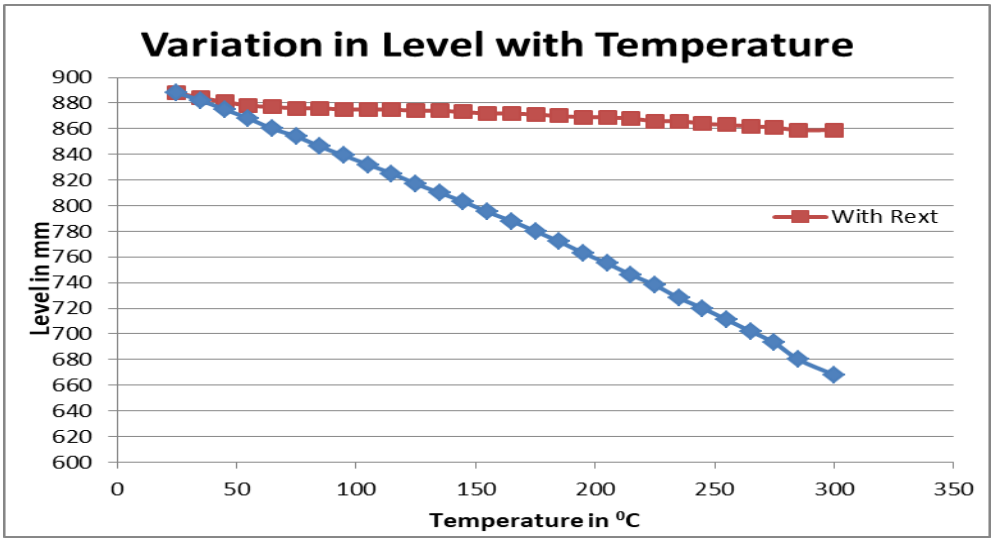

Fig. 9.3 : Variation of Level with Temp. Rise

Table 9.3 : Observation in Stainless Steel medium					
Current = 120mA					**Frequency = 2.5kHz**
True level (mm)	**Measured Sec Voltage at RT(mV)**	**Measured Level at RT (mm)**	**Measured Sec. Voltage at 300 deg.C (mV)**	**Measured Level at 300 deg.C without Rext (mm)**	**Measured Level at 300^0C with Rext (mm)**
0	32.888	0	33.628	0	18
88	32.301	88	33.151	0	106
188	31.602	197	32.615	60	212
288	30.916	302	31.969	161	310
388	30.228	408	31.411	248	409
488	29.562	510	30.852	335	505
588	28.888	614	30.250	429	602
688	28.230	715	29.633	523	698
788	27.679	815	29.007	620	792
888	27.094	888	28.558	667	859

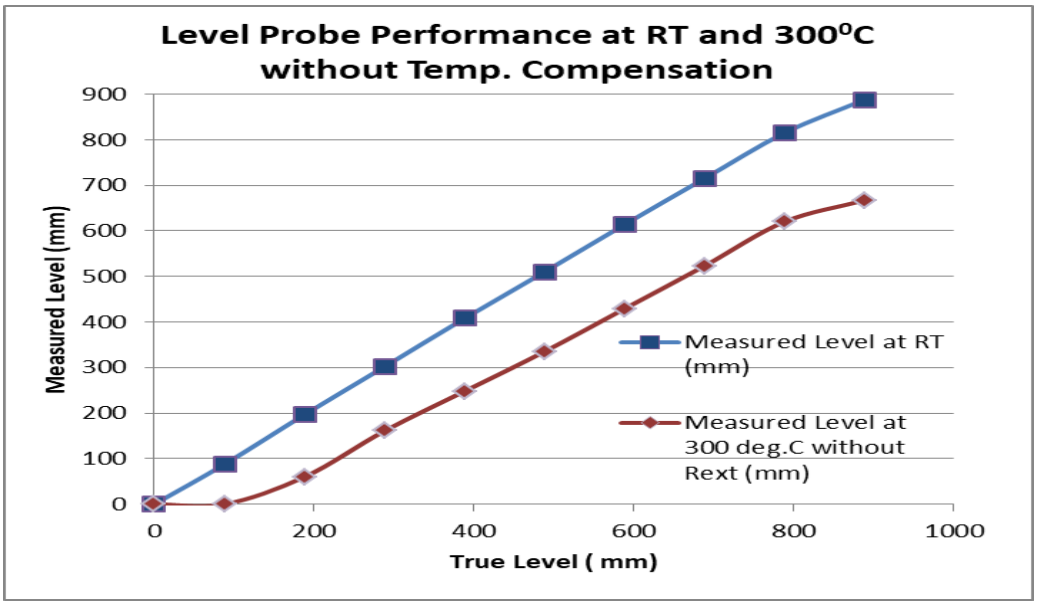

Fig. 9.4 : Reading at room temperature and at 300 ˚C without temperature compensation

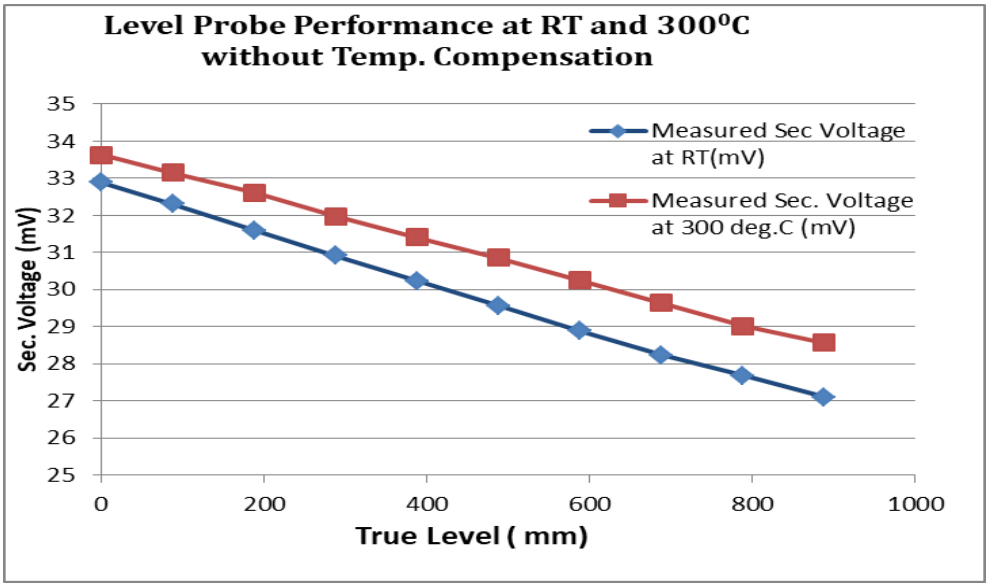

Fig. 9.5 : Voltage output at room temperature and at 300 ˚C without temperature compensation

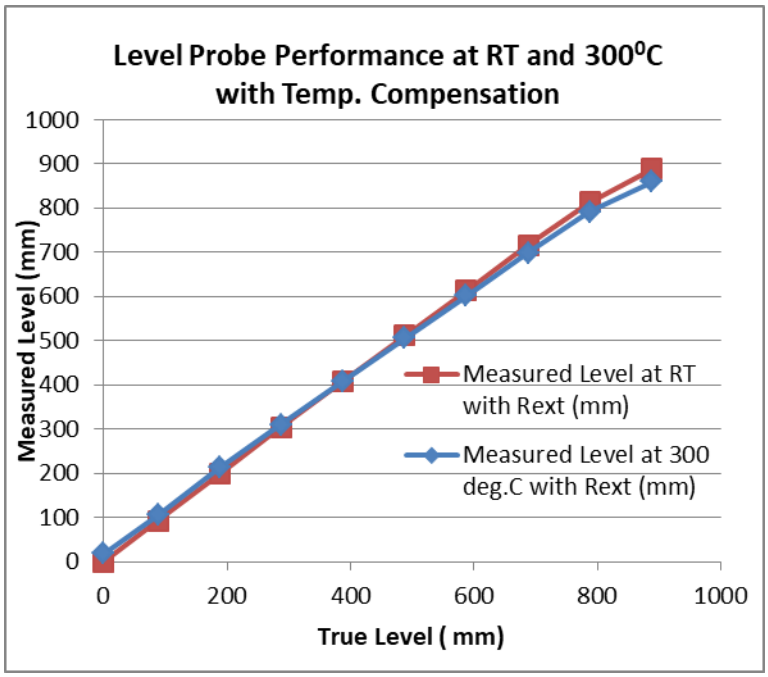

Fig. 9.6 : Level probe reading at room temperature and at 300˚C after temperature compensation

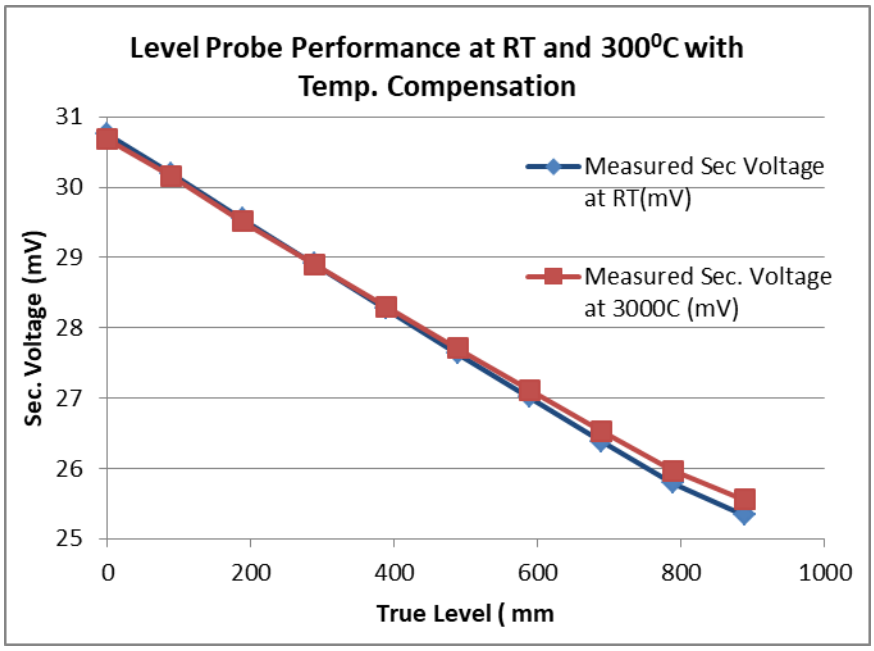

Fig. 9.7 : Voltage output at room temperature and at 300˚C after temperature compensation

9.7 Summary

A setup to monitor the level probe performance at high temperature has been arranged at VJCET . The effect of temperature variation on level probe output has been observed at different levels and also at different temperature. In order to eliminate the effect of temperature on level, it is chosen to design an electrical temperature compensation by connecting an external resistance in parallel to the secondary. Experiments with high operating temperature has been carried out in SS medium to determine the value for compensator resistor. The methodology for electrical compensation has been successfully designed and demonstrated for SS medium. Further testing of probe and electronics are planned in Pb-Li test facility at IPR.

CHAPTER-10

TESTING IN LEAD - LITHIUM MEDIUM

10.1 Introduction

The performance evaluation of the probe in Al and SS medium is found to be satisfactory and the probe is being delivered to IPR, Ahmadabad for further testing and implementation in Lead-Lithium medium. The test procedure to be followed in Lead-Lithium medium and test results are discussed in this chapter.

10.2 Zero and Full Level Setting Procedure in Lead-Lithium Medium

1. Integrate the level probe pocket with test set up by welding and flange bolting . Refer Fig. 11.1.
2. The probe test set up shall be electrically earthed properly
3. Introduce probe into the pocket and bolt the probe to the pocket flange.
4. Connect probe to electronics by shielded cable provided
5. Switch on electronics. A one hour warm-up time must be provided to the electronics after switching ON.
6. After one hour set the primary current as 120mA, Frequency as 2500Hz by following the instructions in the user manual.
7. Observe the stability of current (±0.1 mA) and frequency for minimum 30 minutes.
8. Melt and maintain lead-lithium alloy in the storage tank at 250 ˚C.
9. Preheat the test set up/vessel to 300˚ C
10. Fill lead lithium up to 52 mm level (40 mm bottom clearance and 12mm inactive bottom length of probe) from the vessel bottom using the conductive type low level probe in the vessel. Maintain temperature of lead lithium in the vessel at 250 ˚C. Maintain the probe in this condition for 15 minutes. Then set zero of the level probe by following instructions in user manual.
11. For full level setting, fill the tank with lead-lithium covering the active length of probe using conductive type high level probe. Maintain lead lithium temperature at 250 ˚C for minimum 30 minutes and then set the span of the probe as 888mm following instructions in user manual.

12. An offset setting can be done for displaying the level with reference to the tank bottom if desired.
13. Vary the level of lead lithium in the vessel and observe level readings.

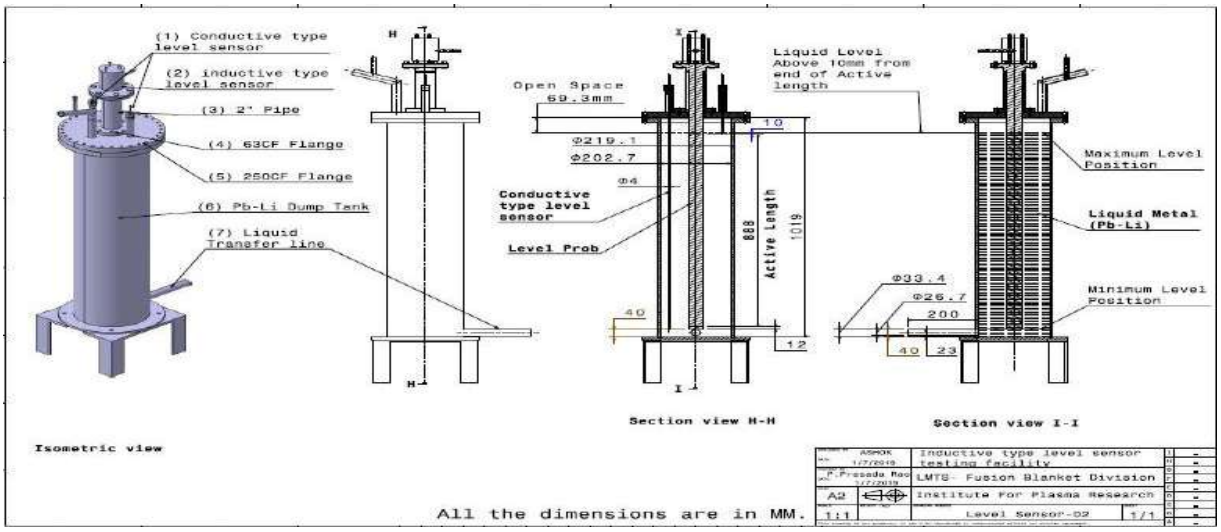

Fig. 10.1 Level Probe test setup in Pb-Li medium at IPR, Ahmadabad.

10.3 Design of Temperature Compensation

In order to compensate for the level variation due to variation in operating temperature an electrical temperature compensation technique is adopted and is already validated for SS medium. In this method an external resistance is connected to the secondary winding for the compensation. Using the equation below and following the procedure the value of R_{ext} is obtained.

$$R_{ext} = \frac{V \times \Delta r}{\Delta V} - r \qquad \text{(Eqn 10.1)}$$

Where R_{ext} : is the external resistance estimated

V: Secondary voltage

Δr : is the change internal resistance

ΔV : is the change in secondary voltage

r : is the internal resistance of the secondary

Procedure for finding R_{ext}

1 Fill the Pb-Li tank to full level i.e. covering the total active length of the probe at its minimum operating temperature of 250 ˚C. Note the values of voltage across primary and secondary winding.

2 Empty the tank upto zero level setting and take primary and secondary voltages correspond to minimum operating temperature of 250˚ C.

3 Repeat step 2 and 3 for maximum operating temperature of 500˚ C.

4 Since assumption is made that, both the primary and secondary are identical, the secondary internal resistance is equal to primary resistance which can be obtained from measured primary voltage and known primary current.

5 Tabulate the obtained data as shown in Table 11.1 and by substituting obtained data in equation 11.1 the Rext value can be calculated for both minimum and maximum temperatures at zero and full levels.

The calculated average value of resistance is connected in parallel with secondary and the secondary output voltage of the sensor is monitored. Set zero and full level as per procedure 10.2 at minimum operating temperature. Now the level probe is ready for use

10.4 Test Result in Pb-Li Medium

10.4.1 DC Output

The 0-10V DC output is validated for Pb-Li medium and the result is verified. The variation in output voltage with respect to level variation is found to be linear.

