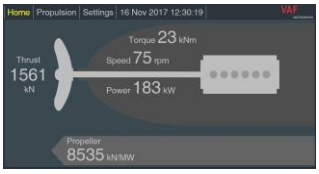
VAF INSTRUMENTS

Technical Manual

Instructions for installation, operation and maintenance



667

PEM4 +SPU3 SYSTEM

For T-Sense®, TT-Sense® and PT2 Flowmeters

Publication nr	TIB-667-GB-0722
Supersedes	TIB-667-GB-1121

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1. PREFACE

1.1 GENERAL

The PEM4 Propulsion Efficiency Monitoring system is a microprocessor based instrument for use with the T-Sense® Optical Torque Measuring System and TT-Sense® Optical Thrust and Torque Measuring System. The T-Sense® is providing torque, shaft speed and power as input for the PEM4 system. The TT-Sense® additionally provides thrust measurements as input.
The PEM4 system is supplied with a robust SPU3 Signal Processing Unit, which can be connected to a large number of extra inputs like flowmeters, GPS, speed log, or one additional T-Sense® or TT-Sense® in case of twin screw vessels.

This completely unique and compact total solution can be used for simple to very complicated configurations.

To ensure safe and correct installation and operation, read this manual completely before installing the equipment and starting operations.

The (micro) SD card should not be exposed to computer viruses, since this could contaminate the (micro) SD card. Contamination could disturb good working of the system.

For any additional information contact:

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Or your local authorized VAF dealer.
Their addresses can be found on www.vaf.nl

1.2 SYMBOLS

The following symbols are used to call attention to specific types of information.

A warning to use caution! In some instances, personal injury or damage to the instrument or control system may result if these instructions are not followed properly.

An explanation or information of interest.

1.3 COPYRIGHT

2. SYSTEM DESCRIPTION

2.1 PEM4 Propulsion Efficiency Monitoring System

The PEM4 system is a modular propulsion efficiency system. This manual describes the combination of the PEM4 with the SPU3 (Signal Processing Unit). The PEM4 stand alone system is able to calculate torque, speed and power output data. The PEM4 stand alone is described in a separate technical manual, (TIB-669 T-Sense® and PEM4 stand alone). The PEM4 system in combination with the SPU3 can manage a maximum of 12 Flowmeter inputs in with PT100 temperature inputs related to a maximum of 8 consumers. Furthermore a maximum of 6 ViscoSense®3D inputs, a speed log pulse, GPS NMEA signal, draft meter and inclino meter can be added as input to the system.
The SPU3 converts all these input signals to one RJ45 Ethernet signal for monitoring purposes through a PEM4 touch screen or using the IVY® Propulsion Performance Management system.
A RS485 Modbus signal is available for connection an external system like Alarm and Monitoring System (AMS) or to connect a separate PC running the optional SPU3 datalogger software.

Functions, which can be performed with the PEM4 + SPU3 system are:

- Measurement and display of the torque, thrust, shaft speed and power.
- Calculation of the average shaft power, shaft speed and torque during the last 1, 4 and 24 hours.
- Calculation of the total energy, total revolutions and total CO_2 emissions including reset.
- Calculation of the fuel consumption in kg per nautical mile, fuel consumption in kg per hour, fuel consumption in gram per kWh (*Specific Fuel Oil Consumption - SFOC*), average fuel consumption per nautical mile, fuel temperature compensation and calculation of the total mass per fuel type per consumer including reset.
- Calculation of thrust, thrust power quotient, when a TT-Sense® sensor is installed.
- Displaying of parameters, engine load diagram and power/speed diagram.
- Above mentioned calculations for twin screw vessels when an additional T-Sense® or TT-Sense® system is installed.

The SPU3 can be installed in the vicinity of the flow meter(s) and/or booster unit or in the engine control room (ECR). The PEM4 touch screen can be installed in a control cabinet or control panel in the ECR and/or on the bridge.

2.2 SYSTEM SECURITY

Besides checking the status of the torque measurement system and/or flowmeters the PEM4 + SPU3 system also checks itself continuously for program and configuration data integrity, normal program flow and power supply conditions. All alarm messages will be logged in a dedicated alarm screen.

3. TECHNICAL SPECIFICATIONS

SPU3	Drawing 0815-1120 (section 17)	
Supply voltage	115 - 230 VAC	
Power consumption	30 W max.	
Protection class	IP65	
Net weight	Approx. 10 kg	
Operating temperature	Lower than 55ºC	
Dimensions	660 x 300 x 165 mm (w x h x d)	
CPU	Beagle Bone, Sitara AM3359AZCZ100, 1GHz, SDRAM 512MB DDR3L 800 MHZ, On board flash 2GB, 8bit embedded MMC	
Flowmeter pulse inputs (backplanes)	Number of pulse inputs	12 flowmeters (max. 8 engines/boilers)
	Input type	VAF Instruments PT2 sensor or Namur
	Max. freq. pulse input	1000 Hz
	Threshold voltage	3 V
	Maximum pulse voltage	8,2 V
Flowmeter temperature inputs (backplanes)	Number of temp. inputs	12
	Input type	3 wire PT100
	Range	0ºC to 200ºC
	Accuracy	± 1ºC
	Update time	1 Hz
Analogue inputs (backplanes)	Max. 9x optional analogue inputs (3 analogue modules with 3 analogue inputs each) Range per analogue input 4-20mA each. Ri = 100Ω *Used for:* • Max. 2 shaft generators (1 analogue input each) • Max. 2 torque meters e.g. VAF-Palco - Torque/speed/power (3 analogue inputs each) • Max. 6 auxiliary power - Total auxiliary power (1 analogue input each) • Max. 6 ViscoSense®3D - Density, Temperature and Viscosense (3 analogue inputs each) • Max. 4 draft meters – Front, Middle SB, Middle PS, Back (1 analogue input per meter) • Max. 1 Inclino meter – Pitch, Roll, Yaw (1 analogue input per signal)	
Signal input (J1) T1 or T1+T2	Input signal from T-Sense® ,TT-Sense® sensors or Auxiliary Engines. RS485 (2-wire), Baud rate: 19200, Data bits: 8, Parity: none, Stop bits: 2, Flow control: None (max1200m cable length)	
Signal input (J2) T2 or Aux1	Input signal from T-Sense® , TT-Sense® sensors or Auxiliary Engines RS485 (2-wire), Baud rate: 19200, Data bits: 8, Parity: none, Stop bits: 2, Flow control: None (max1200m cable length)	
Modbus output (J3)	Modbus connection For data transfer to an external system like AMS or for connection to a separate PC running (optional) SPU3 data logger software. RS485 (2-wire) Baud rate: 57600, Data bits: 8, Parity: none, Stop bits: 1, Flow control: None, Function code 3 (Holding Registers), Modbus slave address 1 (max1200m cable length)	

NMEA input (J4)	NMEA 0183, used for GPS* PEM4 is reading following strings: • $--VTG sentence (“speed over ground” - SOG) • $--VBW sentence (“longitudinal water speed” – STW) RS422 (2-wire), Baud rate: 4800, Data bits: 8, Parity: none, Stop bits: 1, Flow control: None (max1200m cable length) *systems in combination with IVY® are able to read more information available through NMEA
Ship’s speed log input (J6)	Pulse input for speed log. 1-999p/NM
Ethernet output (J10)	One RJ45 Ethernet connection to the PEM4 touch screen, the IVY® Propulsion Performance Management system, or to a PC/network on board. (max100m cable length) Optional a RJ45 Ethernet switch for connecting e.g. a second PEM4 touch screen.

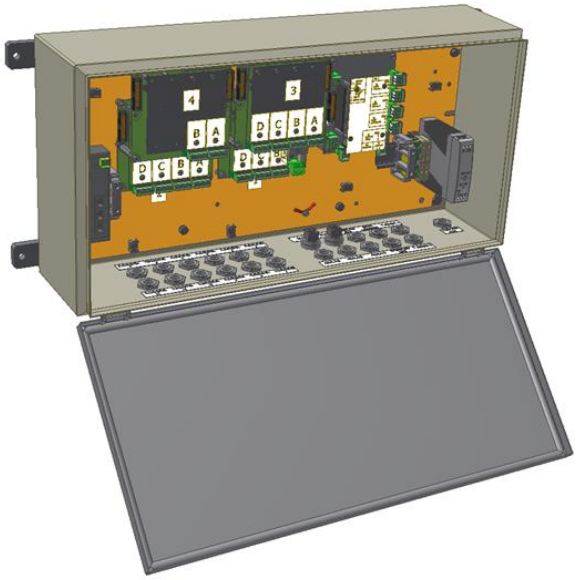

Figure 1 SPU3 Signal Processing Unit

PEM4.7 Touch Screen	Drawing 0815-1023 (section 17)
Supply voltage	115-230 VAC to power supply unit
Dimensions	235 x 150 x 44 (w x h x d)
Cut out	217,6 x 128,6 mm (w x h)
Cut out depth	38 mm
Front panel thickness	6 mm
Connections	RJ45 Ethernet connection on the back-bottom side of the panel
Temperature range	-20ºC up to +60ºC
Display	Color TFT LCD, PCAP Touch screen 7,0” (1024 x 600 dots) with adjustable LED backlight
Net weight	1,3 kg

PEM4.8 Touch Screen	Drawing 0815-1025 (section 17)
Supply voltage	115-230 VAC to power supply unit
Dimensions	218,16 x 162,67 x 46,5 mm (w x h x d)
Cut out	167 x 116 mm (w x h)
Cut out depth	32 mm
Front panel thickness	17 mm
Connections	RJ45 Ethernet connection on the back-bottom side of the panel
Temperature range	-10ºC up to +50ºC
Display	Color TFT LCD, Touch screen 8” (1024 x 600 dots) with adjustable backlight
Net weight	940 g

PEM4.10 Touch Screen	Drawing 0815-1026 (section 17)
Supply voltage	115-230 VAC to power supply unit
Dimensions	260 x 178 x 44 mm (w x h x d)
Cut out	246,5 x 164,5 mm (w x h)
Cut out depth	46 mm
Front panel thickness	3,20 mm
Connections	RJ45 Ethernet connection on the back-bottom side of the panel
Temperature range	0ºC up to +50ºC
Display	Color TFT LCD, Touch screen 10.1” (1280 x 800 dots) with night view
Net weight	2 kg

4. SAFETY INSTRUCTIONS

There are no special safety instructions for the equipment.

5. UNPACKING

Let the equipment acclimatize inside the closed box for at least one hour at the location where the system will be installed.
When the equipment is taken out of the box, please leave the special protection supplied with the equipment as long as possible in place to avoid any damage.
The special protection should be stored for the unlikely event the equipment has to be sent for repair.
Dispose of the packing material should be done according to the laws of the country where the equipment is installed, or according to the rules that are applicable on the vessel.

- Be careful when unpacking the electronic equipment. The content is fragile.
- Do not press on the PEM4 touch screen.
- Be careful not to damage any of the connectors, control modules or wiring.

6. INSTALLATION AND FIRST USE

The PEM4 + SPU3 system will be delivered with the software and correct data settings installed. First connect all the inputs and outputs to the components. Connect for the PEM4.10 version a grounding cable to the grounding screw on the backside of the screen, see section 17 drawing 0815-1126.
The power supply wires should be connected at last.

Note: There is an ON/OFF switch on PEM4 touch screen. When the power switch is switched ON the screen will turn on.

Check if the inputs are connected correctly through menu <ALARMS> <Signals(raw)>.
In case of any errors the connection(s) or connected equipment(s) should be checked and corrected.

6.1 RECORD PEM4 + SPU3 SYSTEM DATA

This information is required when contact the supplier for any reason.

