AUTOMATIC CHANGEOVER OF DG SUPPLY

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ABSTRACT

The process plants are continuously operating round the clock. Any power supply interruption will result in process stoppage leading to severe productivity loss and financial implications. In the event of any failure of TANGEDCO main supply, the standby power should come in line without much time delay. For meeting this requirement an Automatic Mains Failure(AMF) arrangement is required for automatically changing over from utility supply to DG supply in the event of utility supply failure.In this project work,an AMF arrangement is fabricated, wired up, interfaced with laboratory three -phase Alternator and was tested for different sequences. Also a real time AMF circuit was studied for interlocks and various sequences of operation. The connected load details in the college campus were collected and sizing of cables was analyzed from the perspectives of generator operation. Based on the load details collected, the generator was adequately sized, neutral arrangement were all examined and proper sizing is arrived to ensure reliable operation of Diesel Generator for standby mode of operation. The present continuous mode of DG sets along with TANGEDCO supply is compared with the ongoing HT conversion mode of operation. The economics Diesel consumption/TANGEDCO tariff is estimated based on comparative analysis.The location of proposed DG set is also optimized for better flexibility of operation to feed the campus loads without any interruption and also to ensure efficient operation of DG set.Complete role of DG set is investigated by properly taking into consideration all the aspects namely AMF, economics, flexibility of operation etc.

Keywords –Automatic changeover, Generator, Optimum Location, Power supply, Single phase preventer

1. INTRODUCTION

The main idea of this project work is to highlight the economical impact of excessive diesel consumption of Diesel Generators (DGs), reliability issues, lack of flexibility of operation, inadequate sizing of DGs, overworking of Diesel Generators (DG) owing to the negligent attitude of the electricians, improper location of DGs in the electrical layouts, operation with load limitation as constraints and in turn develop an amicable solution to resolve such issues. The complete analysis and design are from our college campus perspectives. These critical problems are addressed in this project by designing an Automatic Mains Failure scheme (AMF) for practical implementation with proper sizing of DG taking into consideration the present connected loads, optimum location for DG with due considerations for connected loads, short circuit rating, rated thermal rating and neutral sizing of all cables and conductors associated with this captive power plant. An extensive work is carried out to study the connected loads in order to arrive at proper sizing of the DG set in order to totally remove the load constraints and to ensure economical, reliable and uninterrupted operation of the Generator. Presently, the DG sets are manually switched on in the event of Mains failure. Number of Generators and capacity of the Generator need to be manually brought into operation will have to be based on prevailing load requirements at the instant of power failure. Once the main power restores, the electricians on duty must switch off the DG at once to avoid fuel wastage. Most of the time this is not happening. Hence the need for an AMF for implementation. First phase of our project is oriented towards the development of an AMF circuit and fabrication of a demo unit as per the designed AMF circuit. Subsequently the AMF unit is put into operation by interfacing with a laboratory alternator and utility mains supply. The sequence of various operations is practically tested at the laboratory level. As a second phase, a practical circuit is developed for real time interfacing with Circuit Breaker panels of captive power plant and utility supply. The third phase is to study and incorporate an overall real time practical circuit, for automatic starting of DG set, monitoring all the required mechanical parameters of associated Diesel Engine with necessary interlocks, in this project work. This project ensures the removal of stress on manual switching of Generators when the mains supply fails.

In section -2 of this paper Generator sizing is done through the analysis of connected loads in the college campus. We have brought out the economics of Generator operation in section-3. Design of Power cables fed from generator is

shown in section-4.The design of Diesel Engine Flue gas chimney requirements as per pollution control norms are explained in section-5. Section-6 explains the optimum location of DG set with regard to various loads.AMF design is indicated in section-7.Results are discussed in section-8.
Earlier work carried out in this area of AMF incorporate different types of circuits. To cite few of our references indicated in this paper, [1] incorporates Schmitt trigger in their design, [2] needs additional protections and [3] talks about power sensor design using microcontroller. In our work we have made a simple design using electromagnetic contactors, electronic timers and single phase preventers.

2. GENERATOR SIZING

2.1 Generator Size Variations

With the latest advancements in the field of electrical engineering, generators are now available in a wide range of sizes. Generators with power supply capacities of 5kW to 50kW are readily available in the personal and home use markets, while industrial generators are anywhere from 50kW to over 3 Megawatts. Handy and portable generator sets are available for homes; RV's and small offices, but larger businesses, buildings, plants, and industrial applications need to use the much larger sized industrial generators to meet their higher power requirements.

In Our College have four generators.
125KVA
140KVA
625KVA
40KVA

2.1.1 Generator Sizing

Many people believe smaller generators can be used for standby electric power because they are not running all the time. This is not only a myth but can actually be very detrimental. Unfortunately, generator under sizing is one of the most common mistakes committed by buyers. Not only does it involve the risks of damaging the new asset (the generator), but it can also damage other assets connected to it, create hazardous situations, and even limit overall productivity of the unit and/or the business relying on it. If nothing else, the key thing to remember here is that more is always better than less.

2.1.2 Details of 625KVA

Rating – 625KVA
Power Factor – 0.8
Ambient Temperature – 40 Degree Celsius
Degree of Protection - IP23
Voltage – 415V, Three Phase,Star connected
Speed – 1500rpm
Diesel tank capacity – 1000L

2.1.3 Generator Sizing calculation for 62KVA generator

Connected load in College = 805KW+ (43.365HP)+38.80KVA
= 805KW+(43.365*0.746)+(38.80*0.9) = 805KW +32KW + 35KW = 872KW
Maximum Demand = Connected Load/Diversity Factor
= 872KW/2.18(from Appendix A) = 400KW
= 400KW/0.9 = 444KVA
% Loading = 80 % = 625KVA*0.8 = 500KVA

625KVA maximum loading is 500KVA.Our maximum demand is 444KVA.So that 625KVA generator is selected.