10.4.2 Calculation of Rext for Temperature Compensation

Table 10.1: Tabulation For External Resistance Calculation

Primary Current I_{pri} = 120mA							Frequency = 2500Hz		
Temp	280^{0}C			380^{0}C					
Level	V pri (V)	IR(Ω) =V/I_{pri} r_{250}	Sec Volt (mV) V_{250}	V pri (V)	IR(Ω) =V/I_{pri} r_{500}	Sec Volt (mV) V_{500}	**Δ r =** (r_{500} - r_{250})	**Δ V =** (V_{500} - V_{250})	**Rext(Ω)=** $\frac{V_{250} * \Delta r}{\Delta V} - r_{250}$
Zero Level	0.9191	7.659	34.126	1.069	8.916	34.457	1.2567	0.3307	122.02

Full Level	0.9415	7.845	27.567	1.090	9.085	27.828	1.24	0.261	123.125
Average Value of Rext(Ω)							**122.6 Ω**		

The calculated average value of resistance is connected in parallel with secondary and the secondary output voltage of the sensor is monitored. Set zero and full level as per procedure 10.2 at an average operating temperature. Now the level probe is ready for use.

10.4.3 Sensitivity of Level Probe in Pb-Li Medium

The Sensitivity of Probe in Pb-Li medium at 280^0C and 380^0C is found to be -7.386μV/mm and -7.43μV/mm respectively and is much higher than minimum required sensitivity of -5μV/mm.

Fig 10.2 Testing of Level Sensor in Pb-Li test facility at IPR, Ahmedabad

10.5 Conclusion

Lead Lithium level probe is tested in lead lithium at operating conditions. The temperature compensation is successfully implemented. The capability of the probe to successfully measure the level continuously is demonstrated with adequate sensitivity and the Probe along with its electronics has been delivered to IPR for further study and testing in Pb-Li medium.

CHAPTER-11

CONCLUSION AND FUTURE WORKS

11.1 Conclusions

Viswajyothi College of Engineering and Technology had taken up the BRNS project titled " Development of Level Sensor for Lead Lithium Loop System." Ref. No. 39/14/03/2017-BRNS/34300 Dtd. 09.08.2017 at an estimated cost of Rs. 33,08,500 (Rupees Thirty Three Lakh Eight thousand and Five hundred). The project execution period was two years. All objectives of the project are accomplished . All deliverables were made. The level sensor was designed, modeled, manufactured tested and delivered to IPR. Further was tested in actual operating conditions and performance was as per design indeed. BRNS project is successfully completed within the time frame and within the sanctioned project cost. All the documents as per the project proposal was submitted to IPR and BRNS. Required documents are uploaded in BRNS website.

11.2 Future Works

There was wide variation of prediction of probe output voltage in FEMM software from the measured value. It is desirable to take up the modeling of the probe in Comsol or other three dimensional software for accurate predictions. Various ways to improve the sensitivity of the probe has to be studied. By increasing the number of turns in the secondary winding and by optimizing dimensions and operating parameters it may be possible Analysis has to be carried optimize the size of the probe and make it more compact. R & D on application of radar type level sensor for lead lithium system applications can be taken up. This method can act as redundant method for level measurement in Lead lithium system which may be a requirement to enhance safety.

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GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY (DAE)
BOARD OF RESEARCH IN NUCLEAR SCIENCES (BRNS)

Project Proposal Application Form (PPA)
(This form is downloadable at URL: www.daebrns.gov.in)

Applicants seeking the BRNS funding should first register on this site. Thereafter apply on ONLINE after selecting appropriate scheme.

NOMENCLATURE

Principal Investigator (PI):A scientist who submits a research proposal to the BRNS for a programme to be carried out at a non-DAE institution.
Co-Investigator (CI): An associate of the PI taking an active part in the project working.
Principal Collaborator (PC): A scientist of the Department of Atomic Energy (DAE) working in any of its constituent units/ PSUs.
Departmental Coordinator (DC): A scientist of the DAE nominated by the BRNS.
R &D units of DAE: Bhabha Atomic Research Centre (BARC), Indira Gandhi Centre for Atomic Research (IGCAR), Variable Energy Cyclotron Centre (VECC), Raja Rammana Centre for Advanced Technology (RRCAT), Atomic Minerals Directorate for Exploration and Research (AMDER),
DAE Aided Intuitions: TIFR, SINP, HRI, IMSC, IOP, PRL, NISER, TMC/ACTREC, HBCSE.
Other DAE Units: Board of Radiation and Isotope Technology (BRIT), Nuclear Fuel Complex (NFC), Heavy Water Board (HWB).
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INSTRUCTIONS

a. Before filling the form please read the instructions and register yourself at *URL:* www.daebrns.gov.in.
b. Applications are accepted ONLINE throughout the year. Processing of application is initiated only when all the required documents have been uploaded and it is complete in all respect and found to be in order. On successful submission and acceptance by the BRNS for further processing, **an application number would be generated after preliminary scrutiny of the submission.** This number would be reflected into the applicant account, which can be seen after logging at this site.**The status of the submitted application, starting from acknowledgement to decision would be updated into the applicant's account.**
c. In addition to online submission, please post duly signed hard copies (2 Nos.) of the application with all supporting documents to BRNS Secretariat, 1st Floor, Central Complex, BARC, Trombay, Mumbai-400085 via government owned SPEED POST. Please quote the application number on the documents posted to BRNS Secretariat.
d. The time required for the processing & sanctioning of the project is typically 4-8 months, depending upon how

soon referees respond and the grant amount.

e. For smooth implementation of the sanctioned project, the BRNS prefers that a project, in addition to a PI, should have a Co-investigator (CI) from the same Department/Institution. The CI is expected to ensure that the project work is carried out even when the PI is on leave/deputation. In case of long leave/deputation, PI is expected to inform the BRNS sufficiently in advance so that correspondence can be addressed to the CI directly.

f. Projects that have direct relevance to the DAE programmes and are carried out in collaboration with a DAE unit will get preference. Such projects shall have a Principal Collaborator (PC) from a DAE unit and are expected to have been evolved after discussion between the DAE unit(s) and the PI. The PI and PC will work on complimentary aspects of the problem.

g. BRNS can consider projects based on multi-centre studies. For such project proposals, the CIs could be from institutions other than that of the PI. In such cases, funds required by the CIs may be shown separately using the same format. If the project is approved, DAE will sanction funds to PI and CIs separately and send the grants to their respective institutions. For such a project submitted by an investigator, BRNS will nominate a scientist from DAE as a Department Coordinator (DC).

h. **ONLINE submission Process**

The process of applying for a research project consists of three sections. Section A is mainly for Application Summary and has to be filled online. Section B is for other details to be uploaded as separate PDF files as described below. Section C is the format of the certificates to be submitted & uploaded after due approvals.

a. **SECTION A (***online forms)*

i. **Registration** is m**andatory for users seeking funds under any of the BRNS schemes. Please upload a passport size photograph (not exceeding 100KB) at the time of registration. On the submission of the registration form, a link for generating the password would be sent to the registered e-mail ID. If the link is not activated within 2 days' time, fresh registration would be required. Subsequent to successful registration, applications seeking the BRNS funding can be submitted online, after selecting appropriate scheme.**

ii. **Application Details (Summary)**

Scheme applied for: *Select from drop down Menu*
Project Title: *(not more than 10 to 15 words)*
Project Duration: *Select from drop down Menu*
Scientific Advisory Committee (suggest): *Select from drop down Menu*
Subject Area: Select from drop down Menu
Key Words
Project Summary/Abstract
Total Budget
SAVE
(Completed application should be submitted within 15 days. During this period information enteredcan be edited.)

9.1.3 View Application

Details of the proposal are to be entered under different heads selectable from the following MENU, which would appear on clicking view application.

View/Edit Application

Application Summary form can be edited here.

Enter PI/CI/PC Details*(Please see Instructions - Sr. No. 5)*

Information required is Name, address/ institutional affiliation, e-mail and phone number.

Enter equipment details

Name, Brief specifications, Make/Model (if specific).
Exchange Rate (if it is of foreign origin) and Cost in Rupees. Please upload budgetary quotation/web-based cost comparison of the equipment's costing more than 1 Lakh.

Suggest Project Reviewers

Information required is Name, Field of specialization (key words), institutional affiliation, e-mail, phone number.

Provide Budget Estimates

Details of yearly budget requirement under the heads of Equipment, Technical Assistance, Consumable, Travel and Contingencies. Enter only the number and staff type (JRF, SRF & RA) required. Budget under the head Salary would get automatically calculated as per the current fellowship rate. The value of Overhead, is automatically calculated.

b. **SECTION B (**Upload Documents)

PDF files (not exceeding 6 MB) are to be to be uploaded under the following heads:

Project Proposal Application (PPA)*(Please see Instructions–Sec. A - Sr. No. 100 to 512)*:

Should list all the objectives, technical details of the work plan, justification for the budget, Summary of **other projects** completed, ongoing and submitted to any funding **agency** including the **BRNS, list of infrastructure and facilities available at applicant's institute.**

Institute Verification Certificate

All non-government institutes/organizations must submit a proof of its recognition from Government bodies like UGC and AICTE. Web link for the list/form showing recognition of the applicant's institute can also be included in the letter.

Certificates from the Institute (PI, CI & PC) *(Please see Instructions- Eligibility)*: The proposal should be forwarded by the Head of the Institution of the Principal Investigator (PI) and Co-Investigator (CI) (wherever applicable).**Consent of DAE authorities for the participation of the PC should be uploaded here.**

Curriculum Vitae (CV)

Should contain the information about Date of Birth, Academic Qualification, Employment History (including post-doc), , Awards & Fellowships, patents awarded, List of publications in peer reviewed journals during the last 10 years that are relevant to the project. The CV of PI, CI and PC should be loaded in separate files.

PI applying for YSRA scheme must include Details of their Ph.D. and Post-Doctoral Work

Certificates (Section-C)

Birth Certificate (only for YSRA)

UPLOAD Reprints (best five)

Application final submit

All the information entered by the applicant including uploaded files can be seen as Consolidated PDF. After final submission, uploaded data would still be visible to the applicant, but it cannot be modified.

10. Scientific Advisory Committees: Depending upon the nature of the project, PI may indicate the name of the Advisory Committee for processing the proposal. In brief, these Committees and their priority theme areas are given below. It may be noted that this selection of committee by the PI is only suggestive and the final decision regarding assigning the committee for further processing remains with BRNS.

10.1 ATC (*Advanced Technologies Committee***):** Accelerators, Lasers, Cryogenics, Computers and other: Applied technologies related to nuclear science, nuclear fusion, accelerators, lasers, cryogenics, photonics and other strategic technologies of vital importance to the Department.

RTAC (*Radioisotopes, Radiation Technology and Applications Committee*): Radiopharmaceuticals, radio-assays, radioisotopes, radiation technologies, mutagenesis, radiation biology, tracer techniques, hydrology, nuclear agriculture etc.

10.2 NRFCC (*Nuclear Reactors and Fuel Cycle Committee)*: Structural/ civil/ mechanical/ metallurgical/ chemical, manufacturing & precision engineering, reactor physics, nuclear fuels, material development, heat transfer, fluid flow, water chemistry, computers and information technology, robotics, automation and controls, sensors artificial intelligence, nuclear safety, nuclear waste management, mineral exploration, mining and geological/earth sciences, environmental impact of nuclear establishments, etc.

10.3 **BSC (***Basic Sciences Committee*): Basic and applied research in radiochemistry, actinide chemistry, radiation and photo-chemistry, Synthesis & application of novel ligands, laser induced chemical reactions, unique catalysts, nano materials, cell and molecular biology, new materials, cancer research, condensed matter physics, nuclear and particle physics, spectroscopy, etc.

10.4 **PFRC *(Plasma & Fusion Research Committee)*:** Theory &Simulationsrelated to MHD activity, plasma turbulence, nuclear fusion, Design and development of materials, equipment, diagnostics and software codes required for plasma & fusion programme. The list of projects under this category can be found in project seedsdocument.

10.5 **SSAC** (*Strategic Studies Advisory Committee*)**:** Studies related to nuclear policy matters and its socio-economic impact that are of strategic interest to the department.

11. **Project Objectives**: Enumerate objectives of the proposal in bullet form.

12. **Key words**: Please provide about 6 key words for indexing the project. The first two **key** words should refer to the major area of research.

13. **Project Summary**: About 100 words summary should bring out the importance of the project, related work being carried out both within the country and abroad, mode of execution of the project, expected outcome of the project like development of a technology, improved product/process, generation of a data base etc.

14. **Detailed Technical Information**(**minimum 1000 words**): Provide 'in-depth' details in this section on as much number of sheets as deemed appropriate under the following headings : (a) Introduction: addressing origin of the proposal , definition of the problem and the objectives, (b) Review of status of Research and Development in the subject: National status &international status , (c) impact of the proposed project in the context of current status, (d) Patent details if any (domestic and international).

15. **Research Plan and Deliverables**: Describe Methodology Organization of work elements, work planned during each year of the project giving milestones and identifying the deliverables at the end of each year. Deliverables should commensurate with the objectives, expected outcome from the project. This will facilitate monitoring of the project and to take corrective actions, if any, required from time to time. Normally, the projects are sanctioned for 3 years of duration. The commencement of the project is considered as the date of the joining of the staff sanctioned or 2 months after the date of issue of the DAE sanction letter whichever is earlier. Mention clearly the part of 3 years of work to be performed by PI, Co-PI (if any) and PC (if any).

16. **Budget Estimates & justification**: If the project is approved, the DAE will provide funds to implement the project only to the institution where the PI is employed. Funds required by the PC for carrying out work in the DAE units will be borne by the respective DAE units. However, funds required for travel and stay of the PC/DC at the PI's institution could be included in the project budget and the PC/DC's travel expenses will be debited to this account. Consolidated amounts need be furnished under Budget Estimates. Justification of the budget estimates is to be furnished separately in the relevant heading to be provided in the form PPA.

a. **Equipment:** Justification for major equipment should be given clearly in at least ten lines. Declaration regarding the non-availability of such equipment(s) in the institution should be made by the head of the institution. Also mention how many other groups will be using the facility and percentage share of availability time for other purposes should be included. Specifications for the equipment to be procured, names of the suppliers and documents in support of the estimated cost, quotations/ proforma-invoice (not more than 1 month old) in respect of such equipment should be provided. Funding of proposal with major equipment will not be considered without this information.

b. **Staff Salary**: The categories of staff who can be employed in a BRNS project and their respective qualifications/experience and salary are as under: Justification of manpower should be clearly mentioned, along with the total number of JRFs/SRFs currently working with the PI and CI.

Category	Qualification/experience	Salary per month*
JRF	M.Sc/BE/B.Tech/BVSc/B.Pharm	Rs.25,000/- for 1st & 2nd year
	& on re-designation as SRF by a committee	Rs.28,000/- from 3rd year
SRF	MTech/ME/MVSc/MPharm/MBBS/BDS **or** M.Sc/BE/B.Tech/BVSc/B.Pharm with 2 years of experience	Rs.28,000/-
RA-I**	Ph.D in Science/ MD **or** MTech/ME/MVSc/MPharm/MBBS/BDS with 2 years of experience	Rs.36,000/-
RA-II**	Ph.D in Science/ MD **or** MTech/ME/MVSc/MPharm/MBBS/BDS with 2 years of experience and possessing exceptional academic record	Rs.38,000/-
RA-III**	Ph.D in Engineering **or** same as for RA-II but selected under specific DAE scheme	Rs.40,000/-

In addition to the Salary, the staff appointed is also entitled to House Rent Allowance (HRA) and Medical Allowance (MA) as per PI's institute/university rules. HRA can be claimed only after appointment of the staff.

** The slab at which the Salary for RA is to be fixed may be decided by the appointing authority taking into consideration the qualification and experience of the candidate.

