

Conclusion

The main focus in this project was to propose a dry type load bank design for generator load testing procedure in place of liquid type rheostat commonly used in industry. At the same time the project analyses the automatic load controlling techniques available in modern load banks.

A MATLAB Simulink model was developed to analyze the effect of the temperature in the set load value of a resistor load bank. The model was combined with a power controller circuit where the controller undertakes the functions of the model.

The main function of the model is to calculate the derating of the total load and compensate that with a PWM controlled power element in an automatic controller action. When the deration is higher than the PWM controlled power, the controller automatically switches on the next power element. The derating is again calculated for the new combination and compensated by the PWM controller. Addition of power element in this way can be continued to account for the derated power such that the balance can be compensated by the PWM controlled power element.

The load testing procedure with liquid type salt water rheostat practiced at Colombo Dockyard for generator load testing was studied for this research. The major drawbacks of the liquid type load testing procedure were the inability to maintain and set accurate load settings and longer setting up durations. This requires the generators to be in operation for a longer period than the testing duration. In practical situation, the additional duration is not only for the setting up time but also for contingencies such as early water preparation, waiting for survey witness etc. The governor response trial cannot be conducted using the current setup where the requirement is to load the generators from 0 to 50% and from 50 to 100% of the rated load instantly.

Time taken for load testing is critical at the outset of a generator commissioning. The equipment and staff are exposed to high risk when liquid rheostats are used for the generator load testing. Hence, doing the test in any weather condition and in fastest possible time with minimum manpower and minimum risk become necessary for ship building projects.

The new design is able to meet all the load test requirements in a single package eliminating critical practical difficulties, time wastages in a more user friendly and controllable manner with economic benefits.

The capacity of the load bank was selected as 1800kW, considering the required capacities for the tests carried out recently and investigating the future projects. The increase in the capacity adversely affects the size and cost of the load bank. A provision was kept to increase the capacity by adopting a separate unit at an extra cost and increase in size.

The wire wound power resistors were selected as the best option to use in the load bank as they have more power per unit volume than any other available resistor type, hence reduce the overall size of the bank. The resistor arrangement was decided such that the space taken up by a single three phase resistor unit is minimized and permitted easy cable routing for the resistor connections through the mounting bar.

The cooling requirement is a major concern regarding the power resistors. The maximum operating temperature for the power resistors given by the manufacturer is 200⁰C. However, derating of the resistors takes place at around 40⁰C according to the relevant derating curve. Hence, the operating temperature was maintained at 40⁰C. For this, separate blowers were provided for each resistor unit. The blower size was decided considering the resistor unit with maximum size. At the implementation stage this size can be reduced according to the actual size of the resistor unit.

The bank provides unity power factor according to the power resistor ratings. Other power factors can be obtained by accompanying reactive elements of same dimensions.

The control system was designed to cater all load test requirements. The protection features were employed to guarantee that the load bank operates in all modes without any safety hazard.

The involvement of the contactors makes the circuit a bit complex. In practical situation, a control contactor may have only couple of NC and NO contacts. In the designed circuit all interlock contacts are defined according to the respective

contactor. But in practice either addition of adder-block or parallel contactor connection is to be provided.

The control system however, can be designed by employing PLC in a much easier manner. The complexity of the circuit, high amount of contactor involvement would greatly reduce with the PLC.

In operation, the actual load that the bank experience is the addition of the resistor load plus respective blower load. For the small resistor units the blower load is very small but this is considerable for maximum resistor unit. Hence, the blower load must be counted in heavy loading conditions. On the other hand, the power factor will vary from unity depending on the proportion of the blower load.

The economic analysis on the present load testing procedures conducted at Colombo Dockyard shows that around 30-40% cost saving is achievable with a dry type resistive load bank. The main reduction comes from the lesser operating time. The case study was done for the vessel (NC210) which does not include shaft generators. When a vessel has shaft generators, the main engines are driven for the load testing where the fuel consumption is more than double compared with the normal generators. Hence, the saving on fuel cost can be further justified.

The major cost components were considered in preparing the BOM as the other components can be fabricated at Colombo Dockyard. The quotation received for the load bank unit was lower compared to the addition of costs of the individual components to make the load bank. This is because the part wise quoted amounts are in the higher margins without any negotiations or higher volume discounts.

It is observed that 90% of the total cost accounts for the power resistors and axial blowers. The blower cost is basically a function of the blower power rating which indirectly depicts the rpm and flow rates. In the design, a separate blower is employed for each resistor unit and hence the number of blowers becomes higher which is the reason for the higher cost proportion. On the other hand there is a possibility of using a large size blower to accompany the set of resistors. In that case, the blower has to be in operation when only small number of resistors is in use. Additionally, the high power rating of the blower will accounts for the total load in the bank. In that case

variable speed option needs to be reviewed to maintain the load bank operating temperature.

