Type: Performance Test		
Model:	Danvest HSD-648	Serial no.: 41711
Customer:	Danvest Energy A/S	Application: Hybrid Power

Test Report

Danvest HSD-648

Test of Danvest Low Load Diesel for Solar-Diesel Projects

Date August 2015

Content

1. Main Purpose

The main purpose of the Danvest Low Load **H**ybrid **S**olar **D**iesel **S**ystem (HSD System) is to facilitate the use of Solar – and or Wind energy for isolated grids giving the highest possible utilization (high penetration) and as a result the highest possible yearly fuel saving, lowest cost of energy and overall low emissions.

2. Equipment

The tests at Pon Power Esbjerg have been carried out using the following equipment.

Test Danvest HSD-648 Unit:	648kWe genset and 3MWe dumpload
Consumer:	1000kWe load bank PON Power
Solar Supply:	simulated by 300kWe genset with an asynchronous alternator

Picture of the test site at Pon Power Esbjerg

In order to obtain the main purpose – the Danvest hybrid system must be able to:

- Handle both excess power and lack of power resulting from variations in Solar / Wind production and consumption at all times.
- Function as a power backup system for backup of Solar / Wind power production in the full operation range of the Danvest modified genset from 0-100% load.
- Maintain an acceptable power quality of the local isolated grid in cooperation with the local net conditions, the consumers and the Solar / Wind power supply.
- Danvest utilize excess energy to achieve reverse power operation and fast genset responds.
- Dump excess Solar / Wind energy.

3. Operation Modes

An overview of the operation modes of the Danvest HSD System with genset load and fuel consumption can be found in Annex 1. The operation modes includes Normal-, Low Load-, Reverse power and dumpload controlling operation (including dumpload controlling at engine clutch out, engine stop, and engine start).

4. Performance Tests

Pon Power Performance test schemes are enclosed in Annex 2 to 5. The tests have included the various operation modes defined in Annex 1. The following are findings from these tests.

a. Normal Operation

Please refer to Annex 2.

Conclusion on fuel consumption:

- Fuel consumption during this test mode does not show significant deviations from the values in the engine data sheet issued by the engine manufacturer (Cummins).

Conclusion on emissions:

- Emission levels are low compared to nominated Cummins genset figures.

b. Low Load Operation

Please refer to Annex 3.

Conclusion on fuel consumption:

- Fuel consumption during this test mode is close to the estimated values based on intrapolation from the engine data sheet.
- The test results indicate that the Danvest modification gives low load operation with low fuel consumption.

Conclusion on emissions:

- The measured values for NOx and UHC and CO2 are roughly reduced to half (during loads from 30% to 10%).
- During the same test – the CO value is reduced to about 1/3.
- The oxygen percent is increased about 25%.
- The soot value has dropped 60%. There is no Cummins soot values for comparison.
- The above values indicate a more complete combustion.
- The NOx reduction happens due to decreasing combustion temperature.

c. Test Reverse Power Operation

Please refer to Annex 4.

Conclusion on fuel consumption:

- Fuel consumption during this test mode is very close to Danvest expectations – and typically very low compared to the total HSD Plant Output.

- The test results confirm that the Danvest modifications allow the genset to run in reverse power and that the fuel consumption in this mode of reverse operation continues to drop to zero (measured as zero) when all the internal friction in the genset is drawn by excess solar power.

  Further excess solar power is handled by the dumpload system.

Conclusion on emissions:

- All the measured emission values continue to drop.
- There is a clear difference in the emission values between the 2kWe values and the reverse power emission values.
- It is seen during the transition from low load to reverse power that the fuel supply is reduced and turned off.
- As there at -64kWe is seen an oxygen percentage at 21.1% - equal to the oxygen content in atmospheric air. This indicates that there is no fuel combustion i.e. the fuel consumption equals zero as stated elsewhere.

d. Engine Clutched Out (Dumpload Controlling)

Please refer to Annex 5.

Conclusion on fuel consumption:

- Fuel consumption before clutch out is measured as zero.
- Fuel consumption is typically very low compared to the total HSD plant output.
- The test results confirm that the fuel consumption in full reverse power operation before clutch out is zero.

  To avoid long time operation in reverse power mode and unnecessary wear the engine is clutched out and stopped.

Conclusion on emissions:

- Zero emissions when engine is stopped.

e. Engine Stop (Dumpload Controlling)

Please refer to Annex 5.

Conclusion on fuel consumption:

- Fuel consumption after engine stop is zero.

Conclusion on emissions:

- Zero emissions when engine is stopped.

f. Engine Start (Dumpload Controlling)

Please refer to Annex 5.
Engine start-up again when dumpload is reduced to agreed set point level.

Engine start-up: Start-up from stopped engine to genset operation was measured to be within 7 sec.

No black smoke observed from exhaust.

g. Dumpload Controlling

Please refer to Annex 5.
Dumpload controlling takes over controlling when fuel consumption on engine goes in zero. When engine is clutched out the dumpload handles the controlling and frequency is stable.

Conclusion on fuel consumption:

- Fuel consumption after engine stop is zero. The system continues with dumpload controlling (power balance between production and consumption).

Conclusion on emissions:

- Zero emissions when engine is stopped.

5. Step Load Acceptance Test

Please refer to Annex 6.

A typical Danvest Hybrid Solar Diesel plant could be based upon:

- Genset 1: 648kWe
- Genset 2: (Standby, identical): 648kWe
- Consumer maximum load approx. 450-500kWe
- Consumer minimum load approx. 200-300kWe
- Solar cells production rate approx. 600-700kWe

A typical design criterion from SMA is that worst case solar power drop is 80% of rated solar power during 10 seconds. This equals 700 x 0,8 / 10 = 56kWe per sec. up to maximum of 560kWe for this Danvest HSD plant example.

Pon Power and Danvest have tested the Danvest modified 648kWe genset and control system's ability to respond to step load changes. Tests were done starting at:

- full reverse power on genset approx. -65kWe (Load test 1 to 8)
- no load on genset approx. 0kWe (Load test 9 + 10)
- low load on genset approx. 20% load of genset capacity (Load test 11)
- (low) normal load on genset approx. 40% load of genset capacity (Load test 12)

The different step load levels and seconds between steps can be seen from each sheet in Annex 6.

Conclusion on step load tests:

- The AVR maintains good voltage stability with maximum deviation at approx. up to 700V and down to 677V - with target 690V – seen worst case 130kWe step/1 sec.
- There is a modest typical drop in frequency – it is quickly recovered – and there is a slight frequency over shoot when the load has been obtained.
- Frequency drop from reverse power seen in Load Test 1 where load steps are 65kWe (10% of genset capacity) per two sec. – the double dip reach down to approx. 49,5 Hz – and the over shoot reach approx. 50,2 Hz.
- Frequency drop from reverse power seen in Load Test 2 where load steps are 65kWe (10% of genset capacity) per one sec. – the dip reach down to approx. 49,7 Hz – and the over shoot reach approx. 50,15 Hz.
- Frequency drop from reverse power seen in Load Test 7 where load steps are 130kWe (20% of genset capacity) per two sec. – the double dip reach down to approx. 49,2 Hz – and the over shoot reach approx. 50,35 Hz.
- Frequency drop from reverse power seen in Load Test 8 where load steps are 130kWe (20% of genset capacity) per two sec. – the double dip reach down to approx. 49,5 Hz – and the over shoot reach approx. 50,3 Hz.
- Frequency drop from zero load seen in Load Test 10 where load steps are 130kWe (20% of genset capacity) per one sec. – the dip reach down to approx. 49,2 Hz – and the over shoot reach approx. 50,55 Hz.

As these large bumps are quickly recovered and occur only at extreme weather changes and as the hardest tests are done at approx. 130kWe/1 sec. which is approx. 2,3 times the worst case step load level criterion from SMA (56kWe/1 sec.) – it is the view that the Danvest system is able to maintain good grid stability and power quality when operating with Solar power.

The tests results shows that the power quality is as good or even slightly better when responding from reverse power operation compared to responding from low load or normal load.

6. Large Load Step Test

Please refer to Annex 7.

The strength of the combination of the Danvest operation and fast responding capabilities is confirmed in the 2 x one big step load tests from 0-300kWe and 0-400kWe in one step.

The genset is running in full reverse power (-65kWe) when the 1 x one big step load is applied – the system and the genset survives and recovers very fast and become stabile.

The variations in frequency and voltage in worst case test 0-400kWe was measured at:

- Frequency variations min. 48,1Hz / max 50,4Hz.
- Voltage variations min. 667V / max 689V.

7. Conclusion

The Danvest Low Load Hybrid Solar Diesel System is tested as well functioning with minimum fuel consumption and emissions. It has proven itself to be an optimal backup for standalone high penetration Solar (and or Wind) power. It is basically the same Danvest system for both Solar-Diesel and Wind-Diesel.

The Danvest HSD System can operate in low load mode and in reverse power with low emission levels, with the fuel consumption reduced to a minimum. The Danvest HSD System has no or very low fuel consumption when solar (and or Wind) covers the power consumption with 100% or more.

During the test period, the Danvest modified genset was operated for approx. 4 hours in reverse power at minus 10/11% load on the alternator with no actual measurable fuel consumption. When the engine is clutched out and stopped and dumpload controlling handles the controlling, the fuel consumption is zero.

The Step Load Acceptance Tests show that a Danvest HSD System has a fast and stable responds from both reverse power and low load. It ensures a stable and fast spinning reserve all the way down in low load and reverse power operation.

The frequency variations are within +/- 0,5Hz for all load steps tests in reverse power and low load with load steps of 10% of the genset capacity per 1 or 2 sec. (65kWe/1 or 2 sec.) which is approx. 1,2 times the worst case step load level criterion known from the solar industry.

When applying larger load steps of 20% of the genset capacity per 1 or 2 sec. (130kWe/1 or 2 sec.) in reverse power and low load, the frequency variations are maximum from 49,2Hz to 50,55Hz.

The tests show that the responds of the Danvest modified genset in the Danvest HSD System does not significantly vary whether the genset is in reverse power or in low load or normal load operation.

If the engine is clutched out and stopped, it takes 7 sec. from start-up the engine to the genset is ready to carry load. During engine stop with dumpload controlling frequency is stable.

The Danvest HSD System is able to handle and survive large sudden load variations (big load step of approx. 60% of the genset capacity was tested from full reverse power operation).

All tests were performed during July and August 2015 by Pon Power Esbjerg.

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August 2015

Annex 1
– Operation Modes

Danvest Operation Modes Overview				Fuel rate	Specific fuel consumption
Engine	Alternator	Genset	%	L/h	L/kWh
Peak load 110%	150% 100%		110		
Normal Load 100% (701kWm)	Normal	648kWe	100 90	162 140	0,25 0,24
		Load sharing	80 60 40	130 105 73	0,25 0,27 0,28
Low load		low load at 30%	30 20 10 0	60 43 25 13	0,31 0,33 0,39
10 - 11% (internal friction) 0%	0% eletrical motor mode (Alt. is running as electrical motor, pulling the engine)	Reverse power on genset	-5 -10 -11	5 0 0	
Clutch out 1500 rpm		Reverse power Estimated -5kWe			
Cool down 10 sec 1500 rpm		Reverse power Estimated -5kWe			
Engine stop		Reverse power			

Annex 2
– Performance Test Normal Operation

PERFORMANCE TEST NORMAL OPERATION

ENGINE TYPE:	CUMMINS QSK23-G3
ENGINE ARR. NO.:	
ENGINE SERIAL NO.:	00324366
FLYWHEEL POWER:	1030 BHP /1500 rpm
GENSET TYPE:	Leroy Somer
FULL LOAD PERFORMANCE:	830 KVA
GENSET SERIAL NO.:	285452/1
GENSET TYPE. NO.:	LSA 49.1L9 C52S/4

SITE: PON POWER **DATE:** 09-07-15 **SERVICE ENGINEER:** LSP

LOAD TEST :

PROGRAM:

FOR STABLE CONDITIONS - ENGINE RUNNING TIME: 15 MIN. BEFORE TEST START.

NORMAL OPERATION

Comments :

Fuel consumption at 100% load on Danvest genset 0,25 L/kWh
Fuel consumption at 90% load on Danvest genset 0,24 L/kWh
Fuel consumption at 80% load on Danvest genset 0,25 L/kWh
Fuel consumption at 60% load on Danvest genset 0,27 L/kWh
Fuel consumption at 40% load on Danvest genset 0,28 L/kWh

Emission levels remained low in all modes of operation with no pollution of the engine.

LOAD TEST – NORMAL OPERATION

HOUR start :		17.55	18.55	19.40	20.25	20.55
FILE PRINT TIME		18.48	19.31	20.16	20.50	21.32
LOAD %		40	60	80	90	100
FLAB VALVE FILTER INLET AIR	OPEN / CLOSED	OPEN	OPEN	OPEN	OPEN	OPEN
FLAB VALVE GEN. VALVE	OPEN / CLOSED	OPEN	OPEN	OPEN	OPEN	OPEN
FLAB VALVE CHARGE AIR	OPEN / CLOSED	CLOSED	CLOSED	CLOSED	CLOSED	CLOSED
ENGINE PREHEATER	ON/ OFF	OFF	OFF	OFF	OFF	OFF
ENGINE ROOM < 38°C	OPEN / CLOSED	19,0	18,8	18,3	17,7	17,5
CONSUMER	KWe	244	382	514	577	638
GEN. SET PRODUCTION	KWe	247	387	521	586	649
SOLAR	KWe	0	0	0	0	0
DUMPLOAD	KWe	2	2	2	2	2
AUX	KWe	1	3	5	7	9
PRODUCED POWER	KW	200	240	280	320	300
PRODUCED POWER / HOUR	KWH	238,1	370,3	507,0	581,8	639,4
PRODUCED POWER TIME	MIN/SEC	50.24	38.53	33.08	33.00	28.09
AMBIENT TEMPERATURE OUTSIDE	°C	13,6	12,9	12,5	12,2	12,2
AMBIENT TEMPERATURE INSIDE ENGINE ROOM	°C	21,0	18,8	18,3	17,7	17,4
AMBIENT TEMP INSIDE ENGINE ROOM (PON)	°C	19,0	16,1	15,7	15,0	15,0
AMBIENT TEMP ABOVE ENGINE (PON)	°C	22,1	19,0	17,9	16,8	16,1
RPM		1500	1501	1500	1500	1501
LUBE OIL PRESSURE	BAR					
COOLING WATER TEMPERATURE INLET ENGINE	°C	78,0	78,0	78,0	78,0	78,1
COOLING WATER TEMP OUTLET ENGINE	°C	81,3	81,9	82,3	82,5	82,7
COOLING WATER PRESS	BAR	2,2	2,2	2,2	2,2	2,2
CHARGE AIR TEMPERATURE	°C	37,3	39,1	40,7	41,5	42,4
CHARGE AIR PRESSURE	BAR	0,57	1,09	1,50	1,70	1,94
CRANKCASE PRESSURE	mBAR	0,8	0,8	0,8	1,0	1,0
EXHAUST STACK TEMP.	°C	428	484	504	510	512
EXHAUST BACKPRESSURE	Mbar	12,5	16,5	20,0	24,0	28,0
O^2	% VOL	12,45	11,00	10,02	9,57	9,30
CO	PPM	211	137	180	206	258
NOX	PPM	823	770	1142	1351	1501
UHC	PPM	620	650	670	710	710
CO^2	% VOL	6,19	7,13	7,85	8,15	8,36

SOOT NUMBER		NA	NA	NA	NA	NA
FUEL CONSUMPTION – Cummins	L / HOUR					
FUEL CONSUMPTION – PON (LOAD CELLS)	KG	44,9	51,6	56,7	62,3	59,7
FUEL CONSUMPTION – PON (LOAD CELLS)	L / HOUR	66	98	127	140	157
FUEL CONSUMPTION	L / KWH	0,28	0,27	0,25	0,24	0,25
FUEL PRESSURE	BAR					
FUEL TEMP IN.	°C	32,4	31,2	30,8	30,4	30,1
FUEL TEMP OUT.	°C	65,8	63,0	63,2	63,2	63,0
FUEL COOLER OUTLET	°C	43,2	38,6	38,9	38,0	36,9
VOLTAGE U1-U2	V	688	687	689	688	688
VOLTAGE U2-U3	V	688	687	689	688	688
VOLTAGE U3-U1	V	688	687	689	688	688
CURRENT L1	A	207	326	438	494	546
CURRENT L2	A	206	324	437	492	545
CURRENT L3	A	204	323	435	491	544
LOAD	KW	247	387	521	586	649
VOLTAGE	V	688	687	689	688	688
CURRENT	A.	206	324	437	492	545
FREQUENCY	Hz	50,0	50,0	50,0	50,0	50,0
READING MADE BY:	INT.	LSP	LSP	LSP	LSP	LSP

Annex 3
– Performance Test Low Load Operation

PERFORMANCE TEST LOW LOAD OPERATION

SITE: PON POWER **DATE:** 07-07-2015 **SERVICE ENGINEER:** LSP

PROGRAM:

FOR STABLE CONDITIONS - ENGINE RUNNING TIME: 15 MIN. BEFORE TEST START.