SPU3 nameplate:

Type No.	SPU3	**Serial No.**	
Supply voltage	V	**Frequency**	Hz
Var.No.		**Power Cons.**	W

PEM4 system info:

Software Version	
Serialnumber	
Hullnumber	
Delivery date	

6.2 INSTALLATION DIAGRAMS OF THE PEM4 + SPU3 SYSTEM

The PEM4 + SPU3 system, consisting of SPU3 signal processing unit and PEM4 touch screen, can be connected to the T-Sense® or TT-Sense® stator control box as shown in below figures.

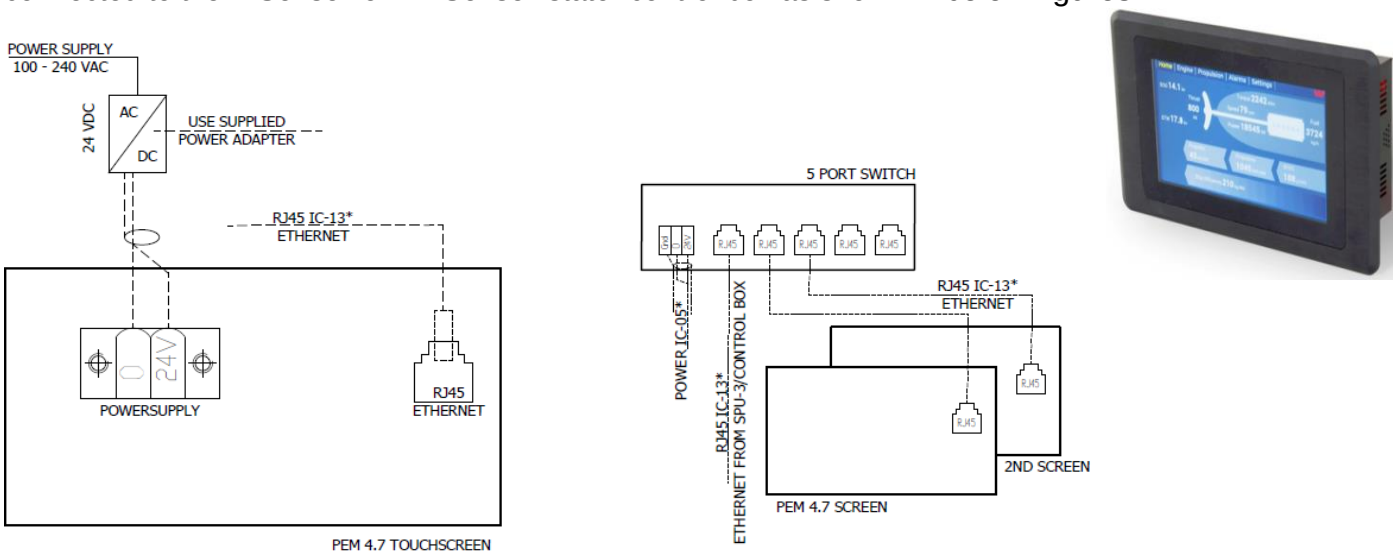

Figure 2 – Example of PEM4.7 + SPU3 system including T-Sense® torque sensor and 2 Touch Screens

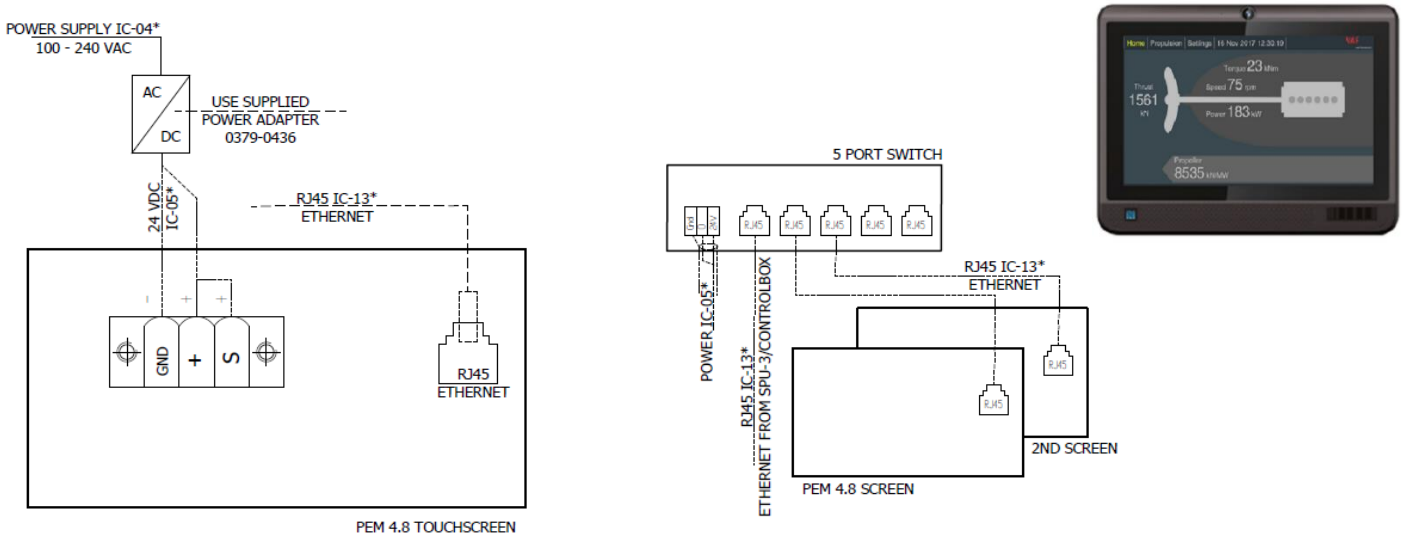

Figure 3 – Example of PEM4.8 + SPU3 system including T-Sense® torque sensor and 2 Touch Screens

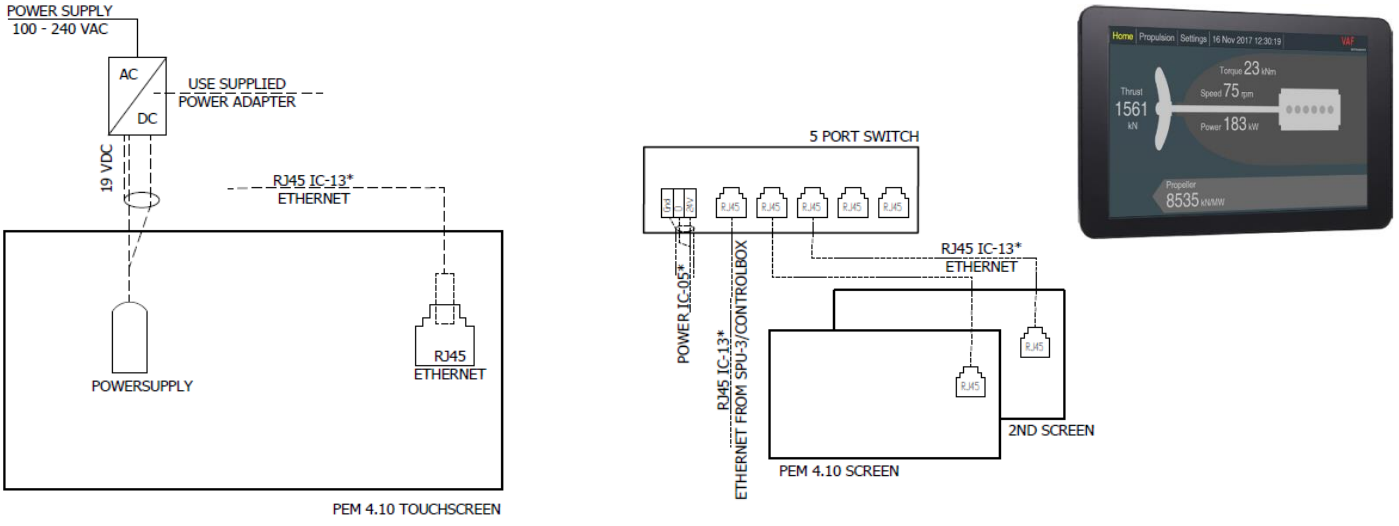

Figure 4 – Example of PEM4.10 + SPU3 system including T-Sense® torque sensor and 2 Touch Screens

6.3 INSTALLATION INSTRUCTION OF THE PEM4 + SPU3 SYSTEM

The propulsion efficiency monitoring system consists of a SPU3 and a PEM4 touch screen, T-Sense® or TT-Sense® sensors, flowmeters, speed log/GPS/NMEA input and draft/inclino meters will be connected to the SPU3. The SPU3 will perform all calculations and data processing to the PEM4 touch screen.

1. Always install the SPU3 with cable glands facing downwards. Do not take electronics out of the cabinet.

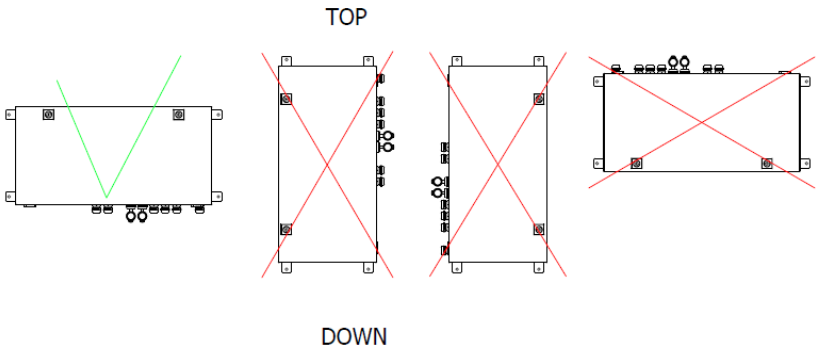

Figure 5 – SPU3 positioning

2. Install the SPU3 in the engine room (ER), engine control room (ECR) or near to the HFO booster units, but as much as possible free from moisture, free from large fluctuations of temperature and particularly free from vibration and shock. Also influences such as large magnetic fields must be avoided. Ambient temperature should under all circumstances be lower than 55°C. External dimensions drawings of the SPU3 can be found in section 17.

3. Connect the RS485 Modbus output from the stator control box of one T-/TT-Sense® sensor to the SPU3 in accordance with drawing 0815-2019 in section 17.
   When available, the second T-/TT-Sense® sensor cable needs to be connected as well.

4. Connect the signal outputs of the flow meters, speed log and/or shaft generator to the SPU3 in accordance with drawing 0815-2019 in section 17.
   Cable shields of the flowmeter cables should always be connected to the SPU3 side only.

5. Connect the RJ45 Ethernet output from the SPU3 to the PEM4 touch screen in accordance with drawing 0815-2019 in section 17.

6. Ensure that all relevant signal cables are properly connected and grounded.

7. Connect the power supply to the SPU3 and PEM4 touch screen(s) in accordance with drawing 0815-2019 in section 17.

8. Check if the output data is available on the touch screen(s) through menu <ALARMS> <Signals(raw)>. If any applicable output data is not available on the touch screen a pop-up alarm screen describing the failure(s) will show up.

Important notes

- Never connect cable shields at both ends to ground, but at one end only, to avoid earth loops.
- Avoid interference on the signal cables by installing them as far as possible away from electric power cables.
- Ensure that the ambient temperature at the SPU3 never exceeds 55ºC.

6.4 CONFIGURATION AND CONNECTION OF THE SPU3

The propulsion efficiency monitoring system is a modular system. Every system is specifically build and programmed.
The table “Flowmeter numbers, description and position” at the inside of the SPU3 cabinet, provides information regarding flow meter (TAG) numbers, configuration of the flow meters, speed log or GPS at the SPU3. The number of backplanes differs per SPU3 configuration.