If the project proposal is approved, Guidelines/Terms and Conditions for recruitment of Staff are issued along with the Sanction letter.

c. **Technical Assistance**: Under this 'Head of Account', the PI can provide overtime/honorarium to existing technical/scientific staff of the institute, engage laboratory attendants/or other help on casual basis subject to the rules of the host institution. These may also include hiring services from outside that are not available in the institute equipment like equipment/experimental set-up fabrication, usage of sophisticated/high end facilities, computer hire charges, computer hire charges etc.

d. **Travel**: The entitlement of mode (Rail/Air) and class of travel will be governed by the rules of the respective institutions to which the PI, CI and PC/DC belongs. One visit per year by PC/DC to PI's institution and vice versa during the duration of the project may be taken as a general guideline. PI may use the funds for travelling to attend a conference within India during the second half of the project. Wherever the project involves fieldwork, PI may include travel funds accordingly in the project formulation.

e. **Contingency**: The amount that can be sanctioned under this 'Head' will vary depending on the type of project (e.g. experimental project, theoretical project, data collection and survey project, engineering project etc.). 5-10% of the total of equipment and consumable cost may be considered as a guideline. However the actual amount would be decided by the BRNS committee. Under the Head 'contingency', the funds can be utilized to meet the expenditure towards advertisement and selection related expenses for the post of JRF/SRF/RA. PI may also utilize this fund towards payment of tuition fee, registration fee and other expenditure of the staff employed for Ph.D. programme of the university. This can also be used for purchase of urgently required laboratory item or for buying books, but books so purchased should be deposited in the departmental library of the Institute and issued as per the rules of the library.

f. **Overheads**: The BRNS allows 15% of the cost of the project excluding contingency as 'Overheads', but not exceeding Rs. 6 lakhs for educational institutions and Rs. 2 lakhs for all other institutions. This is meant to cover the cost of infrastructure, utilities such as water, electricity, communication and administrative services provided by the university/ institute. Each university/ institute can use its discretion to form regulations to use the funds under this head. Some universities/ institutes follow the practice of depositing all overheads in a common corpus and the interest there from is used for the maintenance of infrastructure/ equipment needed for research projects. 50% of the overheads (i.e. 7.5% of

the total) shall be released annually with the grant. The remaining cumulative 50% of the amount spent on overheads shall be paid on completion of the project and submission of the final progress report along with the audited statement of accounts, utilization certificate and the claim form.

2. O**ther Projects**: Please describe each project sanctioned to the PI and CI by the BRNS as well as other funding agencies in not more than 150 words. Description should clearly bring out any overlap of the areas and objectives & methodology of these projects with the submitted proposal.

3. **Facilities**: Provide details about the infrastructure available in the department and the equipments already available in the group.

4. **Curriculum vitae (CV)**:

   Educational qualifications: From Xth standard onwards.

   Experience: List the positions and duration during the last 10 years. Please highlight the experience that is relevant for execution of the proposed project.

   Publications: List only important publications relevant to the area of the proposed research project. However total number of publications and total impact index can be given in the beginning.

5. **Eligibility** Scientists/Engineers working in universities, academic/ research institutions of higher learning and **having a regular position are ONLY eligible to apply**.

   Those working in the DAE units are not eligible for this funding. Scientists and engineers working in R&D organizations of Private Industry or fully supported by Private Industry also need not apply.

6. **Certificates (PI/CI)**: All the applications should be duly forwarded by the competent authority of the host institution with which the PI & CI are associated and their tenure in the institution as per the format given in Certificate 1. Name, Designation, official e-mail ID & office phone number of the authority forwarding the application should be duly filled.
   For Multi-Centre projects, similar certificate is needed from each of the participating institutions.
   A certification from the **Group Director** of the PC as per the format given in Certificate -2 must also be forwarded before submission of the project proposal.

7. **Processing of Applications:** Applications are refereed to specialists in the field. Based on the comments from the referees, the short listed applicants may be invited to a Technical Programme Discussion Meeting (TPDM), for an oral presentation at Mumbai or at any other convenient place, before a panel comprising of the members of the Scientific Advisory Committee and the experts. Based on the recommendations of the TPDM and the available budget, the proposal may be recommended for sanction/revision/rejection. This process may take around 3 to 6 months.

8. **Release of Funds:** Funds for the first year are released along with the issue of initial sanction **for one financial year (1st April to 31st March).** Second year funds shall be released on receipt of a claim from the PI along with technical progress report, **Statement of Accounts (SA)** and **Utilization Certificate (UC**) as on 31st March in respect of the funds received in the first year and **Claim (CL)** for the second year. The grant, however, would be released after deducting the unutilized amount. For the third/ subsequent years, PIs are required to upload progress report and renewal application **(BRNS-PRA)** in the prescribed format. PIs may be called for an oral presentation at a TPDM for monitoring progress of the project. If the progress is found satisfactory, a sanction letter renewing the project for the third/ subsequent years is issued requesting PIs to submit (i) **Utilization Certificate (UC)** and (ii) **Statement of Accounts (SA**) as on 31st March, in respect of the funds received in the second/ previous year and (iii) **Claim** (**CL**) for the subsequent year. It may be noted that transfer of funds from one 'Head of Account' to another is normally not permitted.
   It may be noted that although SA & UC is required to be updated ONLINE, printouts of duly signed copies of SA & UC along with Claim should be sent to the BRNS Secretariat, First Floor, Central Complex, BARC, Trombay,

Mumbai 40085, by SPEED POST. The PRA form should be vetted with comments from the PC. All financial documents should be signed by the PI, Head of the Institution and the Finance Officer/Charted Accountant with official seal.

9. **YSRA Scheme**: Exceptionally bright young scientists **below the age of 35 years** would be considered for **'DAE YOUNG SCIENTISTS RESEARCH AWARD (YSRA)'.** The award carries a maximum research grant of Rs. 25.00 Lakhs in a block of three years and can be utilized for expenditure on JRF Salary, equipment, consumables, travel and other contingencies in connection with his/her research activities. PI has to attach a self-attested document indicating YSRA applicant's date of Birth (Senior School Certificate/Passport) as **Certificate-3**. Under this scheme Co-investigator (CI) is not required and the application can be submitted without **PC.**

10. The sanction of the project is liable for cancellation, in case of suppression of information/fact and/or furnishing false information in the application form.

Content of each of the FILES to be UPLOADED

A. **Project Proposal Application Form** (**PPA**)

100. Title &List of Objectives: *Enumerate objectives of the proposal in bullet form*

Title of the project : DEVELOPMENT OF LEVEL SENSOR FOR LEAD-LITHIUM LOOP SYSTEM

Development of mutual inductance type continuous level sensor for lead lithium system is the objective of the project. Project involves following activities

- Deciding on the number of probes based on process, safety and functional requirements and sizing of them based on geometrical configuration of the lead lithium system at IPR
- Detailed design and specification of the probes considering an ambient DC magnetic field of 200 Gauss
- Manufacturing of a sample probe with the help of an Indian industry
- Evaluation of sensitivity of the probe through finite element analysis at various process conditions and establishing the relation between level and output signal
- Design of electronic circuit required for input source, output signal processing and temperature compensation
- Integrated testing of probe and electronics
- Delivery of sample probe and its electronics to IPR for testing in lead lithium loop system
- Delivery of design and specifications documents to IPR

110. Describe the yearly Research Plan and identify deliverables:
A. At PI/ CI's Institution

Sl. No	Activity	Duration	Start date	End date	Year
1)	Selection of materials for the probe construction	1 month	Beginning of the project 0 th month	2nd month	**1st Year of the project**
2)	Deciding on the number of probes based on process,functional requirements and safety	1 month	2nd month	3rd month	
3)	Sizing of the probe based on geometrical configuration of the system	1 month	3rd month	4th month	
4)	Conceptual design of the probe	1 month	4th month	5th month	
5)	Detailed design of the probe	2 month	5th month	7th month	
6)	Detailed specification of the probes	1 month	7th month	8th month	
7)	Ordering of one sample probe to an Indian industry	1 month	8th month	9th month	
8)	Procurement of raw materials for one sample probe	3 months	9th month	12th month	

9)	Manufacturing of one sample probe with the help of an Indian industry	6 month	12th month	18th month	**2 nd year of the project**
10)	Evaluation of sensitivity of the probe through finite element analysis at various process conditions	6 month	8th month	14th month	
11)	Establishing the relation between level and output signal	3 month	14th month	17 th month	
12)	Design of electronic circuit for input source and output signal processing	3 month	8th month	11 th month	
13)	Design of temperature compensation system	3 month	8th month	11 th month	
14)	Manufacturing, testing and qualification of electronics	6 month	11th month	17 th month	
15)	Integrated testing of probe and electronics	1 month	18th month	19th month	
16)	Preparation and compilations of documents	1 month	19th month	20th month	
17)	Delivery sample of probe, electronics and documents to IPR	1 month	20th month	21st month	

B. At PC's Institution.

Sl. No	Activity	Duration	Start date	End date	Year
1)	Study of physical and chemical properties of Lead-Lithium alloy and arriving at material data sheet	1 month	Beginning of the project 0 th month	1 st month	**1st year of the project**
2)	Integrated testing of probe and electronics in lead lithium system at IPR	3 month	21st month	24 th month	**2 nd year of the project**

200. Detailed Project Proposal Report: ***(minimum 1000 words)***

Provide 'in-depth' details in this section on as much number of sheets as deemed appropriate under the following headings:

(a) Introduction: addressing origin of the proposal, definition of the problem and the objectives

Development of mutual inductance type continuous level sensor for lead lithium system is the objective of the project.

In IN-LLCB TBM Lead lithium alloy is used as a coolant. The system operates at a temperature of around 300-480 ˚ C. Continuous Level measurement in lead lithium system is a challenge due to high temperature of 480 ˚ C and the chemical behavior of the liquid metal alloy. Since lead lithium is a good conductor of electricity, mutual inductance type continuous level sensors is one of the possible choices. The probe consists of a primary winding and a secondary winding made on cruciform stainless steel bobbin. The primary and secondary winding is made of 1 mm dia magnesium oxide insulated stainless steel sheathed copper conductor cable. The bobbin with winding is introduced in pocket of suitable material compatible with the liquid whose level has to be measured. The pocket is then installed on the tank/ vessel where level monitoring has to carried out. The primary is excited with a constant AC sinusoidal current source and it will develop an alternating magnetic field. This field will induce an emf in the secondary winding. When the level in the tank or vessel increases this alternating magnetic field will introduce additional eddy current in the conductive liquid and the field due to the eddy current opposes the main field induced by the constant current source. Reduction in main field due to level increase reduces the induced emf in the secondary winding and this reduction will be a measure of the level increase if the temperature of the liquid is remaining the same. If temperature of liquid changes depending on the temperature coefficient of resistivity of the liquid, the eddy current induced and the resultant flux will change. Hence a temperature compensation is required for this type of level sensors. Targeted resolution of the present design of the probe is 2 mm. Targeted sensitivity of the probe is 4 microvolt mm.

The work done in the country for sodium level measurement can be effectively utilized for this purpose and it can be used as reference design for Lead-Lithium level measurements. The design requirement of level measuring system required for Pb- Li system of IN-LLCB TBM and the Pb- Li loop being constructed in IPR can be successfully met by this project and the feasibility can be demonstrated .

(b) Review of status of Research and Development in the subject: international status & National status

Mutual inductance type level sensors are a choice for measuring liquid metal level at high temperatures. However currently these level sensors are not available in open market internationally and nationally since, their calibration, and sensitivity completely will depend on the type of Liquid metal used and its operational temperature. Indira Gandhi Centre for Atomic Research has developed probes for liquid sodium level measurement and the technology was transferred to an industry in Bangalore. This industry has manufactured and supplied many mutual inductance type sodium level sensors for experimental facilities at IGCAR and for the Proto Type fast Breeder Reactor under commissioning at Kalpakkam. The sensitivity of the level probes depends on resistivity of the liquid metal, temperature coefficient of resistivity, electrical resistivity of the pocket of the probe, bobbin of the probe and the resistivity of the coil winding material. The design of level probes suitable for lead lithium system will be done at Principle Investigator's institute as part of this project. With the technical support of the industry it is planned to manufacture a sample level probe suitable for lead lithium system. Design, development manufacturing and testing of mutual inductance type continuous level sensor suitable for Lead Lithium system is the heart of the project work. Following are the steps involved in this project work.

The project starts from the fundamentals.

- Study of physical and chemical properties of Lead-Lithium alloy and arrive at material data sheet
- Selection of materials for pocket, bobbin and coil for the probe construction
- Deciding on the number of probes required for lead lithium system being constructed at IPR to meet process,functional safety and requirements.

- Sizing of the probe based on geometrical configuration of the lead lithium system
- Conceptual design of the probe
- Detailed design of the probe
- Detailed specification of the probes
- Manufacturing of one sample probe with the help of Indian industry
- Evaluation of sensitivity of the probe through finite element analysis at various process conditions
- Establishing the relation between level and output signal
- Design of electronic circuit for input source and output signal processing
- Design of temperature compensation system
- Manufacturing, testing and qualification of electronics
- Integrated testing of probe and electronics
- Delivery of probe and electronics to IPR for testing in Pb- Li system
- Delivery of all documents and specifications

(c) importance/significance of the proposed project in the context of current status

In order to meet the international commitment of India on the IN-LLCB TBM project, instrumentation of the lead lithium system has to be developed and tested. As this project forms a part of instrumentation development it is very important and assumes significance in the current context. It is also important to utilize to the extent possible the indigenous technology developed for manufacturing sodium level sensors to meet the requirements

(d) Deliverables

Deliverables of this project are

i) A detailed design document for the level probe, which will contain the following:
   a) Arriving at the number of probes required for the Pb- Li system of IN-LLCB TBM and the R&D Pb- Li loop being constructed at IPR to meet the process, functional and safety requirements
   b) Sizing of the probes of the Pb- Li system based on geometrical configuration of the system
   c) Detailed design and specification of the probes
   d) Establishing the relation between level and output signal

ii) Delivery of a sample probe and its electronics to IPR and its testing in Pb- Li system to demonstrate the feasibility. The probe will be accepted by IPR based on the successful demonstration of its sensitivity (4 micro volt per mm) of Pb-Li level measurement , as mentioned in section 200.a

(e) Patent details if any (domestic and international)

No patent is existing

300. BUDGET JUSTIFICATIONS*(give details and justification for each of the budget heads)*

Please add a table with complete budget under section 300 having the following items for all the three years (a) Salary (b) Technical assistance (c) Equipment (d) Travel (PI and PC) (e) Contingency (f) Consumables (g) Institutional overheads (15% max)

Item	**Year 1 (Rs)**	**Year 2 (Rs.)**	**Year 3 (Rs)**
Salary	3,00,000	3,00,000	
Technical Assistance	50,000	2,00,000	
Equipment	5,00,000	11,50,000	
Travel (PI)	70,000	80,000	
Travel (PC)	20,000	20,000	
Consumables	50,000	50,000	
Sub Total	9,90,000	18,00,000	
Institutional Overheads (Max 15%)	1,48,500	2,70,000	
Contingency	50,000	50,000	
Total (Rs)	11,88,500	21,20,000	

310. Give justification for purchase of the equipment, reasons for selecting particular model/specifications.

1. One sample probe and its electronics as per our design and specification has to manufactured and received. It is considered as an equipment. M/s Control Technology, Bangalore is the only manufacturer in India who has manufactured sodium level sensors for IGCAR Kalpakkam.
2. High accuracy HP make digital multimeters which can be used for probe constant current, probe resistance and output voltage can be measured accurately.
3. Oscillator to feed constant current to the probe for testing. HP make oscillator with high frequency stability and voltage stability is required
4. Machined cylindrical Aluninium block for dry testing of probe and electronics simulating lead lithium liquid

320. Details of budget for consumables to be procured by the PI (Amount in Rupees): 1,00,000/=

Sl. No.	**Name of the consumable items**	**Material Purity (in case of Reagents, Chemicals & Metals)**	**Quantity**	**Preferred Manufacturer**
1 2. 3. 4. 5. 6. 7. 8.	Office stationery, Documentation materials, Binding charges Photocopy charges , Printer toner, CDs, Pendrives Other consumables as and when required	NA	Based on requirement	

330. Justification for Staff:

The graduate electrical and electronics engineer has to continuously work for this project along with PI and CI to meet the schedule. An Electrical and Electronics Engineer is most appropriate as he will be able understand the electromagnetic theory behind the working principle of the sensor. This helps in modeling and finite element analysis. Electronic background is essential to actively participate in the design of electronics for the sensor and its testing.

340. Justification for Technical assistance:

During the procurement of raw materials and during the manufacturing inspection of materials with qualified inspection agencies are required. Chemical composition of raw materials has to be done with approved laboratories. Inspection of each fabricated part and assembly has to be carried out separately . Functional testing of electronics and qualification tests have to be carried out. Services of skilled technicians and approved laboratories are required for this purpose. An amount of rupees 2.5 lakhs is estimated for this purpose.