2.1.4 Advantages of choosing the right size generator

- No unexpected system failures
- No shutdowns due to capacity overload
- Increased longevity of the generator
- Guaranteed performance
- Smoother hassle-free maintenance
- Increased system life span
- Assured personal safety
- Much smaller chance of asset dam

3. ECONOMICS OF GENERATOR OPERATION

Diesel Consumption Calculation of 125KVA Generator:
Full load running=125*0.8
Running for 7hrs=100*7=700units
Working duration for each DG/year=9 months=1890hrs
For one day energy consumption=700units
For 9 months energy consumption=9*30*700
No of units consumption by
125KVA DG/annum=1, 89,000units
L = Litre
Diesel consumption/hr. at full load = 28 L/hr.
Total diesel consumption/annum = 28*1890 = 52,920 L/annum
Cost of diesel/L = Rs.53
Total cost of diesel consumption for
125KVA DG / Annum = Rs.28, 04,760
Cost/unit for EB supply = Rs.7.33
Cost/unit through captive power plant = Rs.14.84
Units generated/L of the
Diesel consumption=700/ (7*28) =3L/hr.

Diesel consumption calculation of 140KVA Generator:

Full load running = 140*0.8 =112KW
Running for 7hrs = 112*7 =784units
Working duration for each DG/year = 9 months =1890 hrs.

Table 3.1.Consumed Unit and amount details for 12 months
(By using Appendix F)

Consumed unit	Bill amount in RS
21830.8	178638
17706	146155
14519.2	115058
18058.0	128846
16097.6	115466
20784.4	147454
20113.2	142873
18589.6	132474
18014.4	128548
36427.6	254218
17097.6	122291
18710.8	133301

For one day energy consumption=784units
For 9 months energy consumption=9*30*784
No of units consumption by
140KVA DG/Annum=2, 11,680 units
Diesel consumption /hr. at full load=33L/hr.
Total Diesel consumption /Annum =33*1890 =62,370L/Annum
Cost of diesel/L=Rs.53
Total cost of diesel consumption for
140KVA DG set/Annum=Rs.33, 05,610
Cost/unit through Captive
Power Plant=Rs.15.6
Unit generated/L of the
Diesel Consumption=784/ (7*33)
= 3L/hr.
Diesel consumption calculation of 625KVA Generator:
Full load running=625*0.8=500KW
Running for 7hrs=500*7=3,500 units
Working duration for each DG/Year=9 months =1890hrs
For one day energy consumption =3500 units
For 9 months energy consumption=9*30*3500
No of units consumption by
625KVA DG/Annum = 9, 45,000units
Diesel consumption /hr. at full load=110L/hr.
Total diesel consumption /Annum=2, 07,900L/Annum
Total cost of diesel consumption for
625KVA DG/Annum=Rs.1, 10, 18,700
Units generated /L of the
Diesel consumption=3500/ (7*110) = 4.5 L/hr.
Total consumed unit = 237949.2

Average consumed unit = 237949.2/12 = 19829.1
Total bill amount = Rs.17, 45,322
AverageBill/month = Rs.17,45,322/12 =
Rs. 145443.5

Consumed unit	Bill amount in Rs.
13440	111839
14170	104261
12320	89084
10550	77004
13390	96387
15730	112357

Total consumed unit = 79600
Average unit/month = 79600/12 = 6633 units
Total bill amount = Rs.590932
Average cost/month = Rs.590932/12 = Rs.49, 244
LT bill calculation:
LT charges/month = EB cost of college/month + EB cost of hostel/month + Diesel consumption cost of 125KVA and 140KVAGenerator/month = Rs.1, 45,443 + Rs.49, 244 + Rs.678930 = Rs.8, 73,617

HT bill calculation:
Demand charges = Rs.350/KVA
Unit charges = Rs.8.50/unit
Meter rent = Rs.2000
Tax = 5%

HTCharge
= (Maximum Demand*350/KVA) + (Unit charges*8.50) = (500*350) + (((1, 89,000+2, 11,680)/9) +26462.1)*(8.50)
= (1, 75,000) + (44,520 + 26462.1)*(8.50)
= (1, 75,000) + (6, 03,347) = Rs.7, 78,347

HT EB bill/month
$= (HTcharges + 2000 (HTcharges\ 2000)(5\%)$
$= (7,78,347 + 2000) + (7,78,347\ 2000)\ (0.05)$
$= 7,80,347 + 38,917 = Rs. 8,19,264$

4. DESIGN OF POWER CABLES

The proper sizing of an electrical (load bearing) cable is important to ensure that the cable can:

1. Operate continuously under full load without being damaged.
2. Withstand the worst short circuits currents flowing through the cable.
3. Provide the load with a suitable voltage (and avoid excessive voltage drops).
4. Ensure operation of protective devices during an earth fault.

4.1 Cable Construction

The basic characteristics of the cable's physical construction, which includes:

- Conductor material - normally copper or aluminium
- Conductor shape - e.g. circular or shaped
- Conductor type - e.g. stranded or solid
- Conductor surface coating - e.g. plain (no coating), tinned, silver or nickel
- Insulation type - e.g. PVC, XLPE, EPR
- Number of cores - single core or multicore (e.g. 2C, 3C or 4C)

Installation Conditions

- Ambient or soil temperature of the installation site
- Cable bunching, i.e. the number of cables that are bunched together
- Cable spacing, i.e. whether cables are installed touching or spaced
- Soil thermal resistivity (for underground cables)
- Depth of laying (for underground cables)

4.2 Cable Selection Based on Current Rating

Current flowing through a cable generates heat through the resistive losses in the conductors, dielectric losses through the insulation and resistive losses from current flowing through any cable screens / shields and armouring.