The other option is to go for derating operation by increasing the operating temperature and thereby employing low power low flow blowers which asks for more resistor units and increasing the size of the bank compensating the overall cost. This is a good study for further improvements.

Based on the quotations received, an economical study was done on the design. Considering an average saving of Rs. 100,000 per vessel and average five vessel deliveries per year, an investment of around 7.5 million rupees for a load bank will have a payback period of around 15 years.

Hence, the introduction of a resistive load bank not only reduces the fuel cost involved with the load tests but also saves the critical production time of the new construction projects.



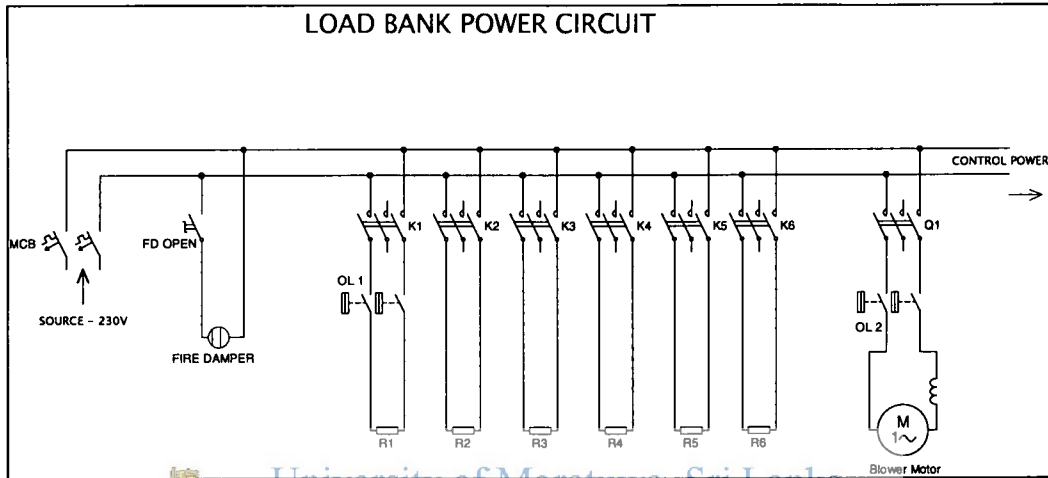
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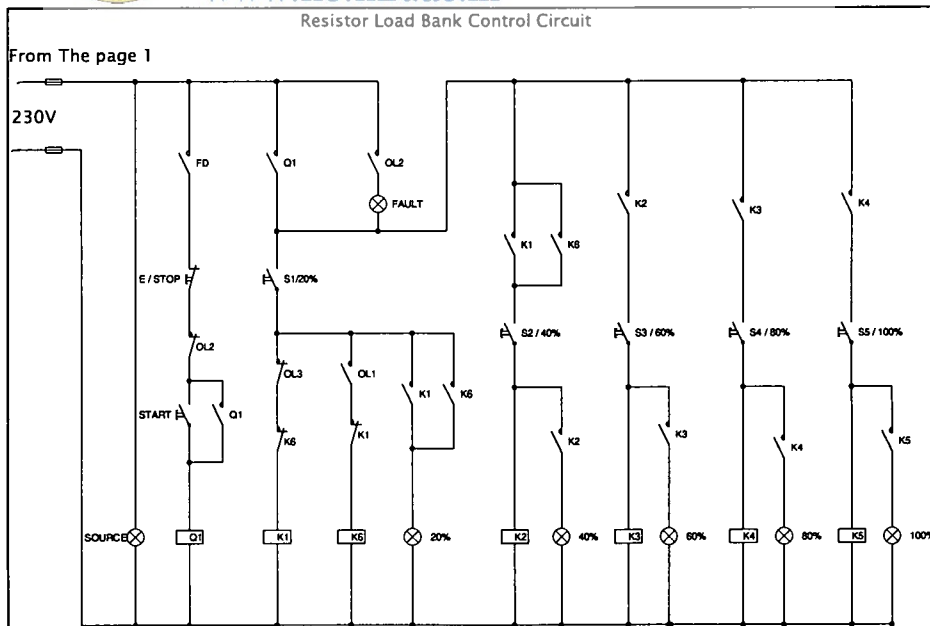
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Annexure-1: Pilot Project

Figure-1 and Figure-2 depict the circuit diagrams of the pilot project. The control system was tested with a single phase power input.



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Annexure Figure -2: Load Bank Control Circuit-Pilot Project

Annexure-2: Quotations

Quotation Received from the Mint Former Industries Limited for a complete load bank of capacity 1800kW.

Mint Former Industrial Ltd

1/F., Po Yip Bldg, 23 Hing Yip Street..

