ENSCO 7500 Power Management System

Design, Functionality and Testing

ENSCO 7500 DP

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E7500 Equipment

- DPS-2 class semi-submersible with a Dual Redundant ASK Dynamic Positioning System
- Eight (8) EMD 710-G7B engines with Baylor S855YNV generators generating 3580 kW/5114 kVa @ 4160V with 0.7 pf
- Total Generating Capacity 21.5 MW
- Two Main Medium Voltage Buses with Tie Breaker
- Eight 3000 hp Thrusters
- A Four Bay Twelve Drive SCR System for Drilling Systems.
- Two Ship's Service Distribution System

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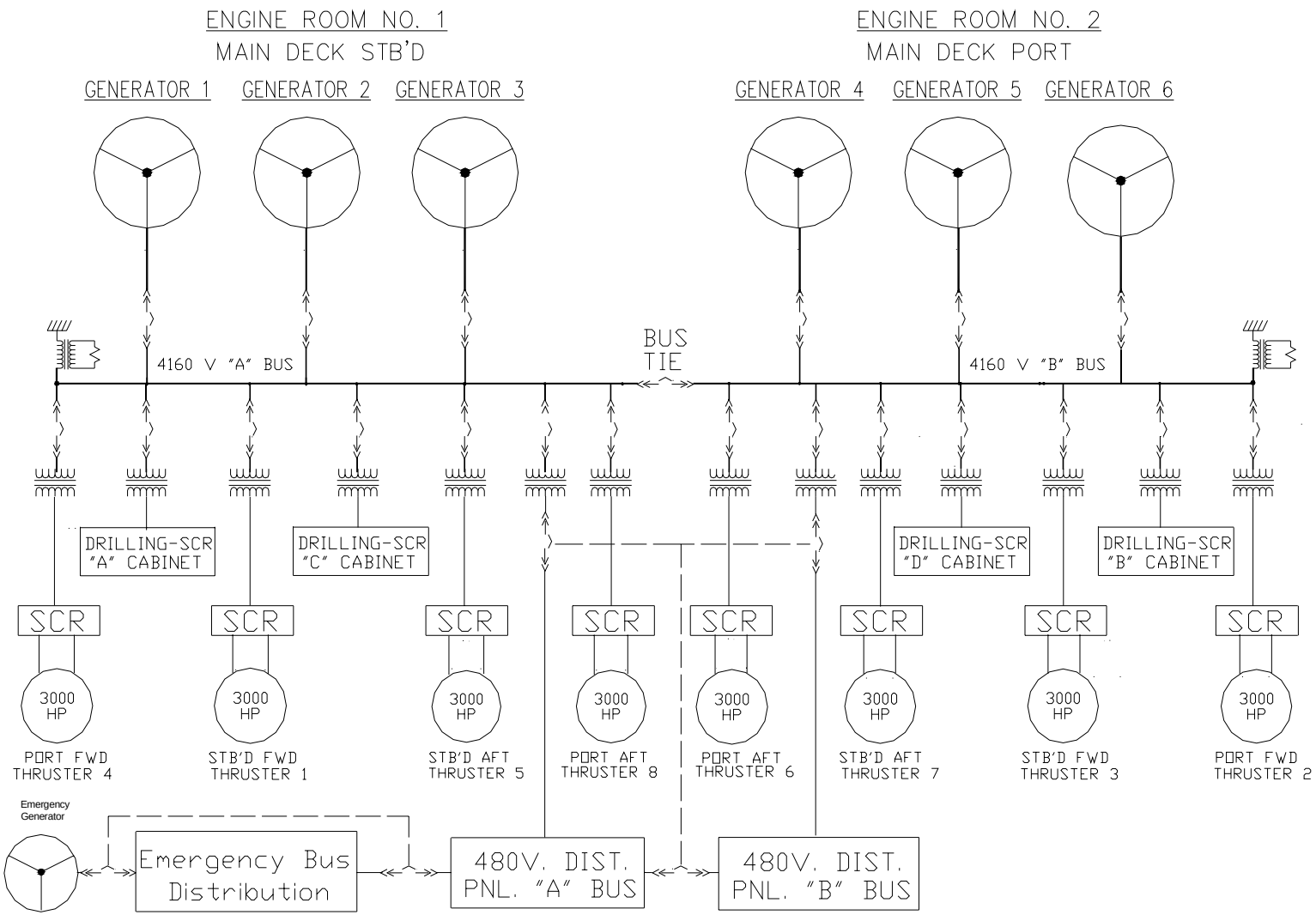
Main Medium Voltage Distribution System



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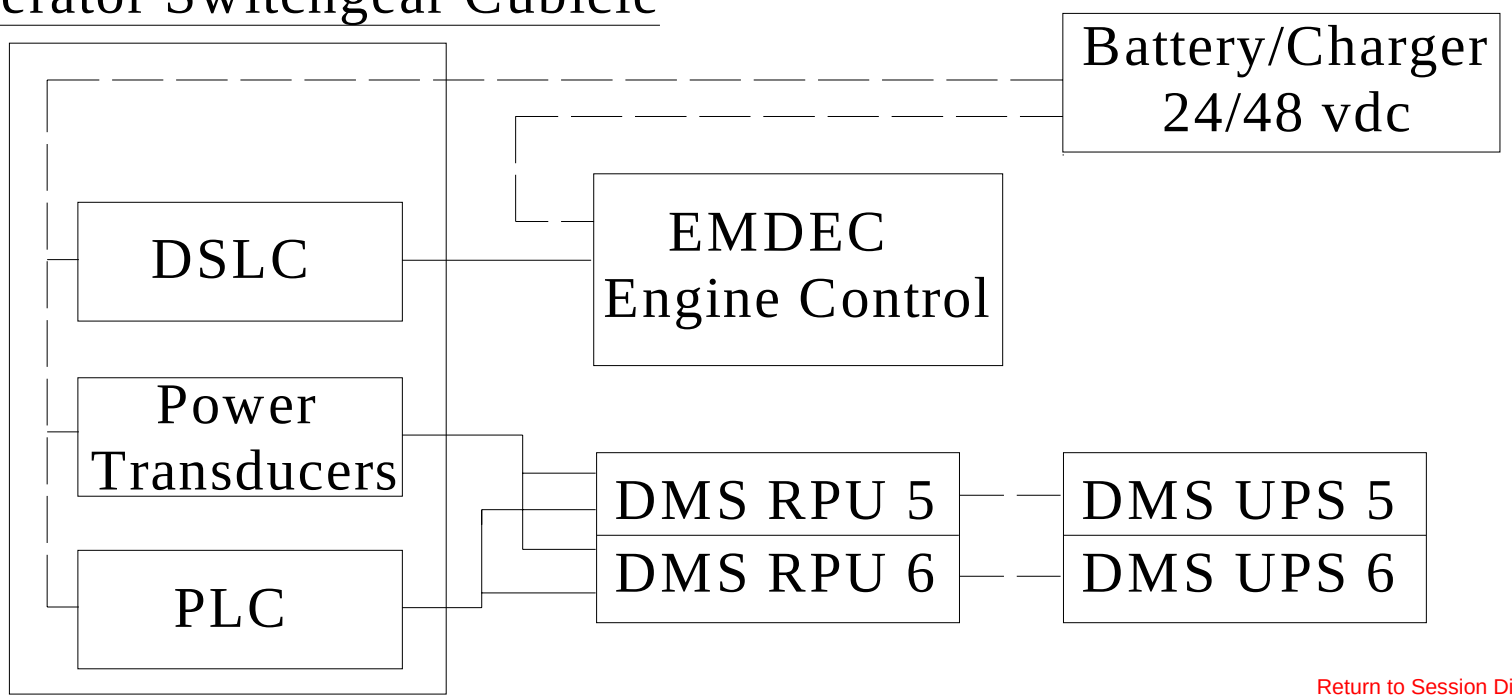
Main Generator Control Configuration

