



POWER

Improving Engine Utilization in DP Vessels

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Improving Engine Utilization on DP Vessels



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Series of Power Management System Modifications

- **Frequency Sensitive - Thruster Drive Fast Phase Back**
- **Modify Load Dependent Start Table**
- **Auto Start - Handling of Different Size Generator Sets**
- **Add Low Pass Filter to Improve Synchronization Time**
- **Coordinate Engine Load Ramp with Availability of Power to DP**
- **Addition of Quick Trips to Improve Service Continuity**

Power System - More Robust - Blackout Resistant

Causes of Blackouts

- **Short Circuits** - protective devices programmed to isolate
- **Overloads** - PMS load dependent start/stop matrix
- **Most severe** - sudden loss of engine under load
 - Fuel system failures - (clogged fuel lines, fuel pump failure, water in fuel)
 - mechanical failure (loss of oil pressure, over speed)
 - Control system failures (false activation lube oil pressure or oil mist detector, crankcase overpressure)
- **Operator error** - usually set up and/or synchronizing generators

Thruster Frequency Spillover Design - Major Components

- Engine/generator size and speed
- Thruster type/arrangement, size, and speed
- DP and power management system supplier
- Engine governor system and its response times
- Voltage regulation system and its response
- Systems must be tuned to work in harmony
- System testing is required
- Spillover is integral part of PMS