Kwun Tong, Kowloon, Hong Kong.

Tel: 852-27958793 Fax: 852-27958189

<http://www.mf-powerresistor.com> admin@mintformer.com

TO : Colombo Dockyard PLC

ATTN : Mr P.H.K.H Puhulwella

FROM: Goman Siu

DATE : 02 December 2010

QUOTATION

<u>DESCRIPTION</u>	<u>UNIT PRICE US\$/PCS</u>
3 Phase Adjustable Load Bank : 1800kW 440Vac Line to Line WYE Power Adjustable : 5kW x 10 10kW x 15 100kW x 6 500kW x 2	

Working Condition : Outdoor with ambient temperature range + 20C ~ +49C

Load Bank Cabinet :

- With built in Cooling Fan systems and with control switch and Indicator at the control panel
- The Load Bank cabinet can be lift with forklift and there are 4 stainless steel Lifting eyes at the top of load bank Cabinet.
- Load Bank Cabinet size : Width 1.5m Depth 3.8cm Height 2.2m
- estimated Cabinet net weight : 2200kg
- with Control Panel
- with Warning Label for High Temperature and Voltage near the control panel
- the Cooling System Intake /outtake openings can prevent objects greater than 12mm diameter from entering the unit
- The main input load bus, load step relays, fuses and blower/control relays will be within the load bank Cabinet.
- There will have a Warning Light at load cabinet outside. When load cabinet is on loading, this Warning Light will be ON.

Protection :

- The cooling fan Systems is connected to a pressure switch. In case there is problem with the cooling system, the load bank will be Power Off Automatically
- with Over Temperature switch built in. In case the load bank internal temperature is higher than design, the load bank will be Power Off Automatically
- The power resistors will be installed in groups and each group is protected by Fuse/Thermostat and with Indicator lamp at the control panel

Control Panel :

- Load Bank Main Switch and Indicator Lamp
- Cooling System Control Switch and Indicator Lamp
- Power Adjustable Control Switch and Indicator Lamp - 33sets
- Full Power and Half Power Loading Switch and Indicator Lamp
- Load Bank Power ON Warning Light switch (we suggest this lamp should be control by the Load Bank Main Switch not individual switch)
- Voltmeter with Indicator Lamp
- Ammeter with Indicator Lamp
- Wattage Meter with Indicator Lamp
- Resistor sets loading Indicator Lamp

Unit Price : US\$63,000.00 / 1set

Remark :

FOB Hong Kong

Payment : 30% deposit and balance L/C when confirm order or Full payment wire transfer when confirm order

Production : within 30 - 40 days after receiving payment

Your comment is welcome.

** End **

Quotation from the Mega Heaters (PVT) LTD.

MEGA HEATERS (PVT) LTD

No : MIH/1129/10


691 STATION ROAD, KOTTAWA, PANNIPITYA,
Tel : 94-11-2851328/011-2898800/011-2898598, Fax: 94-11-2847718
E-mail : mega@almet.lk Web: www.megaheaters.com

PROFORMA INVOICE

Date	23/11/2010	Tel-	077-3752808
Messrs	Colombo Dockyard PLC	Fax	2429000-236
Attn	Mr. P.H.K.Puhulwella	VAT No: 114275514-7000	
Payment : 50% ADVANCE & BALANCE ON DELIVERY			
Delivery	6 Days / Weeks after order confirmation	Ex-Stock	No
Qty	Description Of Goods	Rate	Amount -Rs.
	Design, Manufacture & Supply of Load Bank		-
800	230V x 2Kw Element	4,100.00	3,280,000.00
3	Blower Fan [Cooling Fan 14500rpm] with mounting bracket	130,000.00	390,000.00
5	Bas Bars for 3000amp [6' x 3/8' x 5M]	52,500.00	262,500.00
40	Sub Bas Bar [1' x 1/4"]	4,750.00	190,000.00
12	Bas Bar Mounting for 3000amp	4,250.00	51,000.00
210	Bas Bar Mounting for Elements	160.00	33,600.00
	Magnetic Contactor		-
15	100Kw X 15 250A	44,500.00	667,500.00
1	50Kw X 1 105A	19,500.00	19,500.00
4	10Kw X 4 22A	5,200.00	20,800.00
2	5Kw X 2 18A	3,750.00	7,500.00
3	Contactor & overload for Cooling Fans	4,250.00	12,750.00
3	Current Transformer	7,500.00	22,500.00
1	Digital Power Analyzer	42,100.00	42,100.00
1	Structure For Load Bank	225,000.00	225,000.00
1	Electric Panel Box	72,500.00	72,500.00
1	Overhead Expenses	275,000.00	275,000.00
1	Labour cost	325,000.00	325,000.00
	Warranty: TWO YEARS		-
			-
			-
	AMOUNT		5,897,250.00
	VAT 12%		707,670.00
	TOTAL		6,604,920.00

Validity : 30 Days
Cheques should be drawn in favors of Mega Heaters (Pvt) Ltd. & crossed A/C Payee Only

2,552,750.00


Authorized Signature

Resistor quotation:

From: Sales@mf-powerresistor.com sales@mf-powerresistor.com

> Date: Thu, 30 Dec 2010 17:25:43 +0800

> To: puhulw@cdl.lk, sandra@mintformer.com

> Subject: Re: Online Contact - MF-powerresistor.com

>

>

> Dear Mr Kosala,

>

> Thanks for your e-mail and phone call.