Flow meter numbers, description and position

This table belongs to drawing 0815-2019 Interconnection diagram T-Sense SPU-3 PEM4

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Date: 18-11-15 14:14

Flow meter number and TAG			Temp corr.	Alarm temp °C	Time sample Sec	K-factor Pulses/ltr	Serial number No.
Flow meter	1	ME supply	yes	150	10	4.983	707724
Flow meter	2	ME return	yes	150	10	4.975	707730
Flow meter	3	GE supply	yes	150	10	11.952	707734
Flow meter	4	GE return	yes	150	10	11.940	707740

General info PEM4 monitoring system

Consumers		Configuration of flow meters	Net flow cut-off ltr/min
1	ME	supply/return	0.08
2	GE	supply/return	0.04

Speedlog puls	no	puls/nm
Speedlog NMEA	yes	
GPS (SOG)	yes	

Serial number T-Sense/SPU-3
Serial nr. : 15.2076
Serial number touch screen(s)
Screen nr. 1 : DE2700082
Screen nr. 2 :
Delivery date
Month/day/year: November 18 2015

Figure 6 – Example table “Flowmeter numbers, description and position”

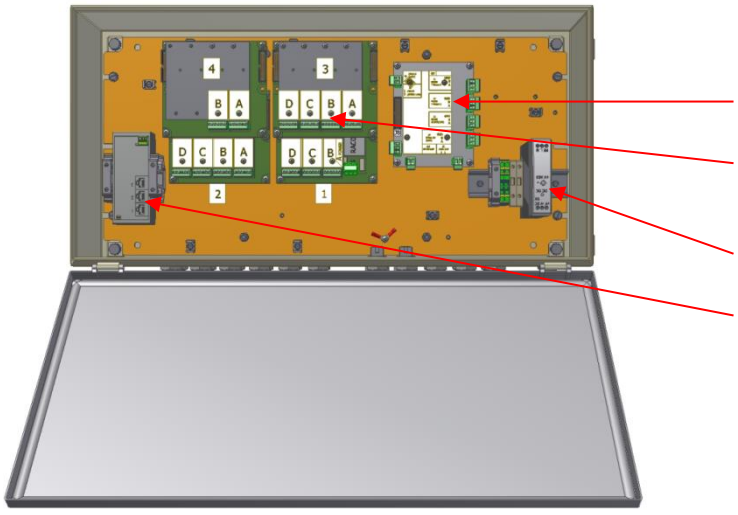


Figure 7 – SPU3 Cabinet layout

PT2 Flowmeters should be connected to the SPU3 according drawing/table 0815-2019 in section 17.

6.5 CABLE SPECIFICATIONS

Specification of the input, output and power supply cables used for connecting the PEM4 + SPU3 system.

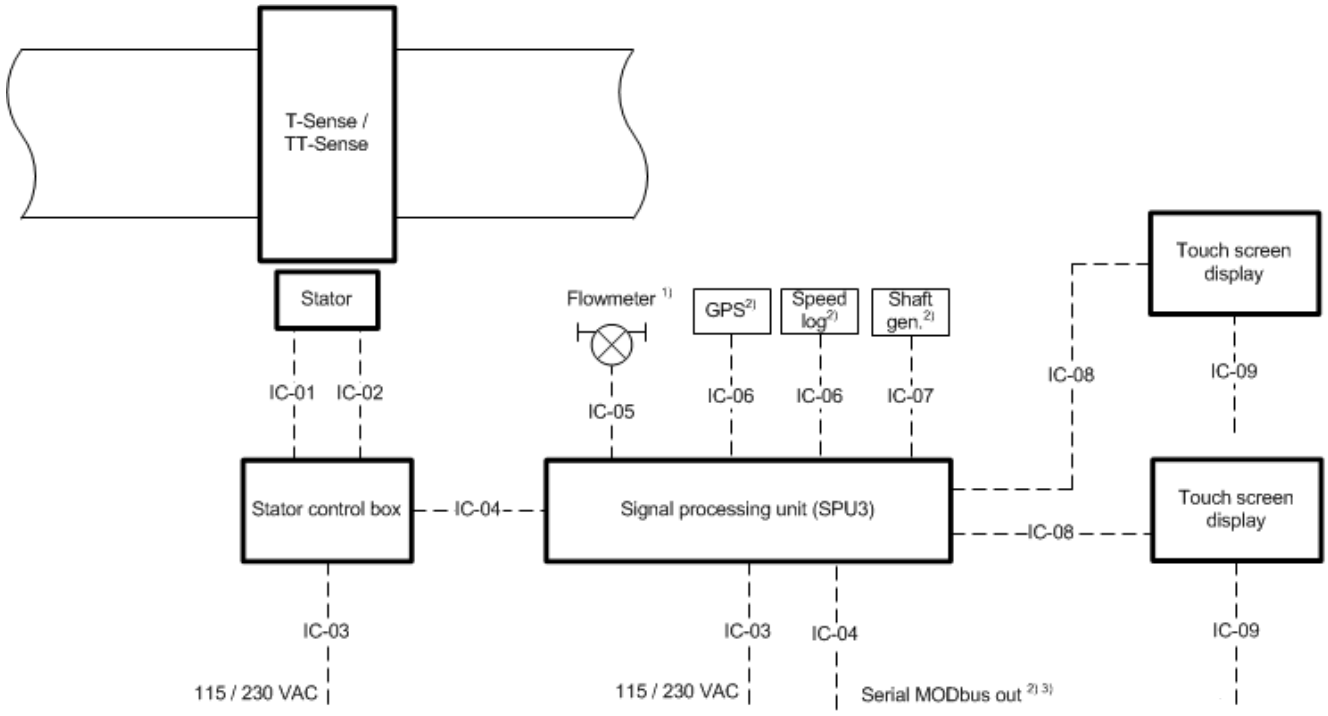


Figure 8 – Specification of input/output cables at Control box, SPU3 and PEM 4 touch screen(s)

1) Number of flowmeters can add up to max. 12 for 8 engines or consumers
2) Optional
3) When used with VAF Datalogger, please refer to SIG 918 for PC settings and connections
4) Pulse and PT100 signals should not be joined within 1 pair

Cable specification

IC-01	Integrated antenna cable 5m	VAF supply
IC-02	Integrated stator cable 5m	VAF supply
IC-03	Power supply (115 / 230 VAC) cable	3 x 1,5 mm^2
IC-04	Modbus connection cable	1 x 2 x 0,50 mm^2, twisted pair, braid shielded
IC-05	Flowmeter cable for pulse and PT100 (3m integrated),	2 x 3 x 0,50 mm^2 or 4 x 2 x 0,50 mm^2, individual screened twisted pair, braid shielded 4)
IC-06	Connection cable GPS or speed log	1 x 2 x 0,50 mm^2 twisted pair, braid shielded
IC-07	Connection cable shaftgen. 4-20mA input	1 x 2 x 0,50 mm^2 twisted pair, braid shielded
IC-08	Ethernet cable	CAT5e braid shielded, RJ45 plug
IC-09	From Power Supply Unit 24 VDC cable 5)	2 x 0,50 mm^2

All screens to be connected under the cable gland on the SPU3 side only.
Cable glands are M20 for cable dia. 7-12 mm.

Note: The maximum number of analogue inputs is 9 inputs, depending on the system configuration.

6.6 MODBUS INPUT FOR T-SENSE® AND TT-SENSE®

The T-Sense® or TT-Sense® signal will be connected to the J1 Modbus input connection (Channel 1). When a second T-Sense® or TT-Sense® is installed the signal will be connected to the J2 Modbus input connection (Channel 2).

Both the J1 and J2 Modbus input connections (resp. channel 1 and 2) can also be used for connection of Auxiliary Engines (AE) input. See section 6.9.
In such situation two, or more, Modbus input signals can be connected to the J1 and/or J2 Modbus input connection.
Therefore the inputs will be set on “Channel 1” or “Channel 2”, with each input a different slave address equal to the slave address of the connected device.
The T-Sense® or TT-Sense® stator box slave address is factory set by VAF Instruments.

6.7 ANALOGUE INPUT FOR TORQUE-, SPEED- AND POWER

It is possible to connect a torque-, speed- and power-meter to the SPU3 system. This torque-, speed and power-meter needs to be equipped with analogue 4–20mA outputs.

The analogue 4–20mA signals can be connected to the SPU3 (Backplane-X) representing the torque-, speed- and power-signal.

Analog input		
Signal	**Type of input signal**	**Terminal number on SPU3 Backplane-`X`**
Shaft torque signal	4–20mA - active	Terminal nr. X1 and X2
Shaft speed signal	4–20mA - active	Terminal nr. X3 and X4
Shaft power signal	4–20mA - active	Terminal nr. X5 and X6

The number of Backplane-“X” might differ per configuration, depending on the total system. Please refer to the connection diagram what comes with the project.

Make sure that the torque meter settings in the SPU3 system itself are set correctly. You are able to adjust these torque meter settings in the “Settings menu” (*advanced level only)*.

When passive analogue outputs have to be connected to the SPU3 system please contact VAF Instruments.

6.8 ANALOGUE OR MODBUS INPUT FOR SHAFT GENERATOR

The PEM4 + SPU3 system is able to calculate the total power generated by the main engine(s) when shaft generators are incorporated in the vessel's propulsion system. When the generators are positioned at the propeller shaft line (inline or tunnel gear type) or connected to the gearbox as a Power Take Off (PTO) the PEM4 + SPU3 system can add up both propulsion power and the measured generator power in order to calculate the correct SFOC values per engine.

Please be aware that the efficiency of the generators themselves is decreasing the overall SFOC value by a certain percentage.

A maximum of 2 input signals (4–20mA or Modbus) can be connected to the SPU3 representing the shaft generator power level(s).

Analog input		
Signal	**Type of input signal**	**Terminal number on SPU3 Backplane-'X'**
Shaft generator one	4–20mA - active	Terminal nr. X1 and X2
Shaft generators two	4–20mA - active	Terminal nr. X1 and X2 + X3 and X4
Shaft generator one	4–20mA - passive	Terminal nr. X5 and X6

The number of Backplane-"X" might differ per PEM4 configuration, depending on the total system. Please refer to the connection diagram what comes with the project.

Modbus input		
Signal	**Type of input signal**	**Terminal number on SPU3**
Shaft generator one	Modbus	Terminal nr. J1 (see section 6.12)
Shaft generators two	Modbus	Terminal nr. J2 (see section 6.12)

Make sure that the shaft generator settings in the PEM4 + SPU3 system itself are set correctly. You are able to adjust these shaft generator settings in the PEM4 Settings menu (*advanced user only)*.

When 2 passive shaft generator outputs have to be connected to the PEM4 + SPU3 system please contact VAF Instruments.

6.9 ANALOGUE OR MODBUS INPUT FOR AUXILIARY POWER

When Auxiliary Engines (AE) are monitored by VAF PT2 flow meters, it is possible to measure the Specific Fuel Oil Consumption (SFOC) of the AE driving the generators.
In order to measure the electric power supplied by the generators to the boardnet, 4–20mA signals or Modbus signals representing the power level of the generators can be connected to an input inside of the SPU3. A maximum of 6 AE's can be connected.

A maximum of 6 input signals (4–20mA or Modbus) can be connected to the SPU3 representing the AE's power level.

Analog input		
Signal	**Type of input signal**	**Terminal number on SPU3 Backplane-'X'**
Auxiliary power 1	4–20mA - active	Terminal nr. X1 and X2
Auxiliary power 2	4–20mA - active	Terminal nr. X3 and X4
Auxiliary power …	4–20mA - active	Terminal nr. X… and X…

The number of Backplane-"X" might differ per PEM4 configuration, depending on the total system. Please refer to the connection diagram what comes with the project.