The component parts that make up the cable (e.g. conductors, insulation, bedding, sheath, armour, etc.) must be capable of withstanding the temperature rise and heat emanating from the cable. The current carrying capacity of a cable is the maximum current that can flow continuously through a cable without damaging the cable's insulation and other components (e.g. bedding, sheath, etc.). It is sometimes also referred to as the continuous current rating or capacity of a cable.

Cables with larger conductor cross-sectional areas (i.e. more copper or aluminium) have lower resistive losses and are able to dissipate the heat better than smaller cables. Therefore a 16 sq.mm cable will have a higher current carrying capacity than a 4 sq.mm cable.

4.2.1 Base Current Ratings

International standards and manufacturers of cables will quote base current ratings of different types of cables in tables such as shown on the Appendix B. Each of these tables pertain to a specific type of cable construction (e.g. aluminium conductor, PVC insulated, etc.) and a base set of installation conditions (e.g. ambient temperature, installation method, etc.). It is important to note that the current ratings are only valid for the quoted types of cables and base installation conditions.

4.3 Voltage Drop

A cable's conductor can be seen as impedance and therefore whenever current flows through a cable, there will be a voltage drop across it. The voltage drop will depend on two things:

- Current flow through the cable – the higher the current flow, the higher the voltage drop
- Impedance of the conductor – the larger the impedance, the higher the voltage drop.

4.4 Cable Impedances

The impedance of the cable is a function of the cable size (cross-sectional area) and the length of the cable. Most cable manufacturers will quote a cable’s resistance and reactance in Ω/km

4.5 Short Circuit Temperature Rise

During a short circuit, a high amount of current can flow through a cable for a short time. This surge in current flow causes a temperature rise within the cable. High temperatures can trigger unwanted reactions in the cable insulation, sheath materials and other components, which can prematurely degrade the condition of the cable. As the cross-sectional area of the cable increases, it can dissipate higher fault currents for a given temperature rise. Therefore, cables should be sized to withstand the largest short circuit current.

4.6 Calculation

120sq.mm cable (from New MV panel to Hostel):
Current Rating
Cable size from New panel to Hostel = 120sq.mm
Current withstand capacity of
120sq.mm cable (by using Appendix B) = 180A
Maximum load in Hostel = 50KW
Rated Current in A
= 50*1000/ (1.732*400*0.9) = 77.2A
Current withstand capacity of 120sq.mm cable is more than the rated current.
Voltage drop calculation
Voltage drop of 120sq.mm = 0.31*10^-3 volt/ampere/meter
(By using Appendix B)
Length of Cable from New
MV panel to Hostel = 200m
= 0.31*10^-3*80*200 = 4.96V
Percentage of Voltage drop = (4.96*100)/240 = 2.06%

Percentage Voltage drop should not exceed 6% (by using Appendix B).So that 120sq.mm cable is suitable for Hostel .

Short circuit fault level estimation
Sub-transient reactance of 625KVA generator = 0.06 ohm
Short circuit current of 625KVA generator
= 625*10^3 /(0.06*1.732*415) = 15KA
Distance from New
MV panel to hostel = 200m
Impedance of 120sq.mm cable
= ((0.30*0.2) ^2+ (0.087*0.2)^2)^1/2
(by using Appendix G) = 6.24 mΩ
Short circuit current rating

$$= \frac{625*10^3}{(0.06+0.0624)*\sqrt{3}*415} = 7KA$$

Short circuit current withstand
Capacity of 120sq.mm = 9KA
(By using Appendix D)
9KA is more than the 7KA.So that 120sq.mm is very safety.

400sq.mm cable :(From New MV panel to MV1 panel)

Current rating:
Connected load in MV1= KS block load + Mechanical lab load
= 89.2KW+42KW = 131.2KW

Full load current rating

$$= \frac{131.2*10^3}{\sqrt{3}*415*0.9} = 202.8A$$

Total current withstand capacity of 400sq.mm = 335A (by using Appendix B)

The current capacity of 400sq.mm is greater than the full load current rating of MV1 panel. So that 400sq.mm cable is applicable.

Voltage drop
Distance from new MV panel to MV1 panel = 50m
Voltage drop = 0.12*10^-3*202.8*50 = 1.2168V
Percentage of Voltage drop = (1.2168*100)/240
= 0.507%
This value is not exceeded 6% as per in the rule in the Appendix B.

Short circuit current
Impedance of 400sq.mm cable
= ((0.09*0.05) ^2 + ((0.086*0.05)^2)^1/2)
= 6.2mΩ (From Appendix G)

$$\text{Short circuit current} = \frac{625*10^3}{(0.06+0.062)\sqrt{3}*415}$$

= 7KA

Short circuit current withstand capacity of 400sq.mm cable is 30KA (by using Appendix D). This value is more than the 7KA.So that 400sq.mm cable is used.
400sq.mm cable: (From 625KVA generator output to new MV panel)
625KVA has three cables. Each cable size is 400sq.mm.
Current Rating

$$\text{Full load current} = \frac{625*10^3}{\sqrt{3}*415} = 869A$$

Current flows through the each cable = 289A
400sq.mm cable withstand capacity is 335A.This value is more than the current flows through the each cable.

Voltage drop
Voltage drop = 0.12*10^-3*289*50 = 1.734
Percentage of Voltage drop = (1.734*100)/240
= 0.72% < 6%
Short circuit current
Impedance of 400sq.mm cable
= ((0.09*0.05) ^2 + ((0.086*0.05)^2)^1/2)= 6.2mΩ

$$\text{Short circuit current} = \frac{625*10^3}{(0.06+0.062)\sqrt{3}*415}$$

= 7KA
Short circuit current withstand capacity of 400sq.mm cable is 30KA (by using Appendix D).This value is more than the 7KA.So that 400sq.mm cable is used.