- Each Engine/Generator has independent control and power equipment
- Each Generator Cubicle has the following equipment
  - Control PLC
  - Power Management Relay
  - Power Transducers
  - Digital Synchronizer and Load Control Module (DSLC)

Generator Switchgear Cubicle



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Power Management Control Systems

- Three Control System are used to implemented the power management functions –
  - Dynamic Positioning – Thrust Reduction
  - Data Management – Engine Starting
  - Drilling SCR Power – Power
- The Three systems act independently – each has dedicated power parameter inputs

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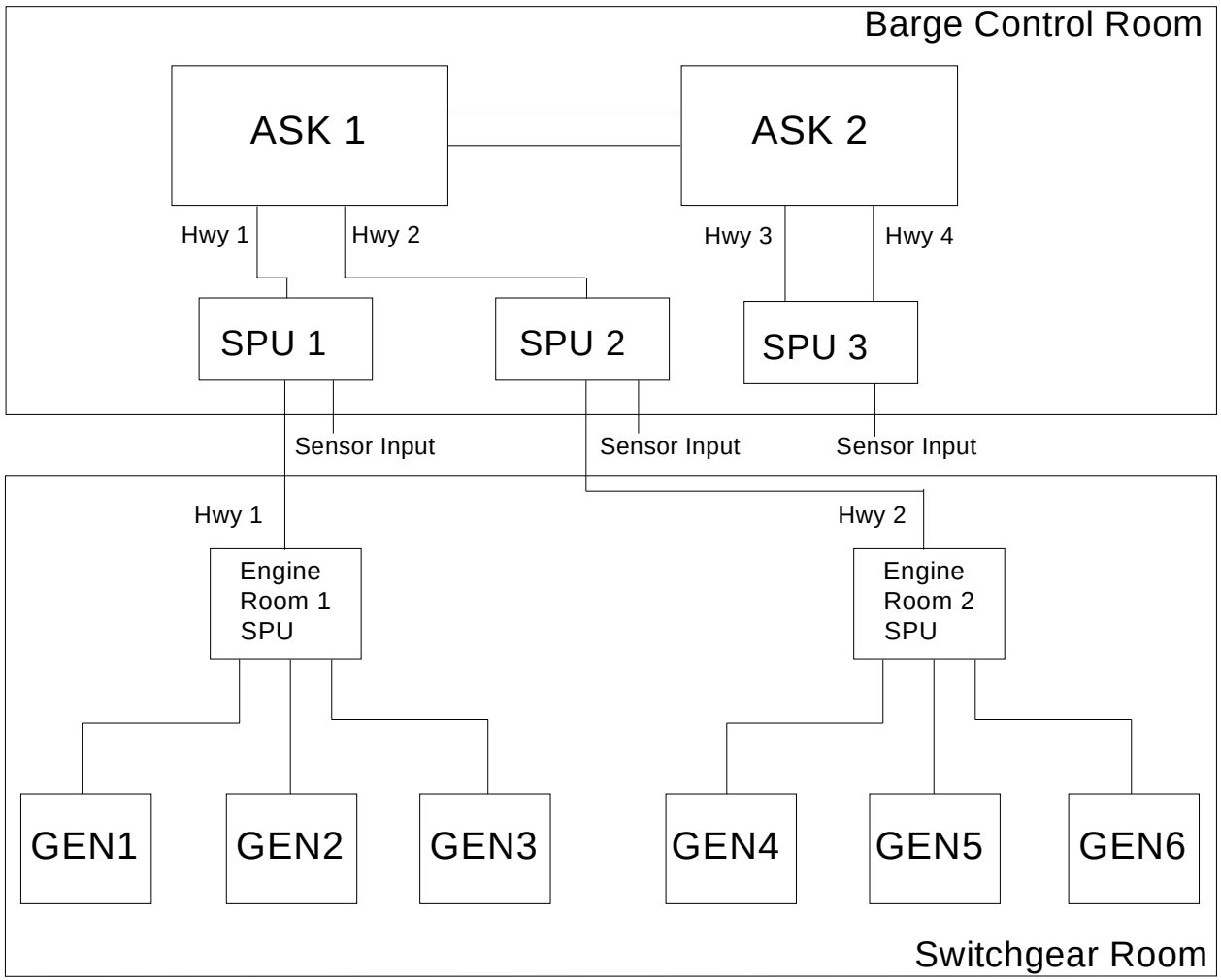
Dynamic Positioning System

- Dual Redundant System with 550 msec. cycle time
- Power Management Input from Each Generator
- Reduces Power Commands to Thruster In Overload Condition