LOW LOAD OPERATION < 190 KW

Comments :

Fuel consumption at 30% load on Danvest genset 0,31 L/kWh
Fuel consumption at 20% load on Danvest genset 0,33 L/kWh
Fuel consumption at 10% load on Danvest genset 0,39 L/kWh

Emission levels remained low in all modes of operation with no pollution of the engine.

LOAD TEST – LOW LOAD

HOUR start :		10.42	11.40	13.05
FILE PRINT TIME		11.31	12.50	13.50
LOAD %		10	20	30
FLAB VALVE FILTER INLET AIR	OPEN / CLOSED	CLOSED	CLOSED	OPEN
FLAB VALVE GEN. VALVE	OPEN / CLOSED	CLOSED	CLOSED	OPEN
FLAB VALVE CHARGE AIR	OPEN / CLOSED	OPEN	OPEN	CLOSED
ENGINE PREHEATER	ON/ OFF	ON	ON	OFF
ENGINE ROOM > 38°C	OPEN / CLOSED	31	33	33
CONSUMER	KW	61,5	125,5	189
GEN. SET PRODUCTION	KW	65	129	193
SOLAR	KW			
DUMPLOAD	KW	2	2	2
AUX	KW	1,5	1,5	2
PRODUCED POWER	KW	30	100	100
PRODUCED POWER / HOUR	KWH	66,5	123,9	180,6
PRODUCED POWER TIME	MIN/SEC	27.03	48.25	33,13
AMBIENT TEMPERATURE OUTSIDE	°C	19,2	21,5	22,4
AMBIENT TEMPERATURE INSIDE ENGINE ROOM	°C	31	33	28
AMBIENT TEMP INSIDE ENGINE ROOM (PON)	°C	28,7	30,6	25,7
AMBIENT TEMP ABOVE ENGINE (PON)	°C	29,6	31,1	35,1
RPM		1499	1500	1501
LUBE OIL PRESSURE	BAR			
COOLING WATER TEMPERATURE INLET ENGINE	°C	77,6	80,1	78,0
COOLING WATER TEMP OUTLET ENGINE	°C	80,2	82,4	81,2
COOLING WATER PRESS	BAR	2,4	2,4	2,4
CHARGE AIR TEMPERATURE	°C	55,0	62,6	43,9
CHARGE AIR PRESSURE	BAR	0,16	0,27	0,39
CRANKCASE PRESSURE	mBAR	0,6	0,6	0,8
EXHAUST STACK TEMP.	°C	270	371	411
EXHAUST BACKPRESSURE	mBAR	10	13	15
O^2	% VOL	16,54	13,55	12,46
CO	PPM	77	123	204
NOX	PPM	458	760	903
UHC	PPM	220	240	400
CO^2	% VOL	3,29	5,05	6,10

SOOT NUMBER		3	4,5	5
FUEL CONSUMPTION – Cummins	L / HOUR			
FUEL CONSUMPTION – PON (LOAD CELLS)	KG	9,5	26,2	24,7
FUEL CONSUMPTION – PON (LOAD CELLS)	L / HOUR	26	41	56
FUEL CONSUMPTION	L / KWH	0,39	0,33	0,31
FUEL PRESSURE	BAR			
FUEL TEMP IN.	°C	39,5	44,7	45,7
FUEL TEMP OUT.	°C	74,8	78,2	75,3
FUEL COOLER OUTLET	°C	43,7	46,8	46,6
VOLTAGE U1-U2	V	688	688	687
VOLTAGE U2-U3	V	688	688	687
VOLTAGE U3-U1	V	688	688	687
CURRENT L1	A	54	121	182
CURRENT L2	A	56	122	181
CURRENT L3	A	57	124	184
LOAD	KW	65	129	193
VOLTAGE	V	688	688	687
CURRENT	A.	56	122	181
FREQUENCY	Hz	50,0	50,0	50,0
READING MADE BY:	INT.	LSP	LSP	LSP

Annex 4
– Performance Test Reverse Power Operation on Genset

PERFORMANCE TEST REVERSE POWER OPERATION ON GENSET

SITE: PON POWER **DATE:** 09-07-2015 **SERVICE ENGINEER:** LSP

PROGRAM:

FOR STABLE CONDITIONS - ENGINE RUNNING TIME: 15 MIN. BEFORE TEST START.

REVERSE OPERATION ON GENSET :

Comments :

Fuel consumption incl. emission at Reverse power operation.

Fuel consumption at 0% load on Danvest genset 13 L/hours
Fuel consumption at -5% load on Danvest gesent 5 L/hours
Fuel consumption at -10/11% on Danvest genset 0 L/hours

As a special test, the Danvest genset was operated for approx. 4 hours in reverse power at minus 10/11% and no actual fuel consumption was measured.

Emission levels remained low and there was no measurable pollution of the engine registered during and after the reverse power test performed.

LOAD TEST – REVERSE POWER

HOUR start :		15.00	10.05	11.20
FILE PRINT TIME		15.40	11.13	14.40
LOAD %		0	- 5	-10
FLAB VALVE FILTER INLET AIR	OPEN / CLOSED	CLOSED	CLOSED	CLOSED
FLAB VALVE GEN. VALVE	OPEN / CLOSED	CLOSED	CLOSED	CLOSED
FLAB VALVE CHARGE AIR	OPEN / CLOSED	OPEN	OPEN	OPEN
ENGINE PREHEATER	ON/ OFF	ON	ON	ON
ENGINE ROOM > 38°C	OPEN / CLOSED	35	38	38
CONSUMER	KW	0	0	0
GEN. SET PRODUCTION	KW	2	-35	-64
SOLAR	KW	0	38,5	122,5
DUMPLOAD	KW	2	2	58
AUX	KW	1,5	1,5	1,5
PRODUCED POWER	KW	0	0	0
PRODUCED POWER / HOUR	KWH	0	0	0
PRODUCED POWER TIME	MIN/SEC	36.37	1.05.13	1.13.00
AMBIENT TEMPERATURE OUTSIDE	°C	20,4	11,7	14,3
AMBIENT TEMPERATURE INSIDE ENGINE ROOM	°C	35	36	35
AMBIENT TEMP INSIDE ENGINE ROOM (PON)	°C	33,2	33,1	32,9
AMBIENT TEMP ABOVE ENGINE (PON)	°C	31,1	48,9	49,1
RPM		1499	1500	1500
LUBE OIL PRESSURE	BAR			
COOLING WATER TEMPERATURE INLET ENGINE	°C	68,4	73,6	72,7
COOLING WATER TEMP OUTLET ENGINE	°C	76,3	77,0	76,3
COOLING WATER PRESS	BAR	2,4	2,2	2,2
CHARGE AIR TEMPERATURE	°C	53,6	55,6	58,0
CHARGE AIR PRESSURE	BAR	0,08	0,03	0,01
CRANKCASE PRESSURE	mBAR	0,6	0,6	0,6
EXHAUST STACK TEMP.	°C	179	113	70
EXHAUST BACKPRESSURE	mBAR	9,0	12,0	9,0
O^2	% VOL	18,67	20,0	21,1
CO	PPM	144	198	0
NOX	PPM	209	76	2
UHC	PPM	530	410	80
CO^2	% VOL	1,68	0,72	

SOOT NUMBER		1	1	0
FUEL CONSUMPTION – Cummins	L / HOUR			
FUEL CONSUMPTION – PON (LOAD CELLS)	KG	6,2	4,1	0
FUEL CONSUMPTION – PON (LOAD CELLS)	L / HOUR	13	5	0
FUEL PRESSURE	BAR			
FUEL TEMP IN.	°C	42,1	34,2	33,2
FUEL TEMP OUT.	°C	75,1	71,9	70,7
FUEL COOLER OUTLET	°C	43,6	43,3	37,1
VOLTAGE U1-U2	V	689	688	687
VOLTAGE U2-U3	V	689	688	687
VOLTAGE U3-U1	V	689	688	687
CURRENT L1	A	0	77	99
CURRENT L2	A	0	74	96
CURRENT L3	A	0	75	100
LOAD	KW	0	-35	-63
VOLTAGE	V	689	688	687
CURRENT	A.	0	74	96
FREQUENCY	Hz	50,0	50,0	50,0
READING MADE BY:	INT.	LSP	LSP	LSP

Comment: 0% load has been performed 07-07-2015.

Annex 5
– Performance Test Dumpload Controlling

(at engine clutch out, engine stop and engine start)

Performance Test Dumpload Controlling

(at engine clutch out, engine stop and engine start)

Consumer kW/h	Solar kW/h	HWD genset kW/h	Operation mode	Dump kW/h	Consumption + Dump kW/h	Production Solar+ genset kW/h	Cooling water temperature C^0	Hz	Fuel L/h	Plant layout L/kWh	Genset layout L/kWh
192	0	200	N	8	200	200	78,3	50	66	-	0,28
192	150	50	LLO	8	200	200	79,2	50	26	0,23	0,39
143	149	2	Idle	8	151	151	76,7	50	13	0,2	-
143	200	-49	Idle	8	151	151	74,8	50	6	0,1	-
129	201	-64	Idle	8	137	137	74,1	50,3*	0	0,08	-
110	197	-64	S.Idle	(20*) 23	133	133	74,5	50,3	0	0,08	-
				Engine clutch out**		☑ Mark OK					
				Engine stop ***		☑ Mark OK					
110	200	-3	E.Stop	87	200	200	74,2	50,3	0		-
105	200	-3	E.Stop	92	200	200	73,9	50,3	0		-
105	123	-3	E.Stop	(15****) 15	123	123	72,6	50,3	0		-
				Engine start		☑ Mark time	7				
				Engine clutch in		☑ Mark time					
			LLO	****	(Total time) 8			50			
				Engine clutch out/ stop*****							
81	153	-64	Idle	8	89	89	74,7	50	0	0,1	-
194	150	52	LLO	8	202	202	75,8	50	26	0,23	-

* = set point

**= 1 minute timing / if < 20kW during 1 minute = back to engine clutch out

***= 1 minute timing / if < 20kW during 1 minute = back to engine clutch out

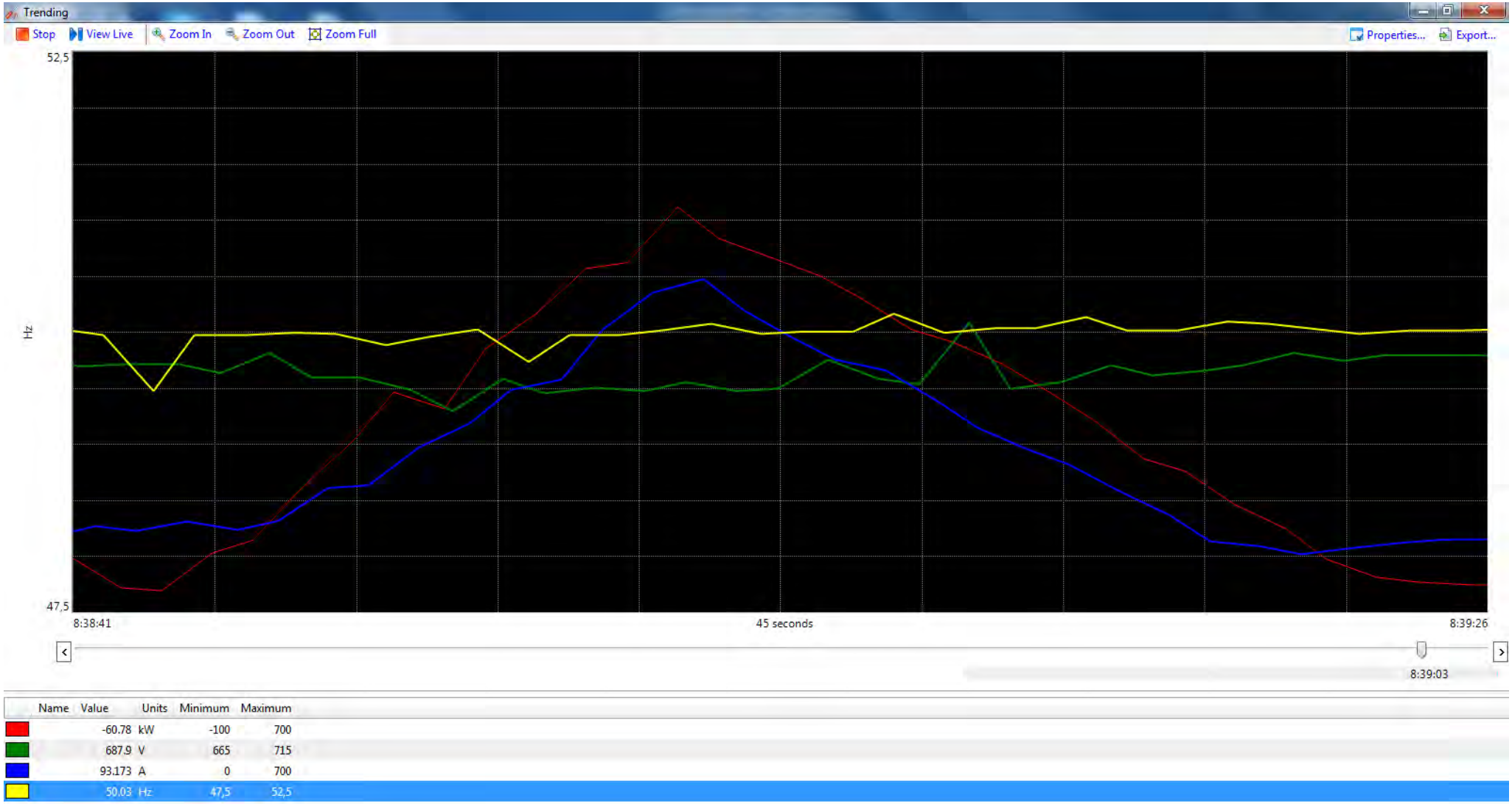
****= from set point 15 time registration until 1500rpm (Total time)

