POWER

Improving Engine Utilization in DP Vessels

John J. May P.E.,
Transocean Offshore Deepwater Drilling, Inc.

Session Chair – Don Wilkes, GlobalSantaFe

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Improving Engine Utilization on DP Vessels

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Marine Technology Society

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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

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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

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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

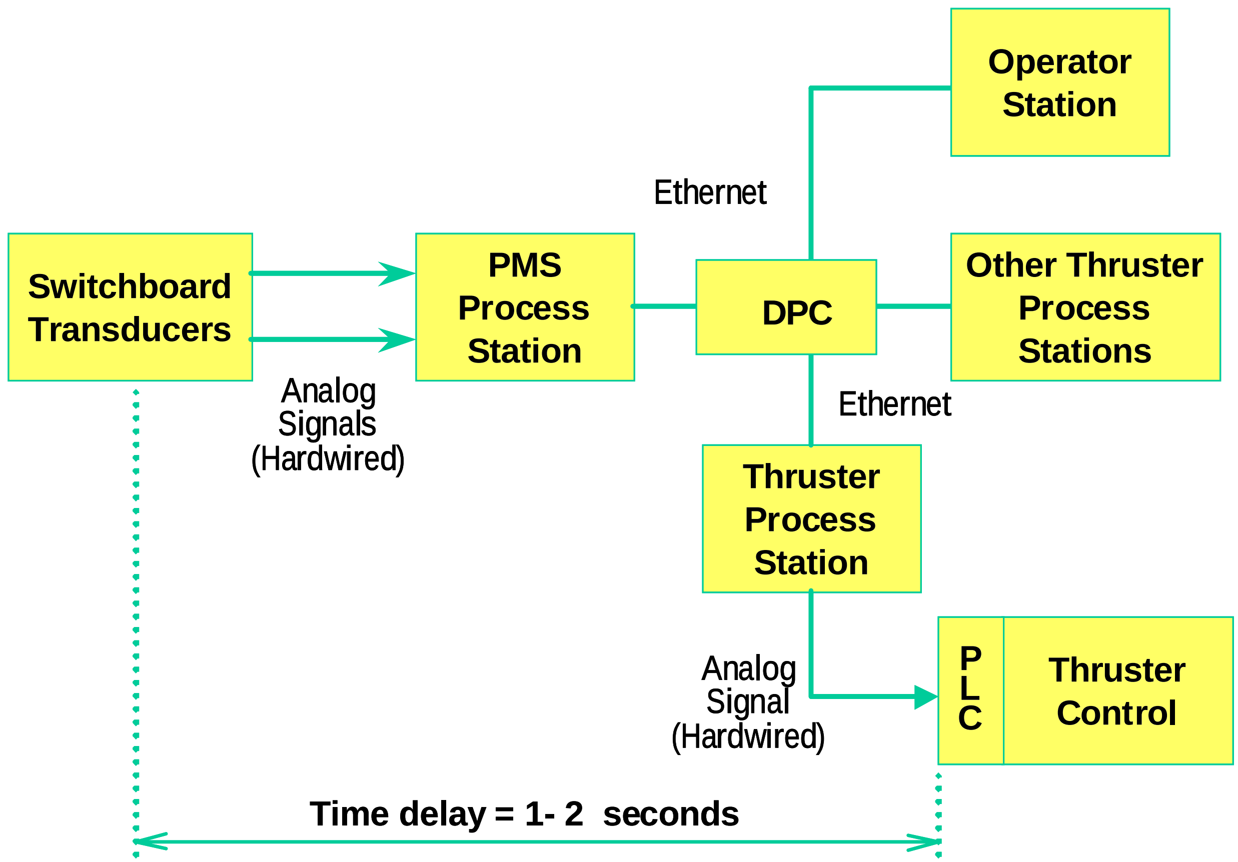

Figure 1 - Thruster Load Limit Delay

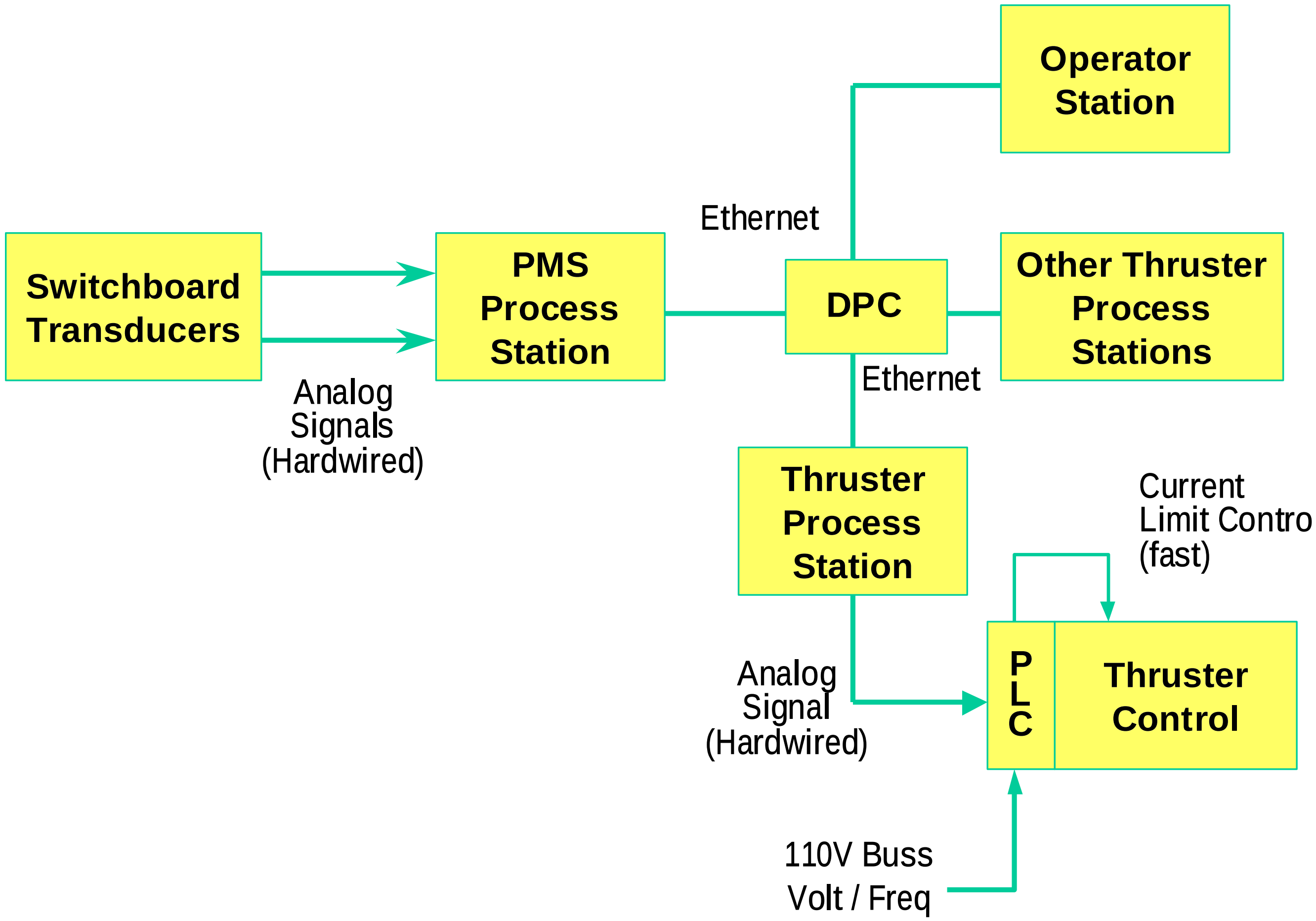

Figure 2 - Frequency Sensitive Power Phase Back

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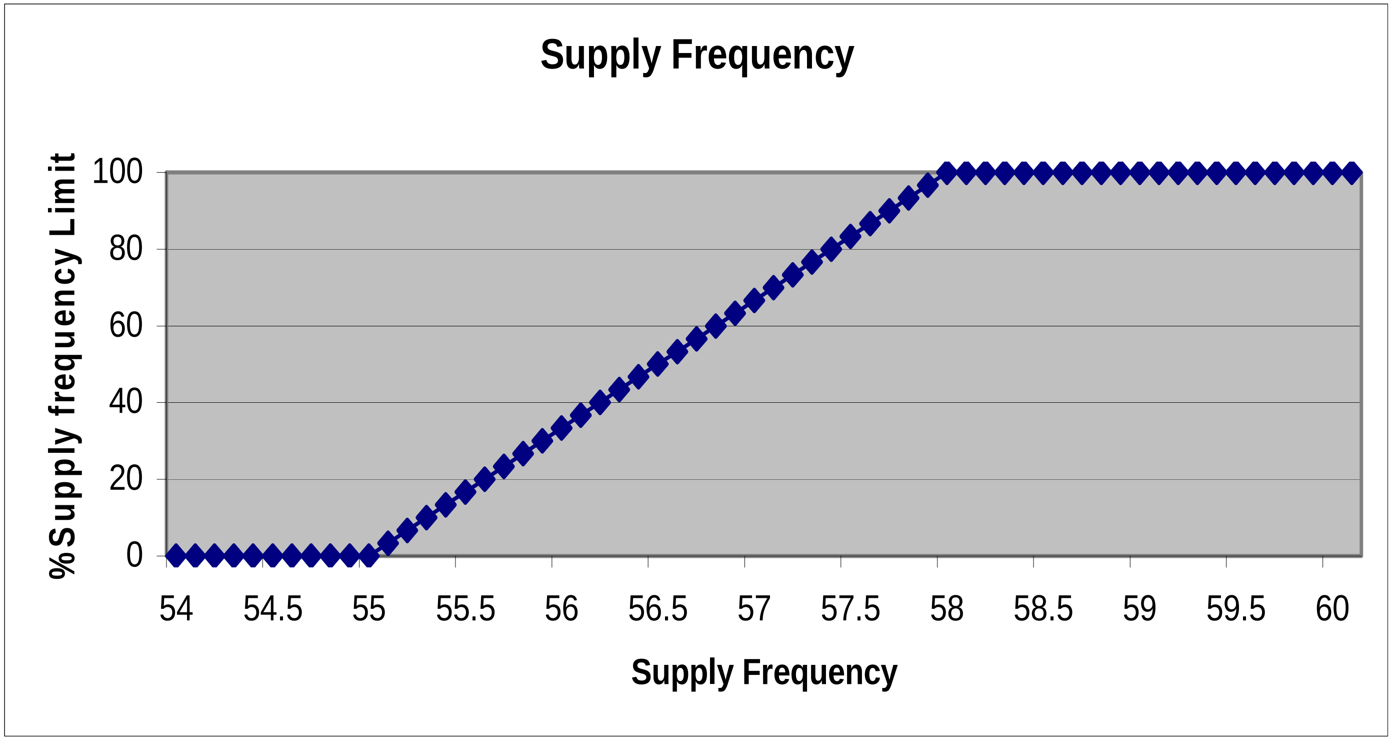