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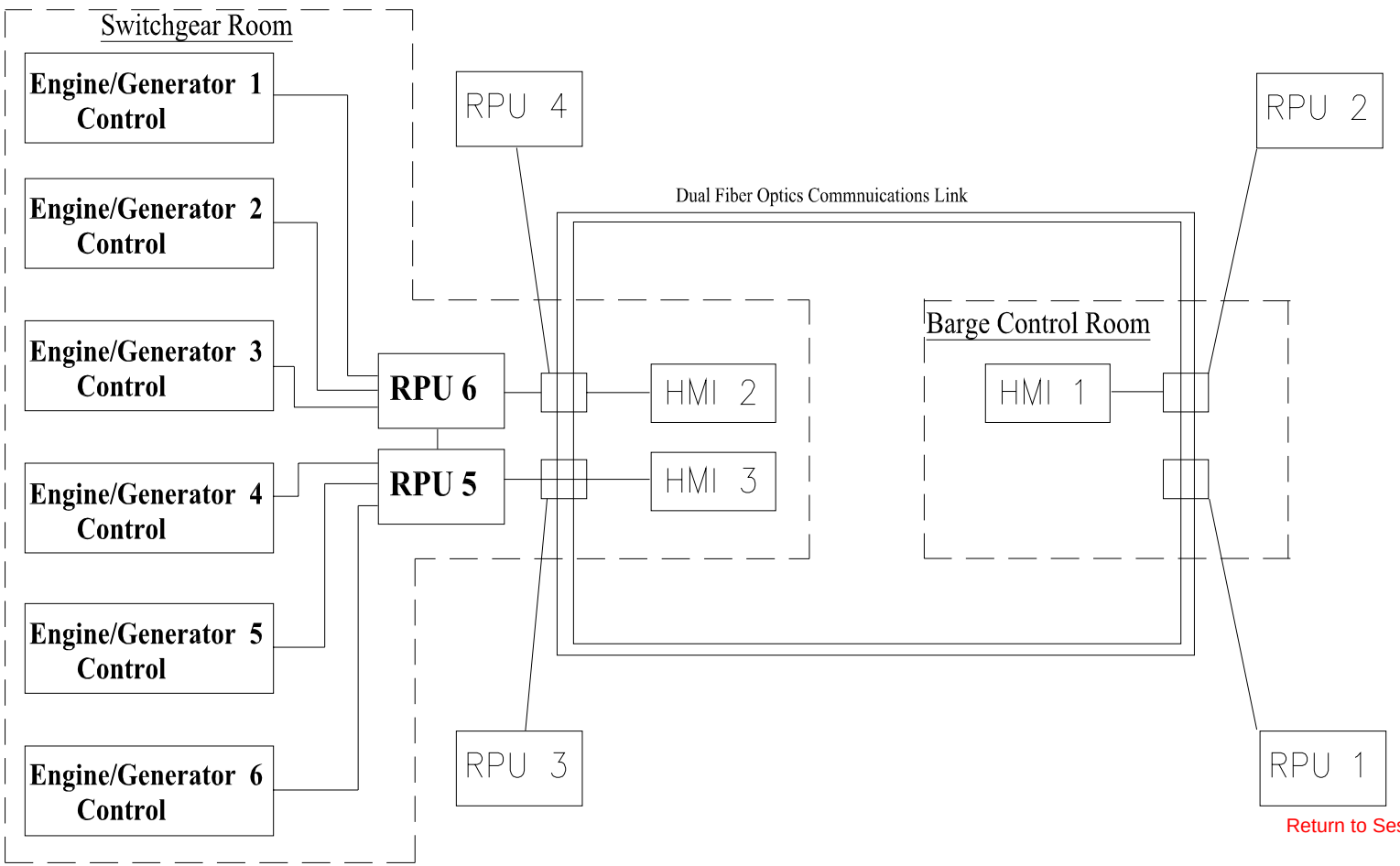
Data Management System

- Dual Redundant Power Management Processors (RPU 5 & 6)
- Dedicated UPS Supplies for all RPUs
- All Program Logic Runs on RPU Processors
- Fault Tolerant Fiber/Copper Communications Network



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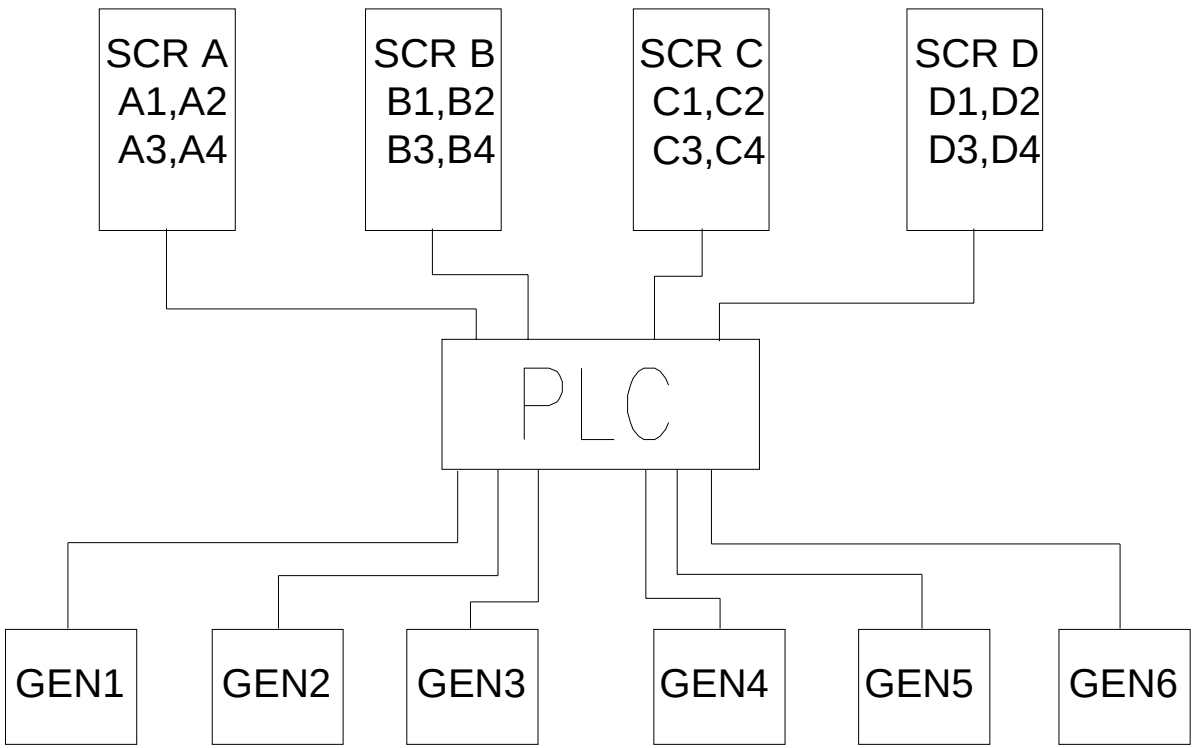
Drilling SCR Power System

- Power Parameter Inputs from Each Generator
- Single PLC Control
- Reduce Throttle Signal to all Drilling Motors