*****=120 minute timing

Annex 6
– Step Load Acceptance Test

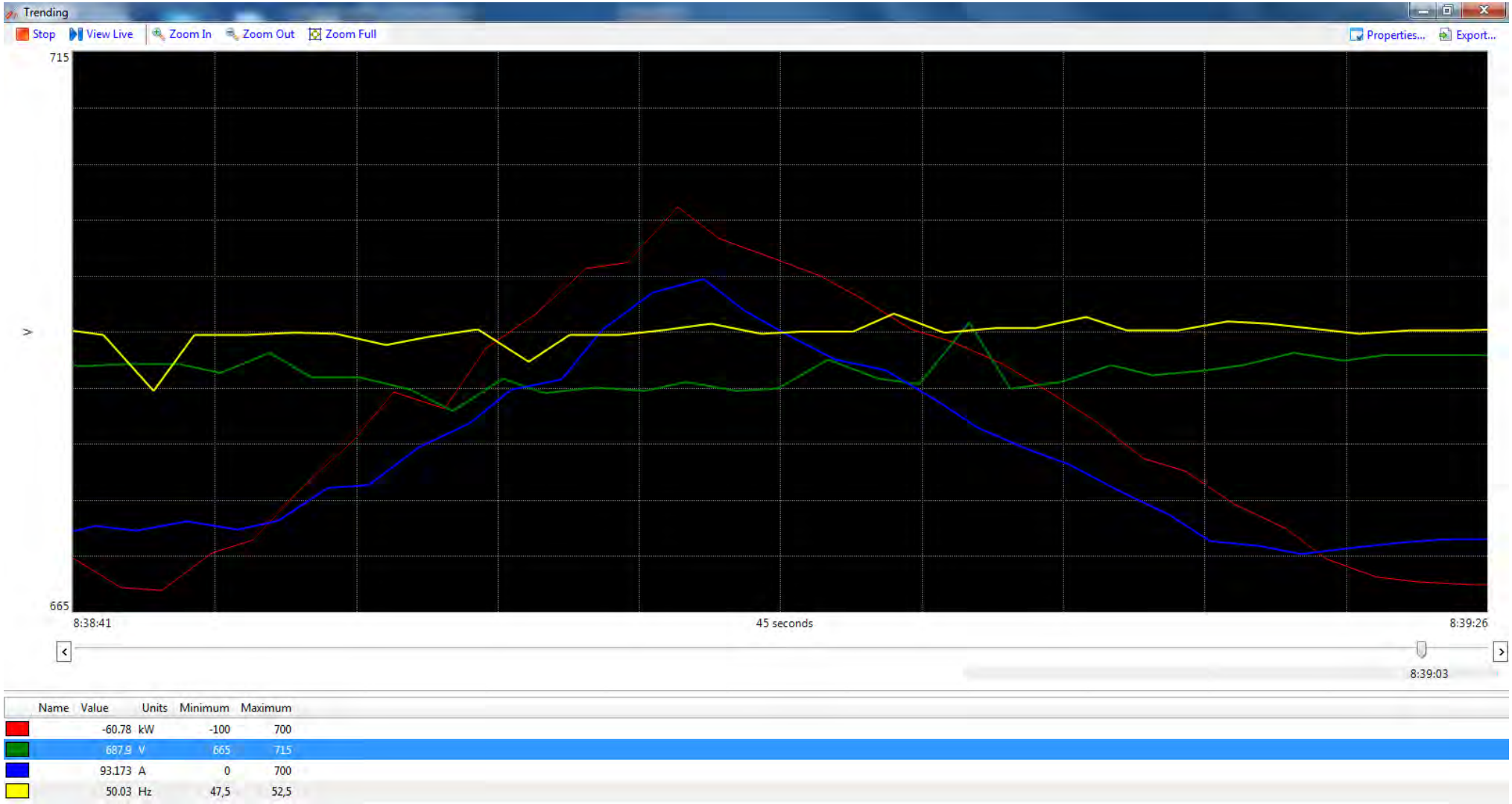
Danvest load test 1: Full reverse power, 63KW, no dumpload, 10% load (65kW) per step, 2 seconds between steps.

Frequency variation min. 49,5Hz / max 50,2Hz



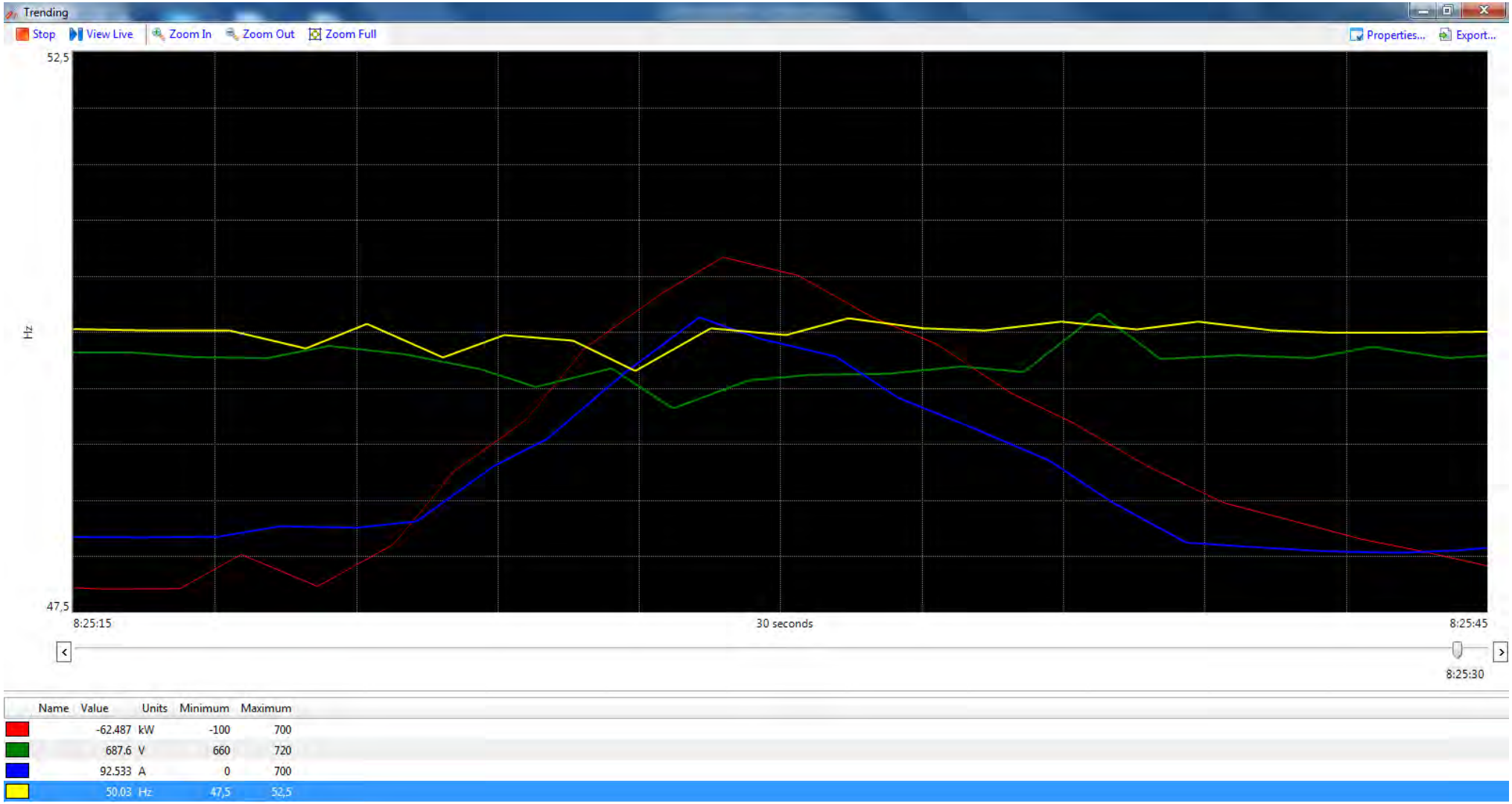
Danvest load test 1: Full reverse power, 63KW, no dumpload, 10% load (65kW) per step, 2 seconds between steps.

Voltage variation min. 683V / max 691V



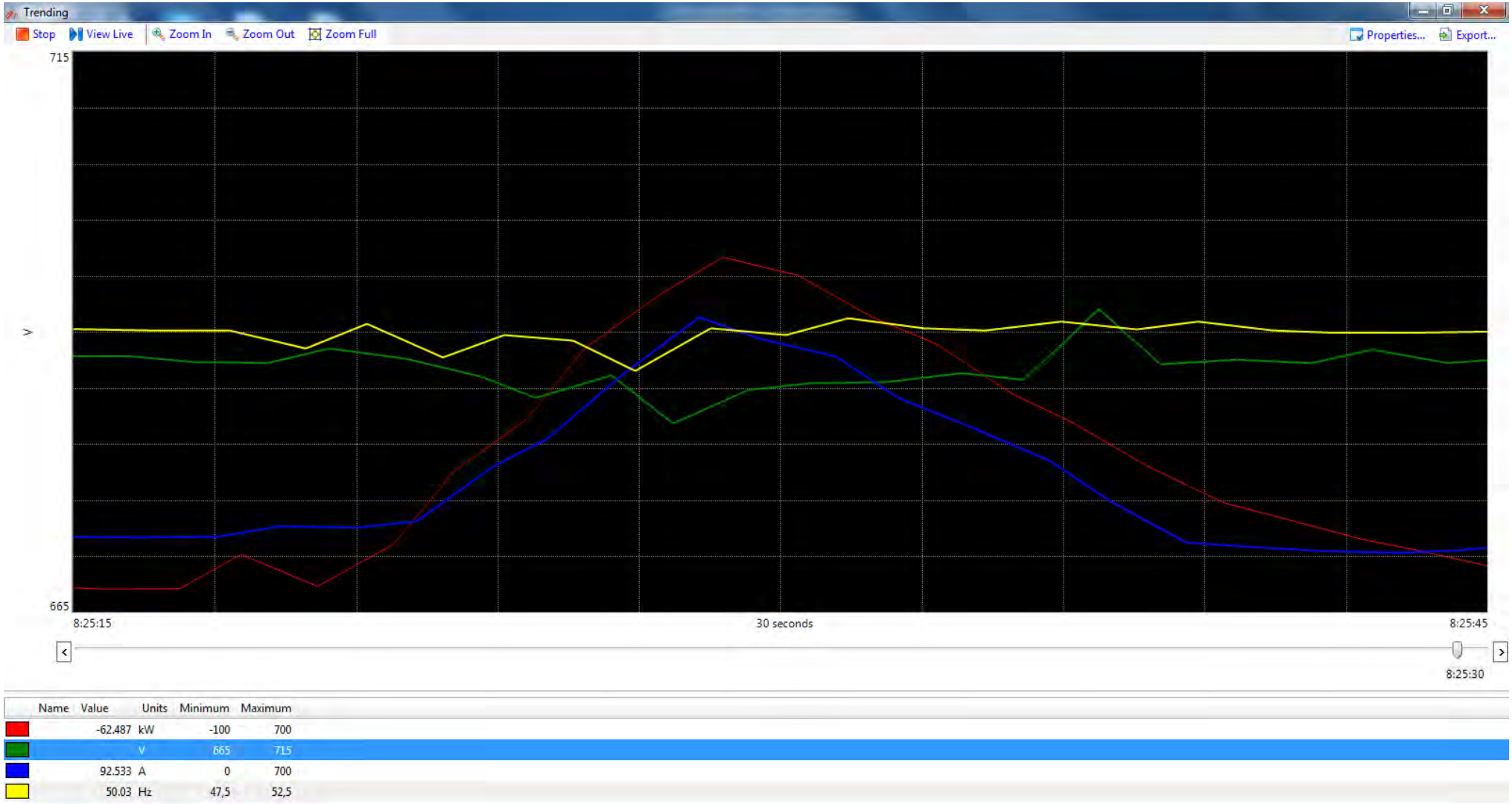
Danvest load test 2: Full reverse power, 63KW, no dumpload, 10% load (65 kW) per step, 1 seconds between steps.

Frequency variation min. 49,7Hz / max 50,15Hz



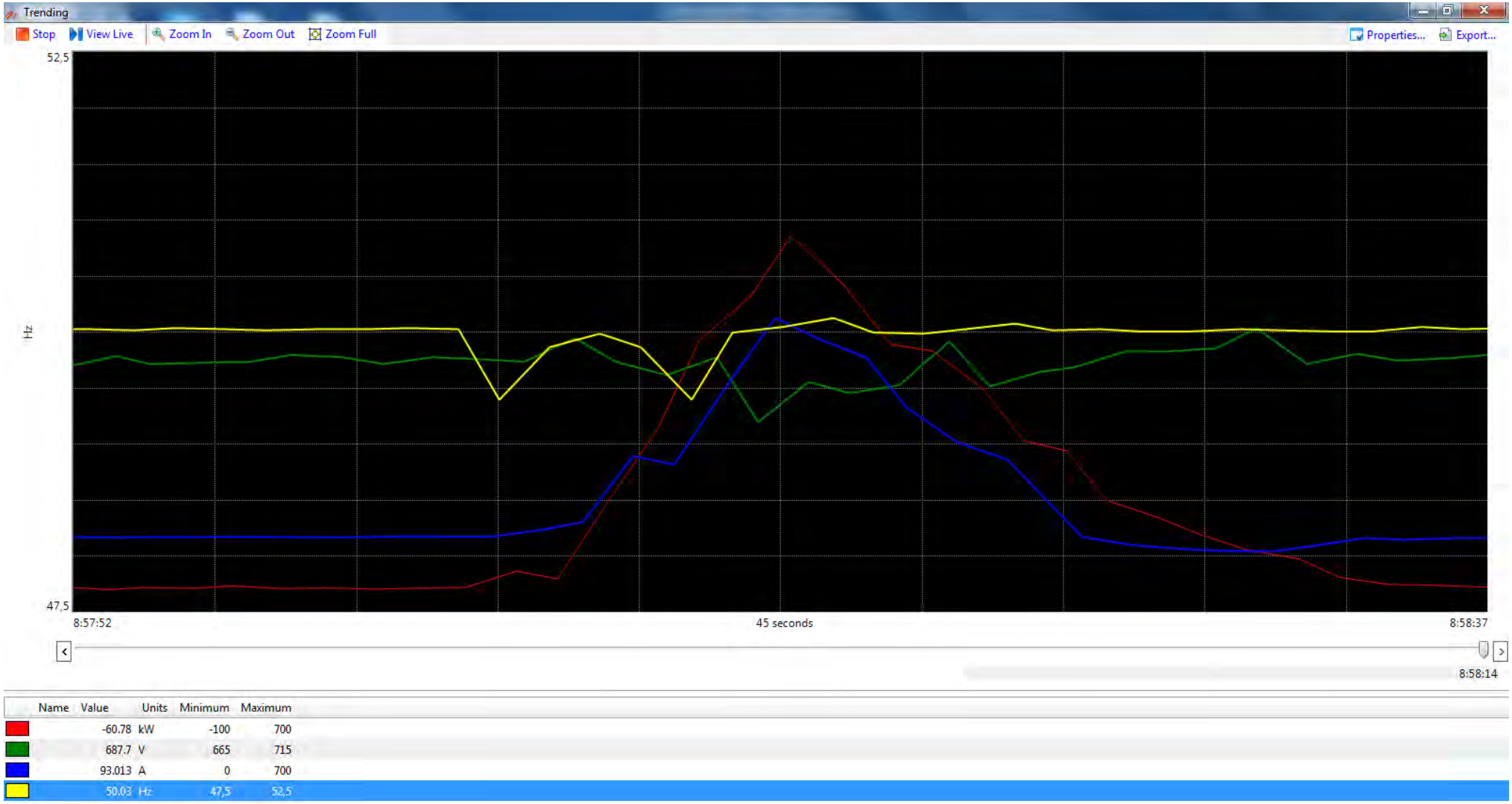
Danvest load test 2: Full reverse power, 63KW, no dumpload, 10% load (65 kW) per step, 1 seconds between steps.