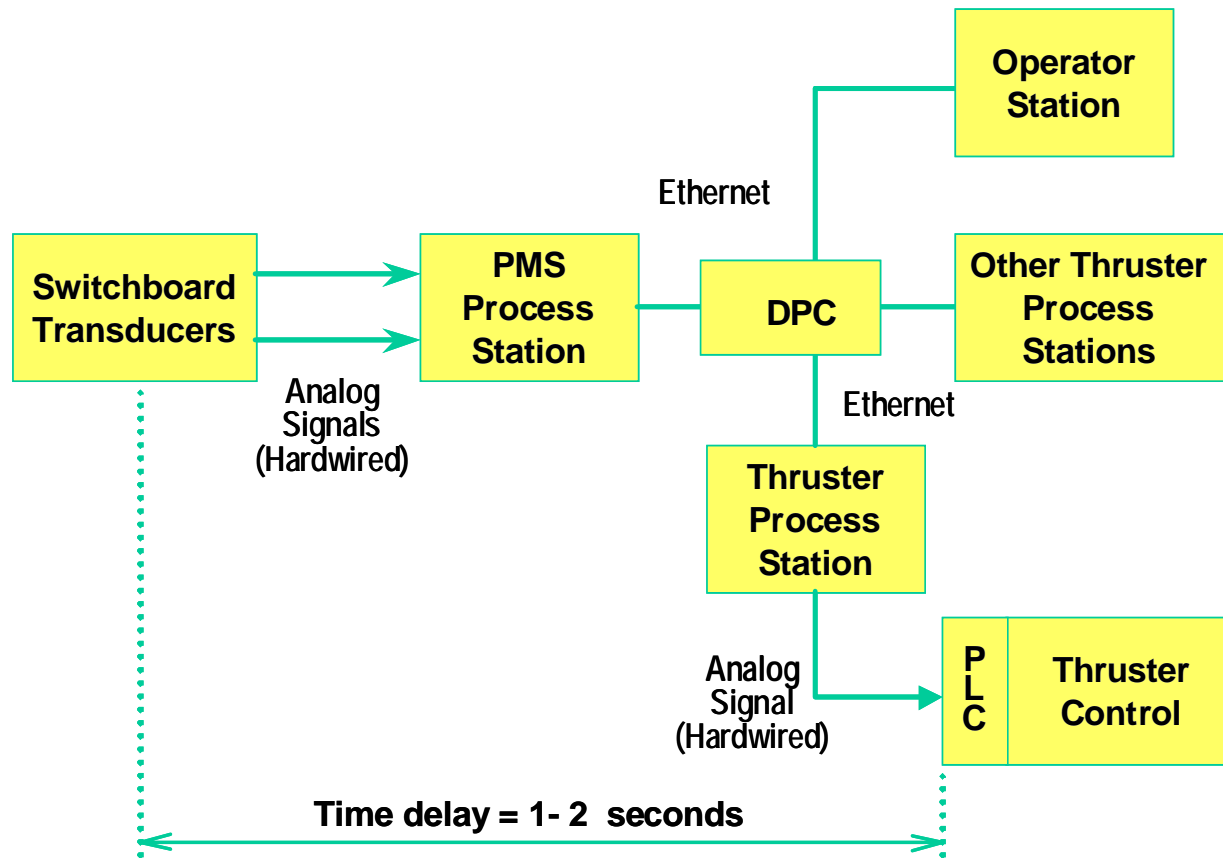


Figure 1 - Thruster Load Limit Delay

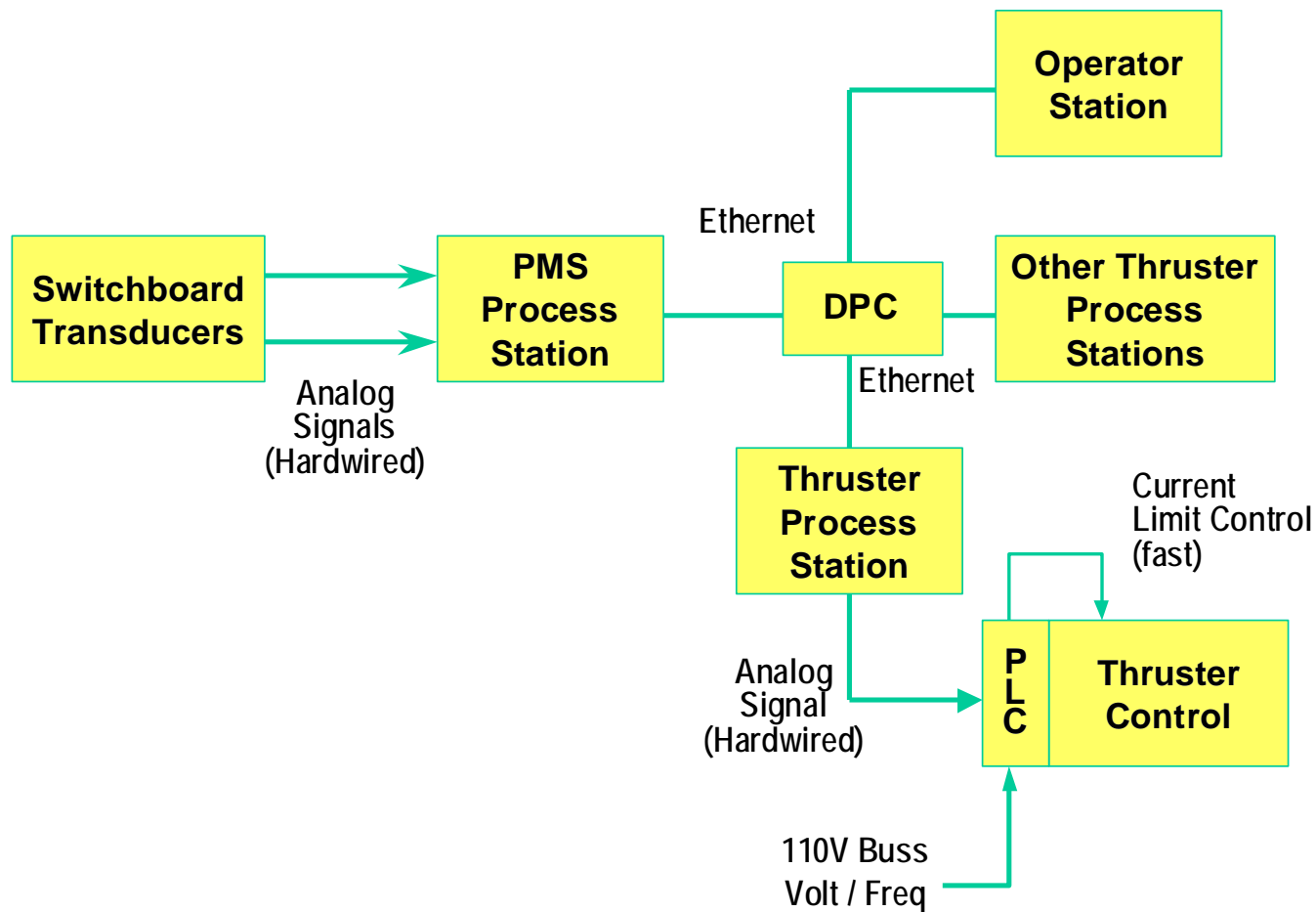


Figure 2 - Frequency Sensitive Power Phase Back

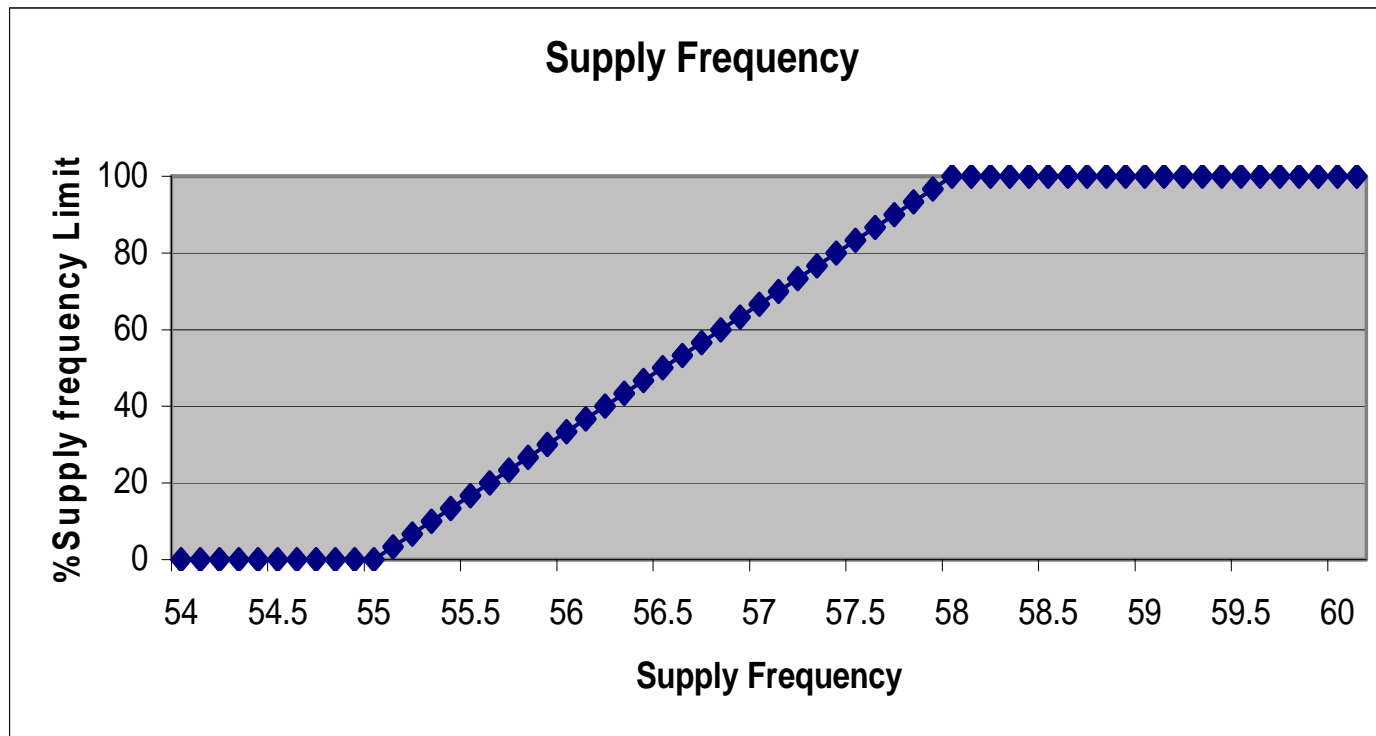
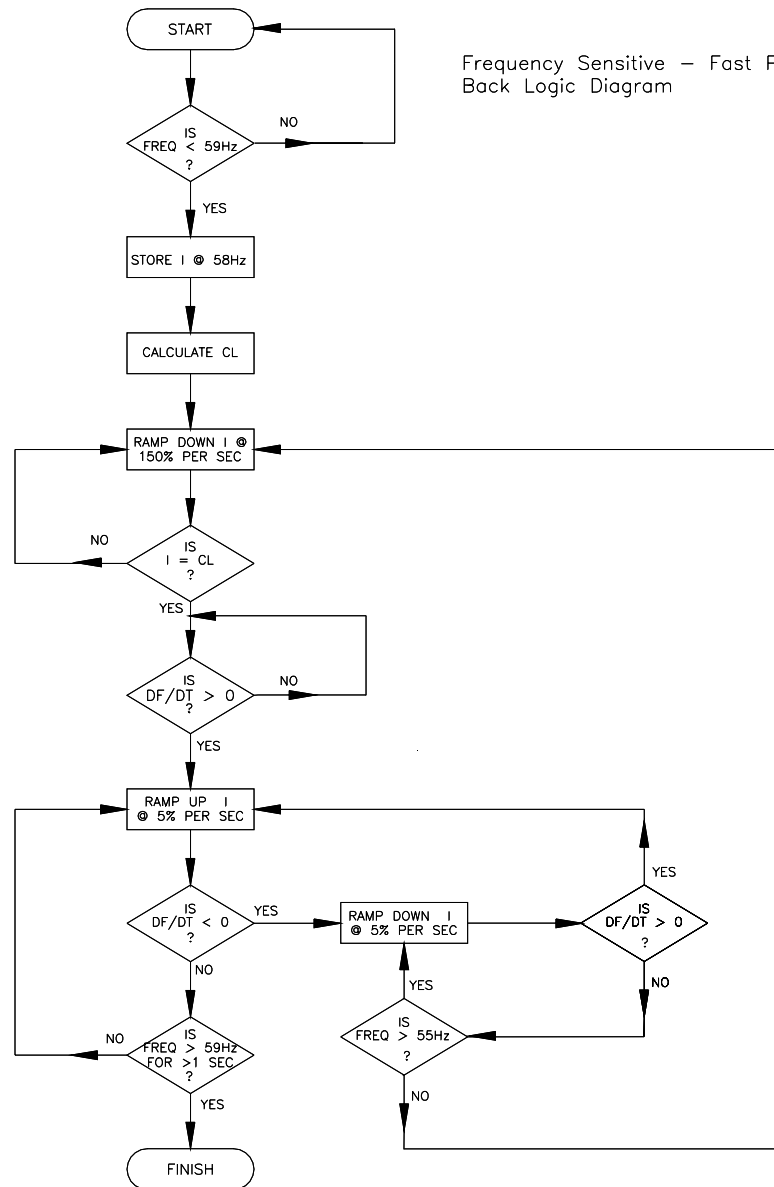