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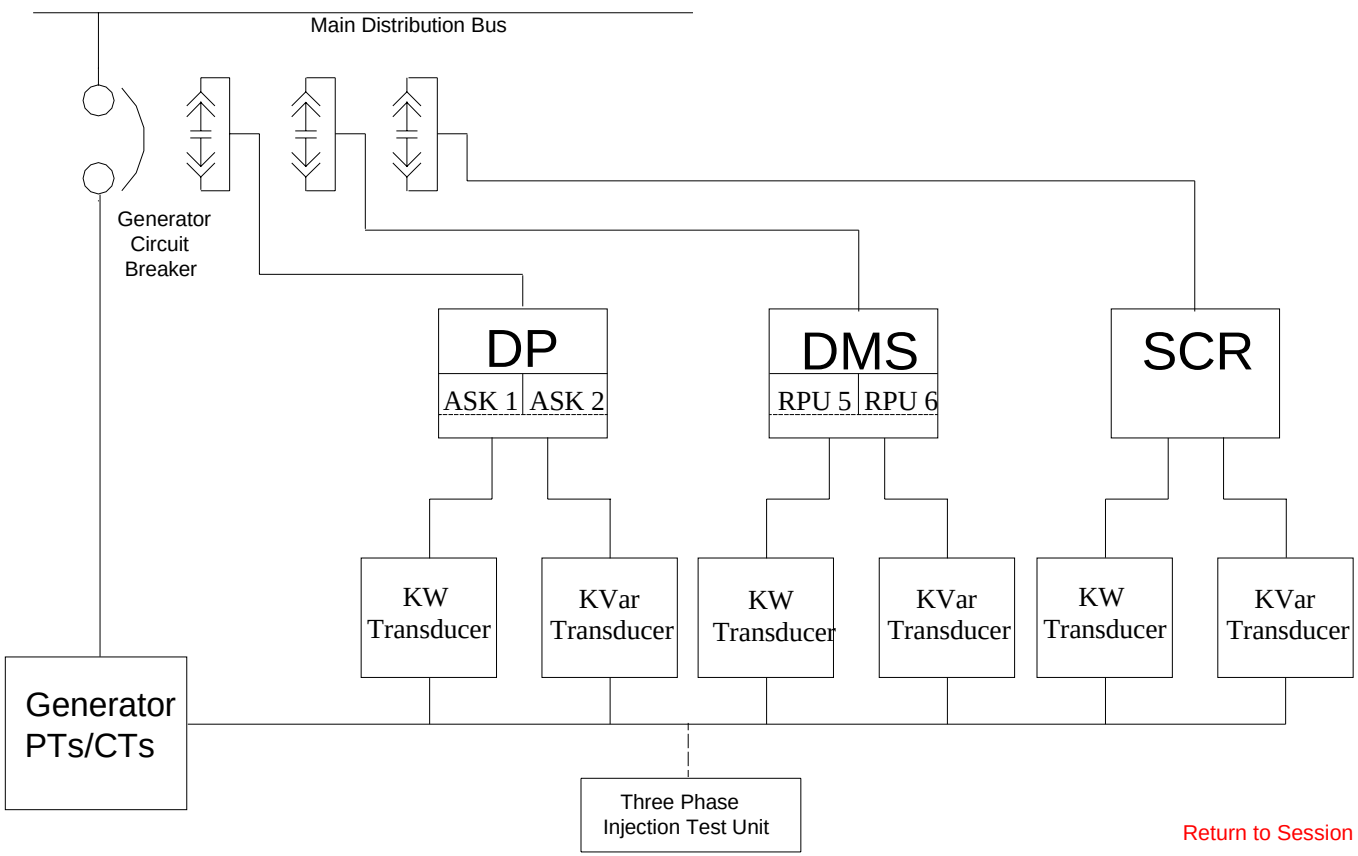
Power Transducer Input

- Each Generator has Dedicated kW & kVar Transducer Inputs to all Three Systems
- Main Circuit Breaker Dry Contacts for Generator Status



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Transducer Calibration Data

	Generator 1																	
	CURRENT SETTINGS				VOLTAGE SETTINGS			Transducer Readings										
p.f.	CT Amps :	A phase angle	B phase angle	C phase angle	A phase angle	B phase angle	C phase angle	KW mA output:	KVAR mA output:	KW	KVAR	ASK kW mA	DMS kW mA	SCR kW mA	ASK kVAR mA	DMS kVAR mA	SCR kVAR mA
0.7	0.00	45.6	165.6	285.6	0	120	240	4.0	12.0	0	0	4.00	4.00	4.00	12.00	12.05	12.00
0.7	1.77	45.6	165.6	285.6	0	120	240	10.7	15.3	1788	1825	10.70	10.71	10.70	15.30	15.35	15.29
0.7	3.55	45.6	165.6	285.6	0	120	240	17.3	18.7	3579	3655	17.34	17.35	17.34	18.61	18.67	18.60
0.7	4.19	45.6	165.6	285.6	0	120	240	19.7	19.9	4224	4314	19.71	19.72	19.71	19.80	19.86	19.80
1	2.48	0	120	240	0	120	240	17.3	12.0	3580	0	20.36	20.37	20.37	12.02	12.07	12.02
0.6	3.55	53.1	173.1	293.1	0	120	240	15.4	19.5	3072	4091	14.66	14.66	14.66	19.38	19.44	19.38

Calculated Readings														
p.f.	KW %	KVAR %	KVAR	kVA	KW	ASK kW	ASK kVAR	DMS kVAR	DMS kVA	DMS kW	(PLC) kW counts	(PLC) kVAR counts	Multilin KW	Multilin KVAR
0.7	0%	0%	0	0	0	10	27	23	23	0	0	15984	0	0
0.7	50%	50%	1825	2555	1788	1813	1824	1825	2562	1798	13395	22565	1780	1804
0.7	100%	100%	3655	5116	3579	3600	3645	3636	5106	3583	26703	29176	3557	3636
0.7	118%	118%	4314	6038	4224	4240	4285	4289	6017	4221	31463	31552	4200	4300
1	100%	0%	0	3580	3580	>120%	29	25	4296	4296	32764	16009	3554	16
0.6	86%	112%	4091	5116	3072	2876	4069	4072	4977	2860	26320	30766	3055	4077

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Dynamic Positioning System Operation
Power Parameters

On-Line Capacity	The sum of the capacity of all online generators. If the generator circuit breaker is closed, then its capacity is added to the variable minus any generators that are 30% below the highest loaded generator.
Hotel/Drilling Load	The Hotel/Drilling is a variable that is calculated as the difference between the total generator power feedback less the total thruster power feedback.
Non-Sheddable Load	The maximum value of either the Hotel/Drill load or the system Reserve Kilowatt whichever is greater.
Upper Power Limit (UPL)	The UPL is the On-Line Capacity minus the Non-Sheddable load. This value is the maximum amount of power that is available for thruster use.