Sl. No	Activity description	1st year	2nd year	Estimated amount Rs.
1.	Charges towards raw material Testing and cortication	50,000		50,000
2.	Charges towards Technical Assistance of skilled and qualified personnel for inspection during Manufacturing of sample probe		1,00,000	1,00,000
3.	Charges towards Technical assistance for Evaluation of sensitivity of the probe through finite element analysis at various process conditions		30,000	30,000
4.	Charges towards Technical assistance during Manufacturing, testing and qualification of electronics		10,000	10,000
5.	Charges towards Technical assistance during electronic circuit checking		10,000	10,000
6.	Charges towards Technical assistance during Integrated testing of probe and electronics		25,000	25,000
7.	Charges towards Technical assistance during Preparation and compilations of documents		5,000	5,000
8.	Charges towards Technical assistance during Integrated testing of probe and its electronics in lead lithium system at IPR		20,000	20,000
9.	Total	**50,000**	**2,00,000**	**2,50,000**

350. Details of travel

	Amount in Rupees			
	Ist year	IInd year	IIIrd year	Total
331. Proposed number of visits of **PC/DC** to **PI's** Institute	2	2		4
331A. Duration of stay (no. of days) during each visit	3	3		6
331B. Total fund required	40,000	40,000		80,000
332. Proposed number of visits of **PI to PC/DC's** institute	1	1		2
332A. Duration of stay (No. of days) during each visit	3	3		6
332B. Total fund required	20,000	20,000		40,000
333. Fund required by **PI** for travel to attend conferences within India.		20,000		20,000
334. Fund for Other visits (please give details) Visit to the Level probe manufacturing industry at and their vendors 5 visits , of two days duration 10,000 for each visit	30,000	20,000		50,000
Total				1,90,000

400. OTHER PROJECTSCOMPLETED, ONGOING AND SUBMITTED

to any funding **agency** including **BRNS**

410. List projects in which PI is actively involved

Sl. No.	Title of the project	Sanction No.	Total cost	Agency	Present status	Role (PI/CI)

PI , Dr. K.K. Rajan was working as Distinguished Scientists and Director Fast Reactor Technology Group in IGCAR, Kalpakkam till April 2016. He was actively involved in the development of sensors for high temperature sodium system and its testing . He has 35 years of experience in design, development and testing of sodium system sensors and components. He has handled more than 24 projects during his tenure in IGCAR with academic and research institutions such as IITs, IISc, FCRI, and ICT Mumbai. He has joined Viswajyothi College of Engineering and Technology (VJCET) in May 2016. In VJCET, he is responsible for research and development as well as industry institute interaction. He has not taken up any outside projects within this short period.

420. Brief description of the project(s) submitted/sanctioned by**PI**(Please see Instruction - Sr.No.22):

(~ 50 word for each project)

-NA-

430. List projects in which **CI**(if any)is actively involved

Sl. No.	Title of the project	Sanction No.	Total cost	Agency	Present status	Role (PI/CI)

CI, Dr. B. Aruna was working as Associate Professor at Hindustan Institute of Technology and Science for the last 23 years. She joined Viswajyothi College of Engineering and Technology in May 2016.

440. Brief description of the project(s) submitted/sanctioned by**CI** (Please see Instruction - Sr.No.22):

(~ 50 word for each project)

-NA-

500. FACILITIES

510. List of **facilities** that will be extended to the investigator by the implementing institution for the project

Infrastructure facilities

Item Name	Yes/No/NR*	Sr. No.	Item Name	Yes/No/NR*	Sr.No
1.	Workshop- **Yes**		7.	Telecommunication - **Yes**	
2.	Water & Electricity -**Yes**		8.	Transportation - **Yes**	
3.	Standby power supply- **Yes**		9.	Administrative l support - **Yes**	
4.	Laboratory space & furniture- **Yes**		10.	Library facilities- **Yes**	
5.	AC room for equipment- **Yes**		11.	Computational facilities- **Yes**	
6.	Refrigerator-**Yes**		12.	Animal/Glass house - No, NR	
	NR*: Not Required				

Equipment and accessories available within the Investigator's group/Dept. which can be utilized for the project.

Sr. No.	Name of the Equipment	Model & Make	Year of Purchase
1.	Oscilloscopes	Local	2010
2.	Test bench	Local make	2005
3.	Normal multimeters	HP	2012
4.	Power supply units	Aplab	2012
5.	Connectors and Cables	Connectwel& V guard	2015

B. Content of CURRICULUM VITAE (CV)

Curriculum vitae (CV) of Principal Investigator (PI), Co-Investigator (CI) and Principal Coordinator (PC)should include the following information: *(*601, 602 & 603 are applicable for YSRA only)*

***601.**Academic Qualifications(Graduation & onwards include GATE/NET)

Name of the examination/Degree	Subjects	Area of specialization	Name of Institute/ University/ Board	Year of passing	Percentage/ Grade

-NA-

***602: Details of the Ph.D. Work:**

-NA-

Title:
Guide:
Institute:
Number of Journal Publications:
Brief Description of Ph.D. Work: *(200 words)*

***603: Brief Description of Post Doctoral Work:** *(200 words for each)*

-NA-

604. Employment History (including post-doc)

Period (Year)	Name of the examination/Degree/ Post as applicable	Area of specialization/ Subjects	Name of Institute/ University/	Number of Journal Publications
1. Employment history of Principle Investigator, Dr K. K. Rajan				
1981-2016	Scientific Officer/Engineer Grade-C to Distinguished Scientist, & Director, Fast Reactor Technology Group	High temperature Sodium system design, construction, operation and maintenance. Development of sensors for high temperature sodium system applications	Indira Gandhi centre for atomic research	80 Journal publications and 125 conference / seminar publications
Employment history of Co- Principle Investigator Dr. B. Aruna				
1993-2016	Associate professor EEE Dept., HITS	Control systems, Advanced control of Electrical Machines	Hindustan Institute of Technology and Science, Padur, Chennai	5 Journal publications and 8 conference / seminar publications
Employment history of Principle Collaborator Dr. Rajendraprasad Bhatacharyay				
1997-Till date	Scientist - SF	High temperature Pb-Li system design and operation, Pb-Li diagnostic development	Institute for Plasma Research, Bhat, Gandhinagar, Gujarat-382428	22 Journal publications and 7 conference proceeding

605.1 : Awards & Fellowships of Principal Investigator

Recipient of many DAE group achievement awards. Leader of the DAE Group achievement award for design, construction, commissioning and operation of SADHANA sodium loop to experimentally demonstrate the passive decay heat removal system of PFBR in 2010. Dr. K K Rajan , principle investigator is a fellow of Institution of Engineers. He is a life member of Indian Nuclear Society and Instrument Society of India.

605.2 : Awards & Fellowships of Co Investigator

Received Best Teacher awards several times from HITS (Hindustan University)
Dr. B. Aruna, Co investigator is a life member of Indian Nuclear Society and Institution of Engineers. She is also a member of IEEE for the last 10 years.

605.3 : Awards & Fellowships of Principle Collaborator

Dr. Bhattacharyay is a life member of Plasma Science Society of India (PSSI)

Signature with date

BRNS FORM-VII

Brief report on BRNS funded PROJECT

Insert Passport size photo here

1. Sanction Number**:39/14/03/2017-BRNS**
2. Mode of Execution: ~~MoU / CRP /~~ **RP** ~~/ YSRA~~
3. Date of Start: **09.08.2017**
4. Date of Completion: **09.08.2019**
5. Total Amount Sanctioned (in Lakhs): **33,08,500/- (Rupees thirty three lakh eight thousand five hundred only)**
6. Amount Received (in Lakhs with date)
7. Category: ~~Facility Development /~~ **Product Development** ~~/ Technology Demonstration/ Applied Research/ Conceptual/Exploratory/ Survey/Others~~
8. Title: " **Development of Level Sensor for Lead- Lithium Loop System"**

9. Name of PI & Affiliation: **Dr. K K Rajan, Prof. EEE, Viswajyothi College of Engineering and Technology, Vazhakulam, Muvattupuzha, Kerala**

10. Name of CI & Affiliation: **Dr. B. Aruna , Prof. EEE, Viswajyothi College of Engineering and Technology, Vazhakulam, Muvattupuzha, Kerala**

11. Name of PC & Affiliation **:Dr. Rajendraprasad Bhattacharyay, IPR, Ahmedabad, Gujarat**

12. Name of major Equipment procured and their cost :

- **Personal Computer - Rs. 41800/-**
- **Waveform Generator - Rs. 99,023.24/-**
- **Digital Multimeter - Rs.59,469.64/-**
- **Sample Probe and Electronics - Rs. 12,95,640/-**
- **Aluminium Blocks - Rs.47,200/-**

13. Present working status of the Equipment**:**

- **Personal Computer - Operational at VJCET**
- **Waveform Generator - Operational at VJCET**
- **Digital Multimeter - Operational at VJCET**
- **Sample Probe and Electronics - Operational at IPR**
- **Aluminium Blocks - Operational at VJCET**

14. Details of the High cost consumables used: **Stainless Steel Blocks – Rs. 90,000/-**

15. Number of Journal Publications with impact factor (attach list as Annex- I): **0**
16. Number of symposia/conference presentations: **2**
17. Number of staff trained under this project: **2**
18. List of Objectives as mentioned in original proposal:

- Deciding on the number of probes based on process, safety and functional requirements and sizing of them based on geometrical configuration of the lead lithium system at IPR -
- Detailed design and specification of the probes considering an ambient DC magnetic field of 200 Gauss – **Accomplished**
- Manufacturing of a sample probe with the help of an Indian industry – **Accomplished**
- Evaluation of sensitivity of the probe through finite element analysis at various process conditions and establishing the relation between level and output signal – **Accomplished**
- Design of electronic circuit required for input source, output signal processing and temperature compensation – **Accomplished**
- Integrated testing of probe and electronics – **Accomplished**
- Delivery of sample probe and its electronics to IPR for testing in lead lithium loop system – **Accomplished**
- Delivery of design and specifications documents to IPR – **Accomplished**

Accomplishments of the projects in 3 to 4 bullets

- A mutual induction type level sensor has been proposed for the level measurement of Pb-Li eutectic alloy.
- Sensitivity evaluation of probe has been carried out using FEMM model
- Manufactured a sample probe and its electronics with the help of an Indian industry and tested in aluminium and stainless steel medium
- Proposed and designed a suitable method for temperature compensation and its validation is conducted in SS medium.

Summary in about 300 words (which is understandable by general scientific fraternity) bringing out the novelty of the work.

Lead-Lithium (Pb-Li) eutectic alloy is considered as the coolant in Indian Lead-Lithium ceramic breeder blanket. This liquid metal alloy is circulated through the blanket modules of fusion reactors at operating temperatures around 450^{o}C. The Lead- Lithium system which supplies the alloy to the blanket module is operating at high temperature and needs redundant level measuring sensors along with other diagnostic devices. The high operating temperature, high chemically active nature of Pb-Li alloy and its reaction with air make its instrumentation difficult over conventional instrumentation. Since Lead Lithium is a good conductor of electricity, mutual inductance type continuous level sensors is the best choice.

Design and development of the level sensor has been taken up based on the experience of mutual inductance level sensor used in sodium systems. Viswajyothi college of Engineering and Technology (VJCET) in collaboration with IPR, Ahmedabad has taken up a BRNS funded research project to develop a MI type Level Sensor for Lead Lithium Loop System.

A detailed study on conceptual design, specifications, modeling and simulation using Finite Element Method Magnetics (FEMM), study on skin depth and temperature compensation of sensor output were carried out at PI's Institution. A sample probe and electronics had been manufactured with the help on an industry and experimental validation of the level probe using aluminium blocks and solid aluminum blocks in place of Lead-Lithium alloy were carried out.

The level sensor comprises of a primary and secondary winding, where primary is excited by a constant AC current source at a fixed frequency and the induced voltage at secondary side is calibrated against the level of liquid metal. The secondary voltage of the probe varies as a function of level of Pb-Li as well as the temperature of the liquid metal. In order to find the exact level of the liquid metal the effect of temperature change on the secondary voltage must be eliminated. A temperature compensation method had been suggested for the sensor output and its experimental validation had been conducted in SS medium.

The probe and its electronics has been delivered to IPR Ahmadabad for further testing and validation in Lead Lithium medium.

Let's Unchain it.

2020 IEEE HAC & SIGHT Projects - Response to COVID-19

IEEE VJCET SB

Mr ALBIN PAUL

Mr ALBIN PAUL

CHERADY HOUSE
KOMBANADU P O
PERUMBAVOOR, KERALA 683546

albinpaul@ieee.org
O: +919447948562

Application Form

Administrative Information

Primary Applicant Name:*
Anish M Jose

Primary Applicant Email:*
anishmj@ieee.org

Primary Applicant is affiliated with which IEEE OU:*
IEEE VJCET SB (STB64351)

Primary Applicant IEEE Member Number:*
95412652

Primary Applicant IEEE Member Grade:*
Please note that a student member may not be the primary applicant.

Member

Co-Applicant Name:
Albin Paul

Co-Applicant Email:
albinpaul@ieee.org

Co-Applicant is affiliated with which IEEE OU:
IEEE VJCET SB (STB64351)

Co-Applicant IEEE Member Number:
95404201

Co-Applicant IEEE Member Grade:
Student Member

Project Name*

Let's Unchain it.

In which IEEE Region will your project take place?*

Region 10

In what country will your project take place?*

If more than one country, please select the primary country, or country where you will begin implementation.

India

Funding requested from HAC in USD*

$2,158.00

IEEE Organizational Unit*

Which IEEE OU is acting as fiscal agent to receive approved funding?

OU Contact Name:*

i.e. name of Section Chair or Treasurer

OU Contact Position:

i.e. Section Treasurer

OU Contact Email*

SECTION 1: Project Overview and Background

Executive summary of project, including location, needs, and intended solution.*

Corona Virus is wreaking havoc in the world. This project is a simple yet effective way to fight COVID-19 with Hand Wash and Hand Sanitization, without touching the bottle or the tap. At the top of the list of the places to avoid right now are hospitals, because that's where all the really sick people go. To prevent the spread of the virus (and other infectious diseases) through hospitals, the project location is Government Taluk Hospital,Adimali, in Idukki District, Kerala. Taluk Head Quarters Hospital situated alongside the 2 NH of 185 & 85(https://goo.gl/maps/hf251uPie6cbkhD18), is one of the major health care providing institutions in

Idukki District. The total bed strength of this institution is 100 and provides medical care for around 900 patients in the O P Department and an average of 120 patients are being given treatment as inpatients, and an average of 8 deliveries are being attended daily.The total human resource strength of the institution is 183 of which 20 are doctors of different specialities.During the period of COVID 19 pandemic diseases, doctors are to examine each patient after washing their hands. The government is not providing enough gears to protect the health care workers from catching the virus themselves Devices such as the automatic hand wash dispenser and the like are quite expensive in the market.The technology behind the solution is a proximity sensor that contains one IR LED &PHOTO DIODE. IR LED produces infrared ray and when we move our hand under the sensor, the IR ray reflects photodiode.Then the proximity sensor gives the output. The output is connected to a relay circuit. The relay acts as a switch. Then the solenoid valve will open and release the jet of water.The valve is connected like a ball valve.The solenoid valve series is connected to the mainline pipe.When the hand is taken away, the reflection stops and hence the output also stops. The relay moves to NC. Then the solenoid valve turns OFF and the water jet is blocked

SECTION 2: Stakeholder Mapping and End-User Engagement

Who are the stakeholders and how will they be engaged in the project? *

Stakeholder: *An individual, group of people or organization that affects or is affected by an intervention. The stakeholders should include the project team, the beneficiary community, and any others that will experience relevant and significant outcomes (intended or unintended, positive or negative). Examples include local governments, non-governmental organizations, service providers, institutions such as schools or hospitals, and so on.*

Basil Eldhose-Active IEEE Volunteer. The second-year Electrical and Electronic Engineering Student. He is the head of the technical team that is responsible for the designing and installing of the prototype in the hospital. He is ell trained and currently works with a few industry experts,

Anish M Jose- Counselor IEEE VJCET SB 95412652- Assistant Professor of Electronics and Communication department, Branch Counselor and IEEE SIGHT Counselor

Babu T Chacko –Counselor IEEEVJCET PES 92152070-Senior Member- He is an assistant professor of Electrical Engineering department and also the counsellor of the Power & Energy Society. He is also our mentor for the project and guides as in the right tracks for the success of this project.

Dr.Josephkunju Paul C, Principle of VJCET

Albin Paul -Past IEEE SIGHT VJCET Chairman 95404201- Final year B Tech Mechanical Engineering UG Student, Project coordinator of IEEE SIGHT Funded project Smart classroom among the woods.

Uthara Pradeep- IEEE VJCET PES chair -B Tech Electrical Electronic Engineering 3rd year student.

Deepa Rajeev -Local administrative officer

Murakesh-Block Administrative Officer

Dr.Praseetha - Superintendent of Govt. Taluk Hospital, Adimali – Has taken up the responsibility to ensure that maintenance of the devices implemented.

Dr.Phenix- Ortho surgeon - He is very energetic and active in the entire planning process and implementation of the prototype. He will ensure all support to keep the project alive and useful.

Dr.Satya Babu- Gynaecologist of Govt. Taluk Hospital, Adimali. Enthusiastic about the project and has vowed to ensure the safety of the patients from the very start.

Akash Prakash -CTO of Volta Electrics-Ensure technical support for the project

We provided 4 days special training program on Arduino Programming and Simulation. We also provided a series of volunteering training program for our volunteers. It covers the recorded version of recommended 9 webinars from SIGHT Digital classroom.