Modbus input		
Signal	**Type of input signal**	**Terminal number on SPU3**
Auxiliary power 1	Modbus	Terminal nr. J1 (see section 6.12)
Auxiliary power 2	Modbus	Terminal nr. J2 (see section 6.12)
Auxiliary power …	Modbus	Terminal nr. J1 (see section 6.12)

6.10 ANALOGUE INPUT FOR VISCOSENSE®3D – DENSITY, TEMP. AND VISCOSITY

A ViscoSense®3D can be connected to the SPU3. Therefore the 4–20mA output signals of the ViscoSense®3D interface box, density, temperature and viscosity, will be connected to the analogue input inside of the SPU3.
Using the density and temperature input the mass flow within the fuel system can be calculated and be shown on the PEM4 screen.
Because the ViscoSense®3D measurement and the volume flow measurement possibly have different temperatures, both measurements (mass and volume) will be calculated at reference temperature and accordingly be multiplied with each other to get the mass flow.

Analog input		
Signal	**Type of input signal**	**Terminal number on SPU3 Backplane-`X`**
Density	4–20mA - active	Terminal nr. X1 and X2
Temperature	4–20mA - active	Terminal nr. X3 and X4
Viscosity	4–20mA - active	Terminal nr. X5 and X6

The number of Backplane-"X" might differ per PEM4 configuration, depending on the total system. Please refer to the connection diagram what comes with the project.

6.11 MODBUS OUTPUT TO EXTERNAL SYSTEM

If applicable the PEM4 + SPU3 system can be connected to an external system like an Alarm and Monitoring System (AMS) or SPU3 Datalogger software through the J3 Modbus slave output, which is at the processor module in the SPU3 cabinet.

COM-port settings for reading out the J3 Modbus signal at SPU3	
Communication protocol	Modbus RTU
Serial interface	RS485 (2-wire)
Baud rate	57600
Data bits	8
Parity	None
Stop bits	1
Flow control	None
Function code	3 (Holding registers)
Modbus slave address	1

The Modbus output data is made available at two 16 bits integers which will have to be converted to 32 bits float according IEEE754. IEEE754 is a standard for binary floating point arithmetic.

Modbus address list

To receive a full list containing the available standard SPU3 Modbus addresses (*ASL-668 SPU3 Modbus registers list*) or in case your AMS system is programmed for 16 or 32 bit integer input signals, please contact VAF Instruments for additional information.

In case more than one (1) SPU3 is connected in the same MODBUS-loop, the slave addresses of these SPU3's are factory set resp. slave-"1", slave-"2", etc.

6.12 MODBUS CONNECTIONS

For connection of multiple slaves to J1 and/or J2 Modbus SPU3 master input, following “multidrop” connection and settings need to be taken into account.

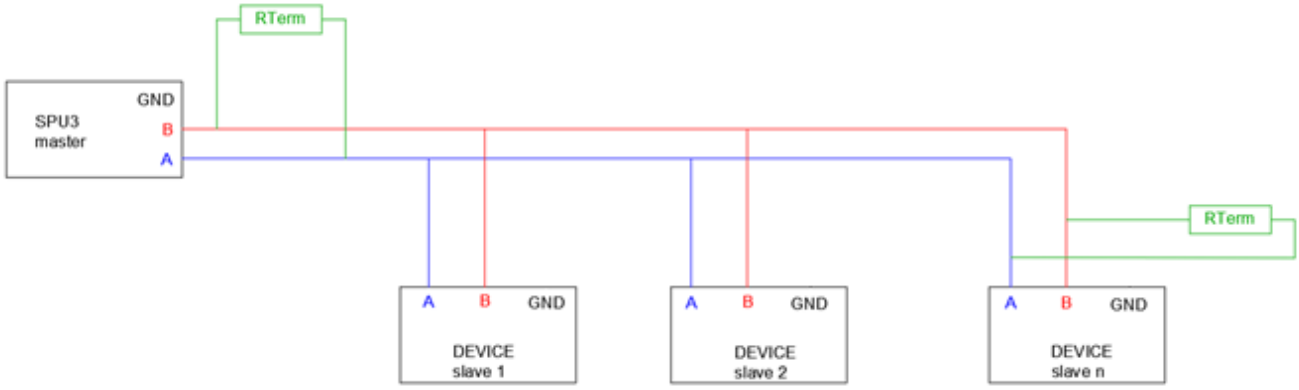
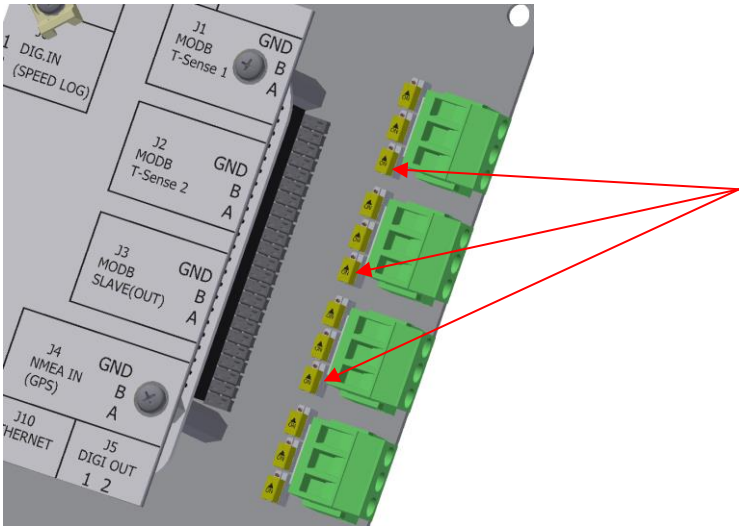


Figure 9 – Multidrop connection diagram

The connection loop needs to be “closed” with termination resistors.
In example Figure 9 the termination resistor needs to be placed at the first device (SPU3/master) and at the last connected device (slave n).



Termination resistor switches.
Set the switch in “on”-position to activate the termination resistor for the corresponding connection.

Figure 10 – Termination resistor switch

The SPU3 termination resistor can be set by way of a jumper switch in “on”-position.

The termination resistor of the last device depends on the device. This can be done using a resistor or by way of a switch. Please contact your supplier.

NOTE:
Do not connect the signal ground to the ship hull.

7. OPERATING PRINCIPLES

7.1 GENERAL

A zero setting procedure is always necessary in order to obtain a correct measurement and reading of the T-Sense® Torque sensor or TT-Sense® Thrust & Torque sensor.
For more detailed information see section 6.4 of TIB-661 T-Sense® or TIB-664 TT-Sense®.

The PEM4 + SPU3 system is an integrated solution for monitoring engine power, fuel consumption and a wide selection of additional data and indicators. The PEM4 + SPU3 system will display the engine load diagram and the actual load of the main engine. The menu structure of the PEM4 + SPU3 system is self-explaining and the system is easy to operate.

A number of conditional messages will inform you about error/fault conditions if applicable.
Setups determining functionality are subdivided in two levels and access is only possible via a right-of-access code. All setups and computations are stored in a battery backup RAM. The PEM4 + SPU3 system is self-checking as for correct functioning of its memories, program run and existence of supply voltage.

7.2 DISPLAYED PARAMETER AND ENGINEERING UNITS

The following parameters are available	**Unit**
• Shaft torque	kNm
• Shaft speed	rpm
• Shaft power	kW
• Shaft thrust	kN
• Total energy	kWh, MWh, GWh
• Total mass	kg
• Time-base	hours, minutes, seconds
• Shaft generator power (to calculate total power)	kW or MW
• Fuel oil flowmeters, max. 12x (*)	l/min
• K-factors flowmeters	pulses/litre
• Fuel temperature sensors, max. 12x (*)	°C
• GPS NMEA Ship's SOG	knots
• GPS NMEA Ship's STW	knots
• Speed log (input)	pulses/NM
• Fuel oil consumption	kg/h, ltr/h or kg/NM, ltr/NM
• Specific gravity	kg/l
• Thermal expansion	%/°C
• Ref. Temperature	°C
• Caloric value	MJ/kg
• Specific Fuel Oil Consumption (SFOC)	g/kWh
• Propeller thrust	kN
• Thrust power quotient	kN/MW

(*) for a maximum of 8 engines/consumers

7.3 EXPLANATION OF PARAMETERS

7.3.1 Shaft torque

The shaft torque is measured in the T(T)-Sense® rotor part and sent wireless to the control box. The shaft torque output of the control box is connected to SPU3 via RS485 Modbus. *) **)

7.3.2 Shaft speed

The shaft speed is measured via a gravity sensor in the T(T)-Sense® rotor part and sent wireless to the control box. The shaft speed output of the control box is connected to SPU3 via RS485 Modbus. *) **)

7.3.3 Shaft power

The measured torque and shaft speed are the input values to the power calculation, which is performed in the T(T)-Sense® stator control box. The shaft power output of the control box is connected to SPU3 via RS485 Modbus. *) **)

7.3.4 Shaft thrust (option)

When a TT-Sense® is installed, which additionally measures shaft thrust, the measured thrust is sent wireless to the control box. The shaft thrust output of the control box is connected to SPU3 via RS485 Modbus. *) **)

*) *Adjustment of the bar-graph-ranges ("Engine Consumption" and "Engine Power") and the horizontal/vertical axis ("Propulsion Power/Speed diagram") at the PEM4 touch screen are programmed at VAF location.*

**) *Zero torque adjustment will be done during commissioning of the T(T)-Sense® rotor and control box. For more detailed information see section 6.4 of TIB-661 T-Sense® or TIB-664 TT-Sense®.*

7.3.5 Shaft generator (option)

The shaft generator output signal should be an active 4–20mA or Modbus signal. The input range is programmed at VAF location.
The total power delivered by the main engine can be calculated by:

Total power main engine = Shaft power + shaft generator power.

Specific Fuel Oil Consumption (SFOC) value is calculated by dividing the engine's fuel consumption by above mentioned Total power.

7.3.6 Fuel oil consumption

Up to 12 flowmeters, each with a pulse and temperature output, can be connected to the SPU3. The SPU3 can handle a maximum of 8 engines and/or consumers. Please refer to section 3 for the flowmeter pulse and temperature specifications.
The K-factor of each flowmeter is programmed at VAF location or can be set via the settings menu by VAF authorised representatives through the PEM4 touch screen.

7.3.7 Fuel oil temperature

For an accurate calculation of fuel oil consumption, it is recommended to connect PT100 temperature sensors within the system. Temperature sensors are strongly recommended when a supply/return system is programmed. VAF type PT2 flowmeters are as a standard equipped with PT100 temperature sensors. The PT100 sensors are connected to the SPU3.
The PT100 range is programmed in the SPU3. No further settings are needed.

7.3.8 Speed over ground (SOG) via NMEA0183

A GPS signal can be connected to the SPU3 through the RS422 port (J4).
The *ship's speed over ground* is hidden in the NMEA0183 protocol. The PEM4 + SPU3 system will read out the $--VTG sentence ("speed over ground") and the value will be displayed in knots.
No adjustments are needed. ***)

7.3.9 Speed through water (STW) via NMEA0183

A GPS signal can be connected to the SPU3 through the RS422 port (J4).
The *ship's speed through water* is hidden in the NMEA0183 protocol. The PEM4 + SPU3 system will read out the $--VBW sentence ("longitudinal water speed") and the value will be displayed in knots.
No adjustments are needed. ***)

7.3.10 Speed through water (STW) via pulse signal from speed log

In case the ship's speed is measured with a (Doppler) speed log, the pulse output signal from the speed log's potential free contact is transmitted to the SPU3 through the speed log input (J6).
The ship's speed range is programmed at VAF location or can be set via the settings menu by VAF authorised representatives through the PEM4 touch screen.
The default setting is 200 pulses/nautical mile. ***)

> ***) *The speed which is displayed and used for calculations is depending on the settings and availability of the signal to the input.*
> *STW-NMEA is 1st choice, STW-Speed log is 2nd choice and SOG-NMEA is 3rd choice.*
> -
> *For example in the situation that "NMEA", "NMEA STW" and "Speed log" are selected as "Enable" in the PEM4 settings menu and their signals are available on the inputs. In this situation the PEM4 + SPU3 system will use STW to display and use for calculations. In case the STW signal is not available, the PEM4 + SPU3 system will automatically use speed log.*

7.3.11 Density

A maximum of 6 ViscoSense®3D systems can be connected to the SPU3 system. The density and temperature signals are connected to the SPU3 through analogue 4-20mA signals.
Using density the mass flow and mass consumption can be calculated.