Figure 3 - Initial Phase Back Current Limit

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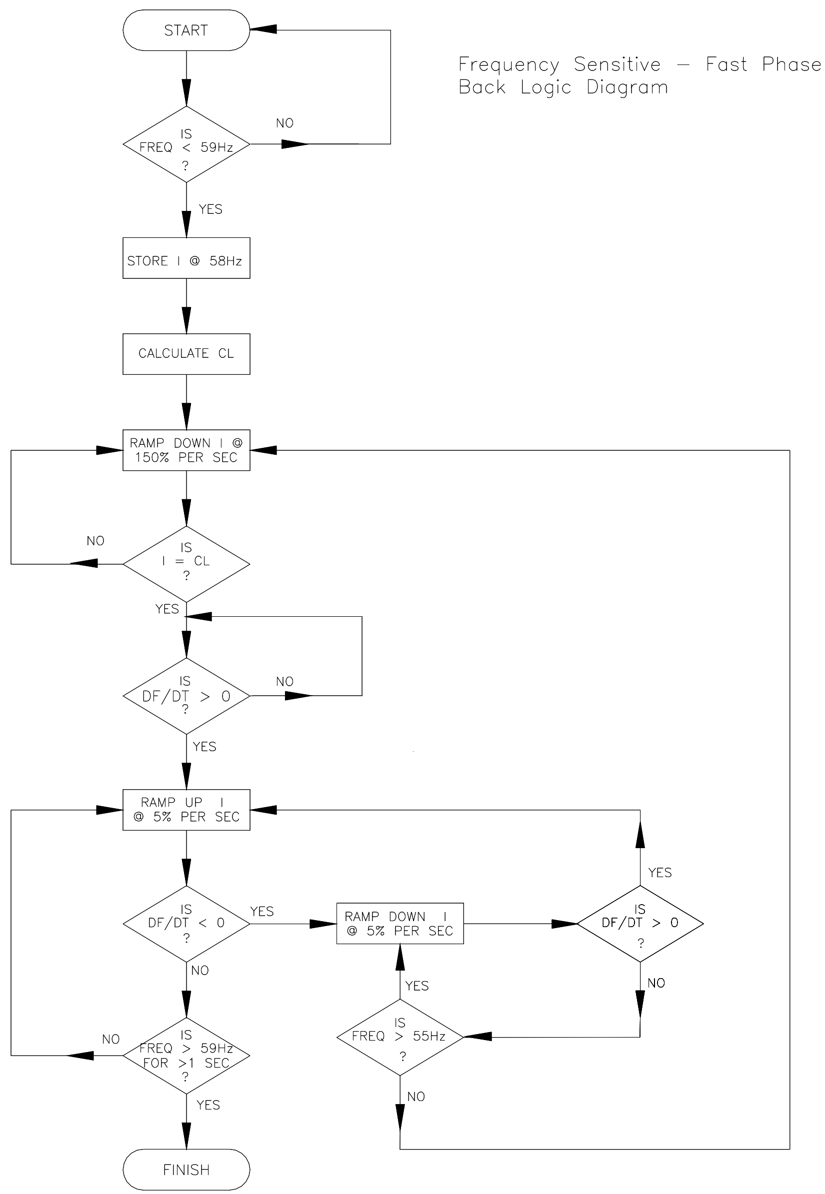
Frequency Sensitive - Fast Phase Back Logic Diagram



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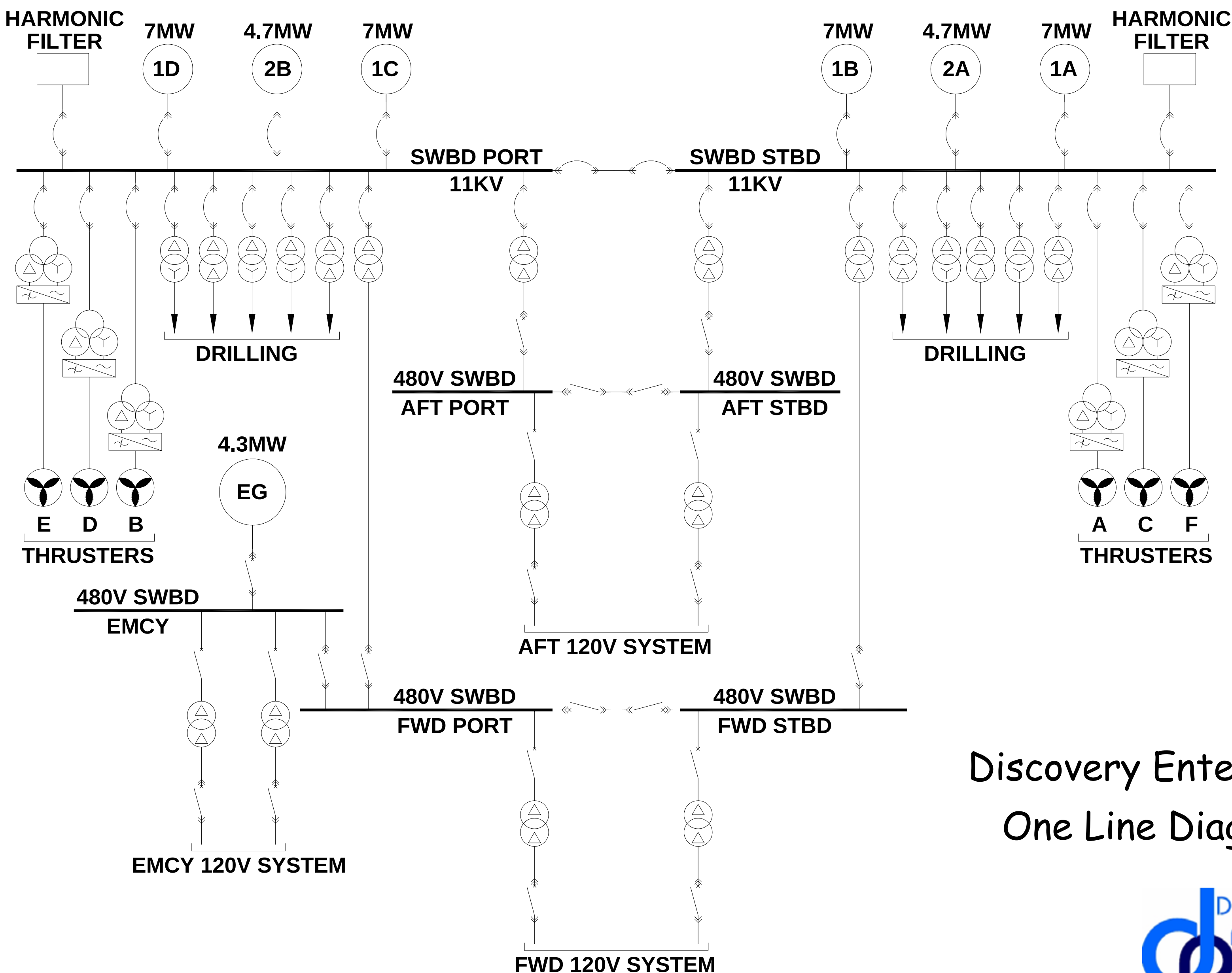