SECTION 3: Theory of Change

This link to a succinct explanation of the differences between inputs, activities, outputs, and outcomes is provided for your reference.

Activities*

Installation of the Automatic sanitizer dispenser at various selected points in the hospital (selection of points was done with the advice of the hospital authorities, for example the operation theatre)

Fitting of the Automatic water tap system on the selected points in hospitals

Preparation of the COVID prevention advice board containing do's and don'ts practices

Fixing of the board near to the points near to the installed automatic sanitizer

Outputs*

Please include how these will be measured.

The output of the project can be effectively measured by counting the number of people using the sanitizer and tap daily. It can be measured by the refining frequency and flow meter reading.

Installation of the Automatic sanitizer dispenser at various selected points in the hospital (selection of points was done with the advice of the hospital authorities, for example, the operation theatre)

Fitting of the Automatic water tap system on the selected points in hospitals

Preparation of the COVID prevention advice board containing do's and don'ts practices

Fixing of the board near to the points near to the installed automatic sanitizer

Outcomes*

Please include indicators and how these will be measured, in addition to opportunities for replication and scaling.

It can be replicated to anywhere in the world to break the chain and can be scaled. The output of the project is measured by the safety of hospital staffs , patients and other people coming to the hospital. The outcome can be ensured by taking the daily COVID 19 status from the district administrative office. To keep the area in the green zone without COVID 19 positive cases.

To ensure the safety of medical and health workers

To ensure the safety of people

To overcome the COVID 19 through best prevention practices

To strengthen the rural health network by reducing the chance of infection.

To ensure better health care services to the underprivileged patients of Tribal & plantation areas of Devikulam Taluk who are mainly depending on the hospital for their health care and other medical emergencies during this time also.

Ensure more hygiene in and out of the area

Assumptions*

Maintenance and refilling of Sanitizer- The hospital authorities assigned certain staffs to ensure the proper maintenance

Age and awareness of people using the sanitizer-Different age group people will use the sanitizer , an awareness video (in mother tongue Malayalam) including the proper use of sanitizer dispenser will be displayed in the display network of the hospital

Please describe any similar projects being implemented in the region where you will be working.*

Are there any similar projects being implemented by other IEEE volunteers, institutions, organizations, or the government in the region where you will be working? If so, what are they?

As a part of Break the chain campaign, IEEE PES and SIGHT of Viswajothi College of Engineering and Technology SB installed an automatic sensor tap at Adimali, Taluk Hospital, Kerala.

https://www.facebook.com/1582470751835190/posts/2907574665991452/?sfnsn=wiwspwa&extid=J6HXmVfeHmx5fZeV&d=w&vh=e

As a part of the break the chain campaign, the students of Sri Narayana Gurukulam College of Engineering, Ernakulam created the Automatic Hand Sanitizer which they installed at the Govt Hospital Thripunithura, Ernakulam, Kerala and at Ernakulam District collectorate.

https://www.facebook.com/233008147097016/posts/995210710876752/

Automatic Hand Sanitizer Dispenser developed by the Research students of Jai Bharath Engineering College, Ernakulam, Kerala. Later they handed over the machine to Perumbavoor Police Station.

https://www.manoramaonline.com/education/education-news/2020/05/16/college-students-with-automatic-sanitizer-dispenser.amp.html

https://www.facebook.com/acvnewspbvr/videos/343850246583144/

A team of staff and students from the department of electrical and electronics engineering, NMAM Institute of Technology, Nitte, designed and developed a simple and cost-effective touch-less hand sanitizer dispenser kit at Research and Innovation Center, Nitte

https://timesofindia.indiatimes.com/home/education/news/nmamit-nitte-develops-touch-less-sanitizer-dispenser/articleshow/7574430

Robo sanitizer challenge accepted by IEEE VJCET SB
https://www.facebook.com/1169702146480669/posts/2725467637570771/
https://www.facebook.com/1169702146480669/posts/2756939361090265/

SECTION 4: Project Implementation Plan

Project work plan and milestones*

Please outline the proposed project work plan, expected timelines, and milestones associated with successful implementation of the proposed objectives.

Do not duplicate what is in the executive summary or theory of change.

5/04-IEEE VJCET accepted the Robo Sanitizer challenge organized by IEEE PES KS YP.We brushed up our robotic knowledge and skills and learned more about the designing and implementation of Automatic Sanitizer dispenser and came up with the most effective solution.

8- We completed the project and challenged other colleges.As per the challenge, we provided technical guidance and support to the colleges to complete the project

10-SB Execom meeting was held.We discussed how this device could be made to the public by implementing it somewhere.A team was also created for the project

15- On the team meeting we discussed various public space for the implementation.There were tons of places which needed equipment like this ASAP.But due to the mobility restrictions of the lockdown situation,many had to be ruled out.

20- Finally,Hospital was chosen since many of our volunteers lived nearby and it would be possible for them to implement on-site without violating lockdown rules. But most importantly,it was chosen because many nearby tribal communities depend on this hospital for medical facilities.

25- Our project technical coordinator discussed the project with Local administrative officers and Hospital authorities.

26/04- A small meeting with hospital Superintend, management and local administrative officers was held and we were permitted to install our automatic tap and sanitizer dispenser.

01/05- Visited the hospital to understand more about the location for fixing the non-contact tap system.Analyzed the hospital and estimated the project requirement to ensure maximum benefit to the community while implementing the project.Listed the materials required for the project and started designing it.

18- Collected the required materials to implement a prototype of the project in the pre-planned design

20-21/05- Completed the installation of the prototype.

22- Tested the prototype.The prototype is now successfully available to the local community

10-17/05- Implementation of Project

Are there any restrictions in place that would impact the execution of your project?*

For example, mobility restrictions due to COVID-19, shelter in place, etc. Please share details of mitigation plan.

There might be slight mobility restrictions due to the lockdown situation but that will not be a problem for us since most of the team member is from around the project site,

Major members of the team are in the same district (Not hot spot). Interdistrict transport is smooth at this time.

We contact a company named Volta Electrics, we ensure their support to complete the project effectively and on time if any mobility restrictions come(Mitigation Plan).

Implementing Team*

Please state how many IEEE volunteers and how many non-IEEE volunteers are projected to take part in this project, including the IEEE Member Numbers if possible. Indicate if the team is an IEEE SIGHT group. (Please note, it is not required to be part of a SIGHT group.)

If readily accessible, provide short profiles for each member of the proposed implementation team (IEEE and non-IEEE) that justifies how their participation will support achieving the objectives of the proposal. The profiles should explain the relevance of their expertise and previous field work experience (particularly in the beneficiary country). Please describe any previous relevant team collaborations.

There are a total of 8 members in our team and they are all IEEE members.

Uthara Pradeep- IEEE VJCET PES chair - B Tech Electrical and Electronics Engineering 3rd year student.

Attended various training programs on electrical wiring and circuit assembly. Expert knowledge in microcontrollers, Relays etc. A trained and passionate volunteer.

Basil Eldhose-Active IEEE Volunteer. A second-year Electrical and Electronic Engineering Student. He is the head of the technical team or the designing and installing of the prototype in the hospital. He is also well trained and currently works with some external industry experts in the domain. Dedicated IEEE PES volunteer with lots of work experience.

Anish M Jose- Counselor IEEE VJCET SB 95412652- Assistant Professor of Electronics and Communication department, Branch Counselor and IEEE SIGHT Counselor

Albin Paul -Past IEEE SIGHT VJCET Chairman 95404201-Final year B Tech Mechanical Engineering student- Project coordinator of IEEE SIGHT Funded project Smart classroom among the woods. Expert in mechanical designing and operations. Recipient of various academic project funding and successfully completed various innovative projects.,

Ananthakrishnan S Nath- IEEE SIGHT VJCET Chairman-95404180- 3rd year BTech Computer Science Engineering student, Expert knowledge in Arduino. Participated and organized various Arduino related events.

Devika Suresh Kumar-Past IEEE SIGHT VJCET SB Treasurer, Current IEEE VJCET Content team Head-95404087

Geo Francis- 96176415- IEEE SIGHT VJCET SB Secretary- Active volunteer with excellent knowledge in project planning, designing and plumbing.

Govind V Shenoy- 94573744-IEEE VJCET WebMaster

All these members are actively volunteered and part of the project implementation team of IEEE SIGHT Funded project Smart Classroom among the Woods.

Team Video
https://drive.google.com/open?id=12D1T_h3avTu_aeJ5THj_96la8LdUlAb

Describe the potential risks and unintended consequences associated with this project.*

This should include, but not be limited to, risk to people, property, and IEEE reputation. How will these be mitigated? Make sure to explain what measures will be taken to prevent safety hazards. Please be as detailed as possible. Highlight any political or economic risk associated with the country in which the project is located. The IEEE Office of Risk and Insurance Management Services (ORIMS) may review proposals to assess risk and provide guidance.

A prototype of the whole system was implemented first at the hospital and based on that work; the hospital authorities requested further assistance in implementing more of these in various points. The whole project was then planned with the hospital authorities, local administrative officers and only then was the project called for. Hence, the risk factors are very small and can easily be avoided.

A company by the name of Volta Electrics, specializing in the electrical and plumbing field will be called on to help with the maintenance effectively, even during mobility restrictions. (Mitigation Plan). They have agreed to support us 100% with all the help we need.

Our team is equipped with expert volunteers having experience in the domain and they are all very passionate and dedicated to see this through with very less complications. We also ensure support from the locals, the governing authorities, hospital authorities and staff, hence almost eliminating all risks to the reputation of IEEE

Are any approvals needed to undertake this project?*

Please list the entities who would need to approve this project, such as the government, community entity, Institutional Review Board, and so on. If you already have the approvals, please include as attachments. If these approvals have not yet been secured, explain your plan to do so.

Approval of the Hospital Superintendent is required to go ahead with this projects.

Letters bearing their signs of approval has already been acquired. The superintendent has the authority to take the decision in this field, hence no sanction letter from any government officer was required. Even then we have met with and communicated effectively with the local government authorities who are very much impressed with the project proposal and has ensured their complete support.

The college management and principal very must be excited with our initiate and project , they ensure full support of the successful implementation of the project. We also get permission to implement the project form our college , Viswajyothi college of Engineering and Technology

Permission letter from the college

https://drive.google.com/open?id=1vV6mTRO2IBCk5y80nZR2qyMJoAntIp31

Please upload any approvals you already have here.

Letter from Hospital.pdf

SECTION 5: External Collaboration

Please note: legal agreements between IEEE and external entities need to be vetted by IEEE Legal prior to signing.

What external organizations (NGOs, government organizations, companies, etc.) are you working with?*

For each please provide the name and URL of the collaborating organization.

As part of the mitigation plan, we ensured the support of Volta Electrics to complete the project, if any mobility restrictions happen due to COVID 19.

Volta Electric is a student start-up registered in Viswajyothi Business Incubation Centre & Startup, Kerala as part of new Kerala government Scheme. They have a branch in Adimali near the project location. The best nearby organization to ensure the success of our project as a mitigation plan.

Volta Electric started 2 years ago as a startup. The employees are well experienced about 5years and with high practical knowledge. The company started as a service centre and manufacturing of LED Lamp.And also started solar, inverter, CCTV, water purifier, LED running board, wiring, plumbing and all type of all electrical and electronic equipment installation and service.

https://volta-electrics-solar.business.site/#posts
https://www.indiamart.com/company/94450745/
https://g.page/volta-electrics-ernakulam?gm

What are the roles and responsibilities of the external organizations and IEEE?*

If there is the need for a legal agreement, note that here. Please upload any documentation.

Letter from Volta (1).pdf

The hospital staffs are responsible for proper maintenance of both devices at all points and also for refilling and keeping the sanitizer dispenser full at all times. They are well instructed by our volunteers on how these chores have to be done.

Volta Electric -As part of the mitigation plan, we ensured the support of Volta Electrics to complete the project, if any mobility restrictions occur due to COVID 19.

SECTION 6: Requested Funding

The HAC Projects Committee prioritizes support of direct project costs, including necessary equipment, materials, supplies, and travel. Travel expenses must comply with IEEE Travel and Expense Reimbursement Guidelines. Given current circumstances, travel expenses should be minimal to zero.

No reimbursement of volunteer salaries will be provided. Reimbursing the salary of anyone contributing to the project must be carefully justified. Associated salary costs should be clearly explained and not constitute any more than a minor part of the overall budget proposed.

No indirect costs will be considered for funding, including but not limited to overhead expenses, Facilities & Administrative (F&A) costs, tuition, etc. Administrative, management, and project management costs may be considered, but they must be clearly justified.

Budget Justification*

*Provide a brief explanation of all proposed project implementation costs presented in the **IEEE HAC Projects Budget Application Form**. Please highlight those expenses for which funding is requested from HAC and the level of certainty of availability of any funding or resources required from third parties.*

The budget is prepared by estimating the requirement in the hospital. As per the request of the hospital, we plan to implement 20 Automatic sanitizer dispensers and 20 non-contact water tap systems at 40 different points in the hospital. The points are determined by the hospital authorities as per the requirements. We finalized the budget by collecting the detailed cost for each component from various shops and fixed the cost based on the quality and cost. We have also optimized the budget of the project as per the technology and also to keep it sustainable in the hospital.

Completed IEEE HAC Projects Budget Application*

*Please complete and submit IEEE **HAC Projects Application Budget Template**, which can be downloaded here. Please save and rename file to Name of Proposal (or abbreviation) to avoid potential confusion.*

Let's Unchain it.xlsx

What, if any, mandatory bank fees would be incurred with a transfer of funds from HAC to the OU?*

Please discuss in advance with the IEEE OU that will be your fiscal intermediary (generally the local Section) if there are any mandatory bank fees that are incurred with a transfer of funds from HAC to the OU. These fees may be included in the project budget; however, the OU must confirm to HAC that these are mandatory.

If none, please state "Does Not Apply."

Does Not Apply

SECTION 7: Additional Information

Have you submitted, or do you plan to submit, this proposal to another funding source?*

All proposals must disclose if an identical or similar proposal is currently under evaluation for funding elsewhere. Please state any entity(ies), including both IEEE and external funding sources.

No

Disclose any potential conflicts of interest regarding this proposal.*

Please note: project teams must abide by the IEEE Principles of Business Conduct. Project leads and any other members of project teams with decision-making authority must complete the Principles of Business Conduct/Conflict of Interest disclosure prior to receiving funding.

We will abide by the IEEE Principles of Business Conduct. Project leads and all other members of project teams with decision-making authority has completed the Principles of Business Conduct/Conflict of Interest disclosure prior to receiving funding.

Is any member of the project team also a member of any HAC or SIGHT Committee?*

If anyone on the project team or involved with the project is a member of any of the HAC or SIGHT Committees, please provide the name of the member(s).

NO

Videos and/or Photos

HAC encourages the submission of videos and/or photos that introduce the project team, demonstrate the need identified, or explain the technological solution to be implemented. (Video submission of answers to certain questions is permitted - please label video files with the question number).
Allowed file types: *mp3,mp4,avi,mov*

Any supplementary materials that further demonstrate worthiness of the project

Could include publications, letters of community support, etc.
Allowed File Types: *doc,docx,pdf*

recommendation letter.pdf
Project team Video- https://drive.google.com/open?id=12D1T_h3avTu_aeJ5THj_96la8LdUlAb

Proposal Submission

By signing this application, I confirm that:

A. all team members named in this proposal consent to this application being signed on their behalf;

B. all individuals and organizations named in this proposal have consented to either participate in or cooperate with this proposal as presented should it be selected for support;

C. to the best of the proposers' knowledge, this proposal is aligned with national policy in the country or countries where project activities will take place, and the proposers will ensure that any necessary ethical approval will have been secured before HAC funds are released;

D. I understand that any proposal which (i) is incomplete, (ii) does not have active local community involvement

and active "local" IEEE Volunteer involvement or (iii) for which a completed IEEE HAC Projects Budget Application Form is not submitted will not be reviewed.

E. the proposers individually and collectively indemnify IEEE, IEEE staff, the IEEE Humanitarian Activities Committee and IEEE HAC Projects Committee members from any liability associated with review of this proposal or subsequent implementation of their project;

F. the proposers individually and collectively acknowledge that any decision by HAC Projects as final;

G. I acknowledge that the information provided on this form will be processed according to the **IEEE Privacy Policy**.

** Active "Local" IEEE Volunteer involvement means that key IEEE members responsible for implementing the project are **currently living** in the country/countries where the project is to take place.*

SIGNATURE*

(On behalf of all named proposers – please sign by typing your full name and IEEE Member number)

Anish M Jose -95412652, Albin Paul-95404201

DATE OF SIGNATURE*

06/01/2020

File Attachment Summary

Applicant File Uploads

- Letter from Hospital.pdf
- Letter from Volta (1).pdf
- Let's Unchain it.xlsx
- recommendation letter.pdf

No. B- 423/2020

THQH Adimaly PIN 685 602
Dated 23/05/2020
Ph.No. 04864 – 298680
Email. chcadimali@yahoo.com

From

Superintendent

To

M/s IEEE Sight
Viswajyoti College of Engineering
Vazhakkullam

Sir

Sub:- Health Service Dept. – Covid 19 - Request for Automatic Hand Wash Dispenser – reg

Ref:-

Adimaly Taluk Head Quarters Hospital situated alongside the 2 NHs of 185 & 85, is one of the mager health care providing instituions in Devikulam taluk, Idukki District. The total bead strength of this institution is 100 and we are providing medical care for around 900 patients in the O P Department and an average of 120 patients are being given treatment as in patients, and an average of 8 deliveries are being attended daily. The total human retours strength of this institution is 183 of which 20 are doctors of different specialty. During the period of COVID – 19 pandemic diseases, doctors are to examine each patient after washing their hands. Since Govt. are not supplying automatic hand wash dispenser, we are forced to procure the same from the open market which is too expensive and we are facing difficulties in procuring adequate number due to insufficiency of fund. If Automatic Hand Wash Dispenser is available in sufficient number, it will be of a great help for this institution in fitting the COVID – 19 preventive activities. We will be much grateful to your esteemed institution, if you supply 20 numbers of Automatic Hand Wash Dispenser and we can provide better service to the poor patients of Tribal & plantetion areas of Devikulam Taluk who are mainly depending this hospital for their health care and other medical emergencies.

Yours faithfully

Superintendant

Copy to

The File

VOLTA ELECTRICS

VOLTA ELECTRICS

Muvattupuzha P.O ,686661;
KERALA electricsvolta@gmail.com

MOB NO: +917356674148, +917034415204

DATE: 26/05/2020

TO: IEEE SIGHT and HAC

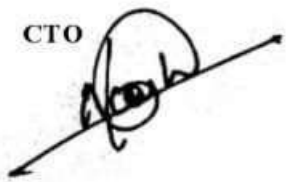
It is our pleasure to inform you that, after meeting with IEEE VJCET volunteers, we are happy to extend our support to Implement automatic Hand Sanitizer and non contact water tap system at Govt Thaluk Hospital, Adimaly , if the COVID -19 pandemic is growing and further lockdown and mobility restrictions are implemented . We have arranged a team nearby that can help them set it up and also to maintain them during lockdown restrictions.

We also appreciate the initiatives and efforts by IEEE VJCET during these tough times to try and reduce the effects of the pandemic and ensure better healthcare service.

Sincerely

AKASH PRAKASH

CTO



Instructions: **THIS FORM MUST BE SUBMITTED WITH YOUR COMPLETED HAC PROJECTS APPLICATION**.

Download form to complete. Once done, **save a copy for your own records, rename the file name with your proposal name (or abbreviation)** and then submit via e-mail together with the completed HAC Projects Application.
Any proposal for which a completed budget is not submitted will not be reviewed. If you need extra lines for Projects Expenses, insert them in the spreadsheet before the Total Expenses line below.

IEEE Humanitarian Activities Committee (HAC)
IEEE HAC Projects Budget Application Form 2020

DATE: 30-05-2020 [Date you submit form to IEEE HAC Projects - DD MM YYYY]

PROJECT ID #: [OFFICE USE ONLY]

PROJECT TITLE: **Let's Unchain It** [Insert the same title as the one on your Grant Application.]

Enter details and amounts in the appropriate columns. **All amounts must be shown in US Dollars.**

Funding or Income Received or Expected from other sources	USD Amount
	$ 100.00

Funding Amount Requested from IEEE HAC Projects	USD Amount
	$ 2,158.00

INCOME

List the details of other funding, income or resources expected or received:

Source of Funding/Resources	Amount/Value
IEEE VJCET SB	$ 100.00
Funding support requested from IEEE HAC Projects	$ 2,158.00
Total Project Income	$ 2,258.00

EXPENSES

List and Group ALL Project Expenses	Expense Amounts to be Paid from IEEE HAC Projects (in US Dollars)	Expense Amounts to be Paid with Other Funds (in US Dollars)
Solenoid Valve - 20 item	$ 364.73	$ 30.00
DC submersible pump- 20 items	$ 92.11	
12 v relay 40 items	$ 78.94	
Bc 547- 40 items	$ 5.60	
Resistor -40 items	$ 2.63	
Wire 100 m	$ 13.15	
Female socket -40 items	$ 13.15	
12 V adaptor- 40 items	$ 184.21	
Bottle -20 tems	$ 92.11	
Pipe - 50 m	$ 52.63	
Clamp- 50 m	$ 52.63	
Screw 200 items	$ 4.60	
Film- 20m	$ 6.57	
Tap 20 items	$ 198.57	
Fta 20 items	$ 13.16	
MTA 40 items	$ 26.31	
Garden hose 10 m	$ 6.57	
Hose clip 20 item	$ 2.63	
Teflon Tape 20 iems	$ 2.63	
Insulation tape 10 items	$ 1.32	
Ball valve 20 items	$ 26.31	
Wash Basin 20 items	$ 891.05	$ 30.00
Water controller 20 item	$ 13.16	
Tip 32 c pnp transistor - 20 items	$ 13.25	
Travel		$ 28.57
Precautionary Boards		$ 11.43
Total Expenses (allocated to HAC Proj)	$ 2,158.00	
Total Other Expenses		$ 100.00
Total Project Expenses	$ 2,258.00	

29-Jan-2020

Recommendation letter

To,

IEEE SIGHT

IEEE Headquarters

USA.

From,

Prabin james ,*SMIEEE*

Assistant professor

Dept of EEE,

Vimal jyothi engineering college

Chemperi p.o.,kannur

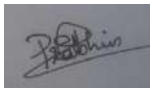
IEEE Member No: 93897561

Sub: Recommendation letter for the COVID 19 project proposal of IEEE SIGHT of VJCET

Dear sir,

I am Prabin james from vimal jyothi engineering college kannur.I have worked as ieee sight education committee for the year 2019.Also I have served as a mentor of the ieee sight project done by the viswajyothi engineering college for the year 2020.IEEE SIGHT of viswajyothi engineering college done a project of " Robosanitizer" in a wonderful manner.I recommend this project suited for the ieee sight COVID 19 project funding.

With regards



Prabin james

IEEE SIGHT project mentor VJCET

SMART CLASSROOM AMONG THE WOODS

2019 IEEE SIGHT Project Proposal

IEEE VJCET SB

Mr ALBIN PAUL

Mr ALBIN PAUL

CHERADY HOUSE
KOMBANADU P O
PERUMBAVOOR, KERALA 683546

albinpaul@ieee.org
O: +919447948562

Application Form

1. Alignment with SIGHT Funding Requirements

a. Project Name*

SMART CLASSROOM AMONG THE WOODS

b. Which SIGHT group are you affiliated with?*

IEEE SIGHT VJCET SB in Kochi Sub Section in Kerala Section -Region 10

c. What kind of SIGHT project is this?*

Local project involving technology deployment in an underserved community

d. Project Location and Project Duration*

Please describe where and over what time period the project will take place.

KUNJIPPARA TRIBAL SETTLEMENT SCHOOL(Multi-Grade Learning Centre)
KUTTAMPUZHA
KOTHAMANGALAM,ERNAKULAM DISTRICT
KERALA STATE
Duration 2019 November 01-05
Official Inauguration on November 14, National Children day in India
It may be varied due to the external climate and weather conditions
https://www.google.com/maps/dir/9.9507274,76.6326168/kunjipara/@10.065677,76.5541208,11z/data=!3m1!4b1!4m9!4m8!1m1!4e1!1m5!1m1!1s0x3b07f3fc46c9297f:0x24d18e0dbaf12876!2m2!1d76.8008578!2d10.1881491

e. Funding Amount Requested*

Please provide amount in USD.

4831

f. IEEE Organizational Unit*

Which IEEE OU is acting as the fiscal agent responsible to receive approved funding?

IEEE VJCET SB (STB64351)

g. OU Contact Name & Position*

i.e. Section Chair or Treasurer

ALBIN PAUL,IEEE VJCET SB SIGHT Chair

h. OU Contact Email*

albinpaul@ieee.org

i. Executive summary of proposed project*

We conducted a surrey at Kunjipara Tribal settlement with the support of SIGHT Kerala Section.We completed the initial planning.Then we estimated the power required for the running of the school with the help of our faculties Er. Babu T Chacko and technical staff Mr Jekson Joseph and estimate of the price and specification of commodities. They have many years of in the field of installing Solar panels across Kerala.Then we check the geographic aspects of installing solar panel and we got clearance from the Forest Department.There is no electricity in the village.We will set up solar panels on the school and the power from it is stored in a battery and an inverter is used to provide electricity to run the smart classroom and also as part of it we have done all essential wiring of the building. It helps to provide better education and training to them and help the teacher to concentrate more attention to those who needed more care.During our last visit(as part of our Gift of Joy program) they also requested for the same.

For the Installation,The panel should be installed south facing. A-frame is made to mount the panel.According to the climate of Kerala, it is installed with a 5 - 10 % tilt. Students from VJCET IEEE will be installing and doing future maintenance of the solar panel and also teach the basic maintenance to the local people.it helps to improve the efficiency of the solar panel.The school lacks electricity connection.So doing such a project is more suitable.Once installed battery water will be changed as required. The basic electrical works and installation works will be done by IEEE SIGHT volunteers and PES volunteers as per taking norms and regulations with the proper guidance and support of our Electrical engineering Faculties and technical staffs. We also take proper safety measures during the entire installation to keep it active with less maintenance.

we also arrange a basic workshop to the local people about the proper use, application and maintenance of it.we also teach them about basic maintenance and give the maintenance toolbox to them.We also engage them in the installation of the panel, it proper guidance, it increases their confidence for basic repairs. we will definitely contact them and visit the school in regular internals to strengthen the network.

it contains laptop,projector,speaker ,light and other basics

Gift of Joy at Kunjipara School

https://m.facebook.com/groups/159705870806231?view=permalink&id=2083549908421808

j. If this proposal is a continuation, please provide the report of the last funded project.

k. Please detail your financial interest in the project:

If applicable, please disclose your significant financial interest (and that of your immediate family) in this project:

The requested amount of fund is used for purchasing the Solar panel, battery, inverter and other materials for the projects as per the budget, and also it is used wisely for the transportation of materials to the location and the efficient installation of the project.

Supporting Letter from Kerala Section-
https://drive.google.com/open?id=0B2jKUsVj3rUOM0cwZ1VTYnE1cmJEMkgwbmhrSVpJX2Y0UGtV

Supporting Letter from Kochi Sub section-
https://drive.google.com/open?id=0B2jKUsVj3rUOdDBrQ3huTktxSDRkdUxZTWpUaVNtc1VCR25v

IEEE Kerala Section and Kochi Subsection supported the project. The analysed our proposal and discussed in the execom meeting, they also realise the pathetic situation in the community and the strength of project proposal .they gave token financial support for implementing the project and to keep sustainable .part of it is used for conducting an effective surrey. The contribution made by section and subsection is included in our budget

2. Proposal Focus

a. Please describe the need this project is addressing*

Please outline the need that your project aims to address at a local level.

Make education more inclusive and accessible to children in the backward community in Kerala to ensure equitable and quality education and promote life long learning opportunities to them by strengthening the Tribal settlement school to a smart and green class room.

Now some students are in a Government Residential school in Town, which is far from their settlement. They are staying in a Government Hostel. But it is not practically possible to send their kids of age below 10 to residential schools. so the children are denied basic education. While we were talking to the people and government officers, they confirmed it can be rectified by strengthening the multi-grade learning centre (Single teacher tribal settlement school). Currently, the children of age from 10 are students at residential school. As per our education scheme, the school curriculum starting from the age of 4. Due to a lack of facilities in their settlement, these tribal students lose their valuable years.

Also, they are speaking an indigenous language that is slightly different from our mother tongue-Malayalam. After successful implementation of our project, SMART CLASSROOM AMONG THE WOODS, they get a better education from childhood onwards. It helps them to learn in the best ways from their bud stage.

There is no school in the forest other than the tribal settlement school (multi-grade learning centre-it is a centre that provides basic education to children up to 4th standard by a single teacher).

b. Please describe the overall project objectives*

Please outline clear, measurable objectives/metrics and how their relevance to the beneficiary community has been validated.

To inspire and support the students from backward communities especially tribal to create a career goal in their mind and provide financial and mental support to them. Thus, to achieve their goal by providing better educational facilities to them. This will allow them to understand more about society and technology. Provide distant learning facilities to them. It is a remote tribal village and they do not have electricity or other basic facilities. It improves the technical skills of IEEE volunteers by providing a learning platform for new skills. It creates awareness among volunteers about the need for conservation of natural resources and effective utilization of energy for future generations without compromising the need for the present generation to grow up.

The objectives of the program are well suited with the theme of this year international Youth Day-Transforming Education.

The project highlights to make education more inclusive and accessible for the children who denied of education due to some reasons..through this project we overcome that and transforms education so that it becomes a powerful tool to achieve the sustainable development goals.

it provides facilities which help to provide quality of education, it is the fundamental tool for sustainable development.

in addition to it coney the message of green energy utilisation, rather than conventional energy consumption.

it is a 1KW off-grid solar installation project is to provide electrical power for the smooth running of Laptop, projector, speaker system, three 18 W LED tube light, two 9 W LED light etc.

c. Alignment with Objectives of IEEE SIGHT & Sustainable Development Goals (SDGs)*

Please briefly explain how this proposal supports the vision of IEEE SIGHT and the Sustainable Development Goals (SDGs). See http://www.un.org/sustainabledevelopment/sustainable-development-goals/ for more information on SDGs.

We provide the benefits of solar energy harvesting technology and development of computers etc to Tribal students who denied basic education due to lack of basic infrastructure

SDG 4-Quality of Education: Provide high-quality education through connecting with the world. the visual and audio learning helps them to learn in interesting and effectively

SDG 7-Affordable and Clean Energy: It is completely solar energy powered

SDG 10-Reduced Inequality: Equip them to grow up (development multiplier

d. Please describe the expected number of people impacted by the project*

17 students studying in school now, so many children are in the village not attending school. They are 269 households in the village. We saw so many children wish to went to school and learn from their budding stage. As per our survey and discussion with them, 32 students will join the school soon.

the project helps to 49 students in the school this year and it helps to all children in the locality and through them the entire community.

It helps their families. 600 people in the village

3. End-User Engagement

a. Please describe the beneficiary community*

Why was this end-user community selected? What local relationships already exist that will help this project be successful?

Kunjippara tribal settlement school is located in Kuttanpuzha Panchayath in Kothamangalam Taluk in Ernakulam district on the outskirts of Cochin, are marginalized and kept away from all the mantras of development and considered inferior in Kerala.The socio-economic and educational deprivation that they face is exposed to detail elsewhere. Many tribal people are excluded from development because of their gender, ethnicity, age, sexual orientation, disability or poverty. In terms of every set of indices of development, relatively tribes are at a much lower status than their fellow people. In work, employment, earnings, health and decision making, they are placed at a disadvantageous position.lack of education is the major problem that they face now.They are from below the poverty line, socially economically, educationally and are having a second-rate status in society.Some of these specific features of this area are that it is the illiterate who outnumber the literate, Nonworkers outnumber the cultivators, females outnumber the male population.The average population of each household is five.The level of education in the surveyed population was seen very low. 60% of them are being taught in schools.There is only a single teacher school in each tribal settlement. 20% of the people have completed 5th standard whereas 20% of them are children attending schools regularly. Illiterate parents are so keen on the education of their children. There is no school in the forest other than the tribal settlement school (multi-grade learning centre-it is a centre that provides basic education to children up to 4th standard by a single teacher). The education of tribal folks has become a major instrument of equalization and national integration, incentives, and special education programs to have considerable progress.Lack of electricity is a great obstacle to development. Installing electricity facilities in the inaccessible forest areas can be solved by solar panels and solar lamps.

b. Please describe community engagement during proposal development*

Please describe how the proposed beneficiary community contributed to the co-design of this proposal and associated implementation plan. How will they contribute to project execution in terms of non-IEEE volunteer effort?