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DP Operator Control Parameters

Reserve Kilowatt	An input value that provides a minimum reserve amount of the On-Line Capacity. This value is normally set above the Hotel/Drilling load. If the value is lower than the Hotel/Drilling load, the system will use the actual Hotel/Drilling load to calculate the Upper Power Limit.
Lower Power Limit (LPL)	A thirty (30) second average of thruster power required times the "Power Lower Limit Margin"
Lower Power Limit Margin	An operator input variable that determines the level of the Lower Power Limit above the average thruster power. The value is input as a percentage.
Active (Operating) Power Limit (APL)	The power limit that is used for limiting thruster loading. The APL can be set to either the UPL or LPL depending on the status of the Power Limit Sustain function. Thruster power limiting takes effect at the APL and it will not exceed the limit.
Power Limit Sustain Function	An operator consoles pushbutton controls this function. When the function is enabled, thruster power is held to the LPL. If the function is disabled, thruster power will be limited by the LPL for ten (10) seconds. If the thruster power demand remains at the LPL of the time period, it will be released to the UPL. Thruster power demand can then rise to the UPL level if necessary. This function tends to smooth out the thruster power requirements. This also allows the operator a time period to access the power requirements and the system situation.

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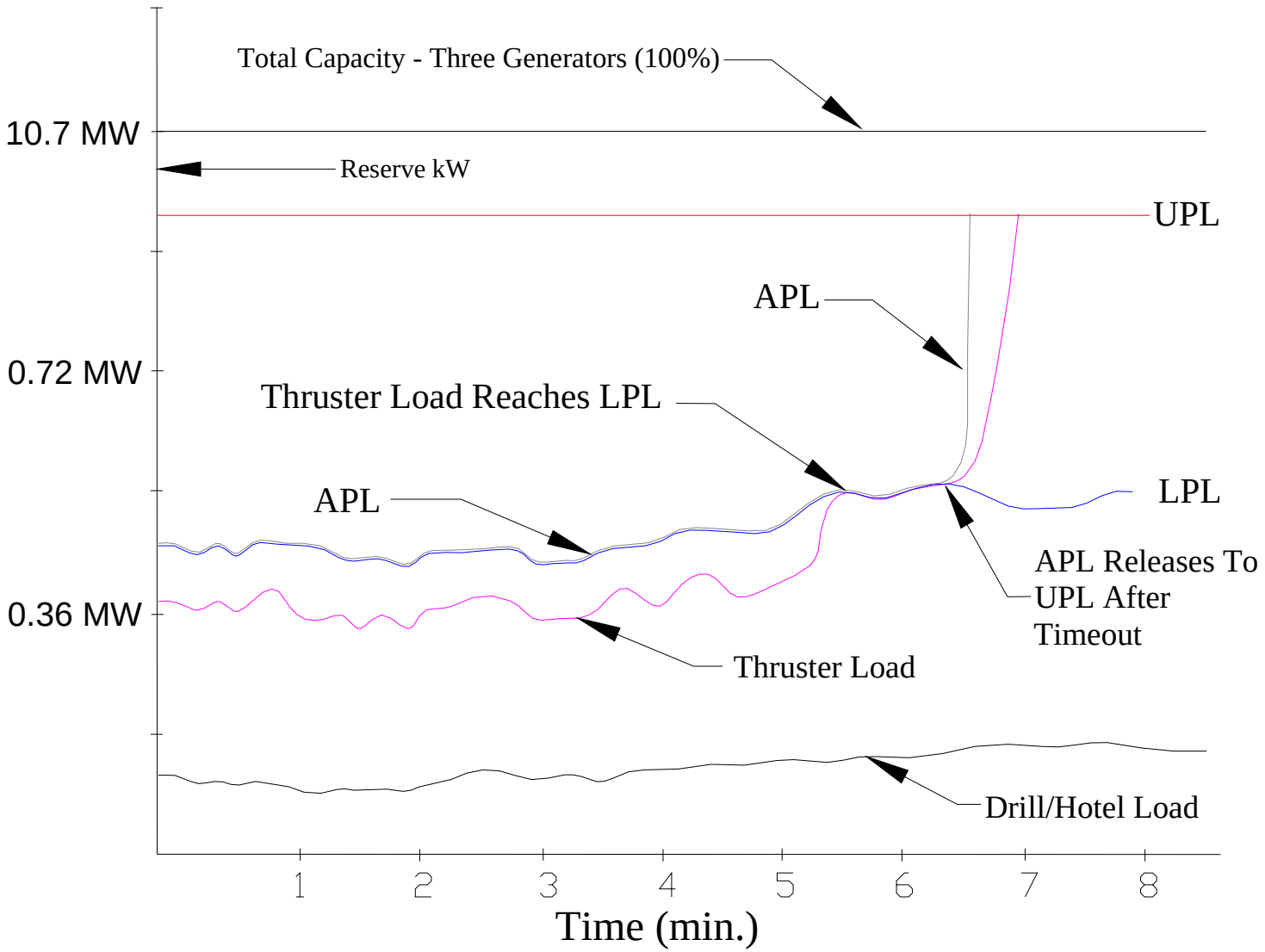
DP Parameters Graphical Representation