7.3.12 Draft

The draft front, middle SB, middle PS and at the back can be connected to the SPU3 through 3 analogue 4-20mA signals.

7.3.13 Inclino

By use of an inclinometer the pitch, roll and yaw can be connected to the SPU3 through 3 analogue 4-20mA signals.

Note: The maximum number of analogue inputs is 9 inputs, depending on the system configuration.

7.4 HOW TO OPERATE

The PEM4 touch screen is designed in such a way that it is easy to operate and self-explaining. By touching the keys on the touch screen gently the next menu is selected, or specific values can be changed.
Browsing through the sections and submenus by touching the relevant keys at the touch screen will help you to find the information you are looking for.

For detailed information on how to operate the PEM4 + SPU3 system and background information on the displayed output, graphs and other indicators please read section 0.

Entering values
Via a numeric keypad you will be able to change specific values.
This keypad will be displayed after touching the values in the light grey sections at the touch screen.
The value will change when a new value is entered and the <Go> key is touched.
If you do not want to change the value, touching the <Go> key again will close the numeric keypad and the touch screen will return to the previous menu.

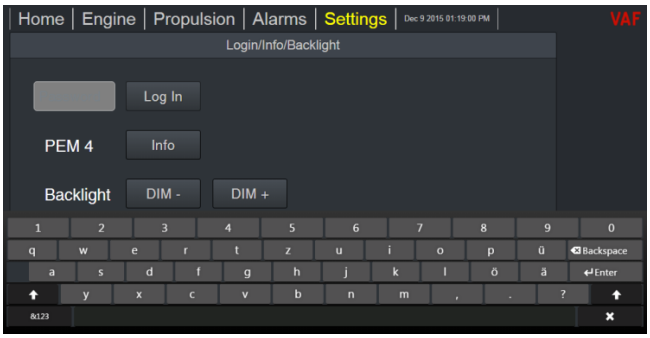


Figure 11 – Onscreen Keypad

Backlight
By touching the <Settings> key at the top right of the touch screen you will find the keys to change the brightness of the touch screen. The intensity of the backlight can be changed by touching the < DIM– > and < DIM+ > keys.

Alarms
By touching the <Alarms> key at the top of the touch screen the overview with current alarms opens. All active alarms are shown in this overview and can be accepted by touching the <Accept> button behind the specific alarm.

After ticking the alarm log key all previous alarms are listed and can be scrolled vertically.

In the submenu Signals (raw) you are able to check the raw sensor output of T(T)Sense®, flow meters, GPS, etc.

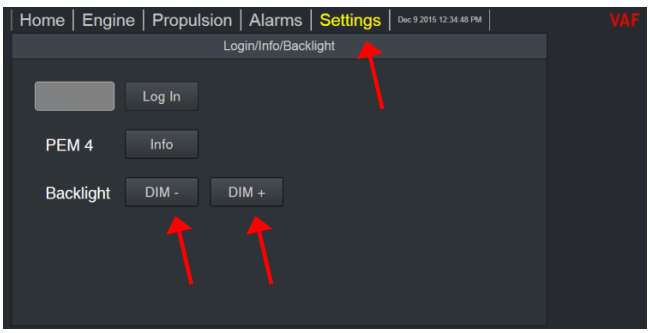


Figure 12 – *Backlight Settings*

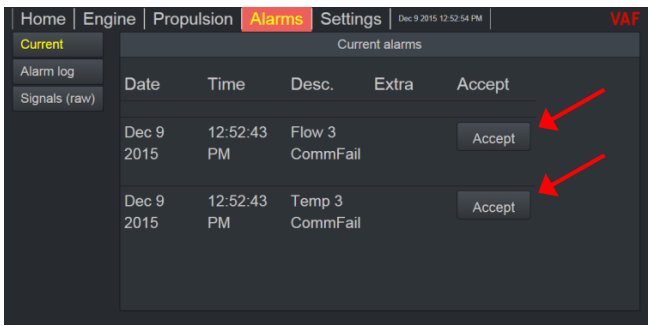


Figure 13 – *Alarms and Signal(raw) menu*

7.5 EXPLANATION OF THE MENUS

7.5.1 Operating menus

The PEM4 + SPU3 system is divided into 5 main menu's: Home, Engine, Propulsion, Alarms, Settings. The first four menus are all relevant system menus for daily use. By touching the relevant keys softly, the specific screen will be displayed.

The **Home menu** shows the main indicators for efficiency monitoring.

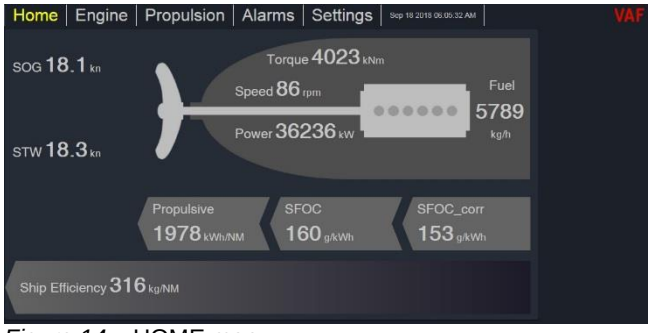


Figure 14 – HOME menu

The **Engine menu** is divided into 8 submenu's:

- Consumption
- Average Consumption
- Total Consumption
- Accumulated Consumption
- Power
- Engine Efficiency (SFOC, SCOC, Averages)
- Specific Fuel Oil Consumption Corrected (SFOC corrected)
- Engine Load Diagram (Shaft Power vs Shaft Speed)

By selecting a submenu, the output data is shown of the flow meters and T(T)Sense® sensors that are directly related to the engine(s) or other consumers.

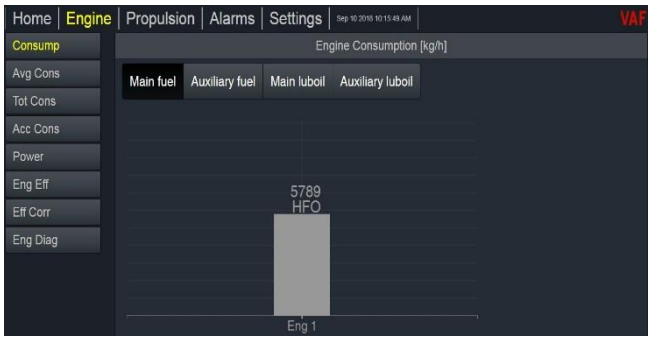


Figure 15 – ENGINE menu

The **Propulsion menu** is divided into 6 submenu's:

- Ship Efficiency
- Propulsive Efficiency
- Power/Speed diagram
- Environment
- Averages
- Conning

The submenus contain indicators representing overall ship efficiency, propeller efficiency and EEOI (Energy Efficiency Operational Indicator).

Figure 16 – PROPULSION menu

The **Alarms menu** is divided in 3 submenus:

- Current Alarms
- Alarm log
- Signals (raw)

In the situation of an alarm due to an error in the system or for example too high fuel temperature, an alarm message will pop-up in the *Current Alarms* submenu. All alarms will be logged in the *Alarm log* submenu. In the Alarm log submenu additional information can be shown through vertical scrolling.
The Signals submenu shows the raw signals coming in from the sensors connected to the PEM4 + SPU3 system.

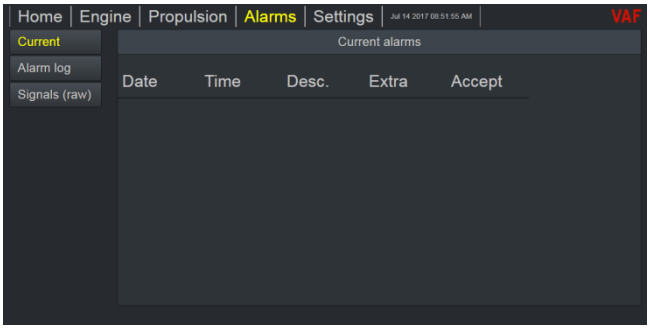


Figure 17 – ALARMS menu

7.5.2 Settings menu Users

In the **Settings menu** you can change the settings of the PEM4 + SPU3 system. The Settings menu is divided into a protected area for adjusting *User settings* and a protected area for adapting *Advanced settings*.
Adapting of Advanced settings should only be done by VAF authorised personnel or in cooperation with VAF authorised representatives.

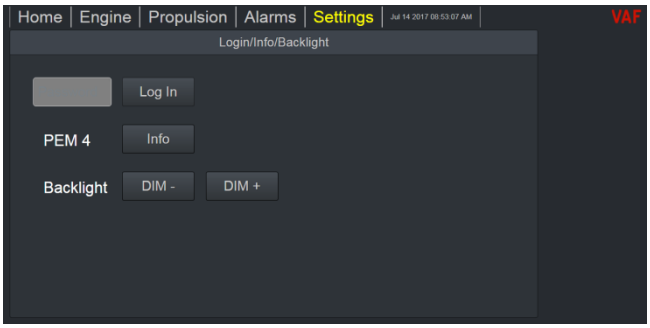


Figure 18 – SETTINGS menu

By entering the password (**1234**) and touching <Log in> the User settings menu is opened.
The settings menu for users is divided in 3 submenus and following data can be set through this settings menu:

- Engine Fuel Settings — Fuel switch temperatures and automatic/manual switching between fuels.
- Fuel Type Settings — When fuel flow meters are connected to the PEM4 + SPU3 system, fuel density, thermal expansion, reference temperature, Remain on Board (ROB), CO2 conversion factor, caloric value, water percentage and sulfer percentage of the fuel can be set.
- MRV Cargo — The amount of cargo, number of persons and the cargo/pax rate can be set.

7.5.3 Settings menu Advanced

By entering the “Advanced” password and touching <Log in> the Advanced settings menu is opened. This mode is used to set the customized parameters. These parameters are programmed at the VAF factory as specified by the customer.
Adapting of Advanced settings should only be done by VAF authorised personnel or in cooperation with VAF authorised representatives. The “Advanced” password is only granted by VAF personnel and VAF authorised representatives.
Process control will be interrupted when the PEM4 is in this mode.

WARNING:
WRONG SETTINGS MAY RESULT IN SYSTEM FAILURE. VAF INSTRUMENTS B.V. WILL NOT TAKE ANY RESPONSIBILITY FOR OPERATIONS CARRIED OUT BY UNAUTHORIZED PERSONS.

7.6 EXPLANATION OF THE MENUS

7.6.1 Home menu

By touching the <Home> key in the top left corner you will be guided to the “Home” screen of the PEM4 + SPU3 system.