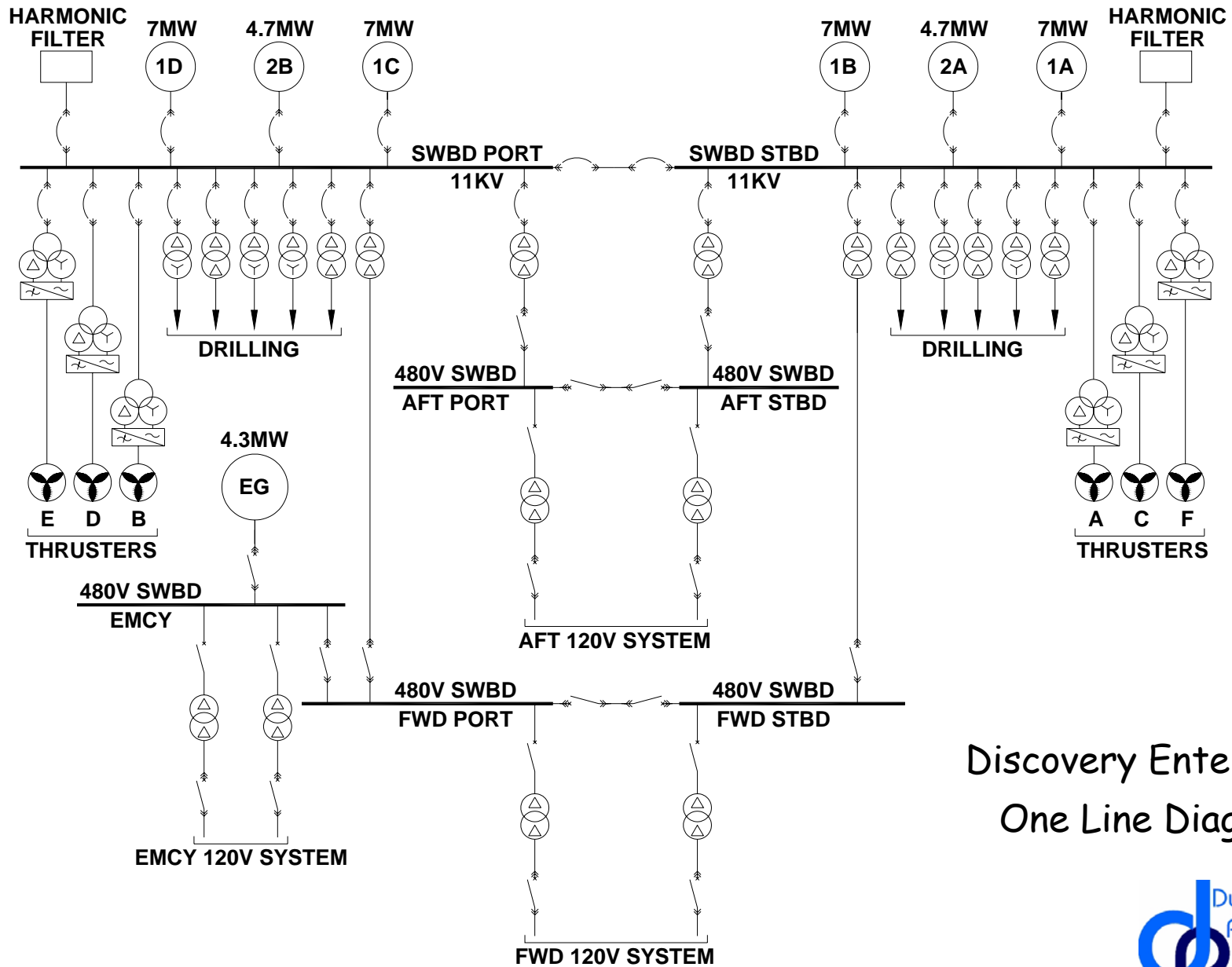
Figure 3 - Initial Phase Back Current Limit

Frequency Sensitive - Fast Phase Back Logic Diagram



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Discovery Enterprise One Line Diagram

Testing of Spillover Tests the Power Management System

- Loss of on-line generator set (FMEA)
- PMS must manage loads Modify Load Dependent Start Table
- Worst case is 2 generator operation with the loss of 1 unit
- Remaining generator must carry 200% of its initial load
- Test system overload capability - failure is blackout
- System must be stable enough to synchronize additional generators

Load Dependent Start Table - Initial				
Number of	Start 1		Start 2	
Generators	Load	Time	Load	Time
2	55	10	100	2
3	68	10	100	2
4	80	10	100	2
5	84	10	100	2

Figure 5 - Initial "Enterprise" Load Dependent Start Table

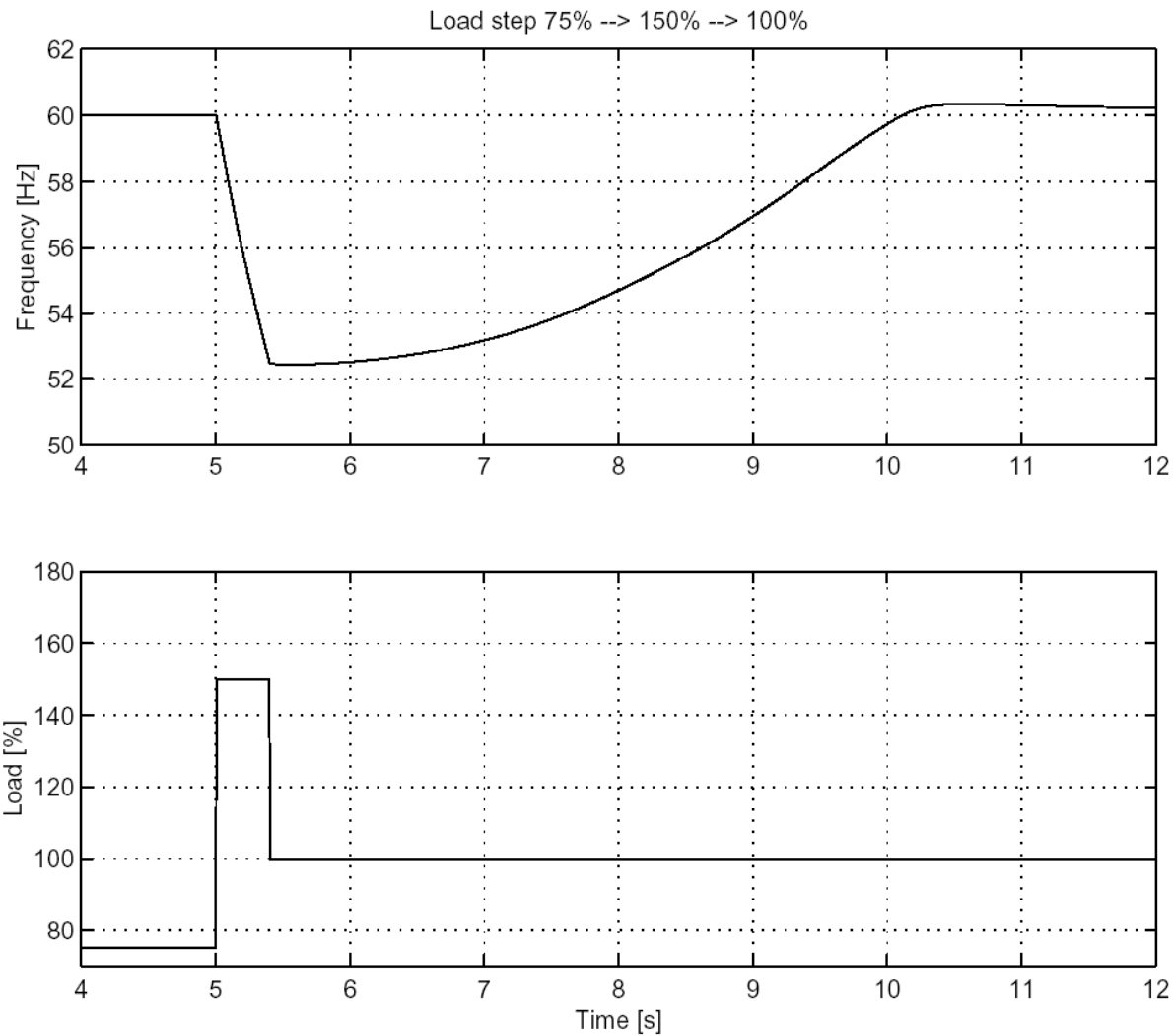


Figure 6 - Engine Response to Step Load Changes

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Engines On-Line	System Capacity	Engine Loss	Remaining System Capacity	Overload Capability	Overload Capability	Overload Capability	Overload Capability
MW	MW	MW	Capacity	110%	140%	150%	160%
2 Engine/Generator Sets							
2-4.7	9.4	4.7	4.7	55%	70%	75%	80%
1-4.7 & 1-7.0	11.7	4.7	7.0	66%	84%	90%	96%
1-4.7 & 1-7.0	11.7	7.0	4.7	44%	56%	60%	64%
2-7.0	14.0	7.0	7.0	55%	70%	75%	80%
3 Engine/Generator Sets							
2-4.7 & 1-7.0	16.4	4.7	13.7	92%	117%	125%	134%
2-4.7 & 1-7.0	16.4	7.0	9.4	63%	80%	86%	92%
1-4.7 & 2-7.0	18.7	4.7	14.0	82%	105%	112%	120%
1-4.7 & 2-7.0	18.7	7.0	11.7	69%	88%	94%	100%
3-7.0	21.0	7.0	14.0	73%	93%	100%	107%
4 Engine/Generator Sets							
2-4.7 & 2-7.0	23.4	4.7	18.7	88%	112%	120%	128%
2-4.7 & 2-7.0	23.4	7.0	16.4	77%	98%	105%	112%
1-4.7 & 3-7.0	25.7	4.7	21.0	90%	114%	123%	131%
1-4.7 & 3-7.0	25.7	7.0	18.7	80%	102%	109%	116%
4-7.0	28.0	7.0	21.0	83%	105%	113%	120%
5 Engine Generator Sets							
2-4.7 & 3-7.0	30.4	4.7	25.7	93%	118%	127%	135%
2-4.7 & 3-7.0	30.4	7.0	23.4	85%	108%	115%	123%
1-4.7 & 4-7.0	32.7	4.7	28.0	94%	120%	128%	137%
1-4.7 & 4-7.0	32.7	7.0	25.7	86%	110%	118%	126%
5-7.0	35.0	7.0	28.0	88%	112%	120%	128%
				= Minimum			

Figure 7 - Load Dependent Start Worksheet

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Load Dependent Start Table - After FSO				
Number of Generators	Start 1		Start 2	
	Load	Time	Load	Time
2	65	90	70	2
3	72	90	80	2
4	80	90	85	2
5	84	90	90	2

Two Engine Operation - Large and Small Engine

- At 60% load for 30 second a standby start will be initiated.
- For short time load Dependent Start see table above (I.e. 70 % - 2 sec.)