Voltage variation min. 682V / max 692V



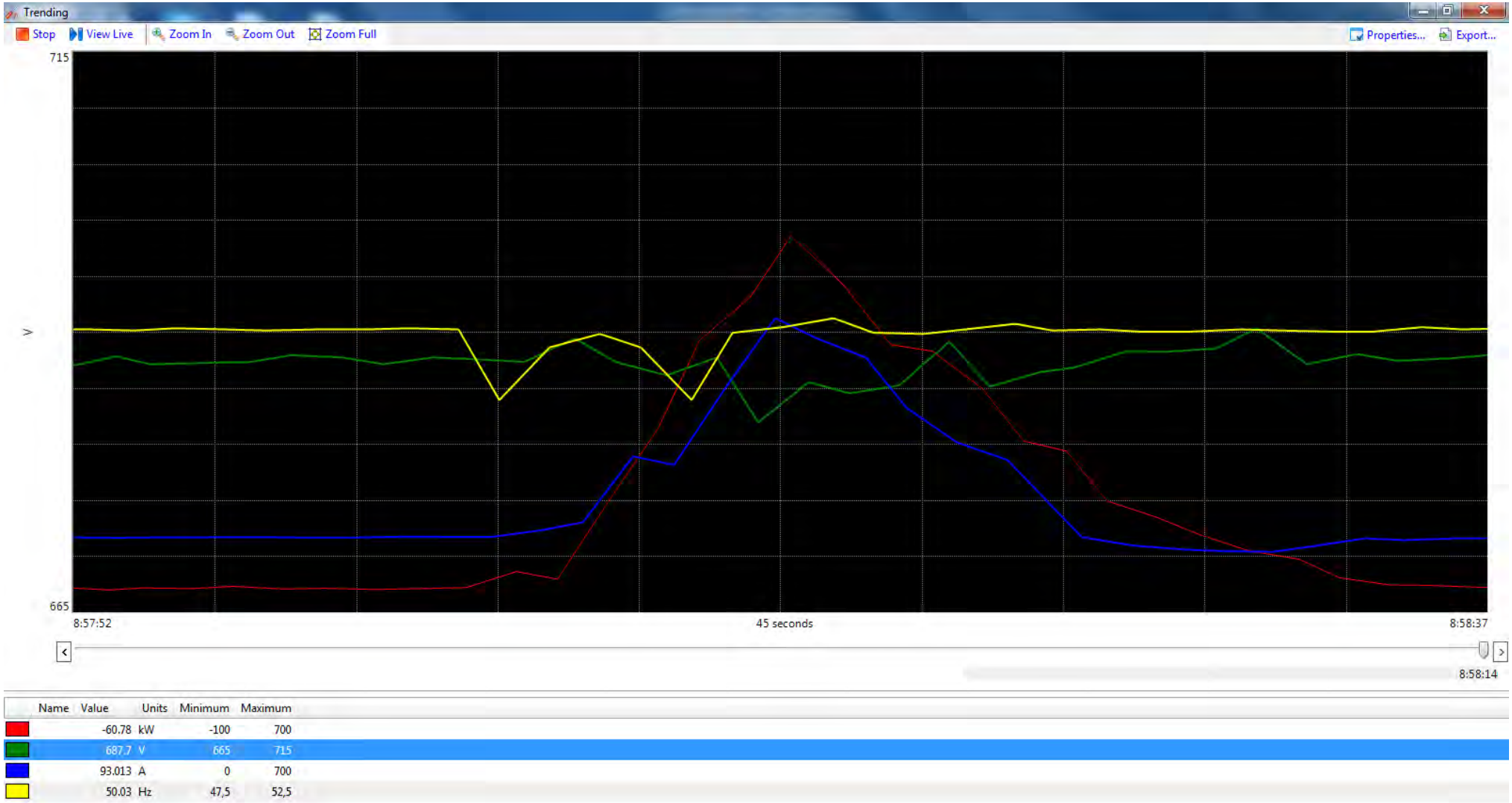
Danvest load test 3: Full reverse power, 63KW, no dumpload, 20% load (130 kW) per step, 2 seconds between steps.

Frequency variations min. 49,4Hz / max 50,15Hz



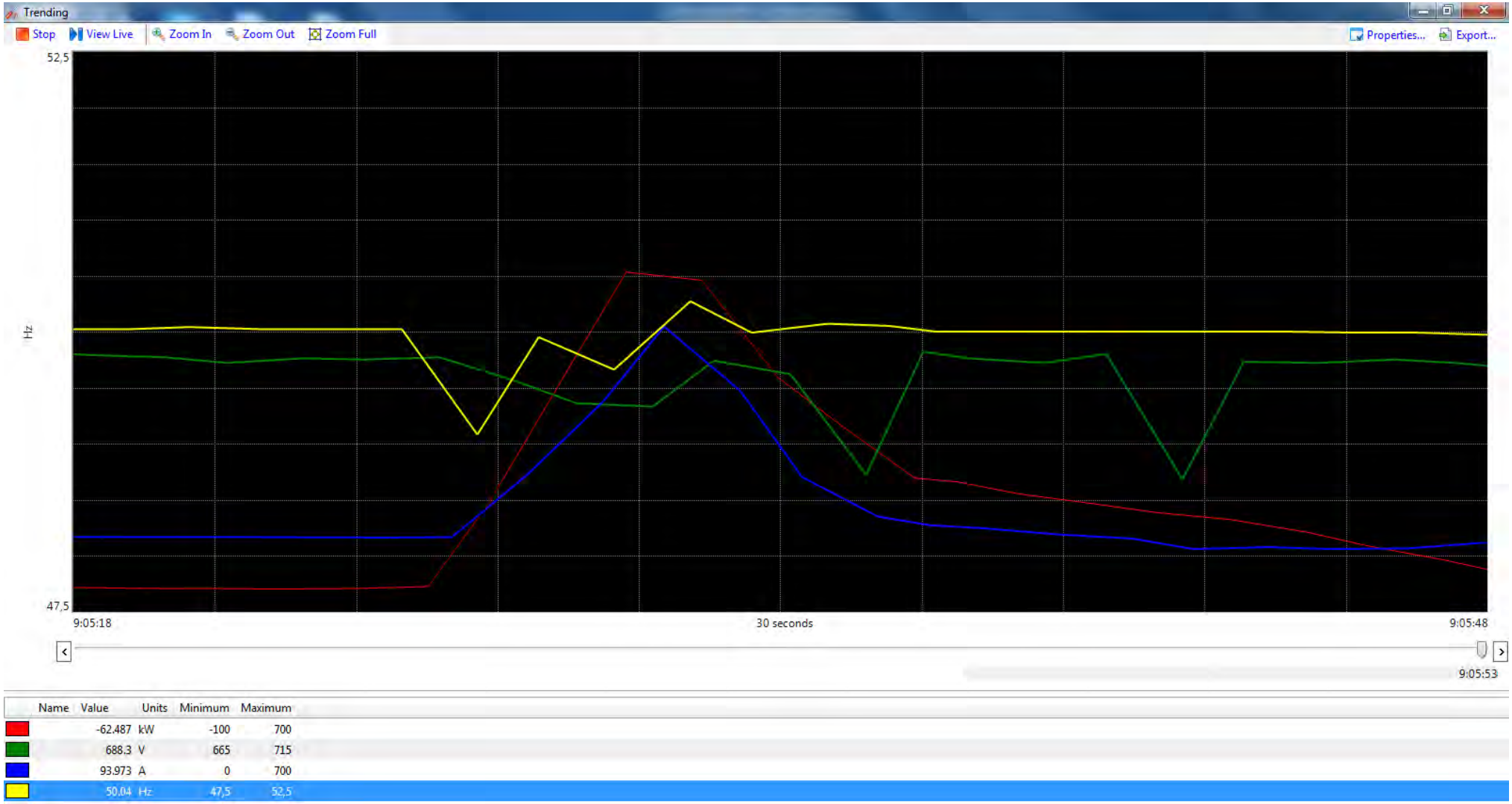
Danvest load test 3: Full reverse power, 63KW, no dumpload, 20% load (130 kW) per step, 2 seconds between steps.

Voltage variation min. 682V / max 690V



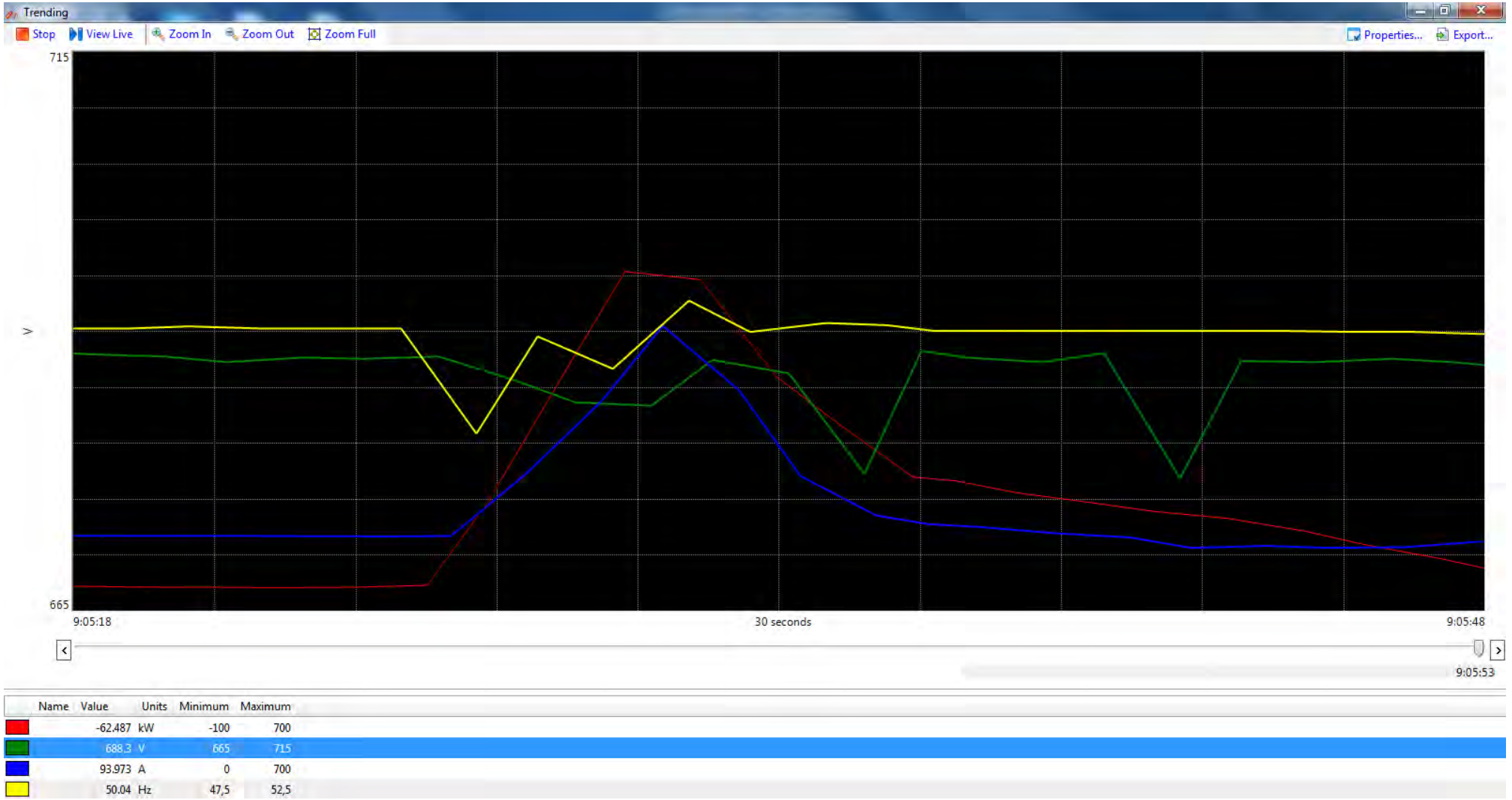
Danvest load test 4: Full reverse power, 63KW, no dumpload, 20% load (130 kW) per step, 1 seconds between steps.

Frequency variation min. 49,1Hz / max 50,3Hz



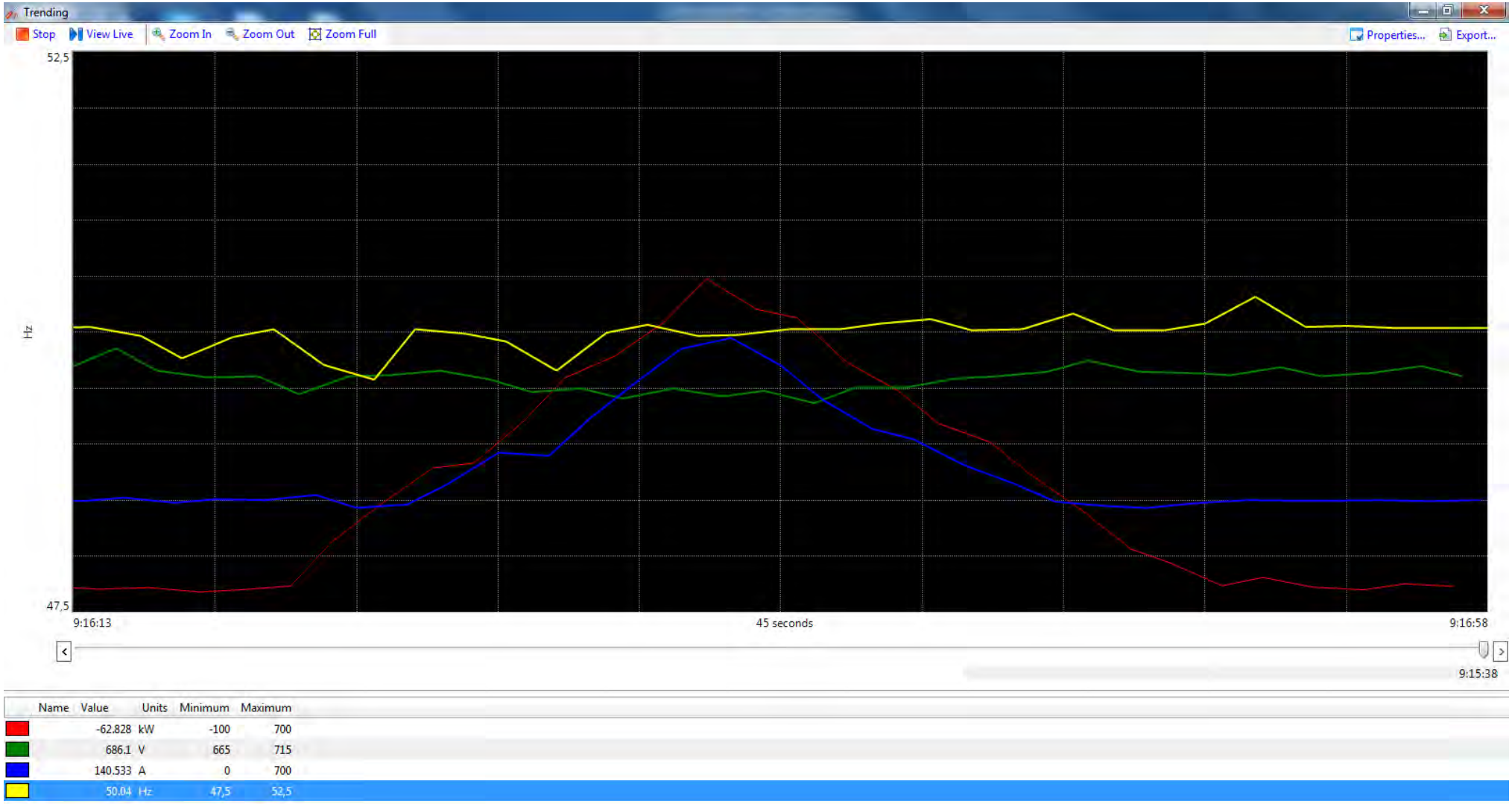
Danvest load test 4: Full reverse power, 63KW, no dumpload, 20% load (130 kW) per step, 1 seconds between steps.