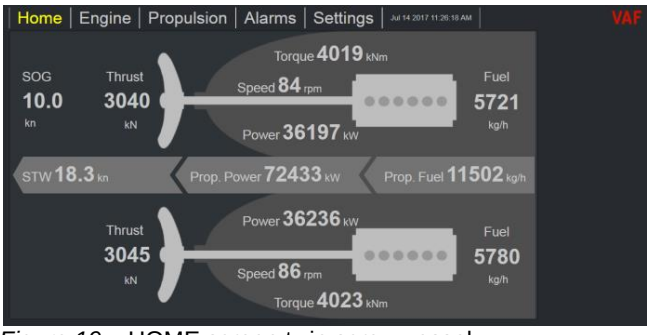


Figure 19 – HOME screen twin screw vessel

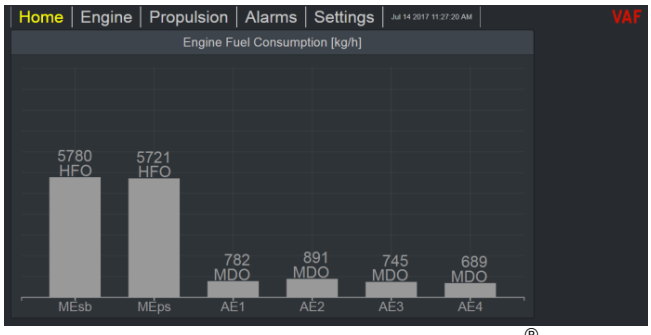


Figure 20 – HOME screen in case no T(T)-Sense® connected

The *Home screen* (Figure 19) is showing all important actual information regarding the Main Engine(s). Fuel consumption, torque, shaft speed and shaft power will be monitored per propeller shaft line. Propulsion system (if thrust measurement is available) and ship speed (if a speedlog or GPS unit is connected). Fuel consumption can be monitored per engine depending on the number of flow meters incorporated in the fuel system.
When no T(T)Sense® sensors are connected to the system, the actual fuel consumption is shown in the *Home screen* according Figure 20.

SOG	Speed Over Ground	knots
STW	Speed Through Water	knots
Torque	Torque per shaft line	kNm
RPM	Shaft speed	rpm
Power	Shaft power per shaft line	kW
Thrust (TT-sense®)	Propeller thrust per propeller	kN
Fuel	Fuel consumption per main propulsion engine	kg/h
Propeller (TT-sense®)	Propeller efficiency	kN/MW
Propulsive	Propulsive efficiency	kWh/NM
SFOC	Specific Fuel Oil Consumption of the main engine	g/kWh
Ship Efficiency	Fuel consumption of the main propulsion engine(s)	kg/NM

Twin screw propulsion
When the PEM4 + SPU3 system is monitoring a twin screw propulsion system the light grey bar in the centre of the *Home screen* will show the “Total Propulsion Power” and “Total fuel consumption” by the main engines.

Ship’s speed input
In case the speedlog signal or GPS-STW signal is connected to the PEM4 + SPU3 system, the *Home screen* will show the ship’s speed through the water (STW).
Note: In case both signals are connected, speed log signal and GPS-STW signal, than the PEM4 + SPU3 system will use the GPS-STW signal to display and for calculations.

In case the GPS-SOG signal is connected to the PEM4 + SPU3 system, the *Home screen* will show the ship’s speed over ground (SOG).

When both SOG and STW are used as input to the PEM4 + SPU3 system you will be able to detect that the vessel is sailing against or with the current.
For example: When SOG is below STW the vessel is sailing against the current.

SI (Metric) or US units
As a standard the PEM4 + SPU3 system is using SI (Metric) units. If applicable the units at the PEM4 touch screen can be set to US standards.
Please contact VAF Instruments before delivery of the PEM4 + SPU3 system if you like to switch the units from SI to US standard.

7.6.2 Engine menu

The *Engine menu* is submitting detailed information about the actual and average fuel consumption per consumer, total fuel consumption per engine, actual and average power per engine, total energy consumed and engine efficiency.

Engine Consumption submenu

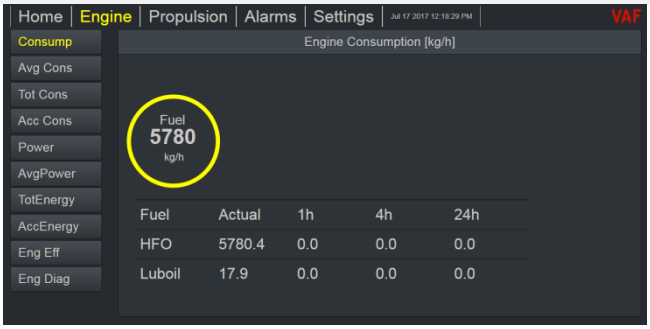


Figure 21 – Fuel consumption screen, one consumer

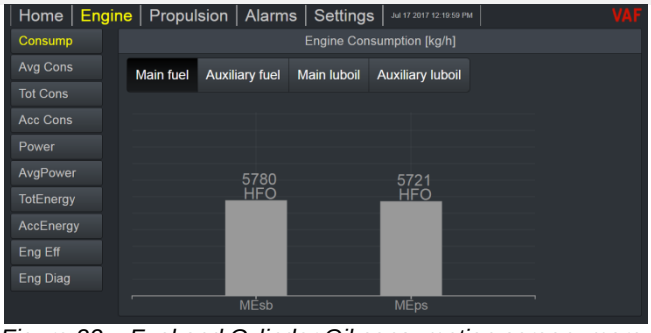


Figure 22 – Fuel and Cylinder Oil consumption screen, more than one engine or consumer

When the PEM4 + SPU3 system is monitoring more than 1 engine or consumer, bar graphs representing the fuel consumption per hour will be shown in bar graphs. These bar graphs are especially designed to have immediate overview of the situation.

As a standard the PEM4 + SPU3 system monitors the fuel consumption per engine in kg/hour. In case you prefer to read out all fuel consumption data in litres/hour you can change the measurement unit in the *Settings menu* in the submenu Fuel type. Please be aware that after switching from kg/hour to litres/hour and vice versa the value at the accumulated fuel consumption counter is not correct.
The value at the Total Fuel consumption counter will be correct again after ticking the Reset key.

In above fuel consumption screens the actual fuel type is shown per engine. The type of fuel can be set per engine or consumer in the same Settings menu.

Average Fuel Consumption submenu

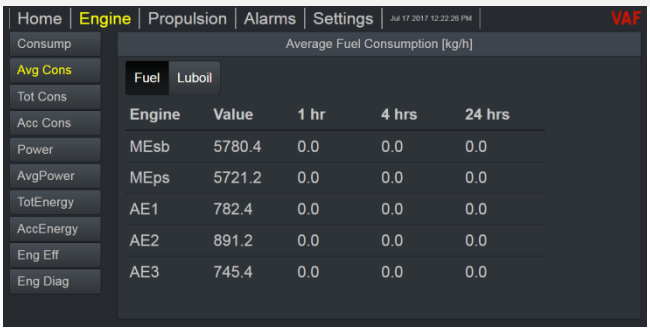


Figure 23 – Average Consumption screen

The four columns show the current fuel consumption and the averages over the last 1-4-24 hours. The average fuel consumption over the last hours the vessel was sailing can easily be compared. Comparing these values helps the crew to efficiently detect changes in fuel consumption per engine or consumer.
When the propeller shaft is rotating the PEM4 + SPU3 system is continuously recalculating the average values.
In case the propeller shaft is not rotating the average values stay as they are. Average values will only be displayed when the system gathered sufficient data to make a correct calculation.

Total Fuel Consumption submenu

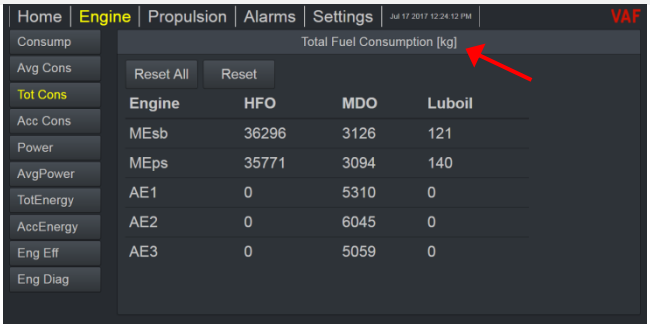


Figure 24 – Total Consumption screen

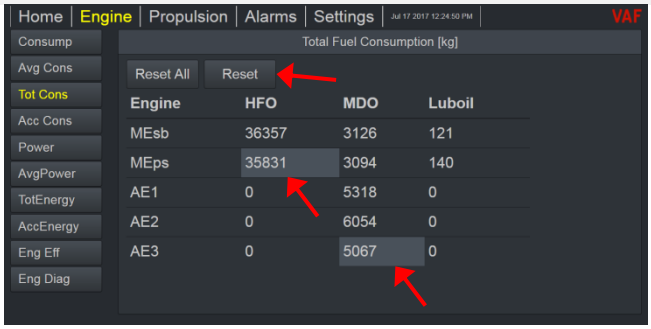


Figure 25 – Resetting specific values

This screen shows the total fuel consumption per engine/consumer and per fuel type in kilograms.
You can reset the consumption values - per engine/consumer and per fuel type - for example if you like to use these counters for generating 24 hours fuel consumption values for a noon report.
Ticking Reset All will reset all the total values at once.

Be aware that by pushing the Reset buttons the values will be set to zero and the previous displayed values will be lost.

If you like to reset certain values and keep other values as they are, you can select specific values by selecting them. After selecting the values they will become light grey. Accordingly you can reset the light grey values by pushing the Reset key.

Accumulated Fuel Consumption submenu

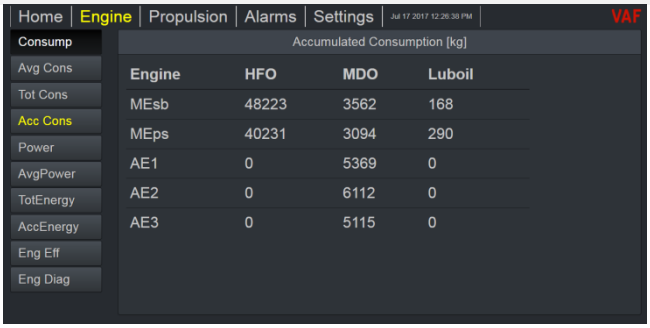


Figure 26 – Accumulated Consumption screen

This screen shows the total accumulated fuel consumption per engine or consumer in kilograms.
The values are cumulative and non-resettable. These counters can be used as a back-up of the Total Fuel Consumption counters.