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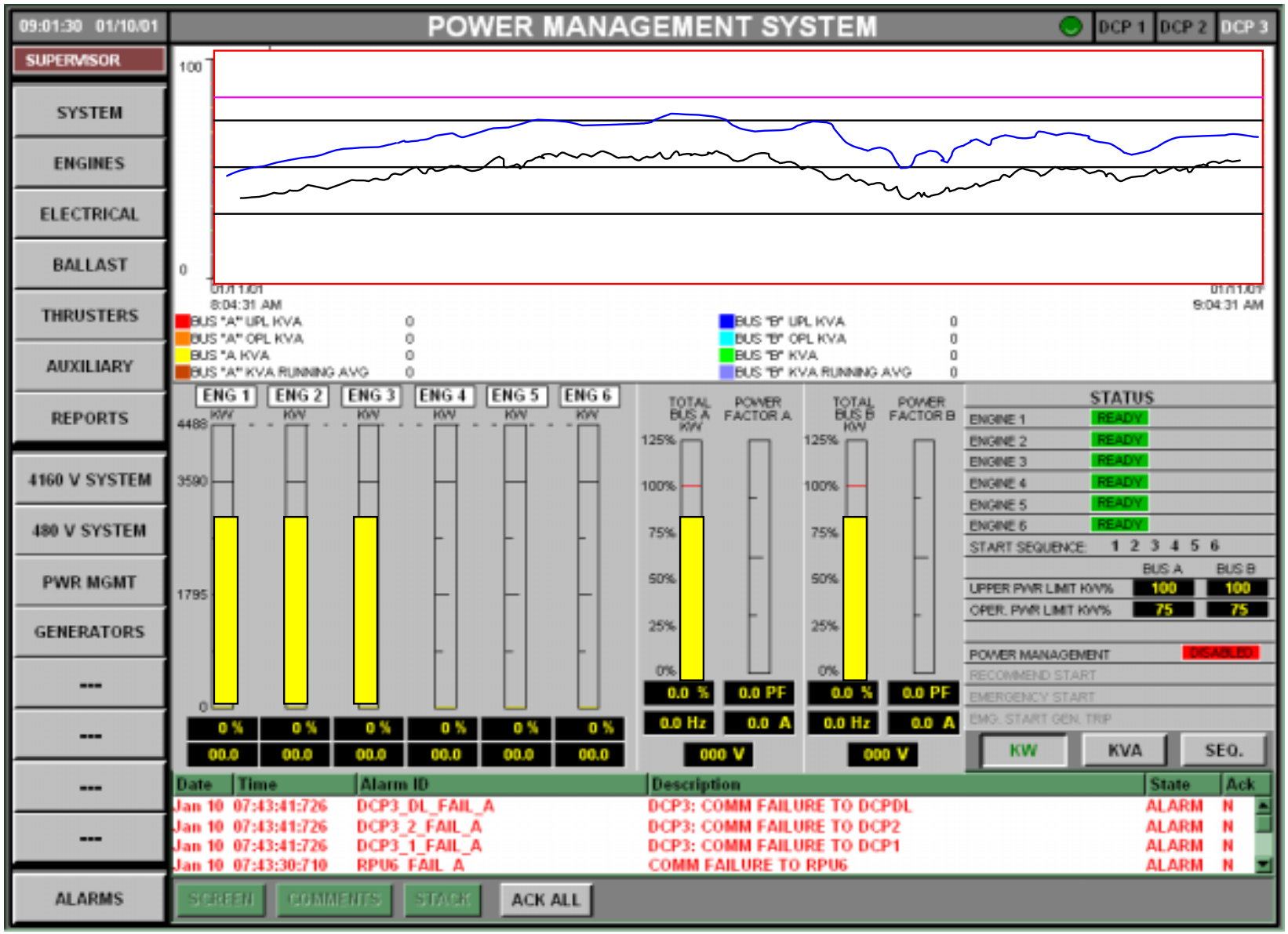
DMS Power Management Mimic Screen



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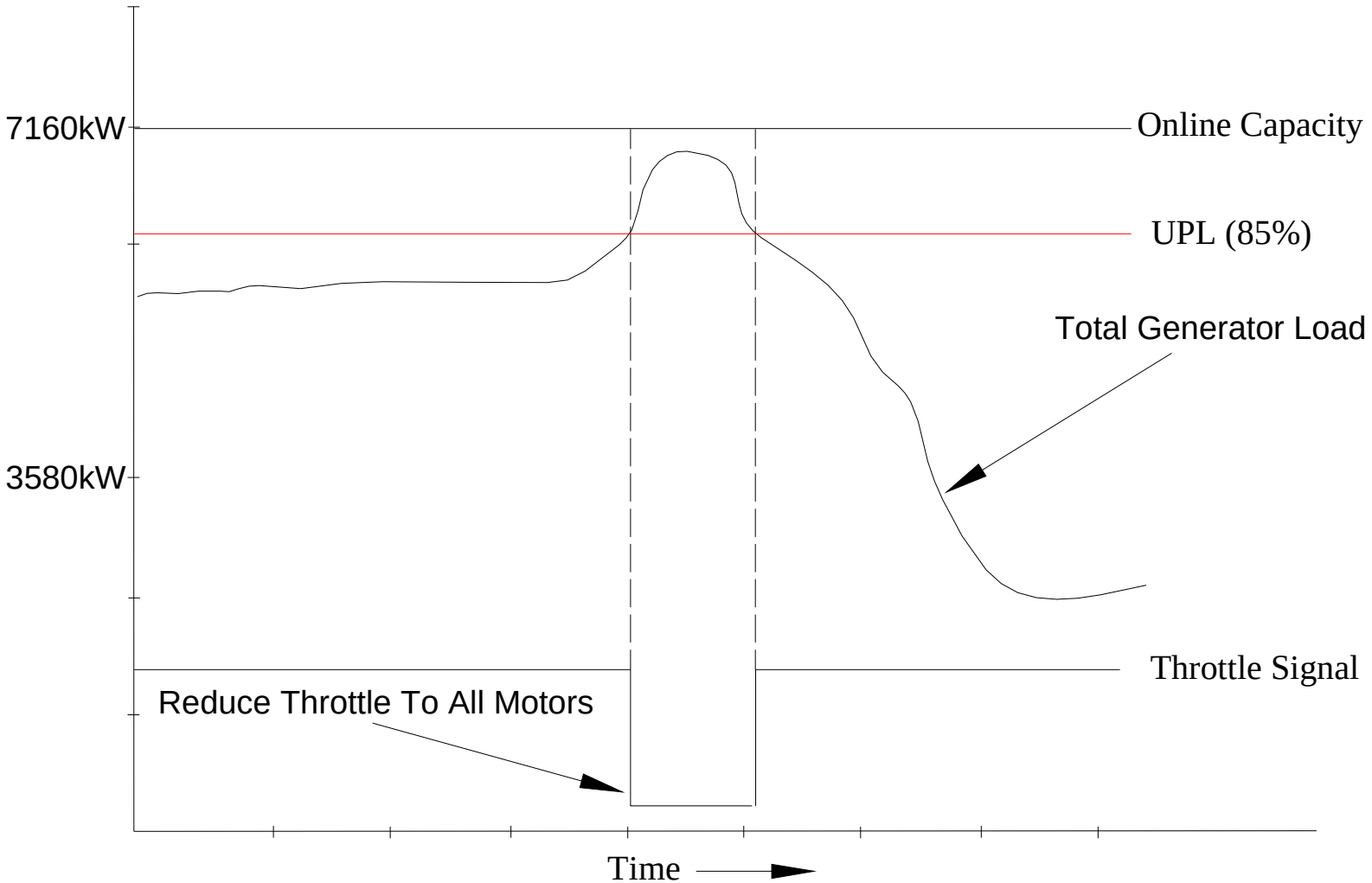
SCR Power Phaseback