Voltage variation min. 677V / max 688V



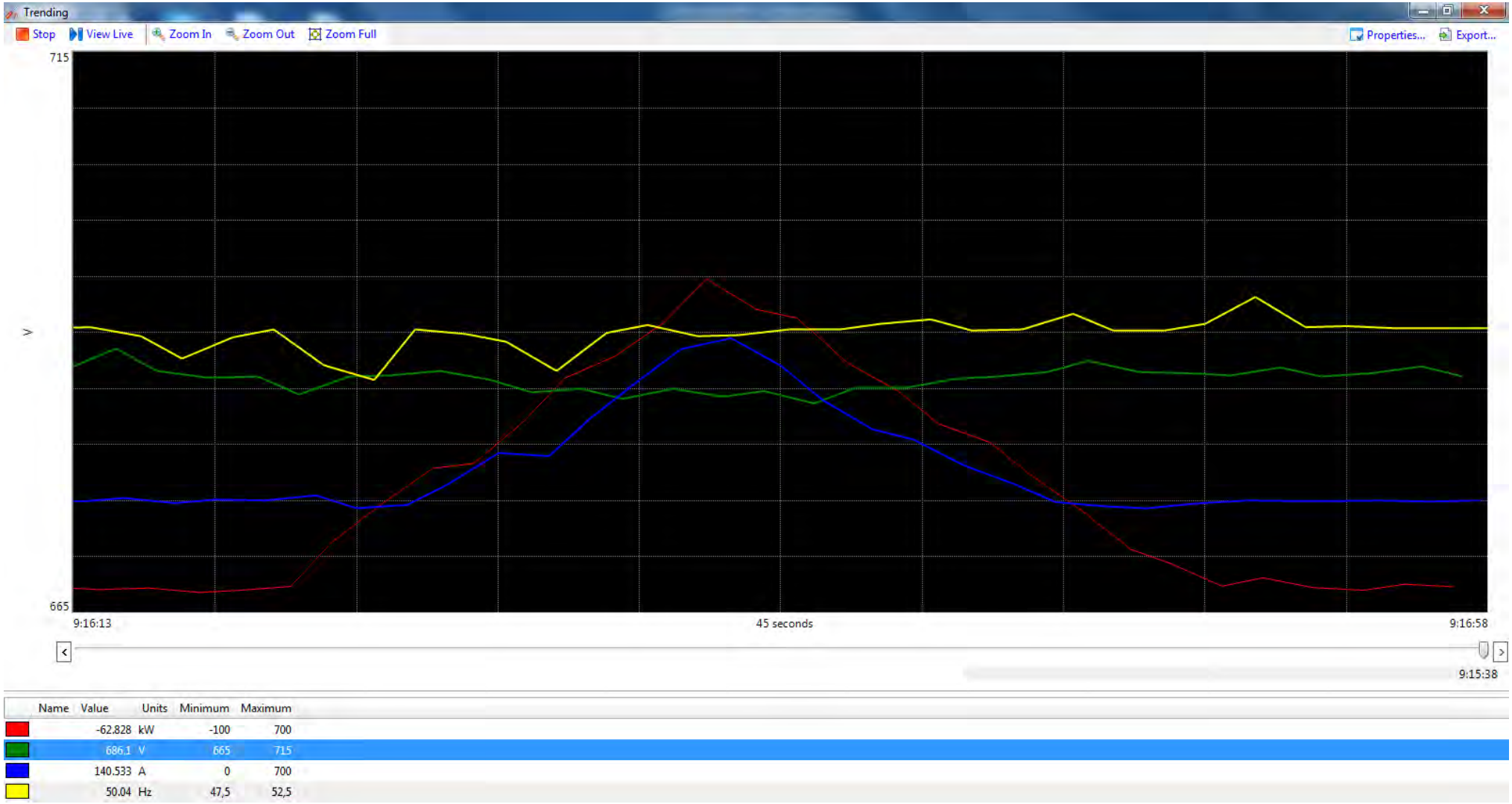
Danvest load test 5: Full reverse power, 63KW, 200KW dumpload, 10% load (65 kW) per step, 2 seconds between steps.

Frequency variation min. 49,6Hz / max 50,3Hz



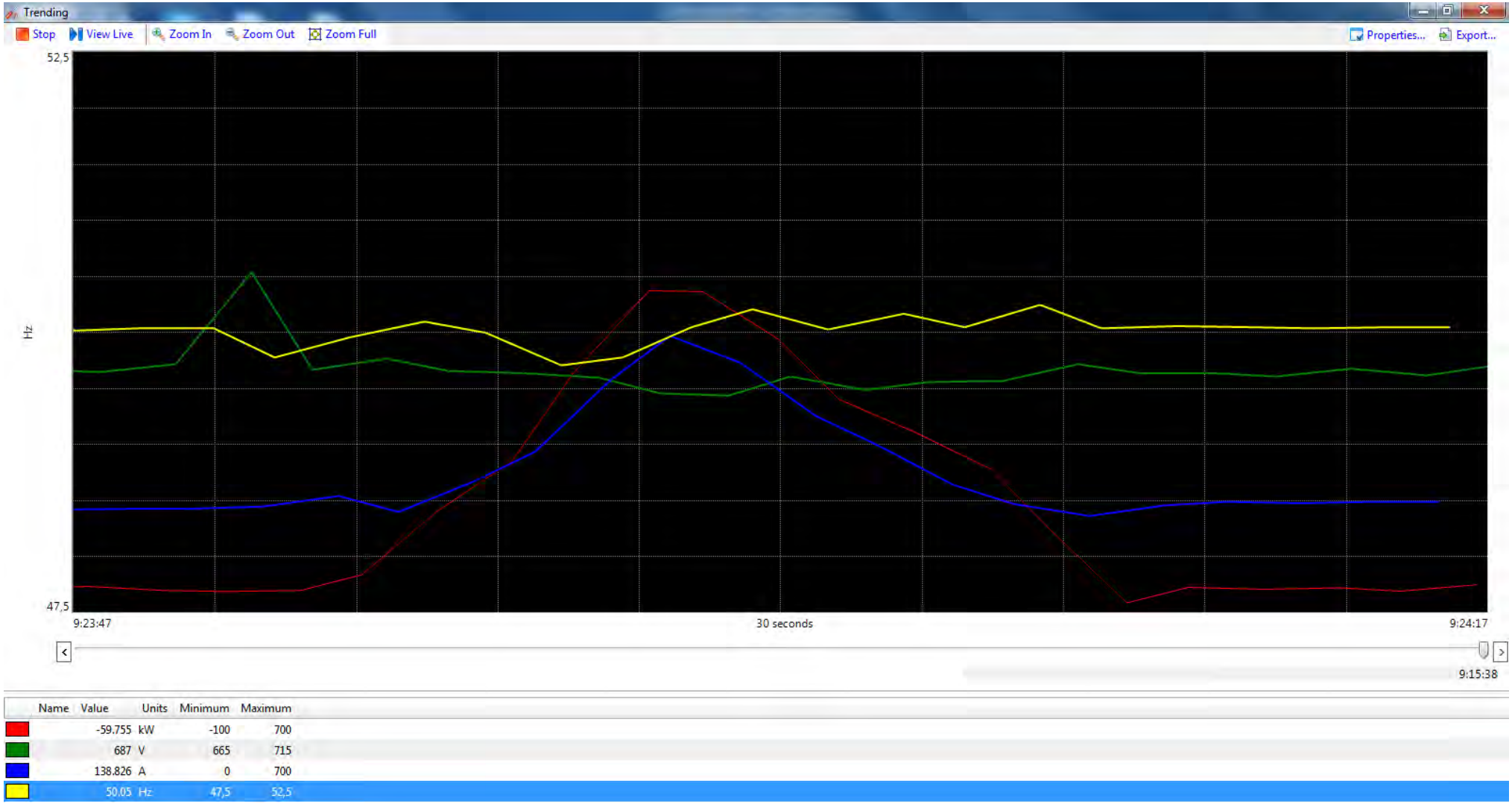
Danvest load test 5: Full reverse power, 63KW, 200KW dumpload, 10% load (65 kW) per step, 2 seconds between steps.

Voltage variation min. 683V / max 689V



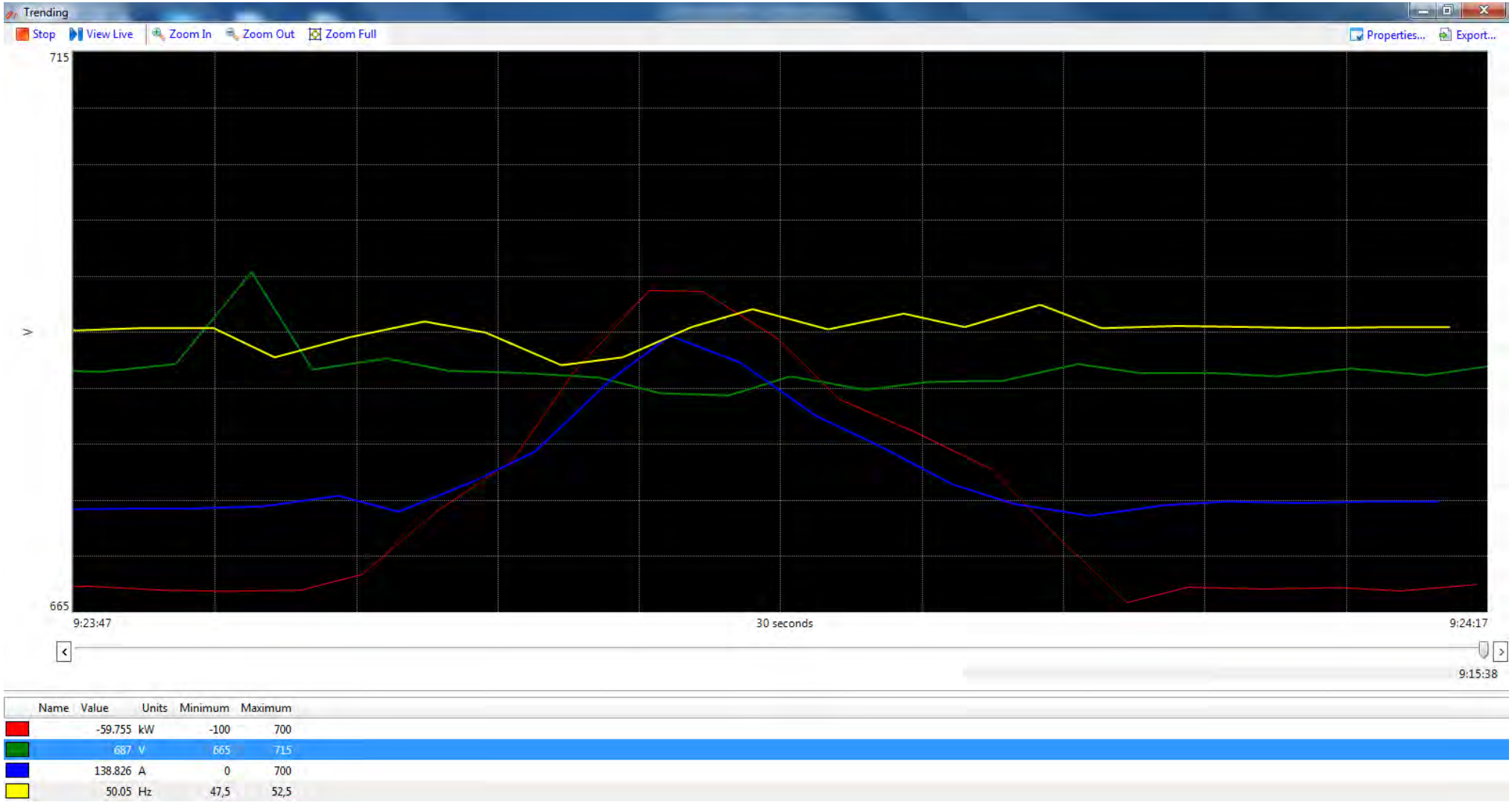
Danvest load test 6: Full reverse power, 63KW, 200KW dumpload, 10% load (65 kW) per step, 1 seconds between steps.

Frequency variation min. 49,7Hz / max 50,25Hz



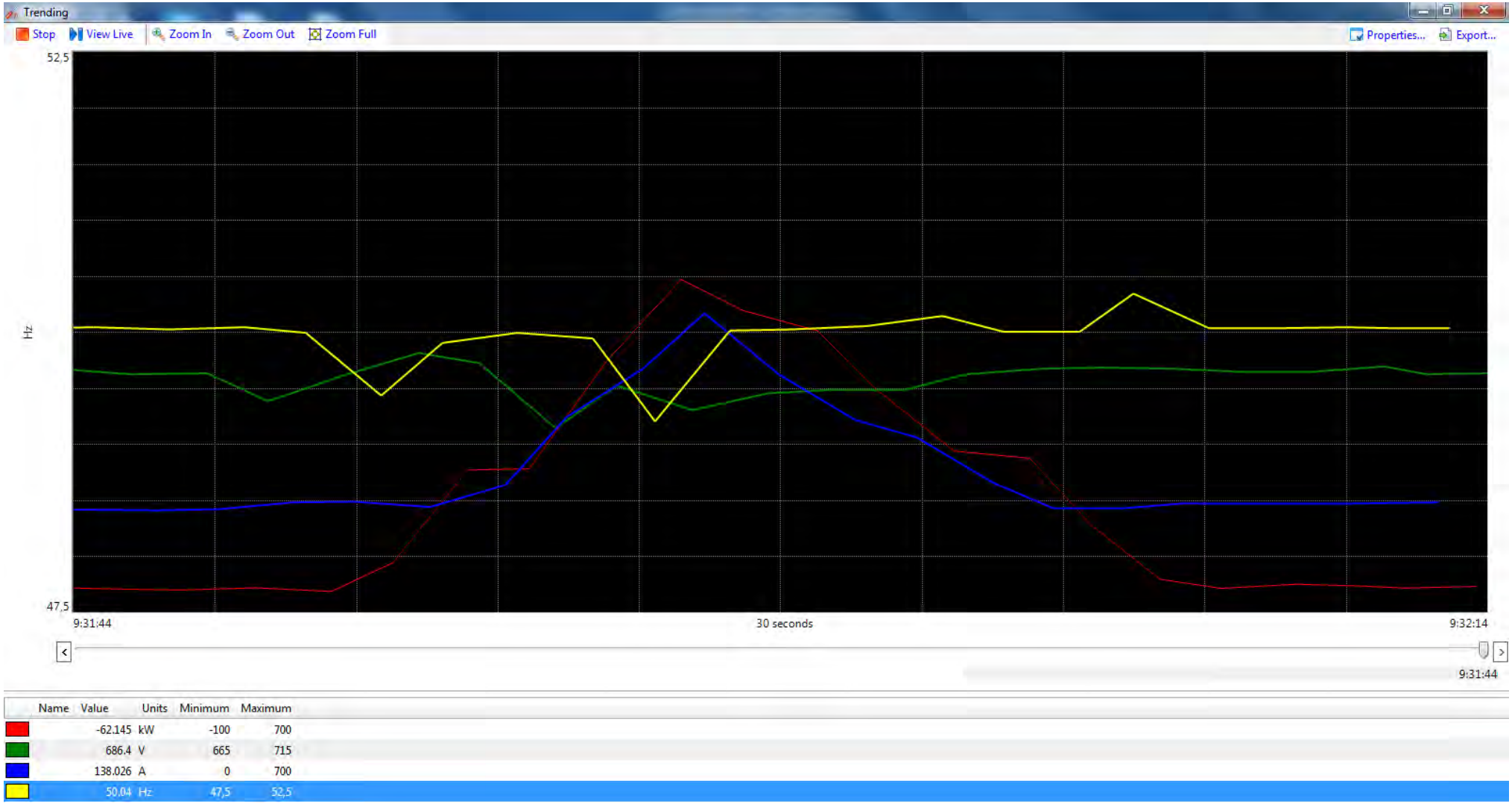
Danvest load test 6: Full reverse power, 63KW, 200KW dumpload, 10% load (65 kW) per step, 1 seconds between steps.