Shaft Power submenu

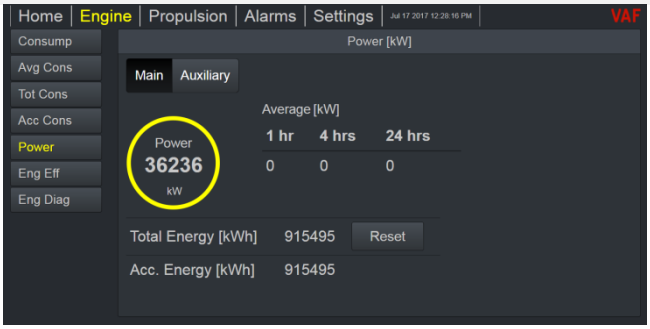


Figure 27 – Shaft Power Screen single screw

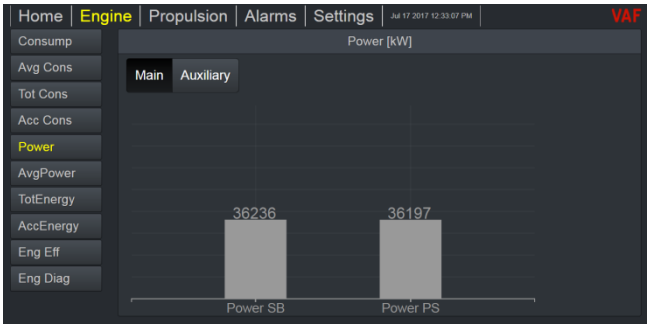


Figure 28 – Shaft Power Screen1/4 twin screw

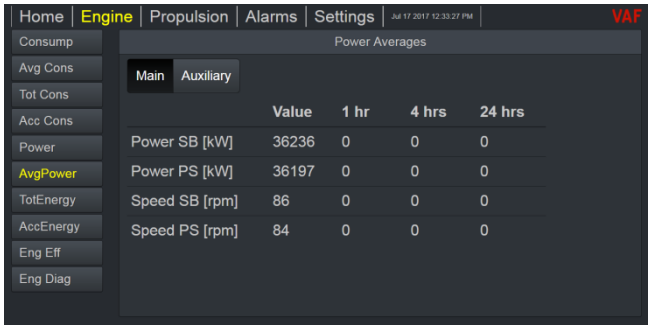


Figure 29 – Shaft Power Screen 2/4 twin screw

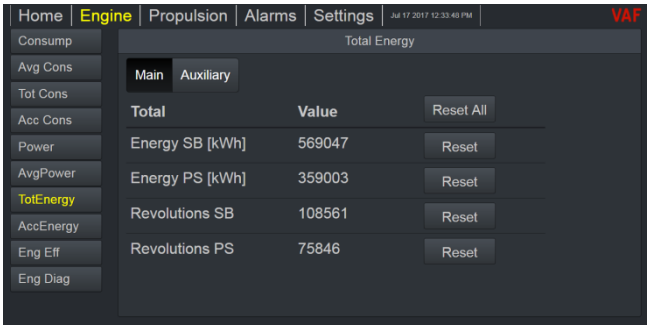


Figure 30 – Shaft Power Screen 3/4 twin screw

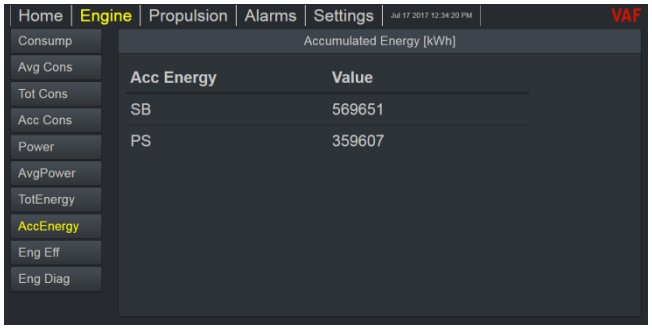


Figure 31 – Accumulated Energy Screen 4/4 twin screw

Single screw

The shaft power submenu for single screw vessels (Figure 27) will show the actual power, the average values over the last 1-4-24 hours and the Total Energy consumed at just one screen.

Twin screw

In case the PEM4 + SPU3 system is monitoring shaft power output for a twin screw propulsion installation the information will be divided over four consecutive PEM4 screens.
The actual power is shown with different bars in the Shaft Power submenu, Figure 28.
The actual power and the average values over the last 1-4-24 hours are shown in the Power Averages submenu, Figure 29.
The Total Energy consumed are shown in the Total Energy submenu, Figure 30.
The Accumulated Energy is shown in the Acc Energy submenu, Figure 31.

Auxiliary Engines

As an option the power level and fuel consumption of the generators driven by the Auxiliary Engines can be monitored through the PEM4 + SPU3 system.
See “Power/Energy Aux” in figure Figure 28, Figure 29, Figure 30. For more details see section 7.6.6.

The values can set back to zero by touching the Reset button.

Engine Efficiency submenu

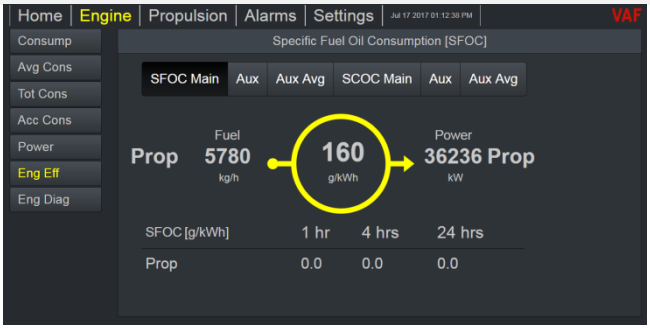


Figure 32 – Engine Efficiency screen single screw

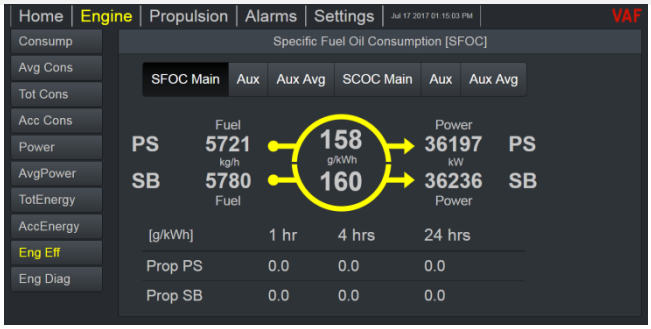


Figure 33 – Engine Efficiency screen twin screw

When the main engine is driving a propeller shaft line equipped with a T-Sense® sensor the SFOC rate will inform you about the Specific Fuel Oil Consumption in g/kWh of this engine. The Engine Efficiency submenu will give you an overview of the amount of fuel consumed per engine and the power delivered at the shaft per engine. The SFOC rate is a key performance indicator for engine efficiency.
As an option the efficiency of the Auxiliary engines in combination with the generators can be monitored. In case lubrication oil consumption is measured the PEM4 + SPU3 system is able to calculate the SCOC value representing the Specific Cylinder Oil Consumption in g/kWh.

Engine Efficiency Corrected submenu

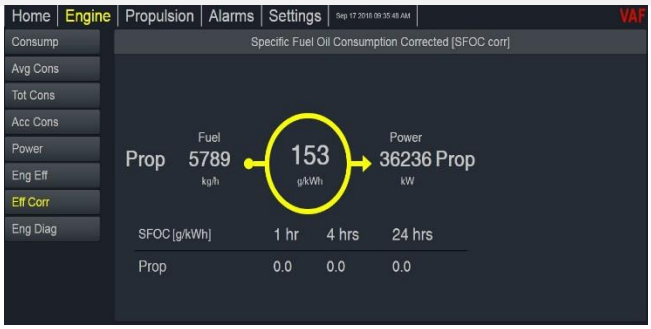


Figure 34 – Engine Efficiency Corrected screen single screw

When the main engine is driving a propeller shaft line equipped with a T-Sense® sensor the SFOC rate will inform you about the Specific Fuel Oil Consumption in g/kWh of the engine. The Engine Efficiency Corrected submenu will give you an overview of the amount of fuel consumed using the user determined calorific value of the fuel. The SFOC rate is a key performance indicator for engine efficiency. The calorific value of the fuel can be set using the Fuel menu (*Settings* tab). The calorific value of the shop can be set using the System menu (*Settings* tab, Advanced user only).

Engine Diagram submenu

Figure 35 – Engine Diagram screen single screw

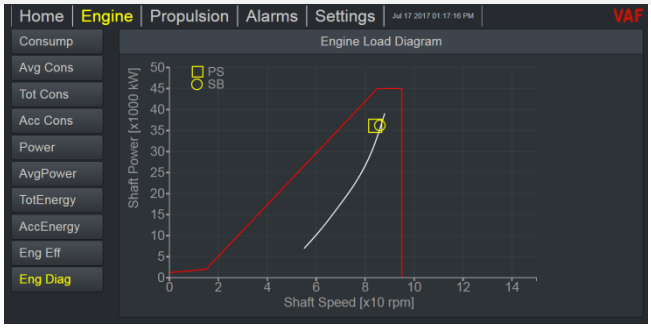


Figure 36 – Engine Diagram screen twin screw

The *Engine Diagram* displays engine load of the main engine, when a T-Sense® or TT-Sense® is connected to the PEM4 + SPU3 system. The load limit lines of the main engine can be set in the Settings menu. The white line can be displayed as an option and indicates a reference line which is for example the sea trial curve of the vessel. The load limit lines make clear up to which torque and RPM level your engine can be loaded. When the actual point (yellow dot) is passing the limit lines (red) the engine is overloaded and can get overheated.
In case of twin screw vessels 2 actual points (Yellow dot for Starboard and yellow square for Portside) will be shown in the same diagram.

7.6.3 Propulsion menu

The *Propulsion menu* is submitting detailed output data regarding efficiency of the propulsion system. In this menu ship speed is the variable that is compared to fuel consumption, CO2 emissions and power generated by the main engines. In the *Environment submenu* you can look up the ship's Energy Efficiency Operational Indicator (EEOI) value, which is an indicator of the CO2 exhaust gas emissions per nautical mile per cargo load unit.

Ship Efficiency submenu

Figure 37 – Propulsion Ship Efficiency screen

In this submenu the fuel consumption of the main engines and the actual and average fuel consumption per Nautical Mile are indicated.

Propulsive Efficiency submenu

Figure 38 – Propulsive Efficiency screen

In this submenu the actual power and the average power level of the main engine(s) are indicated per Nautical Mile.

Power/Speed Diagram submenu

Figure 39 – Power/Speed Diagram screen

In this submenu the actual power of the main engine(s) is presented in a *Power/Speed diagram*. The graph shows the *Total Propulsion Power* of the main engine(s) and the respective *vessel speed* in Nautical Miles. SOG = Speed Over Ground, STW = Speed Through Water.

In the Settings menu there is a possibility to enter a reference curve (see white curve in picture above). In this case the reference curve is a guideline to judge if the vessel is sailing as efficient as just after sea trials. For more details see section 7.6.6.

Environment submenu

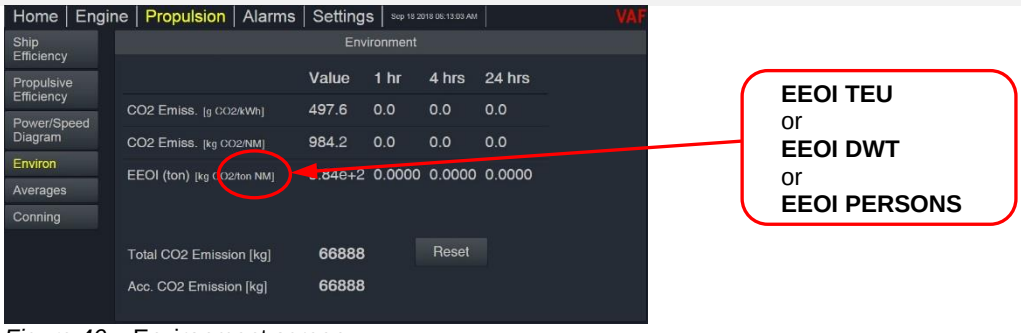


Figure 40 – Environment screen

When fuel flow meters are incorporated in the PEM4 + SPU3 system this screen displays the CO2 emissions In kilogram CO2 per kWh.

When an additional speed signal is incorporated, the system will also display CO2 emissions per Nautical Mile and the Energy Efficiency Operational Indicator (EEOI) which represents kilograms of CO2 emissions per Nautical Mile per cargo unit. The unit for cargo can be adapted to: TEU, DWT or persons.

The emissions in *kg·CO2/NM* and *kg·CO2/kWh* are representing CO2 emissions of the main engine. EEOI is representing the total CO2 emissions of all consumers monitored by the PEM4 + SPU3 system.