4.7 Generator Neutral Sizing

Neutral earth fault current = 15KA/1.732 = 8.66KA
Neutral has two cables. Each cable size is 240sq.mm.(by using Appendix C)
Current capacity of 240sq.mm cable is 35KA (by using Appendix E).This value is more than the neutral earth fault current. So that 240sq.mm cable is applicable.

5. EMISSION NORM

5.1 Diesel Generator Sets: Stack Height

The minimum height of stack to be provided with each generator set can be worked out using the following formula:

H = h + 0.2 √ (capacity of DG in KVA.)
H = Total height of stack in metre
h = Height of the building in metres where the generator set is installed
KVA = Total generator capacity of the set in KVA
Based on the above formula the minimum stack height to be provided with different range of generator sets maybe categorised as follows:

For Generator Sets Total Height of stack in metre
50 KVA Ht. of the building + 1.5 metre

50-100 KVA Ht. of the building + 2.0 metre
100-150 KVA Ht. of the building + 2.5 metre
150-200 KVA Ht. of the building + 3.0 metre
200-250 KVA Ht. of the building + 3.5 metre
250-300 KVA Ht. of the building + 3.5 metre

Fig. 1. Flue Gas Emission Outlet (Control Pollution Control Board Norms)

Similarly for higher KVA ratings a stack height can be worked out using the above formula.
For 625 KVA Diesel Generator the stack height will be

$H = h + 0.2\sqrt{\text{(capacity of DG in KVA.)}}$

$H = 10 + 0.2\sqrt{625}$

H=15 m (refer Fig.1.)

6. OPTIMUM LOCATION

Existing Layout
MV1 (Medium Voltage) Panel

Fig.2. MV1 Panel

The output of step down transformer is connected to MV1 panel through the 185sq.mm cable.It consists of six feeders.MV1panel gives the supply to KS Block,Mechanical Laband RV CS Lab. It has two bus bars, one is EBbus bar and another one is Generator bus bar.It is a two lock one key system.If EB supply is off,the panel is running by the generator bus by interchanging the key.

MV2Panel

Fig.3. MV2 Panel

Its operation similar to that of MV Panel1.It gives the supply to RV Block,MCA Block,Street light,Machines lab.It gets the supply from MV Panel1 through the 240sq.mm cable.

Changeover Panel

Fig.4. Change Over Panel

The changeover panel has two generator busbars, one is 125KVA and another one is 140KVA.By considering the load, particular generators are selected.

Drawbacks of Existing layout

1. If EB supply is available, any one of the generator or both the generators are running. So that more amount of diesel is wasted.
2. Power circuit and lighting circuit are mixed up in the existing layout. For example Power circuits use 15A fuse. ButLighting circuits use only 5A fuse. So if power circuit gets fault means, the lighting circuit is affected. To avoid that situation, power and lighting circuits are separated.

New MV Panel

Fig.5. New MV Panel

It has two busbars.ie.generator bus and EB bus. In the new panel has two generators.ie 125KVA and 140KVA.It has Bus coupler. It is a three lock two key system.

Lighting Panel

Fig.6. Lighting Panel

All the lighting connections are connected to this panel.

625KVA Generator

Fig.7. 625KVA Generator

625KVA generator is used for maximum load operation.

7. AUTOMATIC CHANGEOVER

A Prototype model of control and power circuit was developed for carrying out from three phase alternator to utility TANGEDCO and vice versa.

Power Circuit:

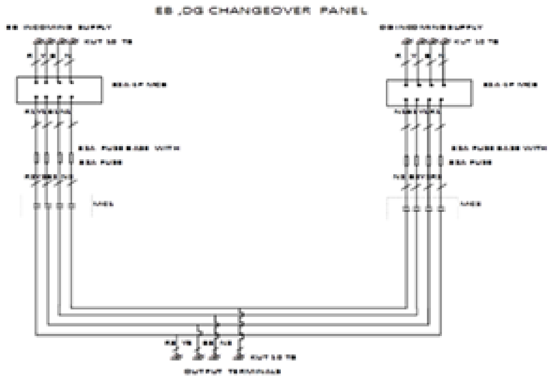

Fig.8. Power Circuit

Detailed Setup

The complete setup after fabrication and wiring was tested after interfacing with a three phase, 5KVA salient pole alternator. The 415V utility TANGEDCO power supply as well as three phase alternator power supply were connected to the fabricated automatic change over power circuit.

Single Phase Preventer (SPP)

Two numbers of single phase preventers are provided in the circuit one for alternator and another one for utility supply control. These single phase preventers are doing a vital function of enabling auto change over, in the event of abnormal conditions like reverse phase sequence, under voltage, over voltage and open phase conditions. In addition to the main three phase input power supply, two phase 415V supply is looped out to provide auxiliary power supply for the function of the preventer. In the event of operation of the preventer for abnormal conditions stated above, a 1 NO (Normally Open), 1 NC (Normally Close) change over contactors will switch over from NO to NC and vice versa. These contactors are wired up in the control circuit to disable or enable the required control function for AMF (Auto Mains Failure) operation.

Electromagnetic Contactors (MC1, MC2)

Two numbers of electromagnetic contactors are employed, one for alternator power and another one for utility power. The coils of the contactors are rated at 415V AC, 50Hz.Each contactor has the configuration of 4NO (main contactor), 1 NO and 1NC (auxiliary contactor). In the event of failure of TANGEDCO supply this contactor will de energize and its NC contact (under de energized condition) will initiate the operation for automatic change over to captive power through an auto manual change over switch (switch kept in auto mode).

While the alternator is in operation, if utility supply rest source, the utility contactor (MC1) will energize, its contact will open and alternator supply is cut off.

Electronic Timers

Two numbers of electronic timers are provided with adjustable time setting variable from 0.3s to 30hr.The timer is energized by 230V AC. The time of operation can be set according to the requirement. The alternator supply will be connected to the load after the set time delay. Once the timer is energized its contact will change over from NO to NC and this NC contact will facilitate the energization of the concerned electromagnetic contactor MC2 provided the automatic switch is in auto mode.

Push buttons

Two sets of push buttons (one for OFF, one for ON) are provided, one set for each power supply. The NO contacts are used in the ON push button and the NC contacts are used in the OFF push button. By selecting the auto manual switch is in the manual mode, ON and OFF push button operations are enabled. However, the OFF push button can be operated both in auto and manual modes.

Miniature Circuit Breaker

The MCBs are used to provide protection against short circuits and also isolating the power supplies.

Control Circuit:

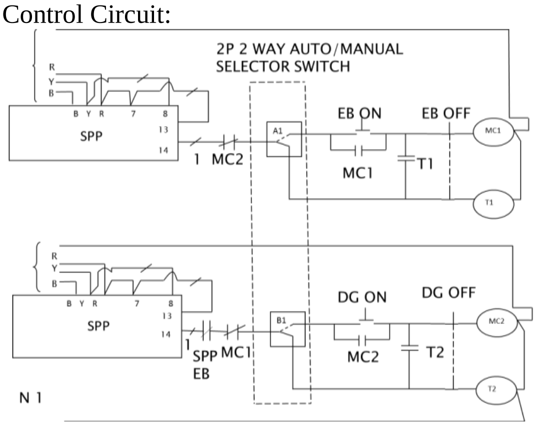

Fig.9. Control Circuit

Testing the circuit

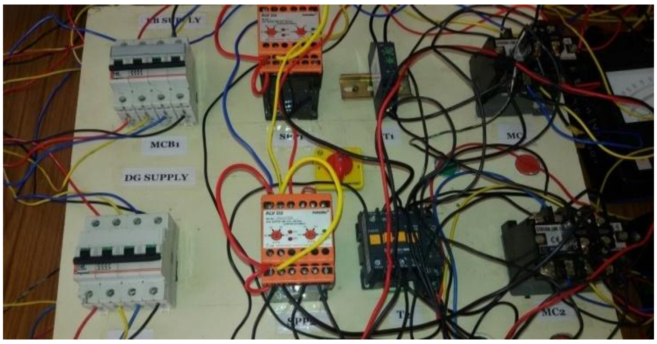

Fig.10. Testing the Circuit

INTERFACING THE CIRCUIT WITH ALTERNATOR

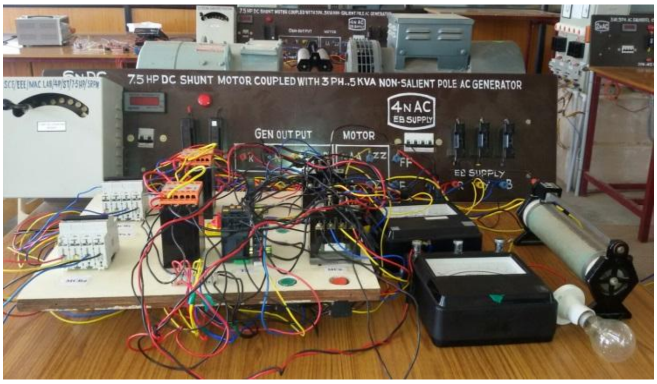

Fig.11. Interfacing the Circuit with Alternator

8.RESULTS AND DISCUSSION

The AMF was interfaced with TANGEDCO utility supply and the following sequences were checked:

- The utility supply was switched off and AMF unit was found automatically cut in and power supply was restarted to the connected load, through alternator.
- The utility supply phase sequence was reversed and AMF unit was found automatically cut in and power supply was restarted to the connected load with correct phase sequence, through alternator.
- The utility supply voltage magnitude was lowered below the "SPP", AMF unit was found automatically cut in and three phase power was restarted to the connected load, through alternator.
- The utility supply voltage fuses were removed one after one in all the phase and AMF unit was found automatically cut in and power supply was restarted in all the phases, through alternator.
- While alternator is in operation, through AMF the TANGEDCO supply was switching over to alternator supply.

- The sizing of cable connected to the load, through alternator was checked for short circuit withstand, thermal rated withstand and voltage regulation to ensure reliable operation during automatic changeover. The voltage regulation was found in all the cables well below 6%(acceptable limit in low voltage distribution on per IEEE Rule).
- The actual short circuit current expected in the cables in the field were found to be lesser than the withstanding capability of the cable(estimated value or theoretically calculated value).
- A chimney height of the 625KVA DG set was calculated based on CPCP norms and was taken up the height of 15m.
- Generator neutral connection are suitably sized to share the generator earth fault current by using two numbers of 40*6mm copper flats.
- AMF operation was checked in the laboratory at various settings of electronic timers.

9. CONCLUSION

This project work is instrumental in providing knowledge and wide technical data to understand more about the economics of DG operation, sizing of DG set for the given load condition, the requirements of AMF operation etc. AMF panels are highly demanded in apartments, foundations, textile, sugar and chemical industries.

The AMF will ensure automatic battery charging of DG set while operating in utility supply mode, automatic starting or stopping of engine, automatic shutdown on faults like over speed, under speed, high temperature, low oil pressure, etc. Automation will avoid excessive diesel consumption and ensure high degree of reliability.

10. REFERENCES

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Appendix A

Diversity Factor in distribution Network

Elements of System	Diversity Factors			
	Residential	Commercial	General Power	Large Industrial
Between individual users	2.00	1.46	1.45	
Between transformers	1.30	1.30	1.35	1.05
Between feeders	1.15	1.15	1.15	1.05
Between substations	1.10	1.10	1.10	1.10
From users to transformers	2.00	1.46	1.44	
From users to feeder	2.60	1.90	1.95	1.15
From users to substation	3.00	2.18	2.24	1.32
From users to generating station	3.29	2.40	2.46	1.45

Appendix B

CABLE CURRENT RATING AND VOLTAGE DROP:

AMBIENT TEMPERATURE:40 Celsius

MAXIMUM CONDUCTOR TEMPERATURE:70 celsius

Al/P.V.C. CABLE sq.mm	CURRENT RATING(Amp)	VOLTAGE DROP Volt/Amp/meter
4	23	9.06*10^-3
6	30	6.02*10^-3
10	40	3.6*10^-3
16	51	2.29*10^-3
25	70	1.44*10^-3
35	86	1.04*10^-3
50	105	0.77*10^-3
70	130	0.54*10^-3
95	155	0.39*10^-3
120	180	0.31*10^-3
150	205	0.25*10^-3
185	235	0.20*10^-3
225	265	0.17*10^-3
240	275	0.16*10^-3
300	305	0.13*10^-3
400	335	0.12*10^-3
500	355	0.10*10^-3

NOTE: As per rule 54 of IER's 1956, the voltage variation for M.V/L.V installations should not exceed 6%. This variation should be could from the transformer secondary side to the tail and load (i.e.) the worst condition.

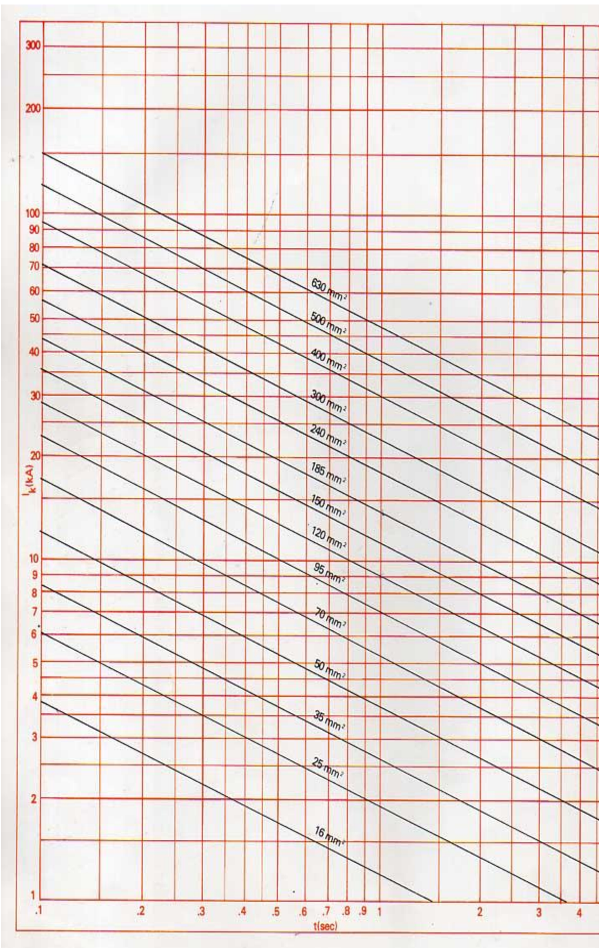
Appendix C

Recommended size of cables for M.V.Alternators

M.V. Alternators KVA 3 phase	PVC Aluminium cable size (Armoured)
110	One Run of 31/2 core 95sq.mm
160	One Run of 31/2 core 240sq.mm
200	One Run of 31/2 core 300sq.mm
250	One Run of 31/2 core 400sq.mm or Two Runs of 31/2 core 185sq.mm
310	Two Runs of 31/2 core 400sq.mm
550	Four Runs of 31/2 core 400sq.mm
860	Bus bar trunking

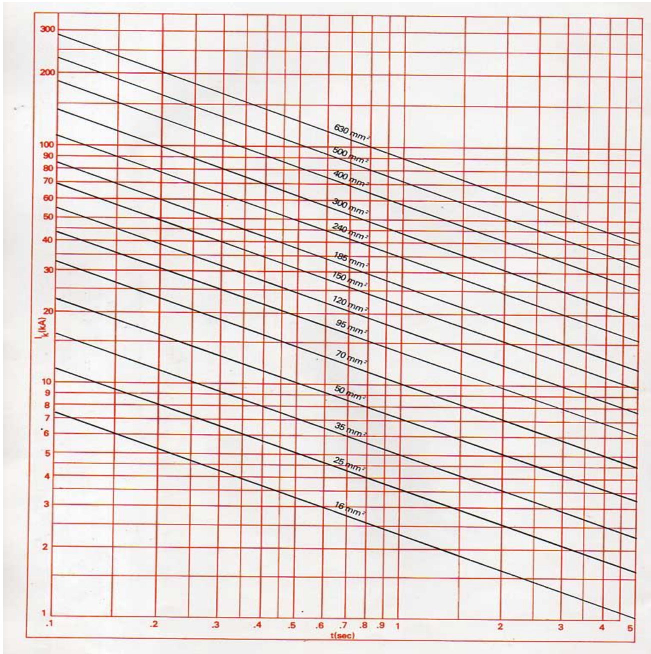
Appendix D

Thermal Short-Circuit Current Rating Aluminium Conductor PVC 70 Degree Celsius Insulation