Voltage variation min. 684V / max 695V



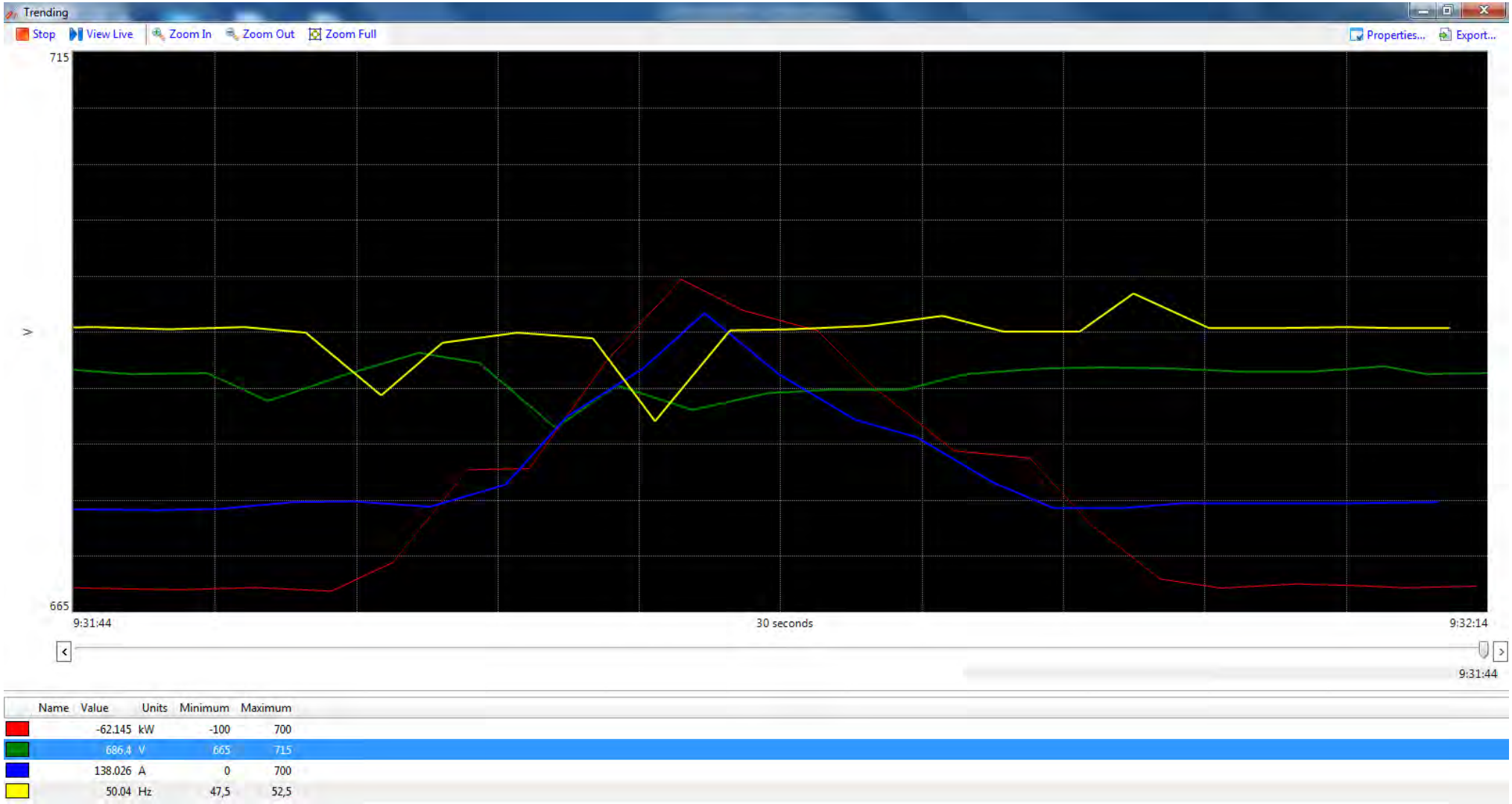
Danvest load test 7: Full reverse power, 63KW, 200KW dumpload, 20% load (130 kW) per step, 2 seconds between steps.

Frequency variation min. 49,2Hz / max 50,35Hz



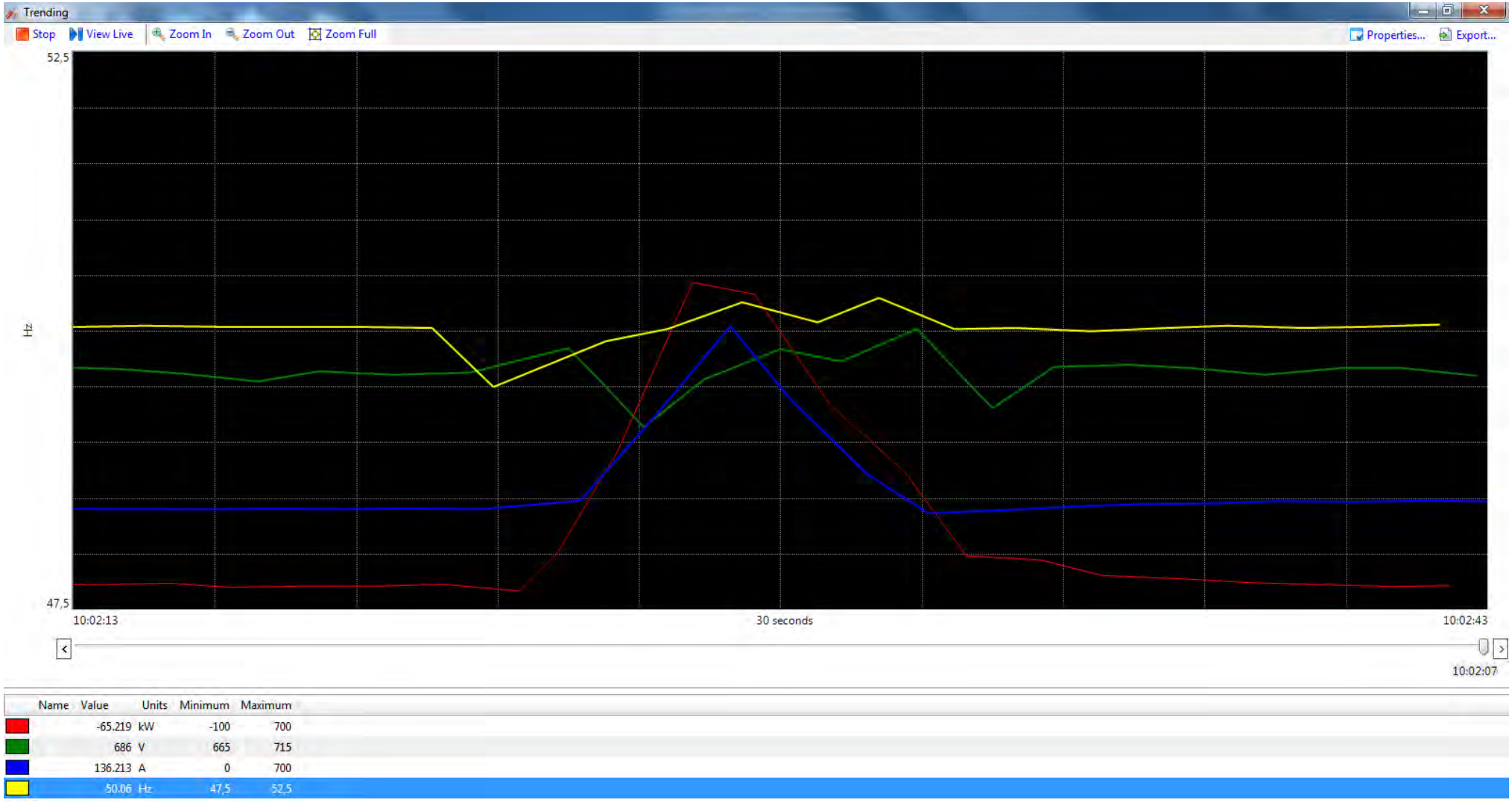
Danvest load test 7: Full reverse power, 63KW, 200KW dumpload, 20% load (130 kW) per step, 2 seconds between steps.

Voltage variation min. 682V / max 688V



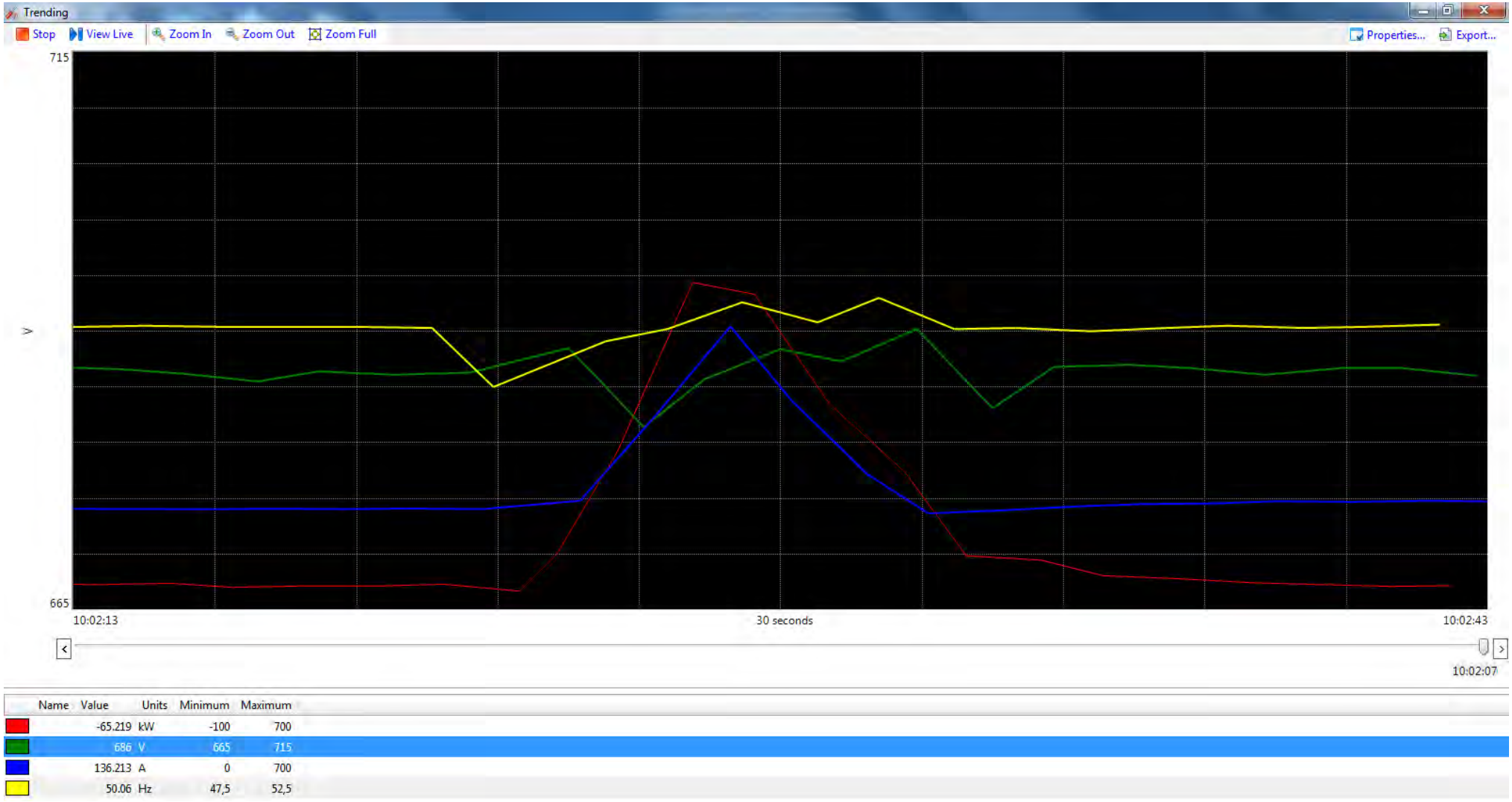
Danvest load test 8: Full reverse power, 63KW, 200KW dumpload, 20% load (130 kW) per step, 1 seconds between steps.

Frequency variation min. 49,5Hz / max 50,3Hz



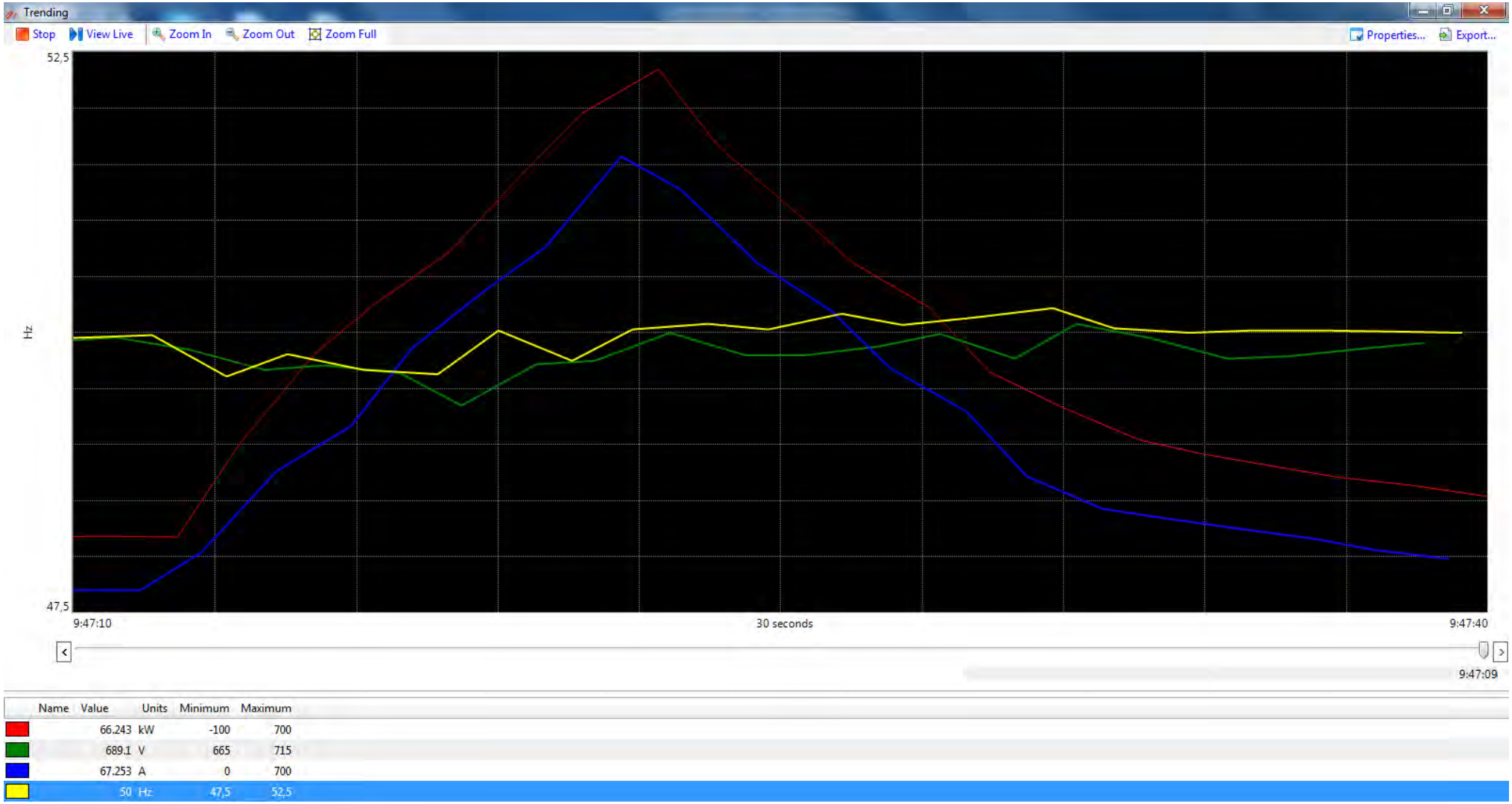
Danvest load test 8: Full reverse power, 63KW, 200KW dumpload, 20% load (130 kW) per step, 1 seconds between steps.