Discovery Enterprise One Line Diagram

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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

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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

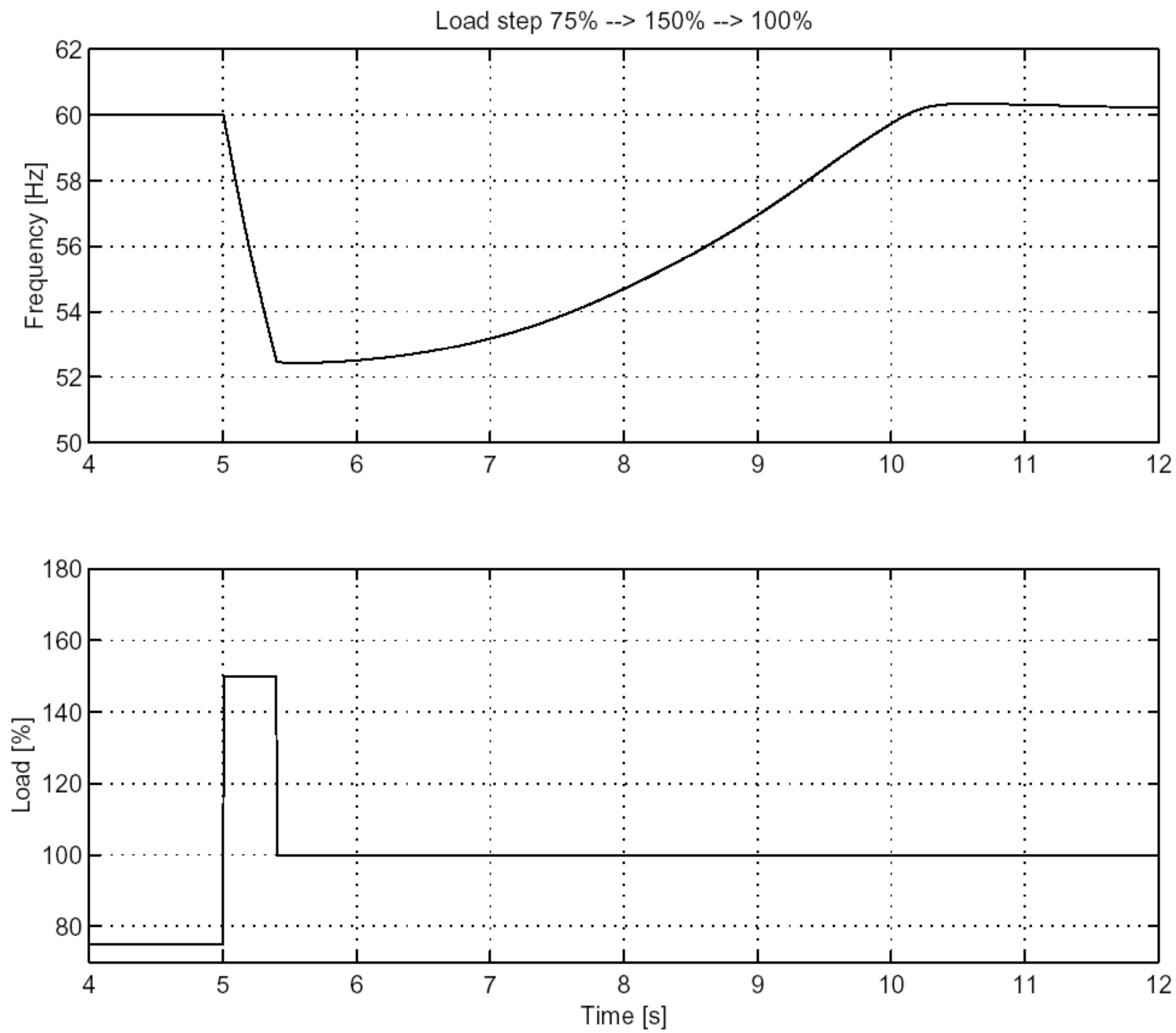

Figure 6 - Engine Response to Step Load Changes