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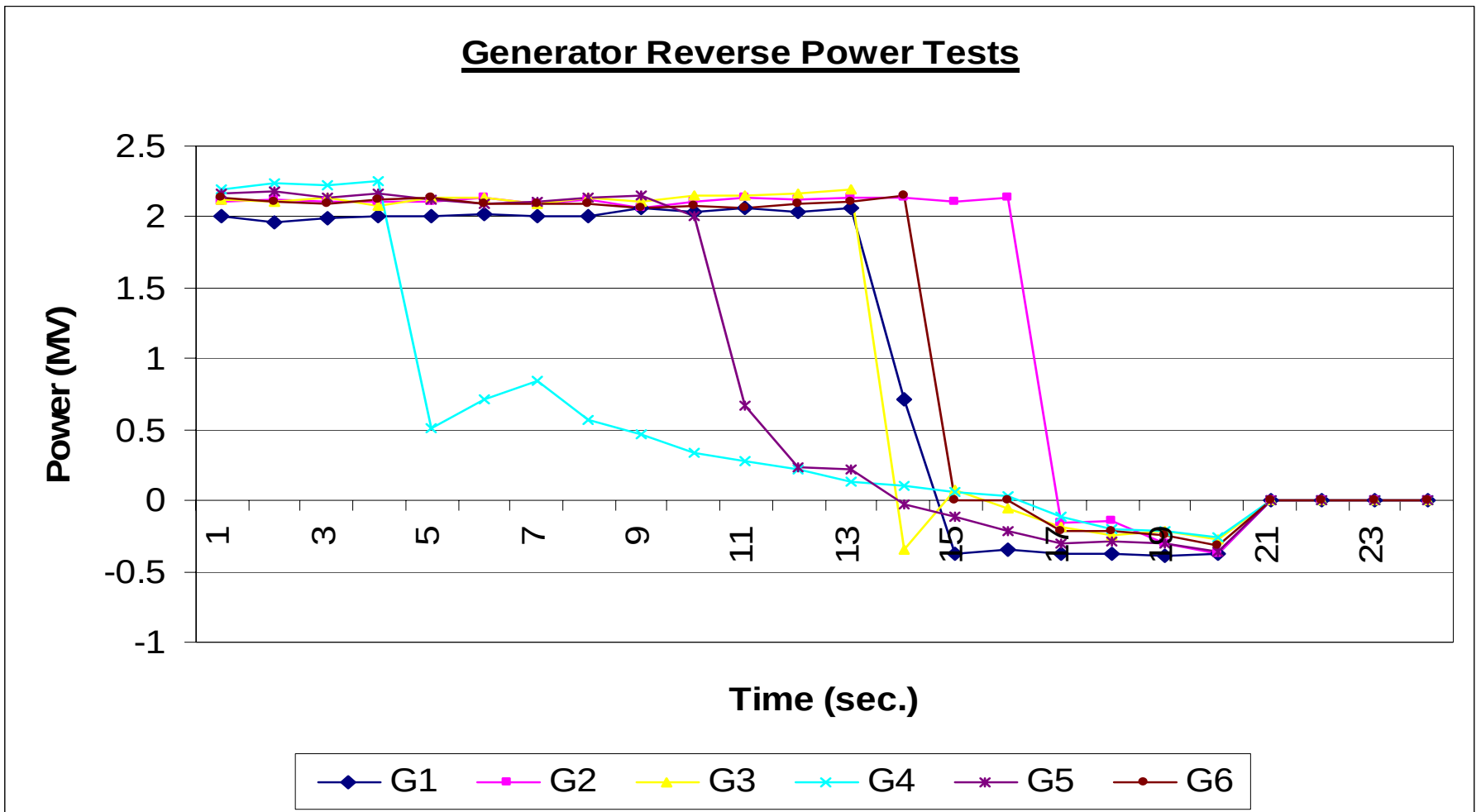
- Two Generator with > 50% Load on Each
- Turn Off Fuel Supply To One Engine
- Time for Circuit Breaker to Open Varies from 2 to 15 seconds.



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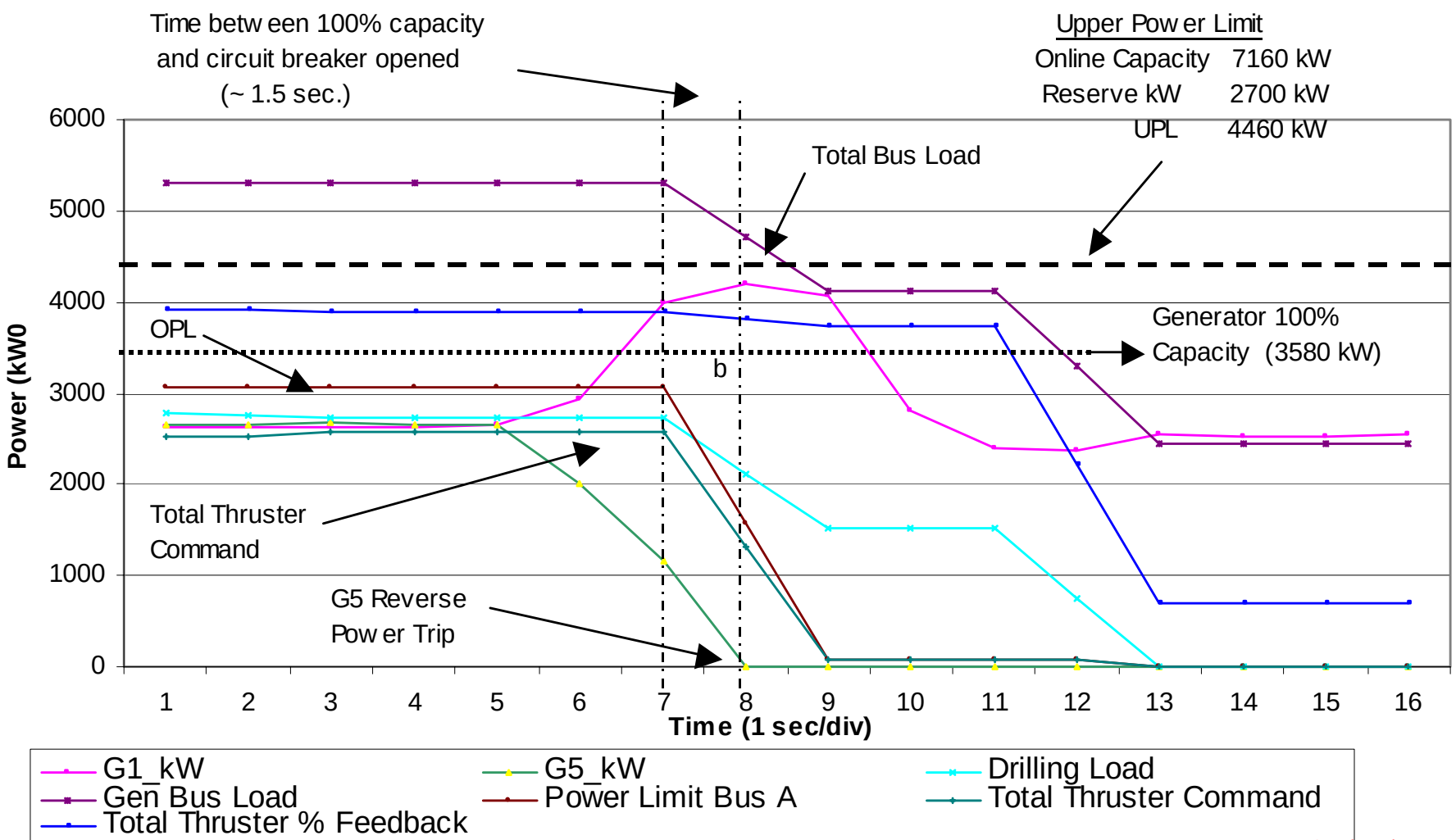
•Two Generators Online With Load > 50% (G1 & G5)