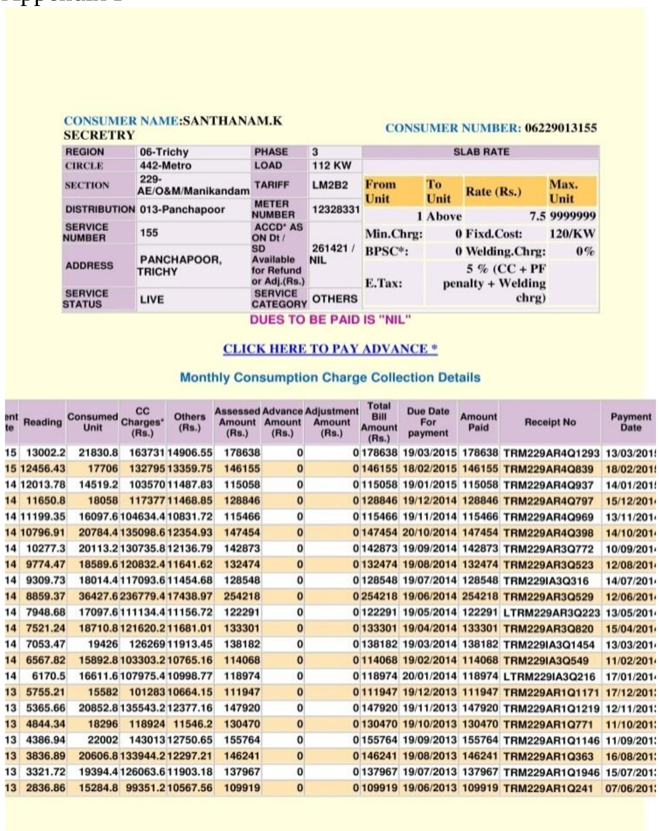


Appendix E

Thermal Short-Circuit Current rating
Copper Conductor XLPE Insulation



Appendix F



CONSUMER NAME:SANTHANAM.K SECRETRY

CONSUMER NUMBER: 06229013155

REGION	06-Trichy	PHASE	3
CIRCLE	442-Metro	LOAD	112 KW
SECTION	229-AE/O&M/Manikandam	TARIFF	LM2B2
DISTRIBUTION	013-Panchapoor	METER NUMBER	12328331
SERVICE NUMBER	155	ACCD* AS ON Dt / SD Available for Refund or Adj.(Rs.)	261421 / NIL
ADDRESS	PANCHAPOOR, TRICHY		
SERVICE STATUS	LIVE	SERVICE CATEGORY	OTHERS

SLAB RATE

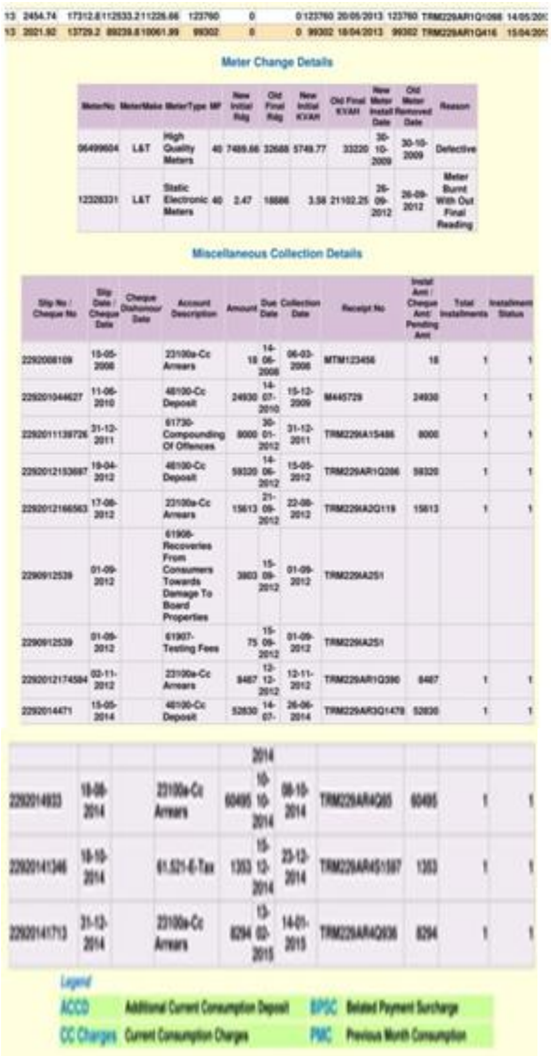
From Unit	To Unit	Rate (Rs.)	Max. Unit
1	Above	7.5	9999999
Min.Chrg:	0	Fixd.Cost:	120/KW
BPSC*:	0	Welding.Chrg:	0%
E.Tax:	5 % (CC + PF penalty + Welding chrg)		

DUES TO BE PAID IS "NIL"