Engines On-Line MW	System Capacity MW	Engine Loss MW	Remaining System Capacity	Overload Capability 110%	Overload Capability 140%	Overload Capability 150%	Overload Capability 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	Start 1		Start 2	
Generators	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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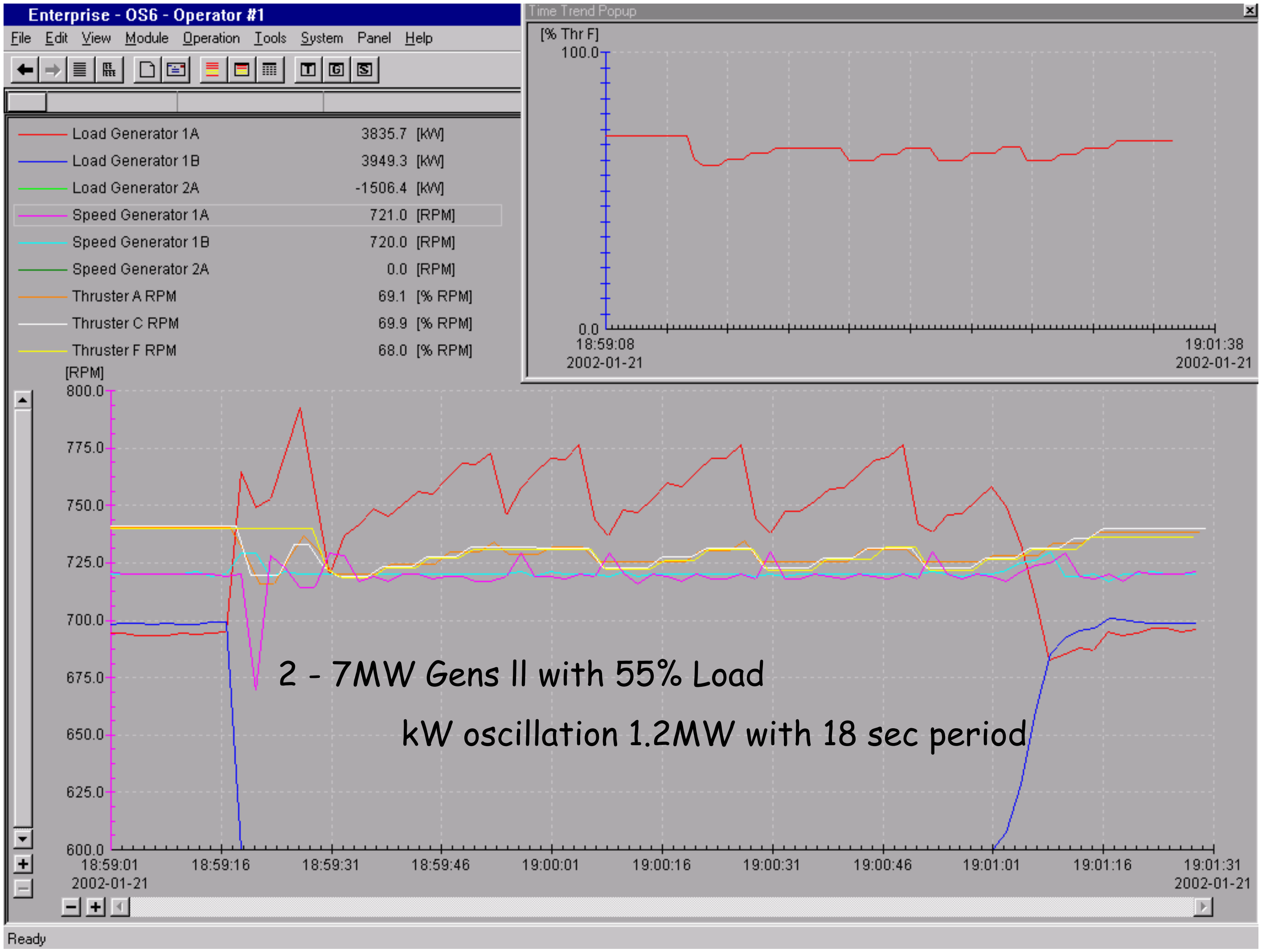