•Remove Fuel Signal To Engine Controller (EMDEC)

ASK Thruster Phaseback 7 August



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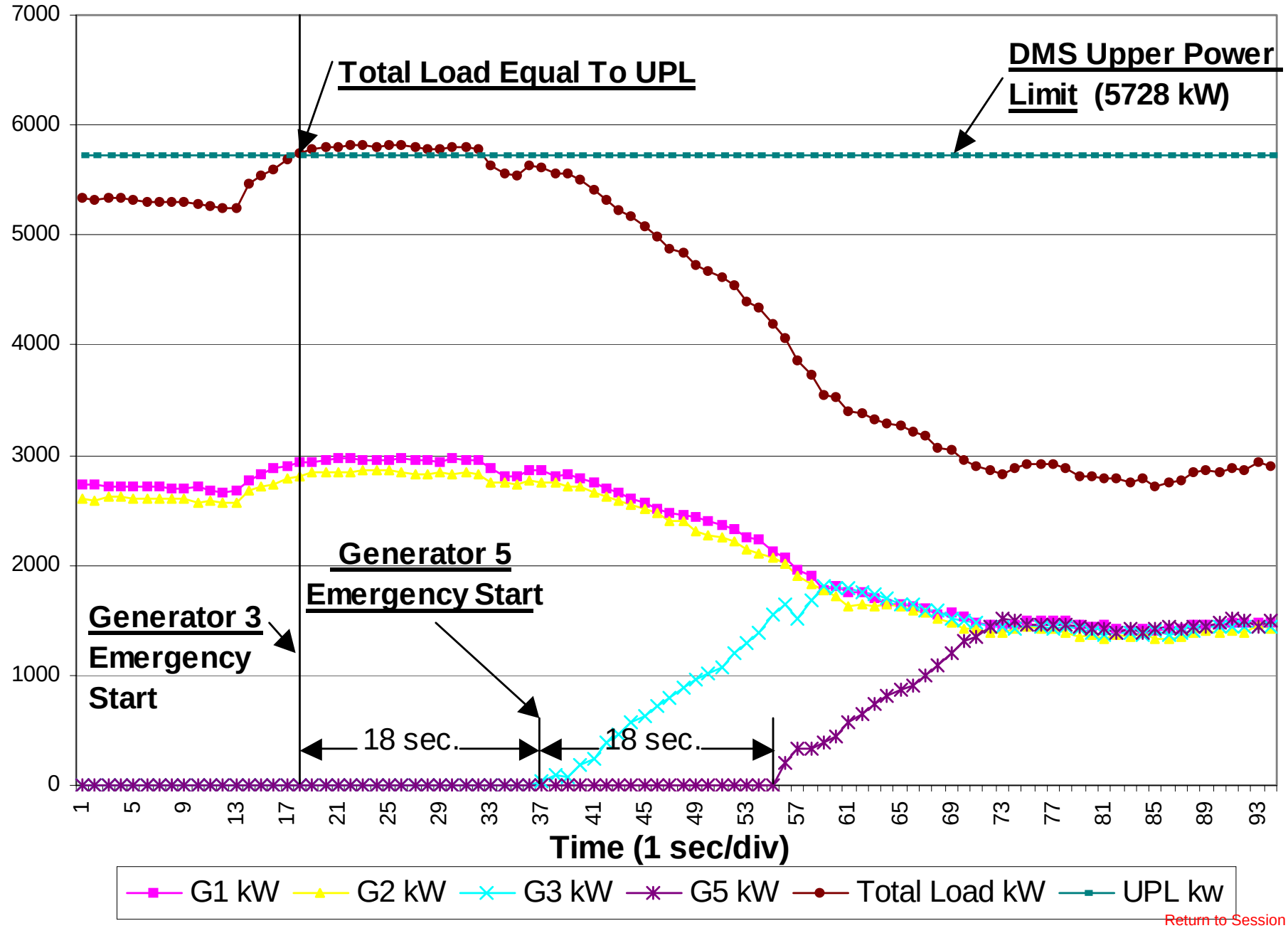
DMS Emergency Start Test 7 August 14:00



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Commissioning Problems

- **Transducer Calibration**

  Switchgear Generator Transducers (kW/kVar) could not be adjusted to full scale values of 120%.

  Calibration of Transducers with Three Phase Test Unit determined that they had Incorrect Outputs.

  Problem Was Determined To Be a Production Error

  Units were modified and calibrated correctly then installed and tested on the rig.

- **Software Calculations**

  During the testing of the transducer with the Three Phase Test Unit, one system did not have the correct value for kVA.

  Problem Was an Incorrect Calculation in The Program Logic

- **System Scaling**

  Original Scaling of Power Values were 0-100% of capacity so overload conditions were not displayed

  Scaling was changed to 0 – 120% of capacity

- **Testing**

  Original Sea Trials satisfactorily tested the system's functions.

  Under actual drilling conditions, there were some pre-mature engine emergency starting.

  Subsequent testing determined the transducer calibration and reverse power timing problem.

  The systems did not take into consideration the variable time for reverse power situations.

  Software was changed in the DP and Drilling SCR to reduce power based on individual generator loading as well as total load.

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Regulatory Compliance

- ABS Guide for Thruster and Dynamic Positioning Systems Requires that the Power System Have The Capability Of Withstanding A Single Fault Bus Failure So That Sufficient Power Remains For Positioning and Auxiliary Systems

Bus "A" Capacity	10.74 MW
Bus "A" Thruster Load (full power)	8.95 MW
Bus "B" Capacity	10.74 MW
Bus "B" Thruster Load (full power)	8.95 MW
Emergency Bus Load	0.40 MW (approximately)
Hotel Load	0.75 MW (approximately)
Drilling Load (Three mud pumps, top drive @ 80%)	4.7 MW

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Conclusion

- Reverse Power Time Needs To Be Considered In The Power Management Logic
- The Engine Performance should be determined and factored into the System Design
- The Load on Each Individual Generator in relation to the others should be used for Power Reduction Logic
- Calibrate all Transducers using Three-Phase Test Unit

  Verify the Power Parameter Scaling and Derived Values on all systems
- Design test procedures that verify the operation of the whole system

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