Figure 8 - Load Dependent Stat Table - After FSO



Figure 9 - "Discovery Deep Seas" Test C11

FSO starts: 270ms

Simrad reacts: 4.18 sec

Simrad Controls 6.2 sec

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Figure 10 - "Discovery Deep Seas" Test C18

FSO starts: .343 sec Simrad reacts: 3.90 sec Simrad controls: 4.95 sec

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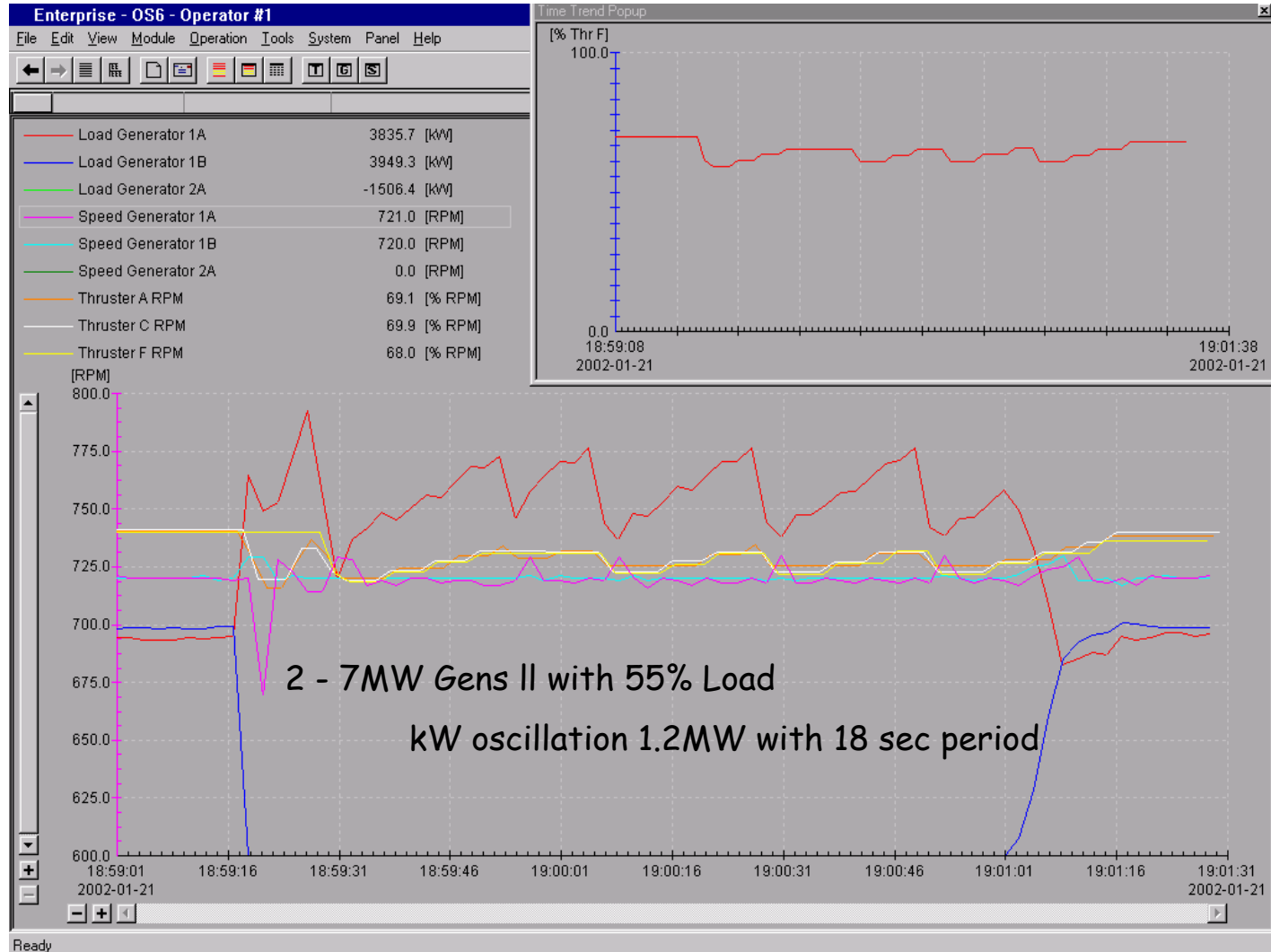


Figure 11 - "Discovery Enterprise" Test

Thrusters: Manual Control

FSO program regulates thruster kW

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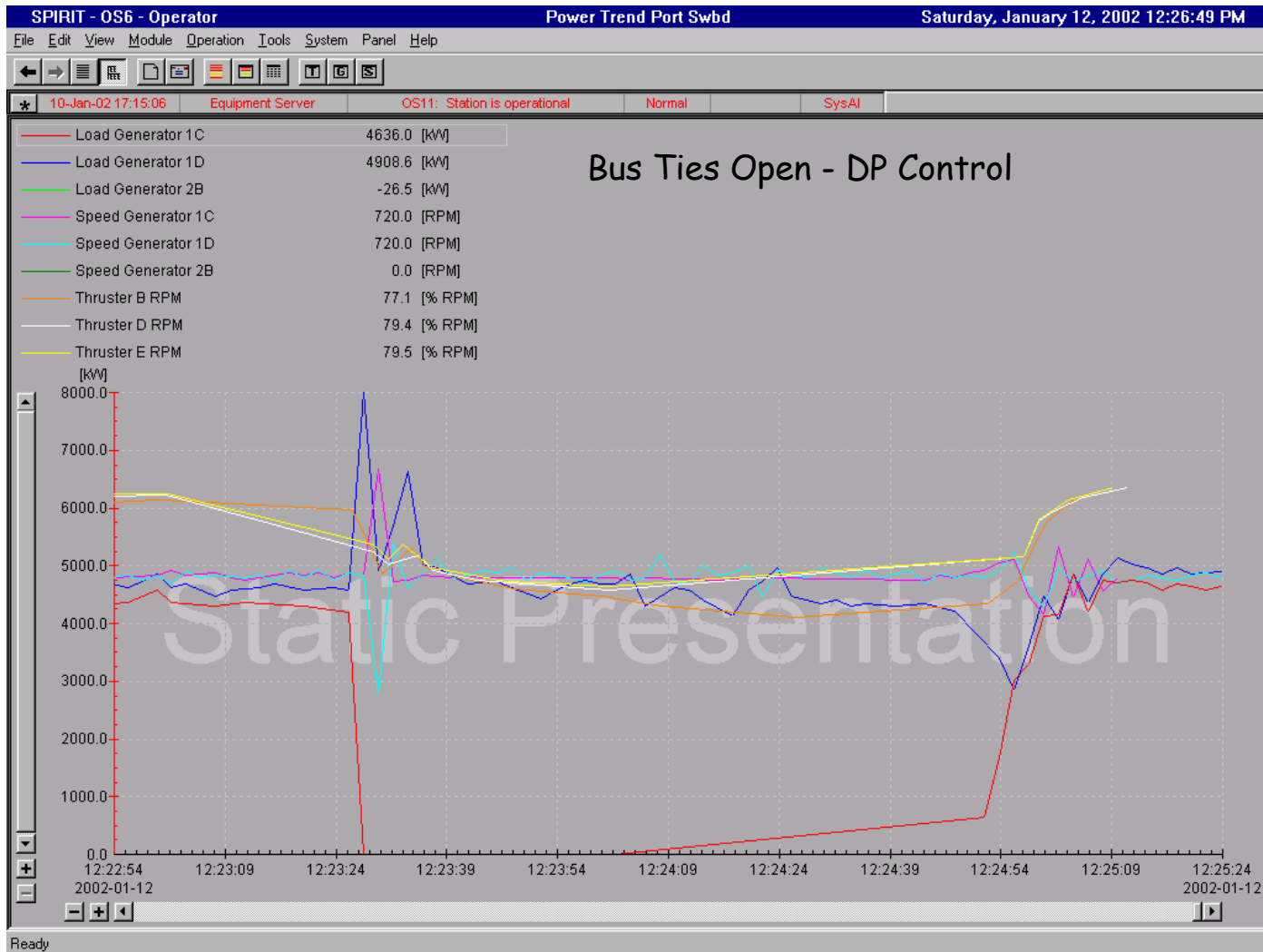


Figure 12 - "Discovery Spirit" Test

Gen 1C is tripped and after 90 sec re-synchronized with Gen 1D

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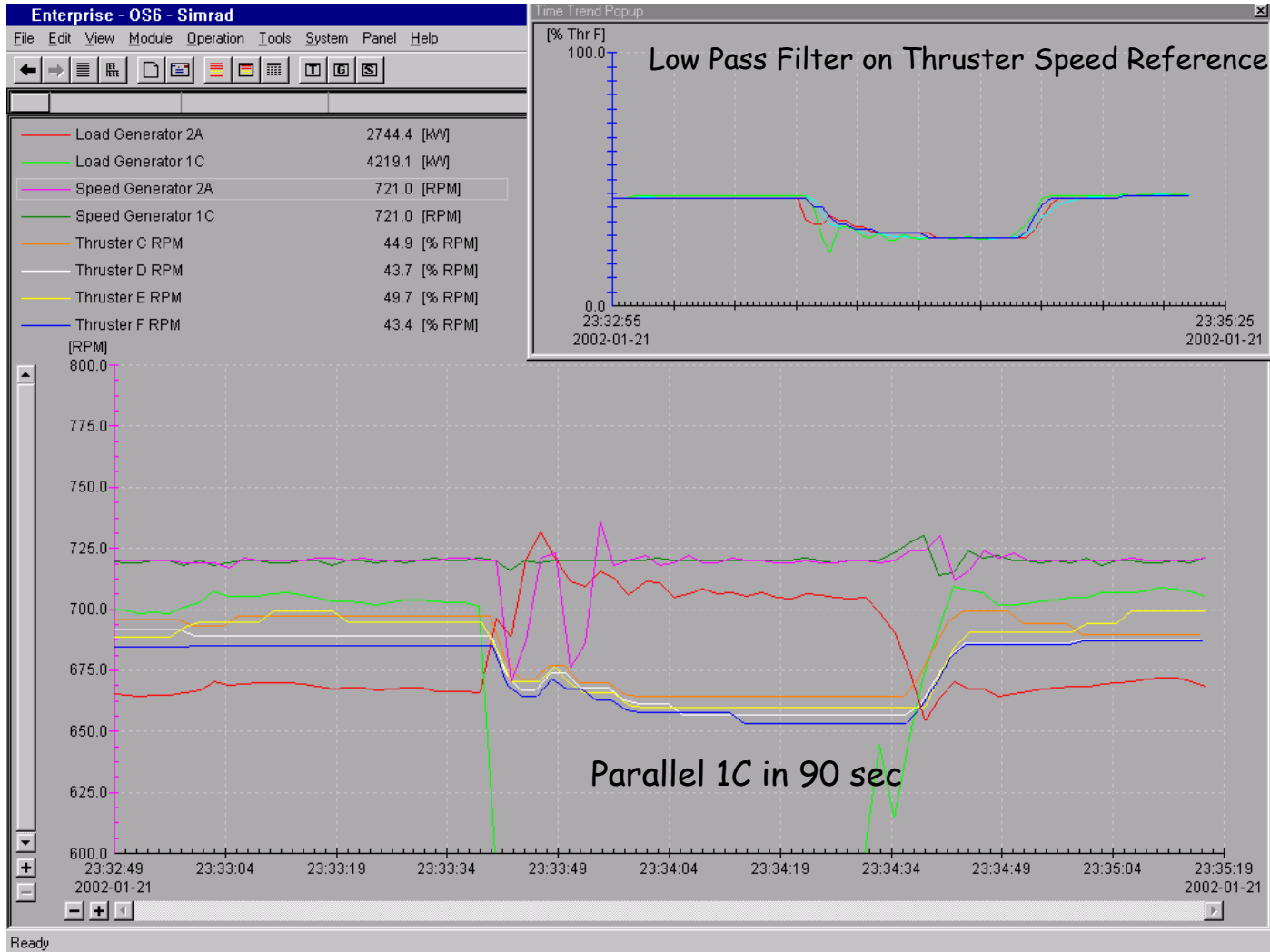


Figure 13 - "Discovery Enterprise" Test

7MW & 4.7MW II with 60%Load

150% Load on 4.7MW Gen

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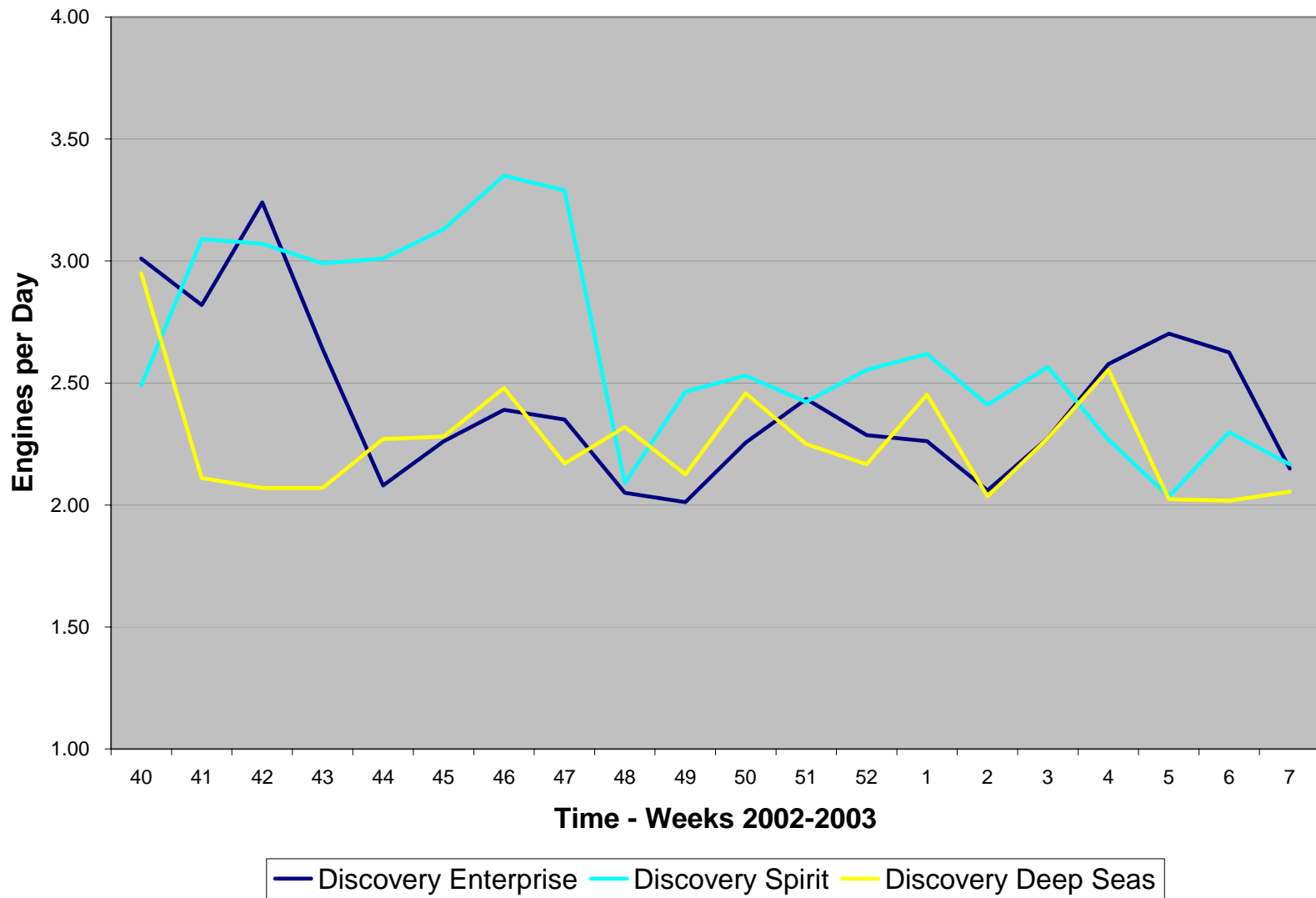


Figure 14 - "Enterprise Class" Engine Hour Summary

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Wartsila Emission Report

- CO emissions are reduced by 42 tons/year; a 59% reduction
- CO₂ emissions are reduced by 491 tons/year; a 1.5% reduction
- Fuel Consumption decreased by 246 tons/year; a 2.5% reduction
- Particulate matter reduced by 5 tons/year; - a 15% reduction
- THC emissions are reduced by 15 tons/year; a 25% reduction
- SO_x emissions are proportional to kW; therefore, no difference
- NO_x emissions are increased to 39 tons/year; an 8 % increase

The improved engine utilization on each "Enterprise" vessels because of the of FSO and PSM modifications have yielded the following benefits:

- Engine hours reduced by more than 25%
- Fuel reduction ~ 10% ~ 300,000 gallons/year
- Lube Oil consumption cut in half
- Overall emissions are reduced
- Engine maintenance and parts reduction ~ \$50,000/year
- Related maintenance labor and parts ~ \$150,000/year