Figure 11 - "Discovery Enterprise" Test

Thrusters: Manual Control FSO program regulates thruster kW

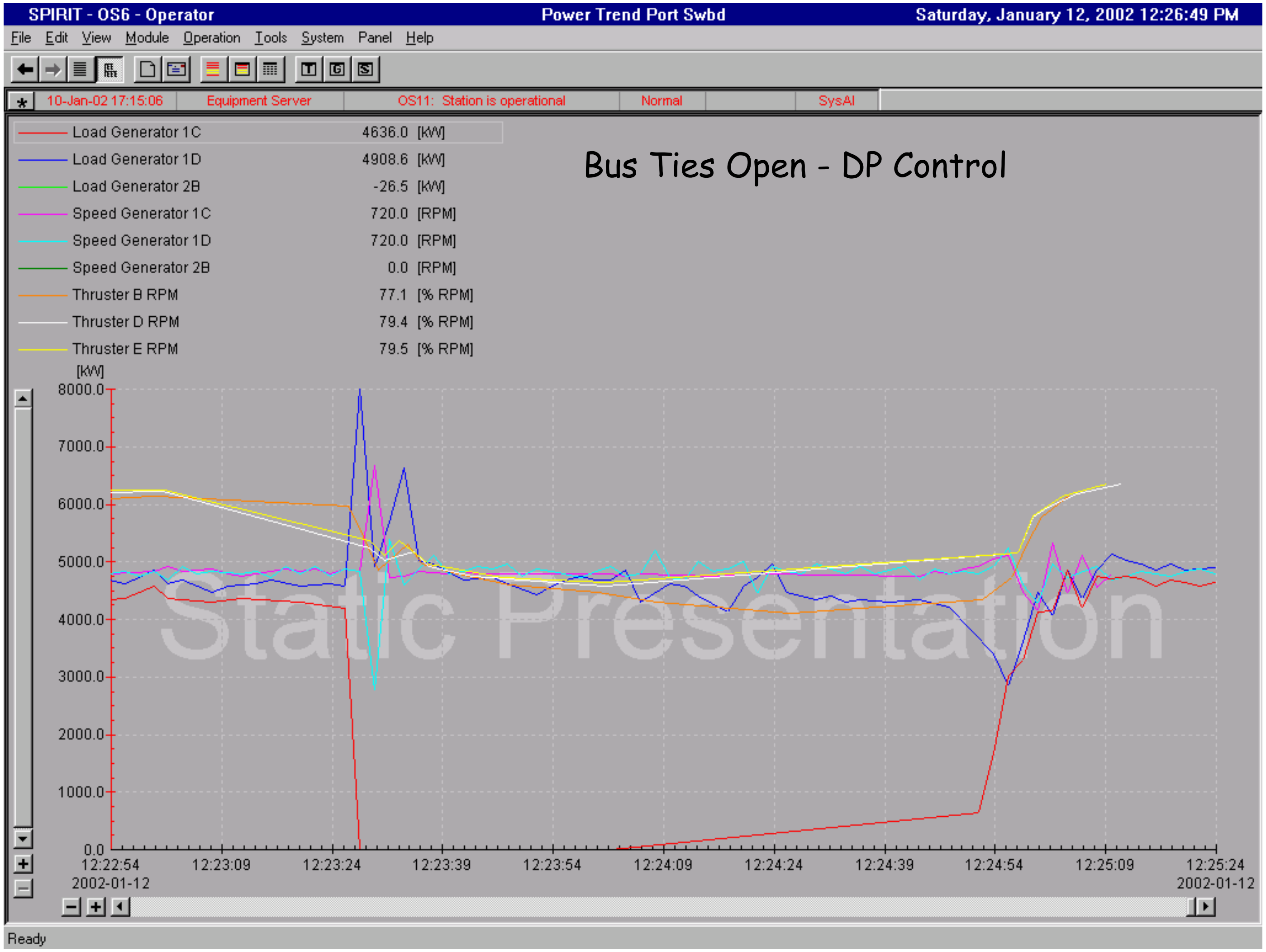

Figure 12 - "Discovery Spirit" Test

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

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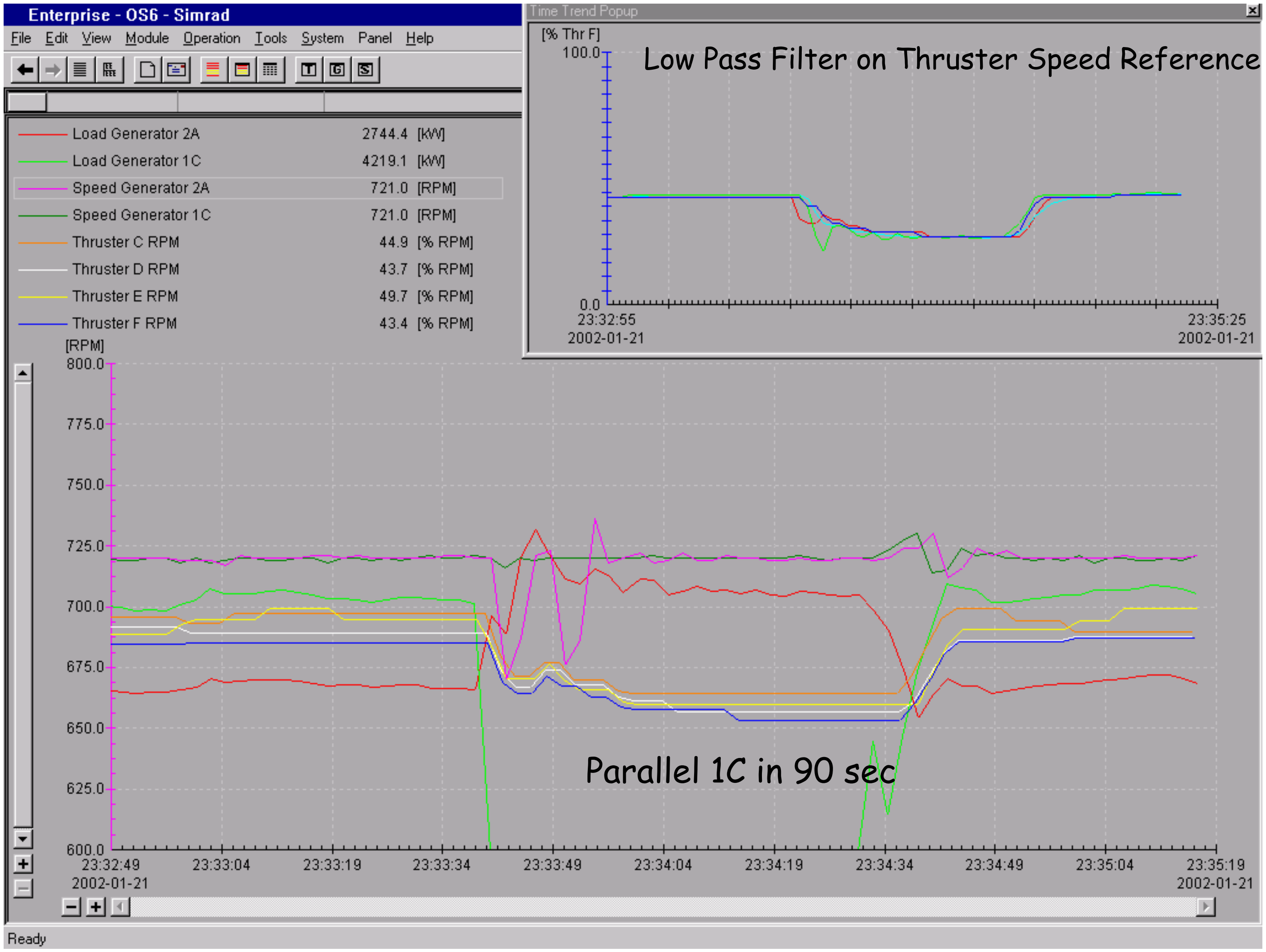

Figure 13 - "Discovery Enterprise" Test

7MW & 4.7MW ll with 60%Load

150% Load on 4.7MW Gen

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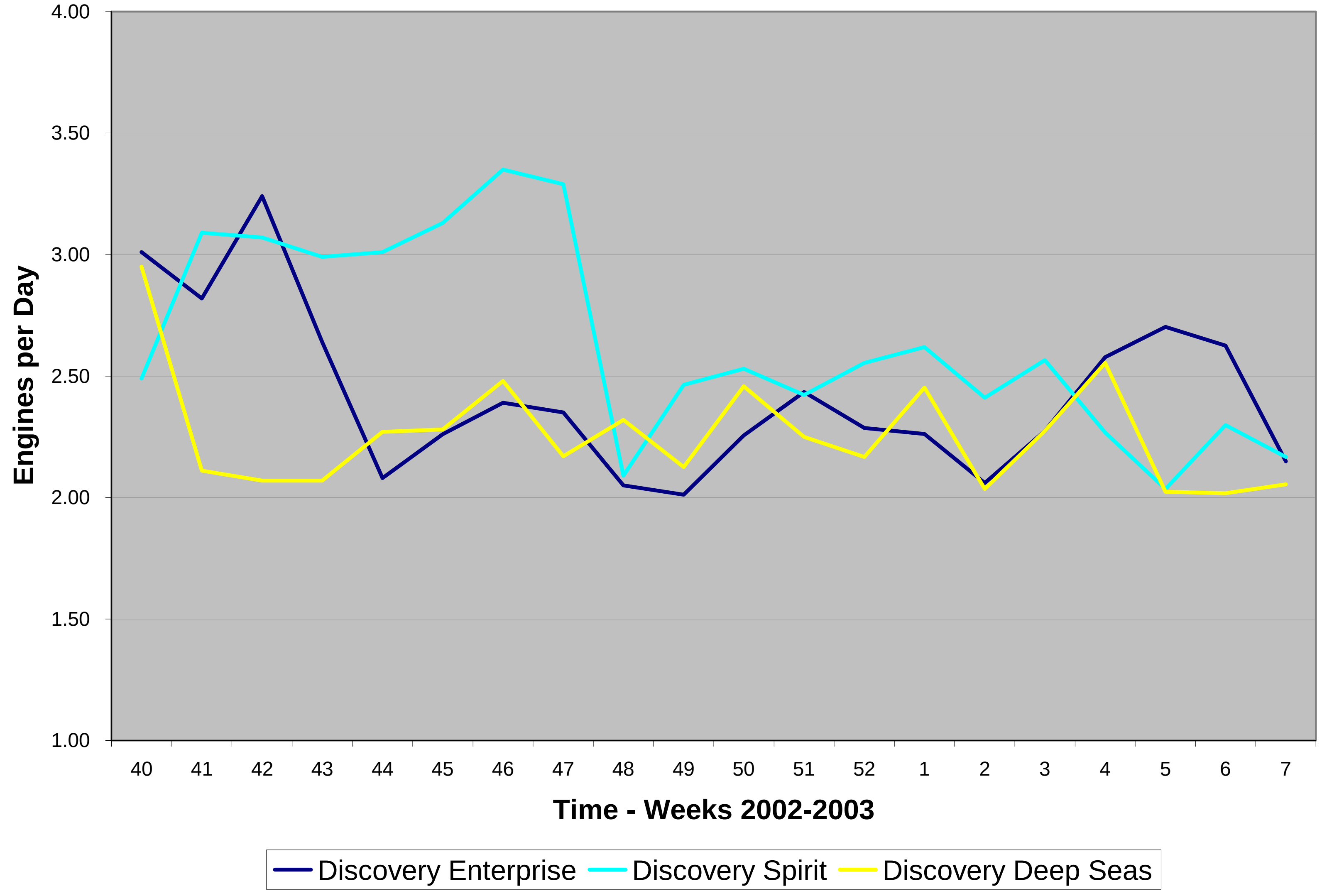

Figure 14 - "Enterprise Class" Engine Hour Summary

Wartsila Emission Report

- CO emissions are reduced by 42 tons/year; a 59% reduction
- CO_2 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

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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

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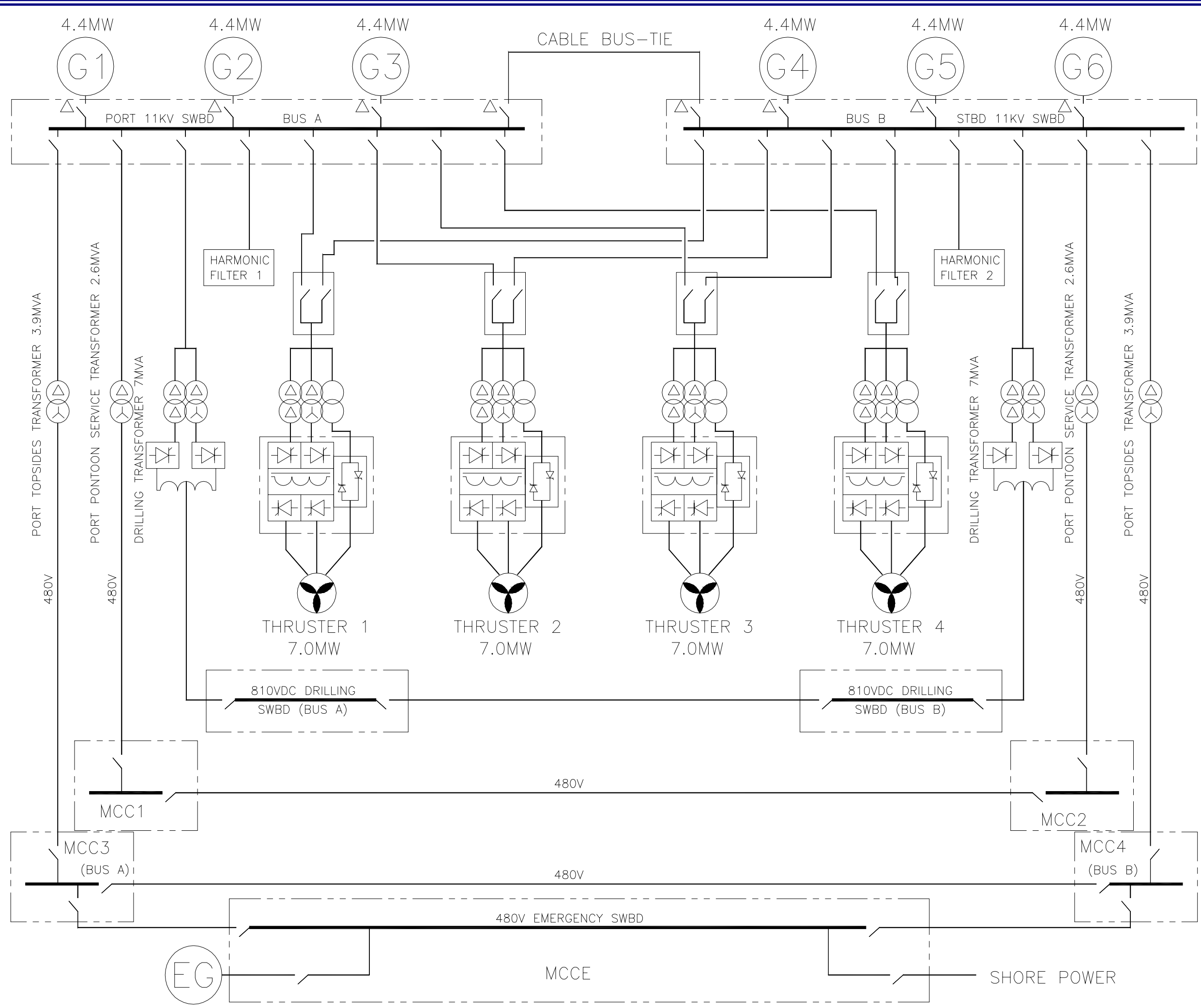