CLICK HERE TO PAY ADVANCE *

Monthly Consumption Charge Collection Details

ent te	Reading	Consumed Unit	CC Charges* (Rs.)	Others (Rs.)	Assessed Amount (Rs.)	Advance Amount (Rs.)	Adjustment Amount (Rs.)	Total Bill Amount (Rs.)	Due Date For payment	Amount Paid	Receipt No	Payment Date
15	13002.2	21830.8	163731	14906.55	178638	0	0	178638	19/03/2015	178638	TRM229AR4Q1293	13/03/201
15	12456.43	17706	132795	13359.75	146155	0	0	146155	18/02/2015	146155	TRM229AR4Q839	18/02/201
14	12013.78	14519.2	103570	11487.83	115058	0	0	115058	19/01/2015	115058	TRM229AR4Q937	14/01/201
14	11650.8	18058	117377	11468.85	128846	0	0	128846	19/12/2014	128846	TRM229AR4Q797	15/12/201
14	11199.35	16097.6	104634.4	10831.72	115466	0	0	115466	19/11/2014	115466	TRM229AR4Q969	13/11/201
14	10796.91	20784.4	135098.6	12354.93	147454	0	0	147454	20/10/2014	147454	TRM229AR4Q398	14/10/201
14	10277.3	20113.2	130735.8	12136.79	142873	0	0	142873	19/09/2014	142873	TRM229AR3Q772	10/09/201
14	9774.47	18589.6	120832.4	11641.62	132474	0	0	132474	19/08/2014	132474	TRM229AR3Q523	12/08/201
14	9309.73	18014.4	117093.6	11454.68	128548	0	0	128548	19/07/2014	128548	TRM229IA3Q316	14/07/201
14	8859.37	36427.6	236779.4	17438.97	254218	0	0	254218	19/06/2014	254218	TRM229AR3Q529	12/06/201
14	7948.68	17097.6	111134.4	11156.72	122291	0	0	122291	19/05/2014	122291	LTRM229AR3Q223	13/05/201
14	7521.24	18710.8	121620.2	11681.01	133301	0	0	133301	19/04/2014	133301	TRM229AR3Q820	15/04/201
14	7053.47	19426	126269	11913.45	138182	0	0	138182	19/03/2014	138182	TRM229IA3Q1454	13/03/201
14	6567.82	15892.8	103303.2	10765.16	114068	0	0	114068	19/02/2014	114068	TRM229IA3Q549	11/02/201
14	6170.5	16611.6	107975.4	10998.77	118974	0	0	118974	20/01/2014	118974	LTRM229IA3Q216	17/01/201
13	5755.21	15582	101283	10664.15	111947	0	0	111947	19/12/2013	111947	TRM229AR1Q1171	17/12/201
13	5365.66	20852.8	135543.2	12377.16	147920	0	0	147920	19/11/2013	147920	TRM229AR1Q1219	12/11/201
13	4844.34	18296	118924	11546.2	130470	0	0	130470	19/10/2013	130470	TRM229AR1Q771	11/10/201
13	4386.94	22002	143013	12750.65	155764	0	0	155764	19/09/2013	155764	TRM229AR1Q1146	11/09/201
13	3836.89	20606.8	133944.2	12297.21	146241	0	0	146241	19/08/2013	146241	TRM229AR1Q363	16/08/201
13	3321.72	19394.4	126063.6	11903.18	137967	0	0	137967	19/07/2013	137967	TRM229AR1Q1946	15/07/201
13	2836.86	15284.8	99351.2	10567.56	109919	0	0	109919	19/06/2013	109919	TRM229AR1Q241	07/06/201



Meter Change Details

Miscellaneous Collection Details

Legend

ACCD Additional Current Consumption Deposit

BPSC Belated Payment Surcharge

CC Charges Current Consumption Charges

PMC Previous Month Consumption

CONSUMER NAME:SECRETRY/ SARANATHAN ENGINEERING COLLEGE

DUES TO BE PAID IS "NIL"

CLICK HERE TO PAY ADVANCE *

Monthly Consumption Charge Collection Details

Tariff Change Details

Previous Tariff	Current Tariff	Tariff Change Date	Check Reading (KWH)	Check Reading(KVAH)
LM01	LM0202	11-12-2008	6590	

Meter Change Details

Appendix G :

No. of cores and cross sectional area	Min. No. of wires	Thickness of PVC Insulation (nom.) mm	Thickness of PVC Inner sheath (mm)	Strip	Wire	PVC Outer Sheath (mm) Strip Armour	Wire Armour	(Approx.) (mm) Strip Armour	Wire Armour	Cable Strip Armour (Kg/Km)	Wire Armour (Kg/Km)	Max. D.C. Resistance at 20 (Ohms/km)	A.C. Resistance at 70 (Ohms/Km)	Approx. Reactance at 50 Hz (Ohm/Km)
3.5C x 25/16	66	121.0	0.30	40.8	1.60	1.40	1.40	25.0	26.5	1100	1260	1.200	1.44	0.97
3.5C x 35/16	66	121.0	0.30	40.8	1.60	1.40	1.40	26.0	27.5	1170	1450	0.868	1.04	0.97
3.5C x 50/25	66	141.2	0.30	40.8	1.60	1.56	1.56	29.5	31.0	1470	1805	0.641	0.77	0.94
3.5C x 70/35	126	141.2	0.40	40.8	2.00	1.56	1.56	33.5	36.0	1810	2405	0.443	0.53	0.90
3.5C x 95/50	156	161.4	0.40	40.8	2.00	1.56	1.72	37.5	40.0	2205	3015	0.320	0.38	0.90
3.5C x 120/70	1512	161.4	0.50	40.8	2.00	1.72	1.88	41.0	43.0	2760	3545	0.253	0.30	0.87
3.5C x 150/70	1512	181.4	0.50	40.8	2.00	1.88	1.88	45.5	48.0	3215	4030	0.206	0.25	0.87
3.5C x 185/95	3015	201.6	0.50	40.8	2.50	2.04	2.04	50.0	53.5	3900	5300	0.164	0.20	0.87
3.5C x 240/120	3015	221.6	0.60	40.8	2.50	2.20	2.36	57.0	60.0	4940	6390	0.125	0.15	0.87
3.5C x 300/150	3015	241.8	0.60	40.8	3.15	2.36	2.52	61.5	66.0	5835	8210	0.100	0.12	0.86
3.5C x 400/185	5330	262.0	0.70	40.8	3.15	2.68	2.68	70.0	75.0	7250	9900	0.077	0.09	0.86