>

> For your concern, the resistor need to derate for temperature higher than
> 40C.

> For the derating curves, our internal maximum temperature is 300-350C
> standard for load bank application.

> This is just suitable for our own in house design and build the load bank.

> In case customers like to build the load bank themselves, we suggest the

> maximum temperature is 275C for long run stability.

> Actually this depends on your load bank design.

> One of our customers told us that they even use the resistor at surface
> temperature up to 400C without any problem.

> I suggest you can buy a few resistors to test according to your design.

>

> Below is our quotation offer :

> Quotation

> 1) Power Resistor : DQR-F series

> 20kW 29 ohm +/-5%

> estimated Resistor unit weight : 28kg

> Unit Price : US\$410.0 / pcs for quantity : 81pcs

>

> 2) Power Resistor : DQR-F series

> 10kW 58.1 ohm +/-5%

> estimated Resistor unit weight : 16kg.

> Unit Price : US\$280.0 / pcs for quantity : 12pcs

>

> 3) Power Resistor : DQR-F series

> 5kW 116.2 ohm +/-5%

> estimated Resistor unit weight : 7kg.

> Unit Price : US\$95.0 / pcs for quantity : 9pcs

>

> 4) Power Resistor : DQR-F series

> 2kW 290.4 ohm +/-5%

> estimated Resistor unit weight : 3.5kg.

> Unit Price : US\$50.0 / pcs for quantity : 9pcs

>

> Remark :

> Ex-Work Hong Kong

> Payment : T/T wire transfer or L/C when confirm order

> Production lead time : 10-15 days after payment

>

> Your value comment can help us offer suitable power resistor and improve
> services.

>

> Kind Regards,

> Sandra Lau

> Mint Former Industrial Ltd

> <http://www.mf-powerresistor.com>



AIRTRADE SYSTEMS PTE LTD

TEL: (65) 62621672, FAX: (65) 62621673, EMAIL: ats@airtrade.com.sg, Website: www.airtrade.com.sg



CERT NO: 160169

Company's Name : Colombo Dockyard
Attention : Mr P.H.K.H Puhulwella
Project : Quotation for Hison Axial Fans

Our Ref No : ATS/F/55352/pc-kg
Date : 06.01.2011
From : Peter Chan/Kelly Goh

Item No	Space Served	Type	Brand	Model	Capacity cmm	SPWVG pa	Fan Speed Rpm	Fan Bkw	Motor Rating Kw	Power Supply V/Ph/Hz	Fan Dia mm	Qty	Unit Price (S\$)	Total Price (S\$)	Remarks
1		Axial	Hison	600-4-a1-29°	333.33	100	1682	2.33	3	440/3/60	600	27	\$ 1,381.00	\$ 37,287.00	
2		Axial	Hison	500-4-a1-26.5°	166.66	100	1680	1	1.5	440/3/60	500	4	\$ 1,212.00	\$ 4,848.00	
3		Axial	Hison	400-4-a1-26°	83.33	100	1645	0.4	0.55	440/3/60	400	3	\$ 930.00	\$ 2,790.00	
4		Axial	Hison	LF350-4-110/5B-20°	33.33	100	1680	0.11	0.37	440/3/60	350	3	\$ 809.00	\$ 2,427.00	
(SINGAPORE DOLLARS: FORTY SEVEN THOUSAND THREE HUNDRED AND FIFTY TWO ONLY)														\$ 47,352.00	

Remarks : Above price quoted are ex factory Singapore.
: Above price quoted are for supply only.
: Fan casings shall be of 3mmthk mild steel material construction and finished with epoxy paint coated.
: Above fans shall be put on unfumigated wooden pallet with plastic wrapped prior to delivery.

Motor Make : ATT,CMG or equal and of Class F Insulation, IP 55, TEFC.

Delivery : Approximately 6-8 weeks ex factory Singapore upon receipt of order & approval of drawings.
Terms : 30 days from date of our invoice.
Validity : 30 days from date of our quotation.

We trust the above is acceptable and look forward to your esteemed order.

Best Regards
Peter Chan

Blower Quotation:

