Purpose

The aim of these series of reports is to give an update of the AAU Testbench concerning its performance and reliability. The overall goal is to mature the digital hydraulic PTO such that it can be implemented in the next generation of Wavestar's WEC. A status of the Testbench is given together with a list of recommended topics to further improve the performance and reliability.

Executive summary

-   The efficiency of the manifold with the new setup (108 Bucher valves) has a weighted efficiency of 84% which is exactly the same efficiency measured with the old setup (30 Bucher valves and 6 Parker valves).

-   The previously observed sampling time issues (24-april-2015) are considered solved and now the target is able to run the logic at the specified sampling time of 1 millisecond.

Contents

Manifold efficiency: New manifold setup - 108 Bucher valves

The efficiency measurements of the manifold with the new setup are the main results of the report.

The old manifold setup consisted on 30 Bucher on/off valves and 6 Parker servo valves and the new and current manifold setup consists on 108 Bucher on/off valves and no Parker valves.

It is anticipated that there is no significant difference between the old and new setup, see Table 1.

	Weighted efficiency
New manifold setup	84%
Old manifold setup	84%

Table 1: *Weighted manifold efficiencies.*

This fact implies that different valve technologies can be used (combined or alone) without having a negative impact on the manifold efficiency, as long as the consumption of the valves is not taken into account. Parker valves need a servo pressure line to be actuated which consumes a significant amount of power (360W, see testbench report from 06-nov-2014) compared to Bucher valves which is approx. 20W per valves.

The following Matlab code includes the measurements of the new manifold setup, and for reference, the previous measurements of the old manifold setup.

Code to calculate the weighted efficiency:
```
% seaState number    SS11 SS12  SS14  SS15  SS16  SS17  SS18  SS19  SS20
seaStateprob     = [23.3 14.6  8.3   20.6  13.3  7.1   3.8   4.9   4.1];
pAvgOutNew_kW  = [2.1   6.3   3.1   8.3   14.5  21.2  15.2  22.2  29.3];
pAvgOutOld_kW  = [0.9   4.9   1.5   7.5   16.0  24.9  14.8  24.2  32.6];
pAvgInNew_kW   = [3.0   8.0   4.4   10.2  17.0  24.4  17.7  25.3  32.7];
pAvgInOld_kW   = [3.0   8.1   4.4   11.0  20.0  30.0  18.7  29.0  38.4];

yearH            = seaStateprob/100*365*24;
pAvgOutNew_kWh = pAvgOutNew_kW .* yearH;
pAvgOutOld_kWh = pAvgOutOld_kW .* yearH;

weightedEtaNewManifold = sum(pAvgOutNew_kW ./ pAvgInNew_kW .*
(pAvgOutNew_kWh./sum(pAvgOutNew_kWh)));

weightedEtaOldManifold = sum(pAvgOutOld_kW ./ pAvgInOld_kW .*
(pAvgOutOld_kWh./sum(pAvgOutOld_kWh)));
```

The tables 2, 3 and 4 are the measurement results of the new manifold setup.

eta[%]		T0,2		
		3,5	4,5	5,5
Hm0	0,25	-	-	
	0,75	70	70	
	1,25	79	81	
	1,75		85	86
	2,25		87	88
	2,75			90

Table 2: *(Hydraulic) manifold efficiencies of the power matrix of the new manifold setup.*

Pout[kW]		T0,2				Pin[kW]		T0,2		
		3,5	4,5	5,5				3,5	4,5	5,5
Hm0	0,25	-	-			Hm0	0,25	-	-	
	0,75	2,10	3,10				0,75	3,00	4,40	
	1,25	6,30	8,30				1,25	8,00	10,20	
	1,75		14,50	15,20			1,75		17,00	17,70
	2,25		21,20	22,20			2,25		24,40	25,30
	2,75			29,30			2,75			32,70

Table 3: *(Hydraulic) input and output power of the power matrix of the new manifold setup.*

Bc		T0,2				Kc		T0,2		
		3,5	4,5	5,5				3,5	4,5	5,5
Hm0	0,25	-	-			Hm0	0,25	-	-	
	0,75	500000	750000				0,75	-880000	-1380000	
	1,25	500000	880000				1,25	-880000	-1130000	
	1,75		1130000	1380000			1,75		-1130000	-1130000
	2,25		1010000	1630000			2,25		-880000	-1130000
	2,75			1510000			2,75			-880000

Table 4: *Control parameters used for each seastate with the new manifold setup.*
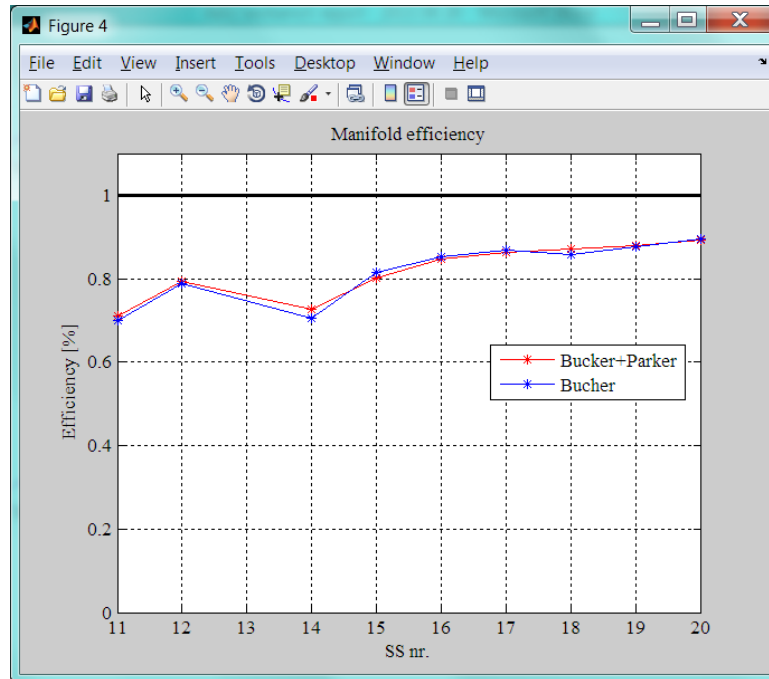
Figure 1: *Efficiency of each seastate with the new (Bucher) and old (Bucher+Parker) manifold setup.*

Sampling time issues

It has been known for a few months (some issues reported in 24-april-2015) that the LabVIEW target had problems keeping the sampling time of the control logic at 1ms. After some help from Michael Bech, Bendt Hejbøl could improve the execution time of the logic so the average sampling time average was 1ms, without having the spike-delays of several milliseconds.

There were several thing which were changed being the main one the use of network variables. They amount of them has been reduced and they were set to run with a FIFO RT buffer.