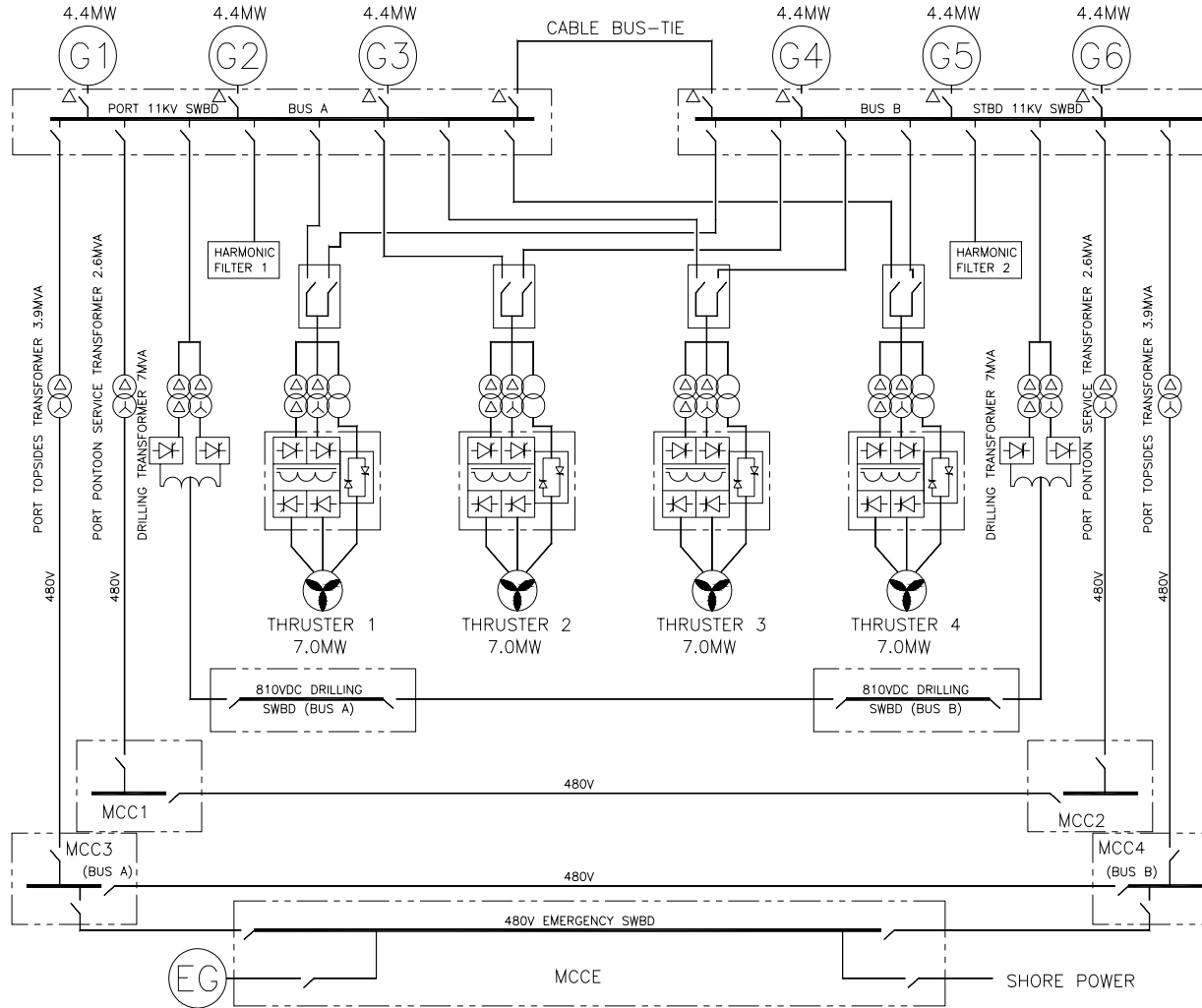


Figure 15 - "Express Class" - Power System One Line Diagram

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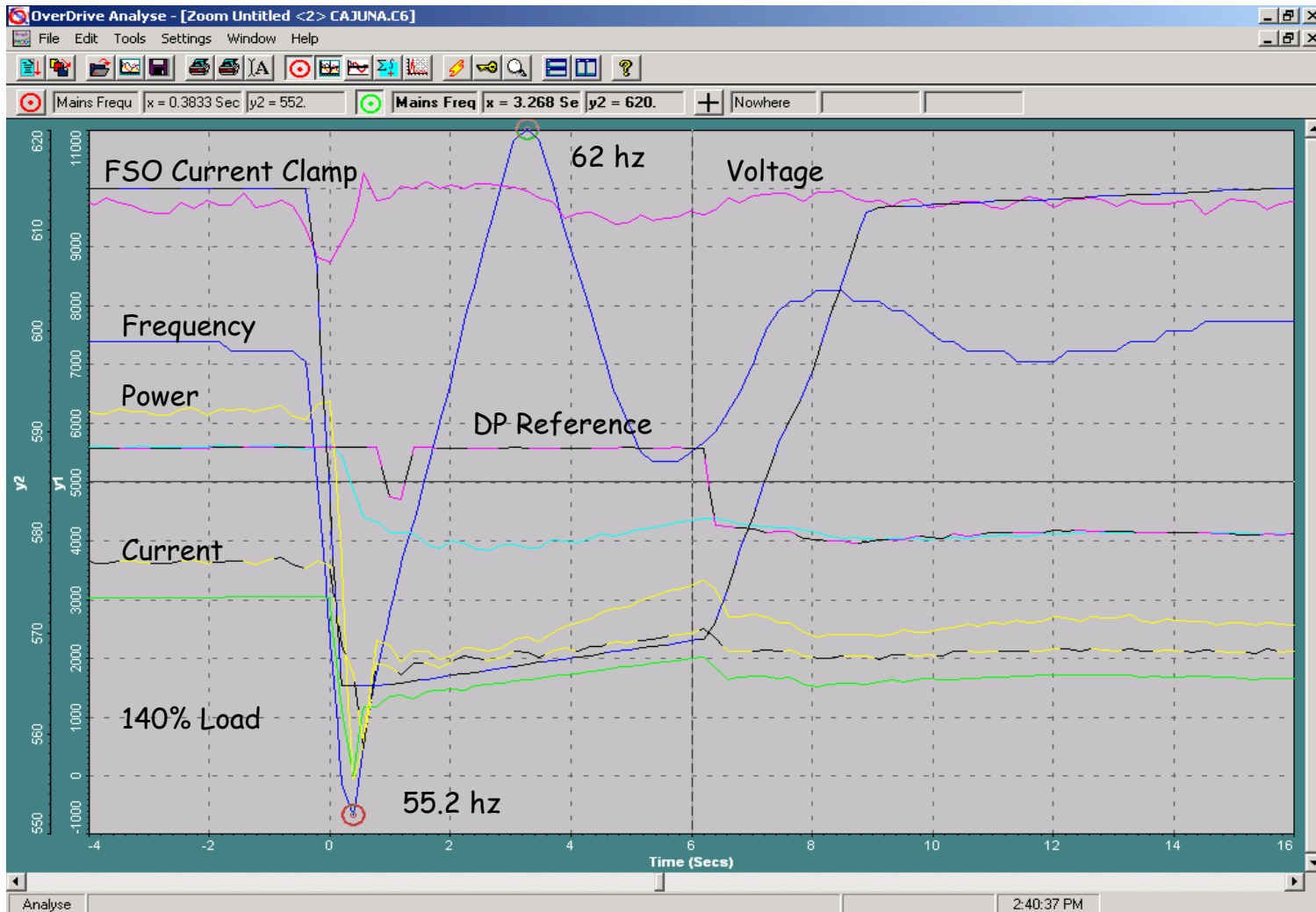


Figure 16 - "Cajun Express" FSO Test

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