Figure 15 - “Express Class” - Power System One Line Diagram

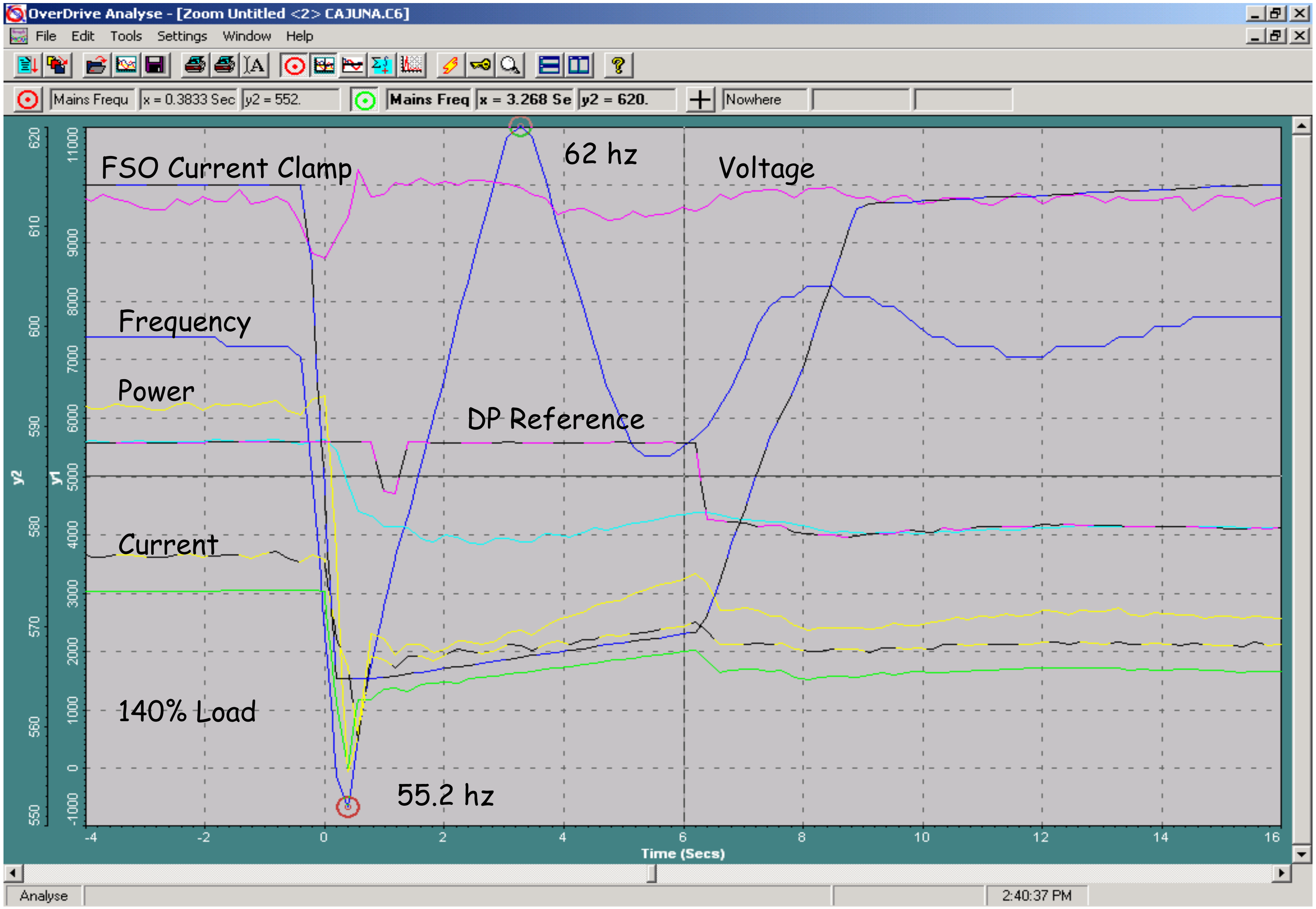

Figure 16 - "Cajun Express" FSO Test

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