When the idea of the project came to our mind we approached the officials. The proposal of the event is fabricated as a joint effort of Honourable MLA Mr.Antony John, Kuttampuzha Panchayath Member Mrs Kanthi and forest official Mrs.Sudha Madam and other beat officials and our Student branch team. Kanthi member is coming from the same background, so she knew the problem faced by them in very well. It helps us to create a proposal with all the necessary things that they require. Sudha madam in the forest department to get all clearance from the forest department and she helps us to design the project by giving the clear picture of the locality.MLA helps us to arrange a surrey in the locality to get more data, on the day IEEE SIGHT volunteers and PES Volunteers analysed the school and locality. Estimated the power requirement required for the running of the school with the help of our faculties Er. Babu T. Chacko and the technical staff Mr Jekson Joseph. They have many years of experience in the field. Then we checked the geographic aspects of installing a solar panel. The program is project is implemented with the help of them and other local people for the success full transportation of materials to the school. We provide proper guidance about the proper use, application and maintenance of it.we also teach them about basic maintenance and give the maintenance toolbox to them. The successful installation and implementation of the project are done with the combined effect of IEEE SIGHT, PES volunteers and the with local community support.

c. Please describe the role of stakeholders in implementation and sustainability*

How will the beneficiary community and any external stakeholders be involved in project implementation and in achieving sustainability beyond the IEEE SIGHT funding phase?

Antony John-Honourable Member of Legislative Assembly, Kothamanagalam in Kerala:He is very energetic and active in the entire planning process, He arranged all necessary sanction from the various government department.he provides all support for the project. He will ensure all support to keep the project alive and useful to coming years. After the successful implementation of the event, he also wishes to replicate the project to other tribal settlement schools across Kerala.

Sudha Madam-Forest Officer,Kuttampuzha-She is the first women forest guard in Kerala and also got appreciation from Prime Minister of India for the successful installation of 500 toilets in the tribal colony.she is from the same community, her knowledge and learning earned during the project which is recognised by the United Nation is helps us from the drafting stage to till now.we are very happy that the support from madam is inspired us and it helps us to implement it in the best way. surely, our project should kelp safe and sustainable.

Kanthi-Member of Kuttampuzha Panchayath:she is very much supporting.we first approached to her while discussing the project from that time onwards she is very eager to implement it to the welfare of the children in the community.She contacted all higher government officials including MLA and forest officers and others to form the committee. she encourages the community people to help us during the surrey and all other procedures.She also arranged transportation of the panels and other materials to the school.

As the local administrative officer and the one among them,she ensures the safety and sustainability of the project after the implementation.

Video of UN India volunteers sanitation project at same location

https://www.youtube.com/watch?v=849R1ZwiJEU

IEEE Kerala Section and Kochi Subsection supported the project. they gave token financial support for implementing the project and to keep sustainable .part of it is used for conducting an effective surrey.

d. Participation by IEEE members from intervention country/countries*

Please explain how the project team--IEEE Volunteers and other local volunteers in the target location(s)--will be involved in project implementation as well as supporting sustainability.

we SIGHT volunteers and PES volunteers conducted a survey at Kunjipara to know the problems faced by them. Along with PES volunteers we estimated the power required for the running of the school with the help of our faculties Er. Babu T Chacko and technical staff Mr Jekson Joseph and estimate of the price and specification of commodities. They have many years of in the field of installing Solar panels across Kerala. Then we check the geographic aspects of installing solar panels

Together we complete the basic electrification works of the building as per taking all safety measures and fulfilling all norms and regulations of Kerala government.

and also our volunteers along with the proper guidance of faculties and technical staffs, we instal the solar panel as per the geographical calculation to get maximum output and implement the project by connecting the school with the world. Along with that to keep sustaining the project we also teach and share the knowledge of proper use application of panels, battery, inverter etc also the sign of misfunctioning of it and the basic maintenance works (repairing works) of it. We already prepared a manual for our project which contains all the details of the operation and functions of the materials used in the project in our local language.it helps them to understand clearly.

it helps our volunteers to apply skills from the classroom to help under-served communities in such an impactful way, it will definitely an incredible experience to us.

Prior to the installation, We arrange a training session from the expert faculties and technical staffs in our Electrical Engineering department who have experience in the field about the fundamentals of solar energy and electrical wiring conventions in Kerala. The training emphasizing the importance of safety, maintainability, and sustainability of the system.

e. Survey of Similar Known Initiatives*

Describe how your proposal relates to similar known initiations.

Bringing Light to Hanchipacha- 12 technical volunteers from the University of Calgary travelled to Peru with Light Up The World and IEEE SIGHT with Light Up the World to install a solar system in Hanchipacha, an off-grid community. The system has had a positive educational, economic, environmental, and social impact in Hanchipacha.

There are so many similarities with the project. Here we light up and powering a school which is the only hope for students from the tribal settlement. And hereby transforming Education. It opens a new world to them and ignites their mind to achieve big dreams. Education is a development multiplier as it plays a pivot role in accelerating progress across all SDGs.Through providing laptop, speakers, projector and screens along with tube light, fan etc it improves the quality of education and should lead to relevant and effective learning outcomes.

There are so many projects going on and also successfully implement on the solar panel installations.

Lighting 75 tribal Houses with Solar Power at Kunjippara Tribal Village (Same village) in Kuttampuzha In Kerala by Cochin shipyard as part of their corporate social responsibility program.

https://www.cochinshipyard.com/CSR_Ruraldev.htm

Kunjippara tribal village has not been provided with any lighting facility. The local tribal (Muthuwan) families of this tribal village have been living in darkness for as long as they can remember. The only light which brought some relief to their sights apart from the daylight was the light from the Kerosene oil lamps and bonfire which they lit during the night time. Continuous purchasing of wax candles was something which was beyond what they could afford and buying oil to light the lamps was also becoming exclusive as the vendors were now charging whatever price to seize the opportunity. Life was already difficult for this group of people and gradually hardships were just increasing. Their children, who came to visit them from hostels, preferred going back soon, as without proper lighting provision they were finding it difficult to complete their vacation homework. Women were suffering from poor vision and partial blindness due to constantly doing kitchen work in the dark. A 'good night's sleep' was considered to be a privilege as on most of the day the men in the families were busy guarding the village from the attacks of the wild elephants.

Mass mobilization of youth volunteers to end open defecation among tribal communities in Kuttampuzha

https://www.in.undp.org/content/dam/india/docs/UNV/Strengthening_NYKS_and_NSS_Best_Practices/NYKS_NSS_Mass_Mobilization_of_Youth_Volunteers_Ernakulam_District

In partnership with Ministry of Youth Affairs and Sports, Government of India, United Nations Volunteers Programme and the United Nations Development Programme aims to provide catalytic support to the Youth Volunteer Schemes in the country and facilitate greater youth participation and voice in peace and sustainable development programmes

4. Expected Impact

a. Please describe the impact on target communities*

Please explain the expected short, medium and long-term impacts for the beneficiary community.

Short term

Empowering a school which is the only hope for students from the tribal settlement is increase the quality of education. It helps the teacher to concentrate on each student and help the skill and helps to mould the students by avoiding the weak point on the students. It helps to encourage the students to come to school and learn well.it creates learning an interesting and easy way. The visual and audio learning helps them to learn quickly and effectively. It helps children to study in near to their house and stay with the parents rather than staying in far away hostels. Help them to learn our mother tongue from their childhood along with their indigenous language, because only the teacher in the tribal school can understand the indigenous language. other school teachers beyond the forest don't know it

Medium-term

Development in school reduces the backdrops from school, Increase the literacy rate, Create awareness about the utilisation of solar energy and the importance of its conservation.

Long term

It opens a new world to them and ignites their mind to achieve big dreams. Education is a development multiplier as it plays a pivot role in accelerating progress across all SDGs.Quality of education plays youth development, which in turn benefits society. Transforming. education is a fundamental tool for sustainable development, It helps them to earn more and they definitely become a good social being and reach in well level in the society and motivate others to achieve their goals.

moulding up them with good human values and skill.it also increase the standard of living.it it helps them to dream big, and sets goals and gives confidence and courage follow passions to achieve goals.it helps to increase the literacy rates. It empowering the community and the become equal to all those who considered them as inferior, it creat them the importance of conservation of energy and effective utilisation of solar energy.

b. Please describe the dissemination of achievements and lessons learnt*

Please explain with which audiences (both within IEEE as well as the broader sustainable development and humanitarian technology communities) you will share project achievements and lessons learned, and how this will be achieved (e.g. identify relevant local/international publications, events, etc).

The lessons we learned and achieved that we earned should be share through the local to the national level television channel and newspapers.it should definite shared through social media like Facebook, WhatsApp, Instagram pages. we post the detailed description in newsletters of section, council and on SIGHT.we also take video coverage of the program and upload it on Youtube to motivate others to invest their time and skill on similar works.We always sharing our events on official SIGHT FB Page

c. Please describe the potential for replicating or scaling project outcomes*

What potential (if any) is there to replicate or scale expected project outcomes?

Yes.the event we planed as a pilot event.The project has a strong potential for replicating and scaling up.While we discussed it with Kerala section chair Sameer sir, first shows the potential of the project.We also discuss it with Honourable MLA Antony John sir he also offered full support for it. On the same time get the same request from Usha teacher from Thalavechupara Tribal school.She also requested to implement the same project on their school where the condition is similar to Kunjipara School.After successful installation of the project at Kunjipara then we planned to visit and conduct survey Thalavechupara.

There are so many areas, lots of children denied education in the world due to lack of facilities,the project will definitely act as a gift to the children. The is no electricity in remote areas in India and also greater in across the world. the solar is a sustainable and efficient solution to these areas after checking the environmental factors.Spread the light in darkness

b. Please describe the proposed technology and relevance to local environment*

Please summarize and justify proposed technologies that will be used to achieve the project objectives. Please explain how they are appropriate and relevant to the local environment in which the project will be implemented (e.g. local community members can be trained to maintain o repair, etc.).

We IEEE SIGHT volunteers and PES volunteers conducted a survey at the Kunjipara village and collect maximum information, problems that they face and all essential details for the project. we also visit the school and calculated the energy requirements in the school and also check the geographical and environmental aspects for the installation of solar panels with the expert team consists of faculties, technical staffs who have years of experience in the installation of solar projects, forest officers, local administrative officers and local community people. Along with we estimated the cost and decided specification of panels and other components. the location is suitable and feasible for the installation of solar panels in technical and other fields. we get clearance from the forest department. A few years back Cochin Shipyard successfully implemented a project which provides solar-powered light to some houses in the village and they also installed a few street lights on the path to the village.it is still in working condition and proves the installation is possible and successfully done in early as a small project.

Prior to the installation, We arrange a training session from the expert faculties and technical staffs in our Electrical Engineering department who have experience in the field about the fundamentals of solar energy and electrical wiring conventions in Kerala. The training emphasizing the importance of safety, maintainability, and sustainability of the system. in this project we instal solar panel as per the required angle to get maximum efficiency as per the standards, regulation and topography of the land, the generated electricity stored in the battery after proper conversion and passing through the inverter and other components as per prefabricated design under considering safety and sustainability factors. After proper electrical wiring of building with the help of expert technicians and faculties, we provide tube lights and basic devices to school and also connect the laptop, projector, audio systems etc to enhance learning systems. At the end of the installation, we will arrange a small ceremony with representatives of the local community where the importance of the community education and value of the solar system will explain in most excellent way ,and we provide a training session to selected people about proper maintenance of it, and equip them to keep it sustainable. We also provide basic repairing tool kit and the manual of its operation which we created to them.it is a 1KW off-grid solar installation project is to provide electrical power for the smooth running of Laptop, projector, speaker system, three 18 W LED tube light, two 9 W LED light etc.

c. Please describe the implementing team*

Please provide short profiles for each member of the proposed implementation team (IEEE and non-IEEE) that justifies how their participation will support achieving the objectives of the proposal. Please explain the relevance of their expertise and previous fieldwork experience, if applicable. Please describe previous relevant collaborations of the team.

1,Mr.Antony John-Honourable Member of Legislative Assembly, Kothamanagalam in Kerala: He is very energetic and active in the entire planning process, He arranged all necessary sanction from the various

government department. he provides all support for the project. He will ensure all support to keep the project alive and useful to coming years. After the successful implementation of the event, he also wishes to replicate the project to other tribal settlement schools across Kerala.

2, Sudha Madam-Forest Officer, Kuttampuzha-She is the first women forest guard in Kerala and also got appreciation from Prime Minister of India for the successful installation of 500 toilets in the tribal colony .she is from the same community, her knowledge and learning earned during the project which is recognised by the United Nation is helps us from the drafting stage to till now. we are very happy that the support from madam is inspired us and it helps us to implement it in the best way. surely, our project should kelp safe and sustainable.

3, Kanthi-Member of Kuttampuzha Panchayath: she is very much supporting .we first approached to her while discussing the project from that time onwards she is very eager to implement it to the welfare of the children in the community. She contacted all higher government officials including MLA and forest officers and others to form the committee. she encourages the community people to help us during the surrey and all other procedures. She also arranged transportation of the panels and other materials to the school.

As the local administrative officer and the one among them, she ensures the safety and sustainability of the project after the implementation.

https://www.youtube.com/watch?v=849R1ZwiJEU

https://www.theweek.in/webworld/features/society/A-forest-officers-toilet-mission-for-tribals.html

4, Jaya -Teacher of Kunjipara Tribal Settlement school. work hand in hand with us to implement in school. From the survey, we understand the contribution made by the teacher to moulding up the children in the village. even though she is not from the village her intense work motivates us in all stages of the project. She goes to school on Monday morning and came back from the colony on the weekend only. she spent the days with them.it is practically not possible to travel to school daily. She has also family in the town, but she sacrifices the time to provide better education to children in the backward community. She is qualified and has excellent knowledge about computers and maintenance of solar Panel. Due to the experience, she knows their indigenous language which is slightly different from our mother tongue and also the nature of people in the colony. It provides confidence to us that the implemented project will be safe and sustainable.

5, Siyan-Forest Beat officer of Kunjipara section. we knew him from our last project 'Gift of Joy' at the same location.he is a very supportive and active person. He helps us to get all sanctions and clearance from the forest department. The project is implemented in the forest area where he is in charge of it.

6, Sijo -A wellwisher and active social worker from Kutampuzha, He is the representative of the Kunjipara Community people

7, Dr.Joseph Kunju Paul, Principle of VJCET -Our mentor for the project. he guides as in the right tracks for the successful implementation of the project.

8, Dr. Sameer S M, IEEE Kerala Section Chair-Supportive, inspiring, motivating external guide for our project. His contribution to the projector is precious. His pieces of advice and suggestions improve the quality of the project from the initial stages to till now,

9, Anish M Jose- Counsellor IEEE VJCET SB 95412652- Assistant Professor of Electronics and Communication department, Branch Counsellor and IEEE SIGHT CounsellorHe is the man behind the project. The step taken by him to the project is inevitable to help the backward community people in Kerala.it helps to spread the light of the advancement of technology to the people in darkness.

10, Babu T Chacko –Counsellor IEEEVJCET PES 92152070- He is an assistant professor of Electrical Engineering department and also Power & Energy Society, Counsellor.

We conducted surrey and energy requirement calculations with the proper guidance of him.

11, Mr Jexson- Expert Technical staff of VJCET and experienced in the solar panel installation field. he also part of the survey and the estimation of components. He is the technical guide for our installation and successful completion of the project. His experience in the domain really helps us during each stage.

12,Sivadas T Nair- Counsellor IEEEVJCET Computer Science Society 94570554

13, Albin Paul -IEEE SIGHT VJCET Chairman 95404201-Sucussfully organized various IEEE SIGHT and other events. Final year Mechanical Engineering student and

Active National Service Scheme Volunteer. Received special appreciation from Honourable District Collector, Ernakulam for Green protocol initiating project in last year.

14, Aishwarya G Prabhu –IEEEVJCET Chairperson VJCET Student Branch 94574662-Motivating and inspiring IEEE Volunteer .Final Year computer science student

15,Anusree R –IEEE VJCET SB PES Chairperson-94187546-Final year Electrical and Electronics Engineering Student, Actively volunteering in each stage of the project

16,Basil Eldhose-Active IEEE Volunteer. The second-year Electrical and Electronic Engineering Student. His energetic contribution during the study of the local environmental, geographical factors and estimation of the electrical component is very excellent. Dedicated PES volunteer with lots of experience in the solar panel installation field. He also earned training and currently working with some external industry experts in the domain.

17, Ananthakrishnan S Nath- IEEE SIGHT VJCET Vice-chairman-

18, Devika Suresh Kumar-IEEE SIGHT VJCET Treasurer

19, Uthara Pradeep-Active PES Volunteer and trained student in the solar panel Installation field

5. Project Implementation Plan

a. Timeline and milestones of project*

Please outline the proposed work plan, expected timelines and milestones associated with successful implementation of the proposed objectives.

05/01/2019-We met Mr.Sijo and Mrs.Kanthi and they gave the details and condition of Kunjipara school which is situated in the forest.

09/01/ 2019- We discuss the project on VJCET SB SIGHT Execome meeting, it is the first official meeting of the Project.on the meeting, we decided to visit the place and meet the higher officials.