Voltage variations min. 682V / max 690V



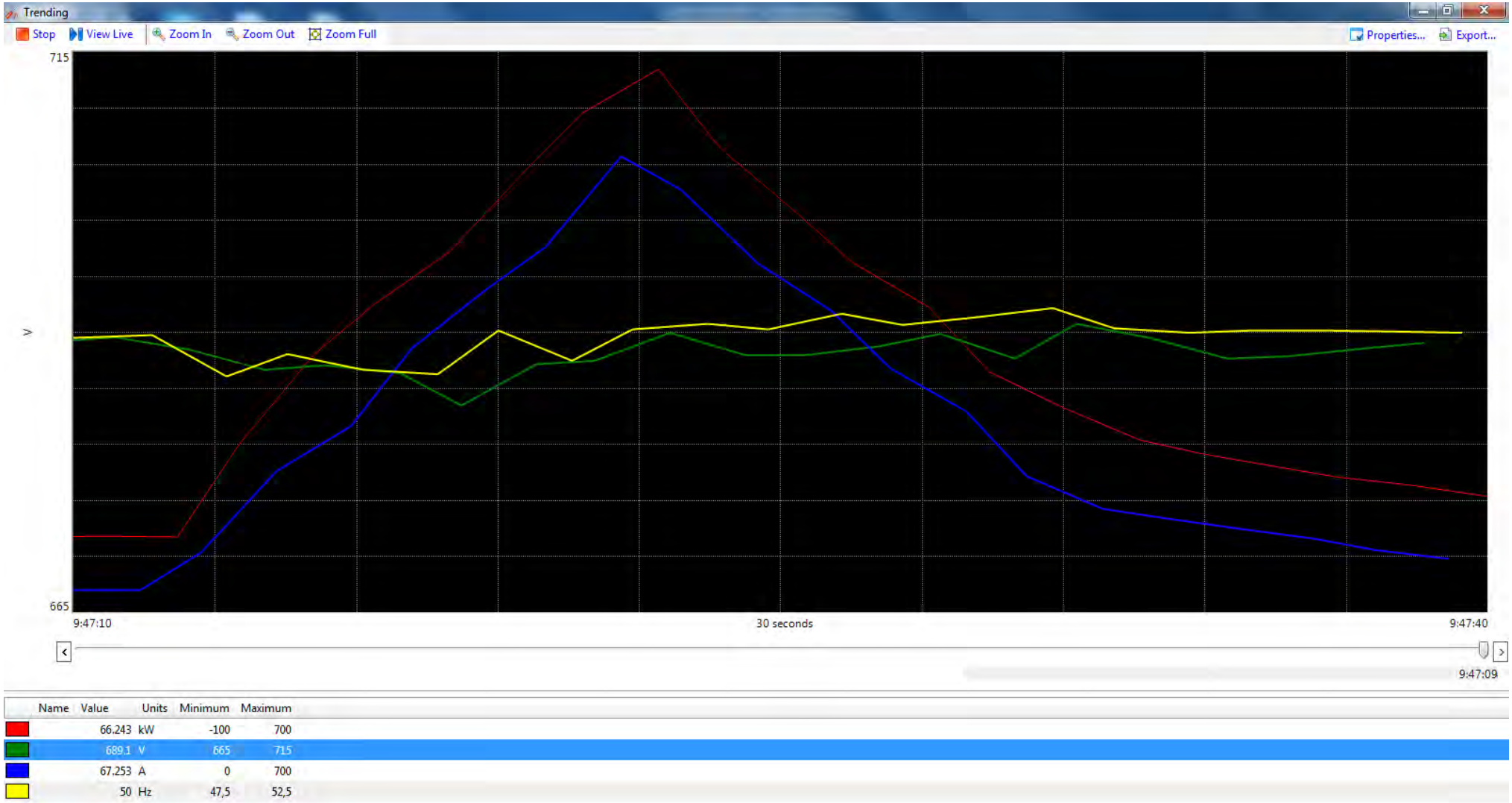
Danvest load test 9: Start at no load, 10% load (65 kW) per step, 1 seconds between steps.

Frequency variations min. 49,6Hz / max 50,2Hz



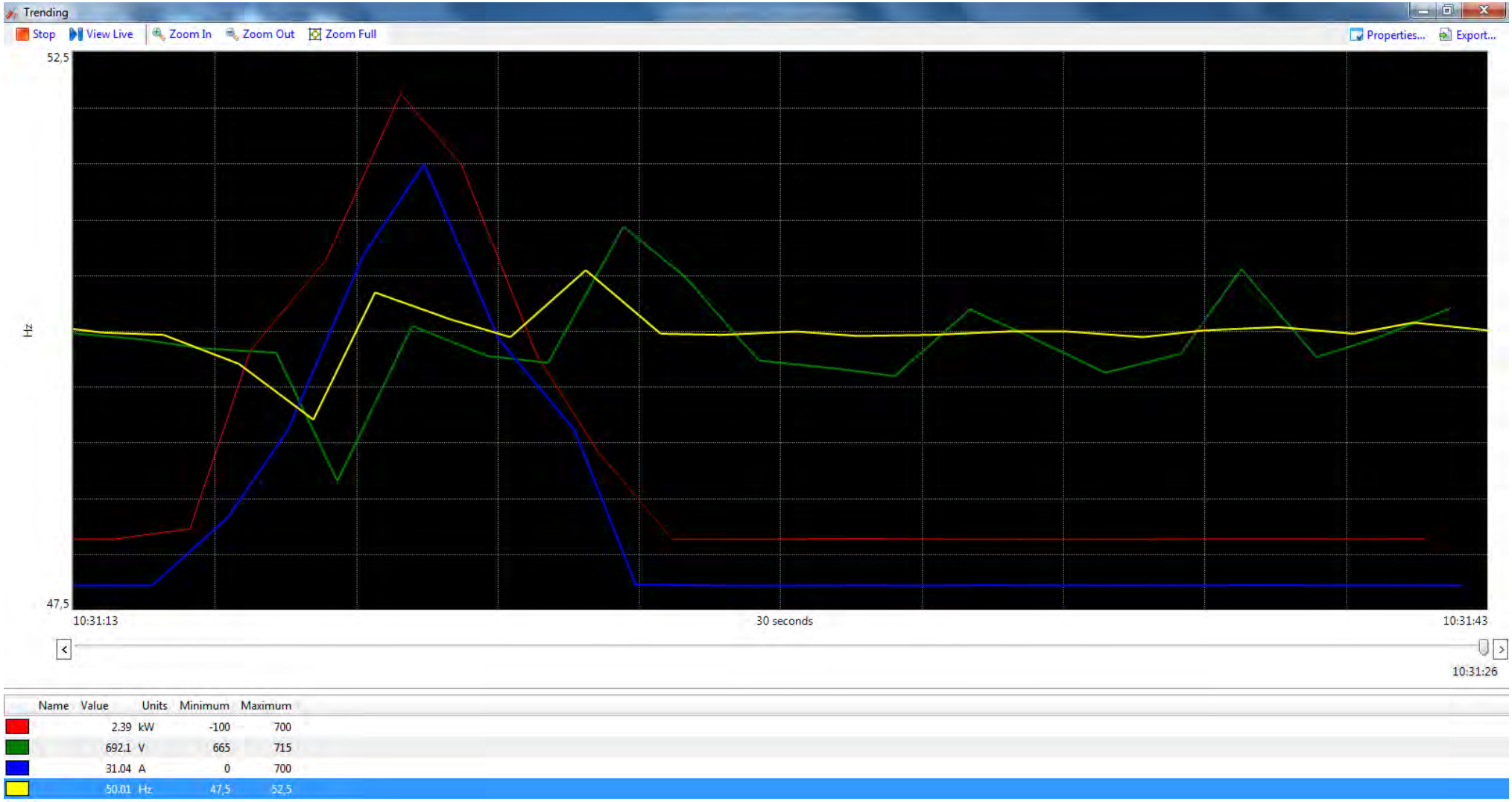
Danvest load test 9: Start at no load, 10% load (65 kW) per step, 1 seconds between steps.

Voltage variations min. 683V / max 691V



Danvest load test 10: Start at no load, 20% load (130 kW) per step, 1 seconds between steps.

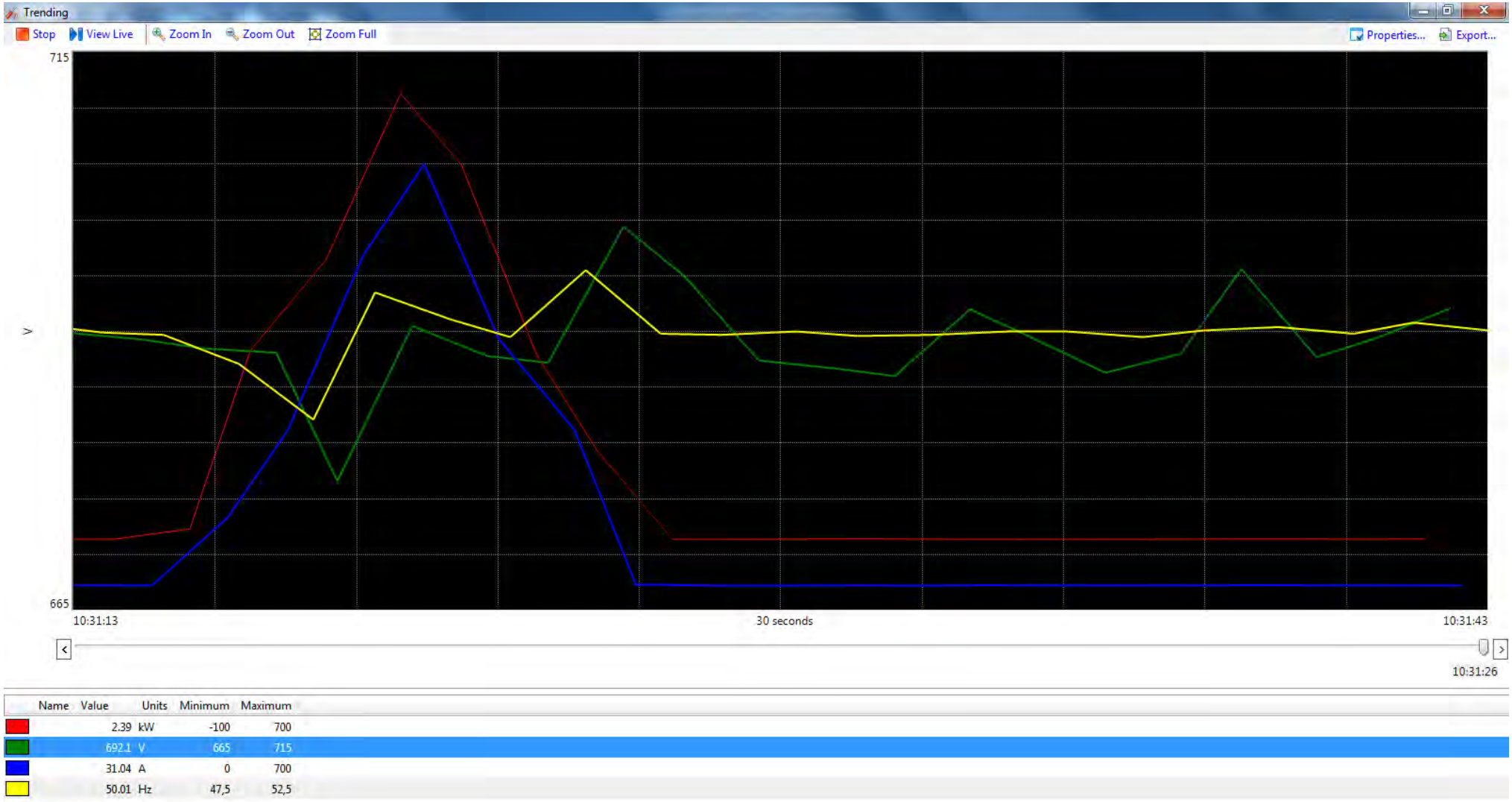
Frequency variation min. 49,2Hz / max 50,55Hz



Name	Value	Units	Minimum	Maximum
	2.39	kW	-100	700
	692.1	V	665	715
	31.04	A	0	700
	50.01	Hz	47,5	52,5

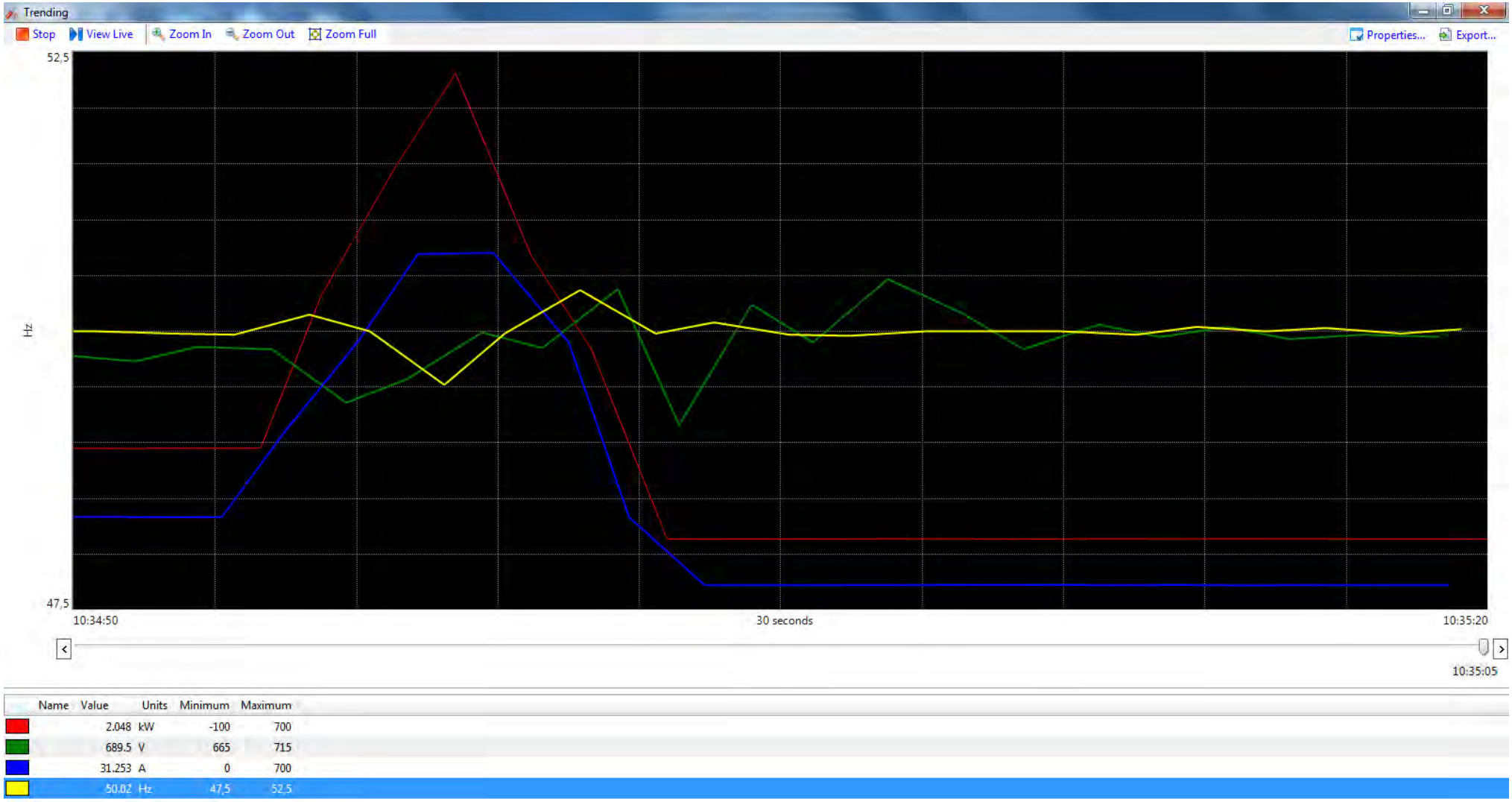
Danvest load test 10: Start at no load, 20% load (130 kW) per step, 1 seconds between steps.