After these days we collect maximum information about the tribal colony, forest area, school and understand more about various SIGHT and HAC calls.

30/01/19-We present the initial idea of the project to VJCETSB execom meeting. All are really interested in it and together we planned to go ahead with the project. On the meeting, we decided to meet the Antony John, MLA and forest officers.

09/02/2019-Mrs.Kanthi, member of Kuttampuzha local body, Jaya teacher of Kunjipara school and us visited the Kuttampuzha Forest office and discuss the project with the forest officers and they gave clearance and sanction for our project. They assign Mr.Siyan, forest Beat officer for providing further helps. During the meeting, we got the excellent guide Mrs.Sudha Madam. She got an award from PM of India for developing proper sanitation facilities in the tribal colony in last year. It was a turning point of the project. Her advice and guidance help our project to improves planning.

23/02/19 - We met MLA along with the teacher. He ensures all support. It motivates us to go ahead with the project. At that, he also mentions the potential of the project for replicating and scaling up.

01/03/19-The refined project presented again on the SB execome meeting and we decided to form a committee for the further proceedings.

After that, we look at the various SIGHT and HAC funded projected and also the various projects call.

13/03 -We arrange an execome meeting of SB SIGHT groups and discussed more the linking of our project with SIGHT vision, mission and UNSDGs and also further steps to mould a good project.

24/03 - The first meeting of the committee members of the Project. we decided to conduct a surrey in the village and also ready to check the environmental and geographical factors. we prepare a questionnaire for it.

During the time we contacted Kerala section chair,SIGHT chair and Kochi Hub and discussed our project. They also ensure full support.

06/04 - Committee member and Volunteers visited the school and conducted surrey. Then we estimated the power required for the running of the school with the help of our faculties and technical staff. also, we check the geographical and environmental aspects for the installation of solar panels.

29/04 -The survey report is presented on the Project Committee and we estimated the cost and decided specification of panels and other components. As part of immediate help, we decided to organize an event Gift of Joy at the school.

21/05 -Gift of Joy

12/08 -official Tittle Launch through SIGHT Fb page.
upcoming -as per our wish and planning
01-05/11
Official Inauguration on14/11, National Children day in India

d. Please describe the risk analysis and contingency planning*

Please highlight potential risks (e.g. availability of IEEE and non-IEEE volunteers with necessary skills and expertise, team members not previously working together, person effort by the beneficiary community, resources committed by partners, end-user acceptance, ethical issues, etc.) and explain how these risks will be managed and reduced. If your proposal assumes access to funding or other resources from third-parties, you must explicitly state this and explain how the project will be completed if such third-party funding or resources are not received.

Through proper and effective surrey and analysis the environmental, geographic, safety, standards, norms and all other constraints we develop an excellent plan and budget with technical specifications.Our team consists of faculties, technical staffs who have so many years of experience in the field and active and trained IEEE volunteers to implement the project.In addition to that, we also arrange a workshop and training from the industry experts about the fundamentals of solar energy and electrical wiring conventions in Kerala.The training emphasizing the importance of safety, maintainability, and sustainability of the system. Installation the solar panel and wiring of school are done with the help of faculties and Technicians.We already know each other through the official committee meeting and other programs.The team spirit helps us to the success of the event. Active participation of the beneficiary community from the survey onwards is the motivating us for the implementation of the project.our committee consists of a representative form them.The permission from the forest department has a little risk while we design the project. But the forest officers gave all permission and sanction for the project. They are very much impressed with the objectives and outcome of the project.The transportation of material is another difficult task for them while we discuss it on first meeting. During our visit to Village for the survey, we discuss it with local administrative officers,Sudha madam and community people. They remove our burden and they ensure they will manage and arrange proper transportation facilities to transport the materials to the school.Sudha Madam's experience on the implementation of Sanitation facilities with United Nation' India Volunteers will motivate us. During that time also the support from community people is valuable.Considering the fact that school is located in the forest and the transportation of materials requires more cost. Forest team is always accompanying our crew to guide and manage any unexpected trouble in the forest. We also take the medical first aid kit and emergency rescue kit to survive any situation.Through effective teamwork and planning, we managed and avoided all risks of the implementation of the project. The project fabricated with the beneficiary community, they are very much excited and waiting to implement the project. There are no ethical issues or similar on this projects and area. There are no third parties or other external resources for the project. We sat together and designed the project in an effective and excellent way, we completely analyse the risk and solve it.The forest department also permitted to use the private road(restricted for public) for transportation of material to school, if any unexceptional difficulties arise due to extreme weather and road .The forest team arrange a training class while we entering to forest to overcome the unexpecting Wheather changes like land slides etc

6. Sustainability of Project Outcomes

a. Which project components will continue after funding from SIGHT is finished?*

The solar panel, Battery, Inverter, electrical wiring in the building, laptop, projector and speaker system will remain after funding. Our SIGHT group is decided to adopt the school to ensure the technical and all development of the school and students. It keeps the project is alive and fulfilling the objectives and acquires the goals.

b. What are the plans for the continuation of project components?*

Our SIGHT group is decided to adopt the school to ensure the technical and all development of the school and students. It keeps the project is alive and fulfilling the objectives and acquires the goals. Through the continuation, we can encourage the children to set career goal and dreams to achieve and keep them in the track to achieve the goal. It will definitely ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. It helps us design and implement so many programs and event to the bright future of the children. It helps us to know the suffers and problems faced by the vulnerable community, and it leads to finding the proper solution to them and to implement to reduce their miserable life. During the surrey, they discussed their problems, among that lack of education is a very very crucial and important one.so we decided to solve it first.

c. Please describe how the project outputs will contribute to the long-term outcomes*

Please expand on how these outputs will contribute to long-term outcomes, including empowerment of community.

Making education more relevant, equitable and inclusive is crucial to achieving sustainable development. Education is a 'development multiplier' in that it plays a pivotal role in accelerating progress across all 17 Sustainable Development Goals, be it poverty eradication, good health, gender equality, decent work and growth, reduced inequalities, action on climate or building peaceful societies.

By implementing good quality facilities for getting the education to the children, it encourages and motivated to learn. Through our project, we ensure the quality of education in interesting and effective learning ways through the enhancement of computer and visual technologies in most sustainable ways to the children denied education due to lack of facilities. It opens a new world to them.it help to learn quickly and effectively.it reduce dropouts from schools, it encourages other children to come to school.it moulding up them with good human values and skill.it also increase the standard of living.it it helps them to dream big, and sets goals and gives confidence and courage follow passions to achieve goals.it helps to increase the literacy rates. It empowering the community and the become equal to all those who considered them as inferior, it creat them the importance of conservation of energy and effective utilisation of solar energy.

d. What is your plan for measuring project outcomes?*

Measuring the success of the project is done by the analysis of the achievement goals. The outcome of the project is measured by measuring the new admission to the school, and also by taking the dropout from school. The ultimate success of the event reaches to the society when the students grew up. It is done by measuring the position of the students after education and value of the project, works done by these students to the entire humanity and world.in immediate assessment is done by By measuring the number students joined in school, and check it with previous year admission status and also measuring the improvement in Literacy rate .it increases the standard of living and also by measuring the educational standard of students,.The quality of education helps them to learn quickly and effectively. It will mould them with good human values and skill.it also increase the standard of living.it it helps them to dream big, and sets goals and gives confidence and courage to follow passions to achieve goals. We can also measure the outcome in the long term by checking the number of students joined in colleges, the domain of their studies, an achievement that they gained, scholarships that they received etc .it's outcome will be reflected on the job that they earned after their studies.

7. Requested Funding

a. Budget*

Please be as specific as possible, breaking out costs for major items. If this is a multi-year project, please include the total project budget and the budget for the current calendar year.

You can download the **suggested budget template here**. Please do not adjust the formatting of the document.

Please note that IEEE SIGHT cannot make any contribution towards (a) costs associated with the person effort preparing or implementing a project, (b) indirect costs (including but not limited to overhead rates, F&A, tuition, administration, management, etc., (c) consultancy, (d) technology development that could be deployed anywhere or (e) any projects which IEEE SIGHT considers to be primarily focused on research or commercial activities or considers sufficiently focused on addressing local needs.

SCAW Budget (1).pdf

8. Supplementary Material

Supplementary Material

If you have any additional supporting documentation please add it here.

IEEE.docx

KERALA STATE COUNCIL FOR SCIENCE, TECHNOLOGY AND ENVIRONMENT
AND
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
Centre for Engineering Research and Development
Jointly Organize

INNOVATE 2019 OF KSCSTE

Application Form

1. Mode of Participation: Individual Group (Please tick the category)
2. Title of the Project: **Fully Automated Weed Controller**
3. Name of the Applicant (Group leader for team): **Kevin G Amamthuruthil**
4. Name and Official Address of the Mentor: (Should be a faculty of the Institution)

   Mr. Unnikrishnan T G
   Assistant Professor
   Mechanical Engineering Department
   Viswajyothi College of Engineering and Technology
   Muvattupuzha-Thodupuzha Road Vazhakulam, PO,
   Muvattupuzha, Kerala 686670

5. Name and Address of the Institution:

   Viswajyothi College of Engineering and Technology
   Muvattupuzha-Thodupuzha Road Vazhakulam, PO,
   Muvattupuzha, Kerala 686670
   Phone : 0485 226 2977

6. In case of group participants details of group members

Name	Phone no	Email Id	Signature
Kevin G Amamthuruthil	7907502905	kevingamamthuruthil98@gmail.com	
Sagar Vincent	9496610332	sagarvincent@gmail.com	
Ameer E A	9605486154	ameerea101098@gmail.com	
Aldrin Baby	9539852907	aldrinbaby1234@gmail.com	

7. **Details of the proposed project:**

i. **Abstract of the Project:** The objective of this project is the replacement of hand weeding in organic farming by a device working autonomously at field. The fully automated weed controller was designed using a structured design approach, giving a good overview of the total design. A vehicle was developed with a solar powered source, four-wheel drive and four-wheel steering. The available power and the stability of the vehicle does not limit the freedom of research regarding solutions for intra-row weed detection and weeding actuators. To fulfill the function of navigation along the row a new machine vision algorithm is used with an expected error of less than 25 mm. The vehicle is a versatile design for an autonomous weeding robot. The result of the design has good potential for autonomous weeding in the near future.

ii. **Summary:** The project is mainly designed for large scale farmers. While there is sufficient equipment available to control the weeds in between the rows, weed control in the rows (intra-row weeding) still requires a lot of manual labour. The spraying of pesticides have largely been independent of manual labour since introduction of large scale spraying using drones and helicopters. This severely affects the soil quality, life of earthen organism and contributes heavily to soil pollution. This design is a step towards the optimal use of pesticides along with the mutual benefit of reduced labour and cost reduction. An autonomous weeding robot replacing this labour, could mean an enormous stimulus for organic farming.

iii. **Methodology in detail (including drawings):** The working of the design involves three major processes:

A) Analysis & Detection

Machine Vision (MV) technology is used for recognition of crop and weeds. Machine vision is the technology and methods used to provide imaging-based automatic inspection and analysis for such applications as automatic inspection, process control and robot guidance. MV technique uses color and shape as parameters of recognition of crops and weeds. It involves image acquisition, software processing for identification and out instructions for positioning of the arm plate.

B) Arm Mechanism

The arm mechanism uses a wheel with encoder to have precise distance measurement movement. It also uses dead reckoning relative to the body surface of the bot for precise positioning of arm plate. Two arms provide transverse movement of the plate, whereas the other arm provides longitudinal movement. The rotating head above provides rotational motion to the three arms.

C) Navigation

Navigation is the process of guiding the bot across the field with respect to crop rows. The main technologies involved are GPS, dead reckoning and machine vision. Navigation is done through the following steps.

- First the bot uses GPS to constantly determine if it is in the required field.
- If the bot is inside the field it uses GPS and MV to determine whether it is in headland or not.
- If it is not in headland, it performs the weeding through the row. Once it reaches headlands it uses MV and dead reckoning to adjust it self to the next row.
- These steps continue till the whole field is completed.
- In order to navigate through the rows, the bot uses machine vision technology.

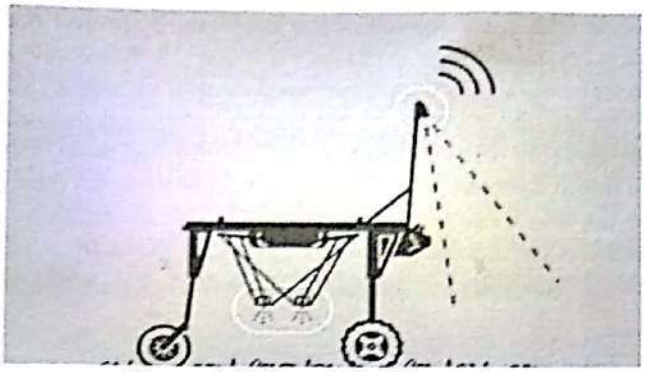


Figure 1. 2 D model of the design

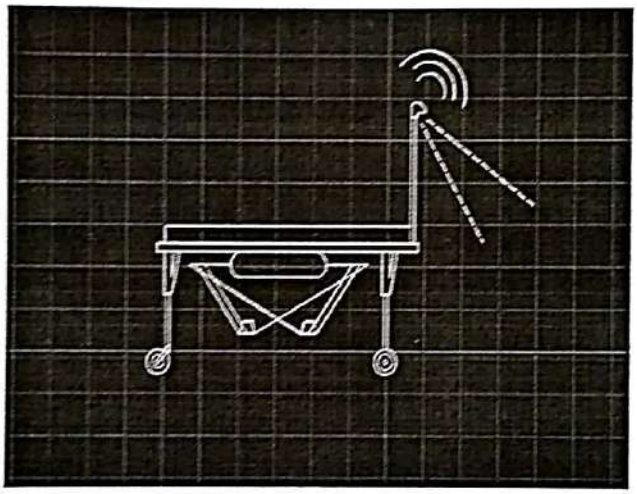


Figure 2. CAD drawing of the design

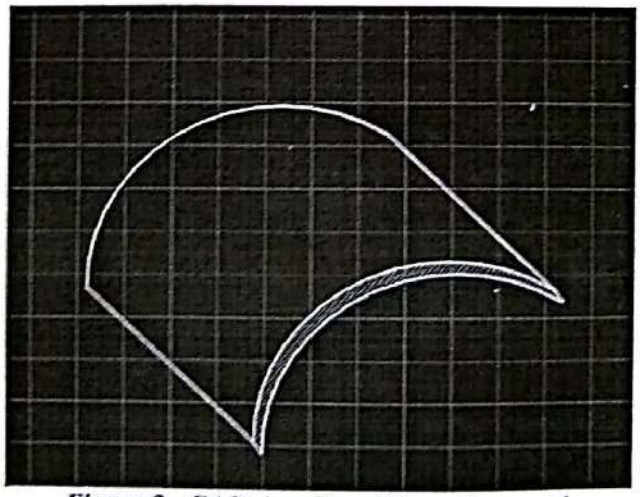


Figure 3. CAD drawing of the solar panel

iv. **Expected social relevance/ benefit of the project**: The project is mainly designed for large scale planters. Our designed model will replace hand weeding in organic farming & applicable in combination with other weed control measures. Manual control of the vehicle must be possible for moving the vehicle over short distances. Weeding a field autonomously done so we can ease our work. Ability to work both day and night this will increase in the working time. The weeding robot is self restarting. Removes more than 90 % of the weed. Damage to the crop is as low as possible and it is very energy efficient because our major source of energy is solar. So there is a future scope for this machine all over the world as this machine can reduce large amount of labour cost.

8. **Budget details of the Project:**

Sl. No.	Items	Cost (Rs.)
1	LUMINOUS OFF-GRID SOLAR SYSTEM (4 HP)	23,000
2	360 deg - CAMERA	1,500
3	GPS SYSTEM	1,500
4	VISION PROCESSING UNIT (VPU)	9,000
5	ECU	9,000
6	WHEELS(4)	5,000
7	SPRAY PUMP (PESTICIDES)	2,000
8	DRILL BIT	300
9	ALUMINIUM MATERIAL REQUIRED (110 kg)	15,000
10	MOTOR (0.5 HP)	2,000
	TOTAL	**68,300**

9. Whether the project has been exhibited in any National/State level contest?
If yes please provide the details: No

10. Whether the project won any prize in National/State level contest?
If yes please provide the details: No

We declare that the above statements are true to the best of our knowledge.

Unni Krishnan
UNNIKRISHNAN T H
Signature of the Mentor

Kurup
Kevin & Ammanathucutty
Signature of the Applicant

VISWAJYOTHI COLLEGE OF ENGG. & TECHNOLOGY
Office seal
MUVATTUPUZHA
KERALA
VAZHAKULAM