Voltage variation min. 677V / max 699,5V



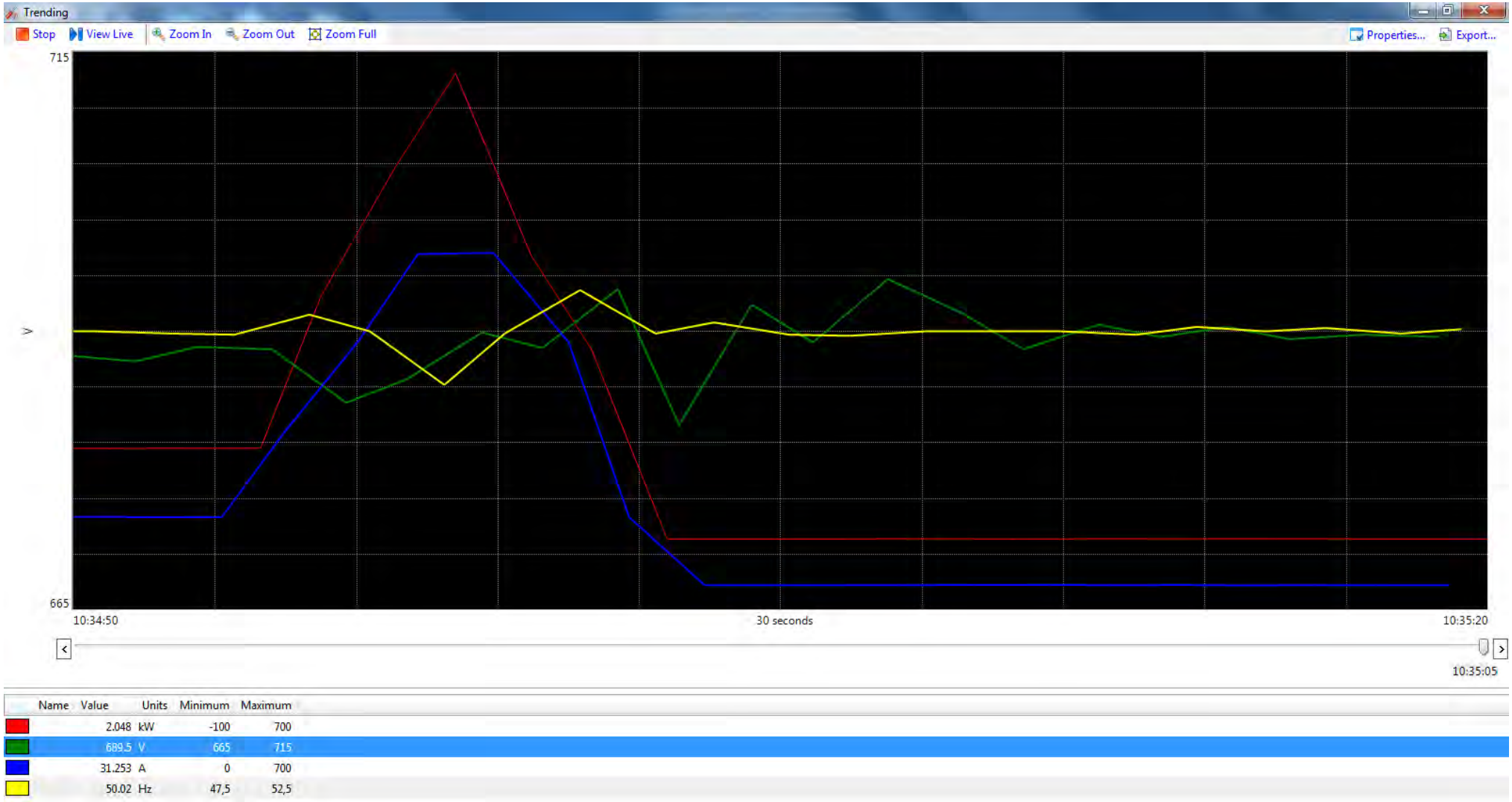
Danvest load test 11: Start at 20% load, 20% load (130 kW) per step, 1 seconds between steps.

Frequency variations min. 49,2Hz / max 50,4Hz



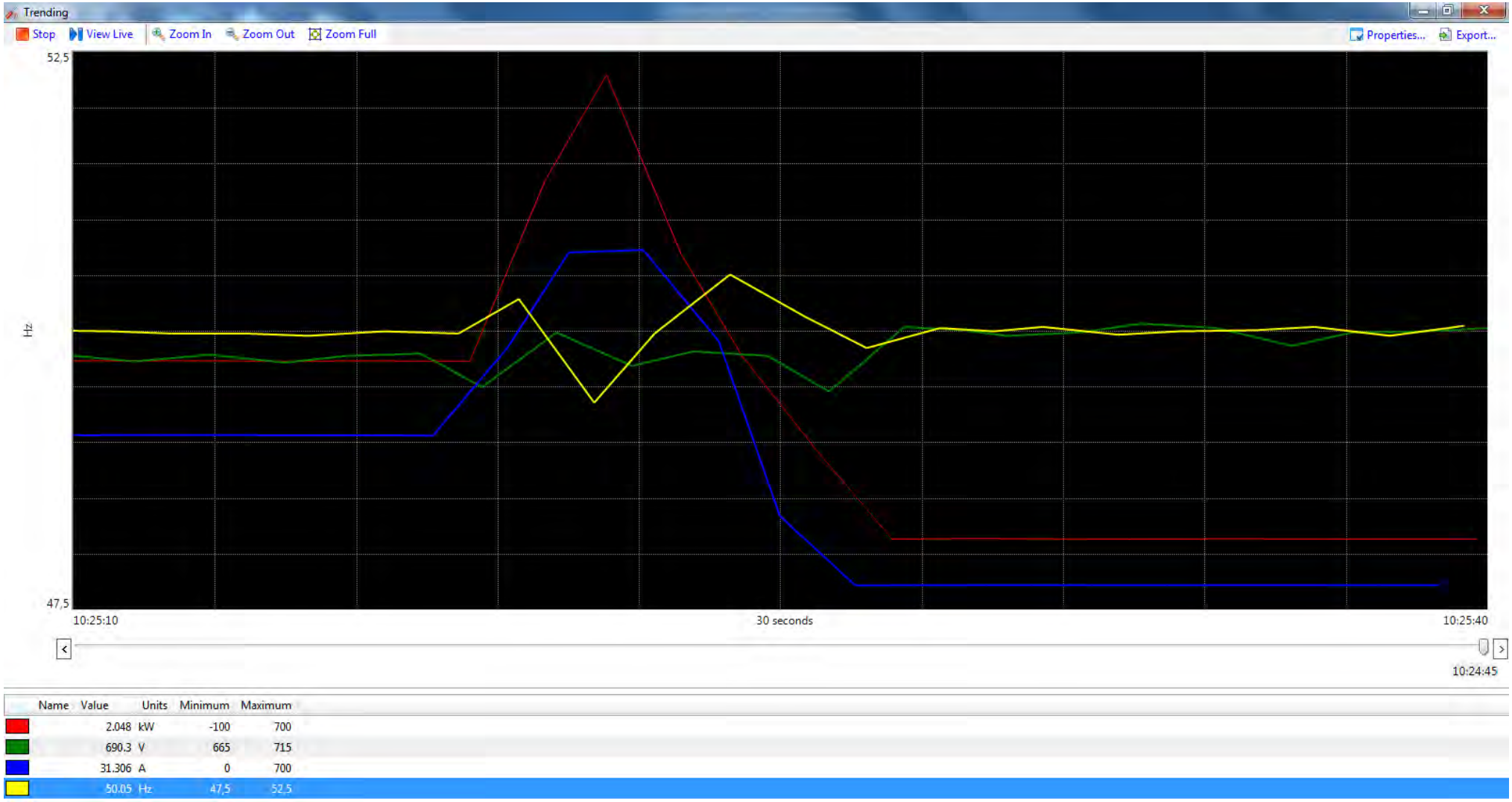
Danvest load test 11: Start at 20% load, 20% load (130 kW) per step, 1 seconds between steps.

Voltage variations min. 682V / max 695V



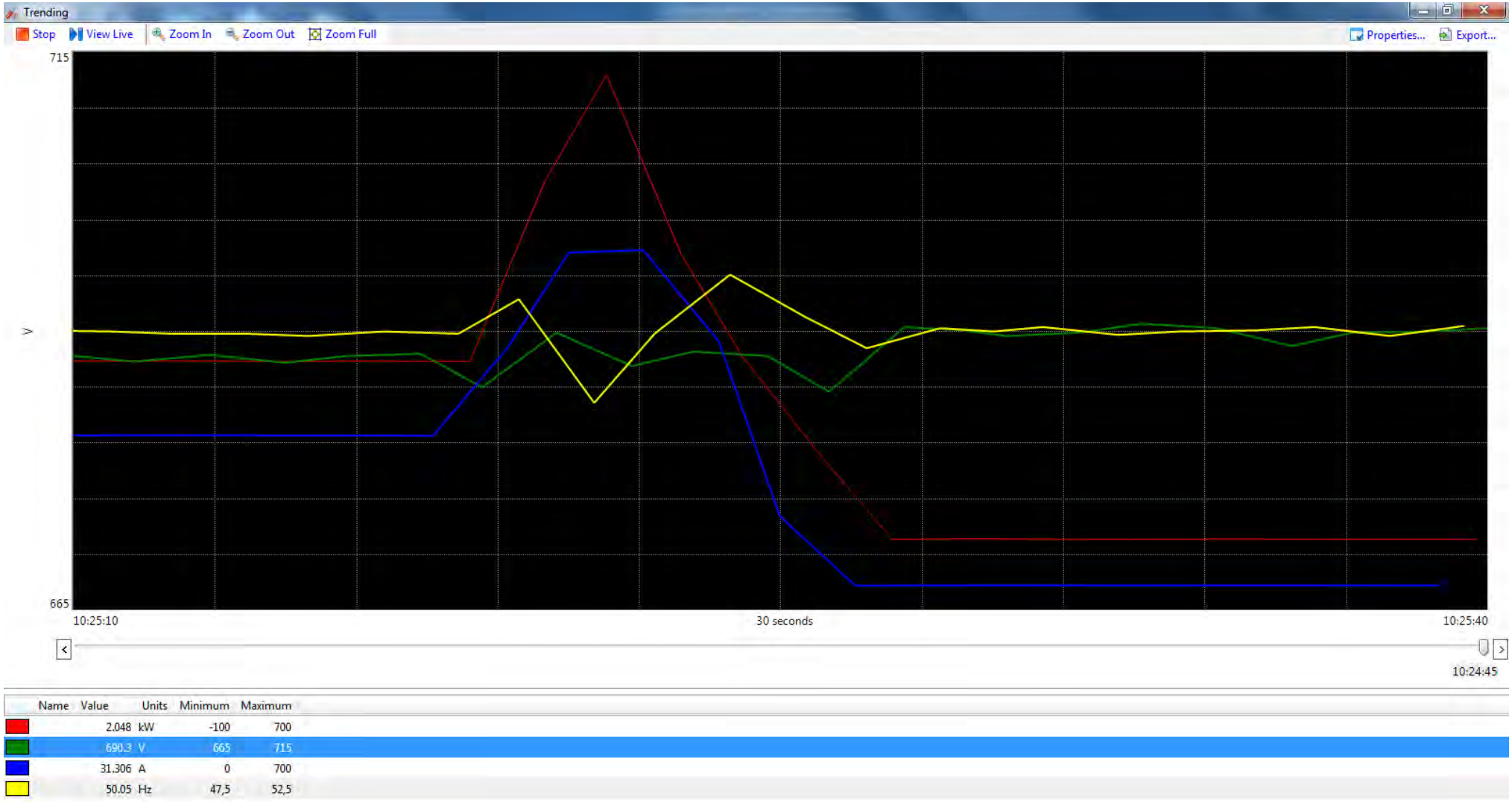
Danvest load test 12: Start at 40% load, 20% load (130 kW) per step, 1 seconds between steps.

Frequency variations min. 49,35Hz / max 50,5Hz



Danvest load test 12: Start at 40% load, 20% load (130 kW) per step, 1 seconds between steps.

Voltage variations min. 685V / max 691V



Annex 7
– Large Step Load Test

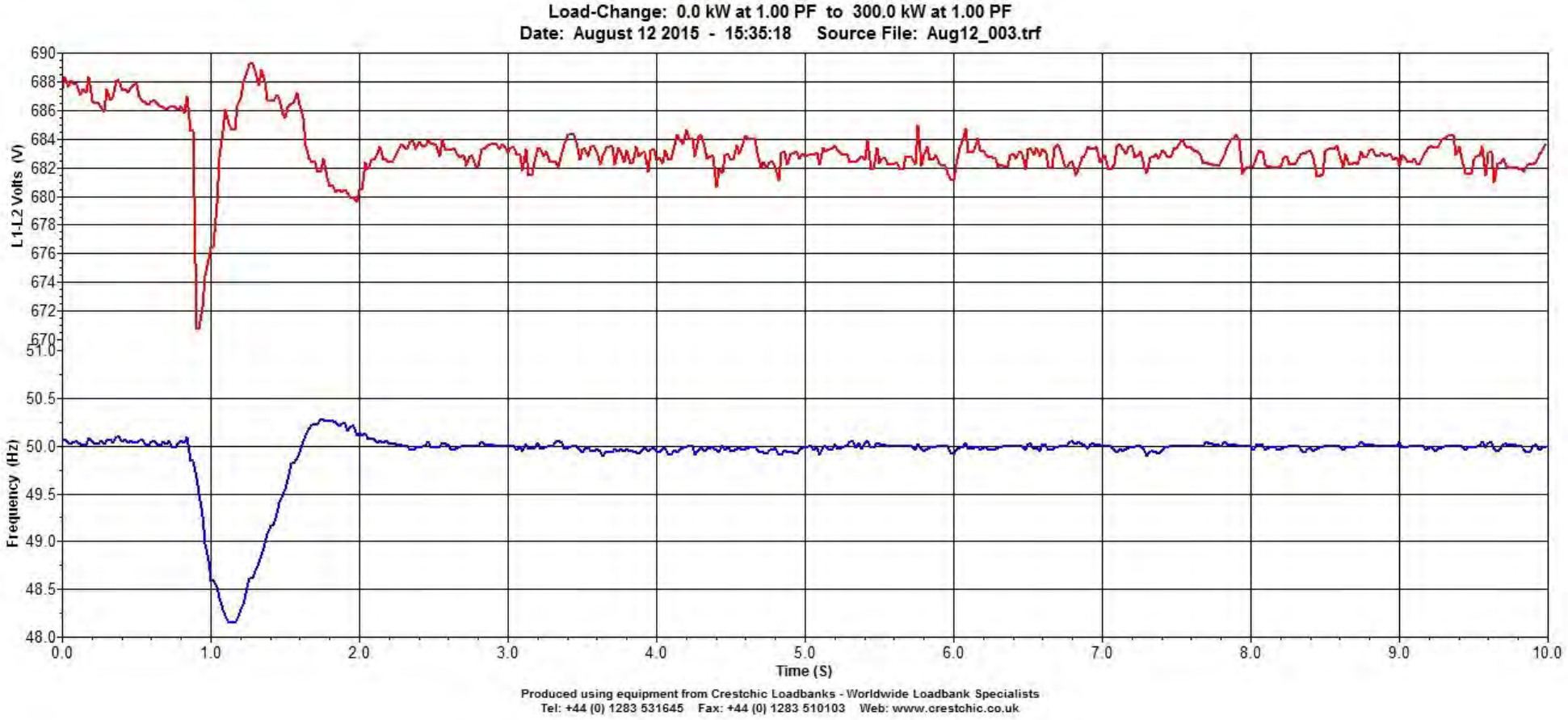
Test is performed starting at full reverse power:

- approx. (minus) -65kWe on Danvest genset
- asynchronous genset supplying this excess power
- the consumer (load bank) is at 0kWe

Step load test 300kW

Frequency variations min. 48,2Hz / max 50,3Hz

Voltage variations min. 671V / max 689V



Step load test 400kW

Frequency variations min. 48,1Hz / max 50,4Hz

Voltage variations min. 667V / max 689V