Averages submenu

Figure 41 – Averages screen single screw

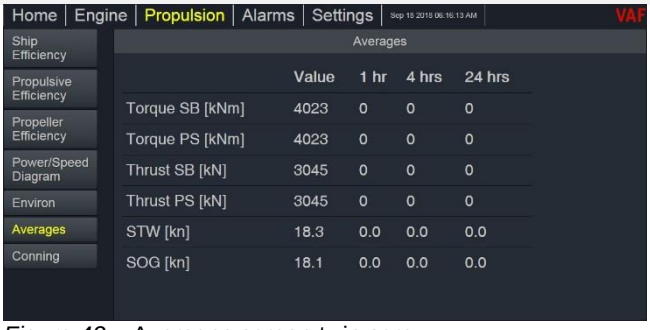


Figure 42 – Averages screen twin screw

The Averages submenu indicates the average vessel speed and average torque values.
When Speed Over Ground (SOG) and Speed Through Water (STW) are measured simultaneously you will be able to judge if the vessel is sailing with or against the current.

Conning submenu

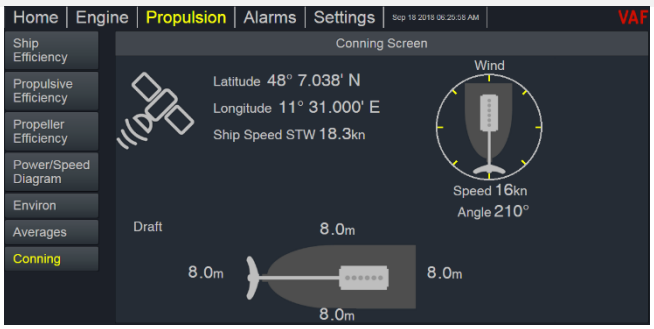


Figure 43 – Conning screen

The Conning submenu indicates the vessel position, speed trough water, draft of the vessel and the wind speed and angle.

7.6.4 Alarms menu

At the top of the screen you will find a key representing the internal alarm functions. In case the PEM4 + SPU3 system detects an alarm the *Alarm key* becomes red. An Alarm Message will appear on the *Alarm Screen*.
In the *Signals (raw) submenu* you will notice that the output values from the faulty sensor are changed to “0” and are colored red. When the alarm condition has been eliminated the alarm will no longer be active and the *Alarm key* will turn to normal again. The following alarms might appear:

Alarm	**Possible cause**
Flowmeter 1-12, pulse sensor fail	Faulty sensor or connection/cable between SPU and meter
Flowmeter 1-12, temp sensor fail	Faulty sensor or connection/cable between SPU and meter
Flowmeter 1-12, temp high	Temperature high set point override
T-Sense 1-2, communication fail	Modbus connection/cable between SPU and control box is broken or wrongly connected. *Remark: First try to swap the 2 NMEA signal wires.*
GPS/ship speed, communication fail	Connection/cable between SPU and sensor is broken or wrongly connected. *Remark: First try to swap the 2 NMEA signal wires.*
Shaft Gen. 1-2, sensor fail	Connection/cable or 4–20 mA analogue output is faulty
Shaft Gen. 1-2, communication fail	Cable connection is OK, but IO-module in SPU3 is faulty

Touch the *Accept button* in order to accept the internal alarms. After ticking the *alarm log key* all alarms will be listed and can be scrolled vertically.

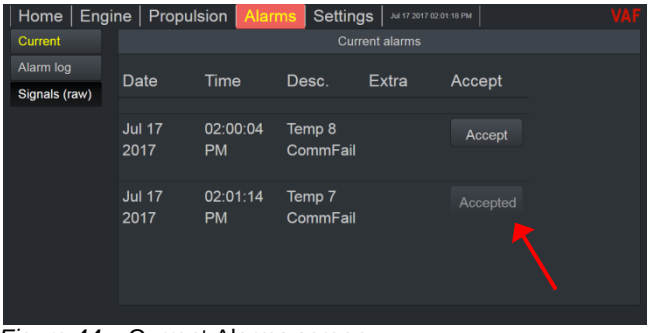


Figure 44 – Current Alarms screen

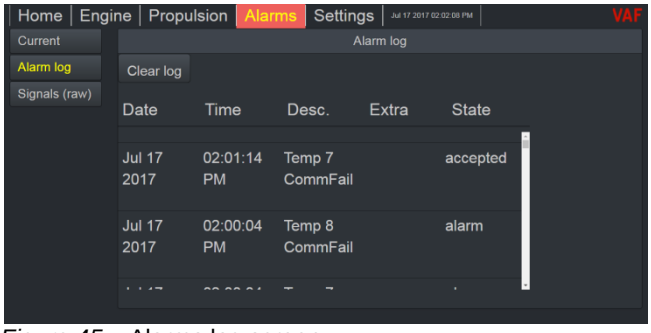


Figure 45 – Alarms log screen

7.6.5 Signals (raw) menu

Within the Alarms menu you will also find the *Raw signals submenu*, which allows you to monitor the raw signals coming in from the T-Sense® torque sensor or TT-Sense® torque and thrust sensor. Also other signals like the pulses and temperature of the flow meters, density, ships's speed and other sensors.

In the *Signals (raw) submenu* "Flow" you can look up the actual flow meter measurements in l/min per flow meter and the corresponding temperature of the fuel inside the specific flow meter. This amount is not yet compensated for gravity change due to temperature deviations of the fuel. Flow values will be converted to a **reference temperature of 15.6°C** if temperature sensors are incorporated in the fuel system. The difference between the Supply flow and Return flow values represents the fuel consumption per engine.

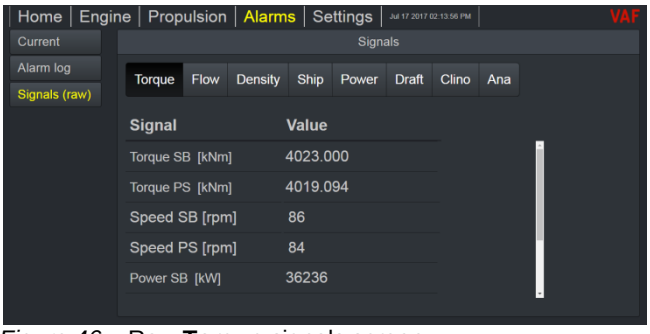


Figure 46 – Raw **Torque** signals screen

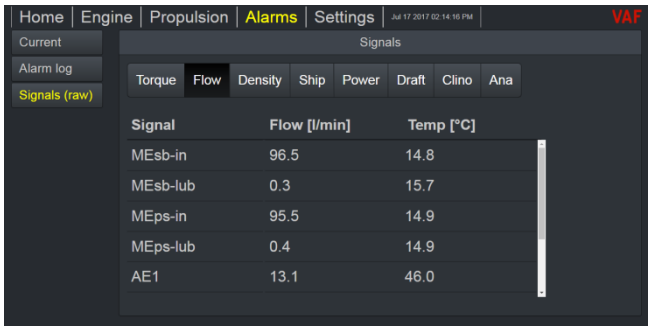


Figure 47 – Raw **Flow** signals screen

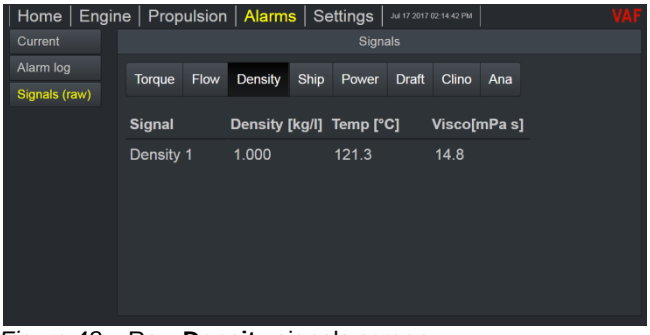


Figure 48 – Raw **Density** signals screen

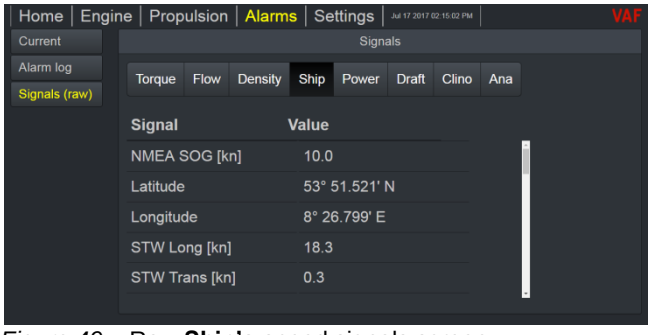


Figure 49 – Raw **Ship's** speed signals screen

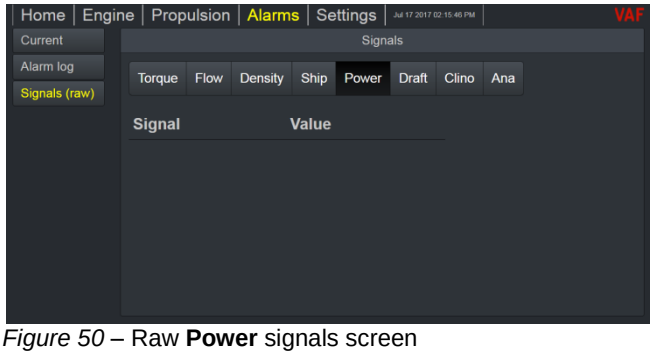


Figure 50 – Raw **Power** signals screen

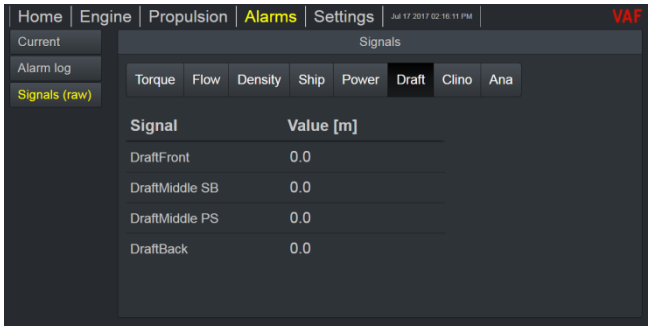


Figure 51 – Raw **Draft** signals screen

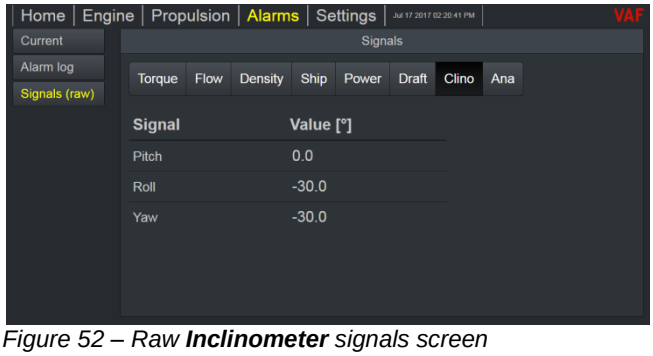


*Figure 52 – Raw **Inclinometer** signals screen*

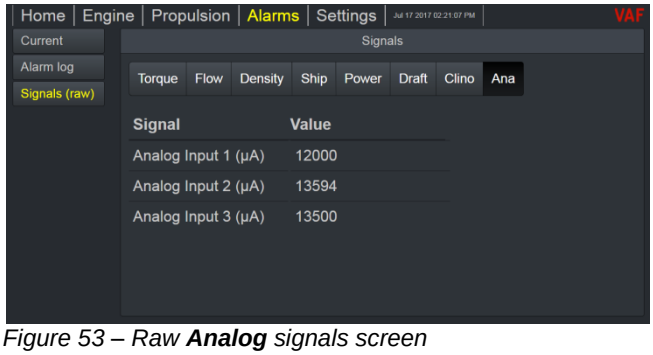


*Figure 53 – Raw **Analog** signals screen*

7.6.6 Settings menu

The *Settings menu* is accessible by entering a 4-digit password. Two different modes are available: an **user** mode and an **advanced** mode.

All the User mode settings are also available through the Advanced mode settings. Adapting of Advanced settings should only be done by VAF authorised personnel or in cooperation with VAF authorised representatives.

The *Settings menus* is accessed through entering the specific code in the *Settings screen*.

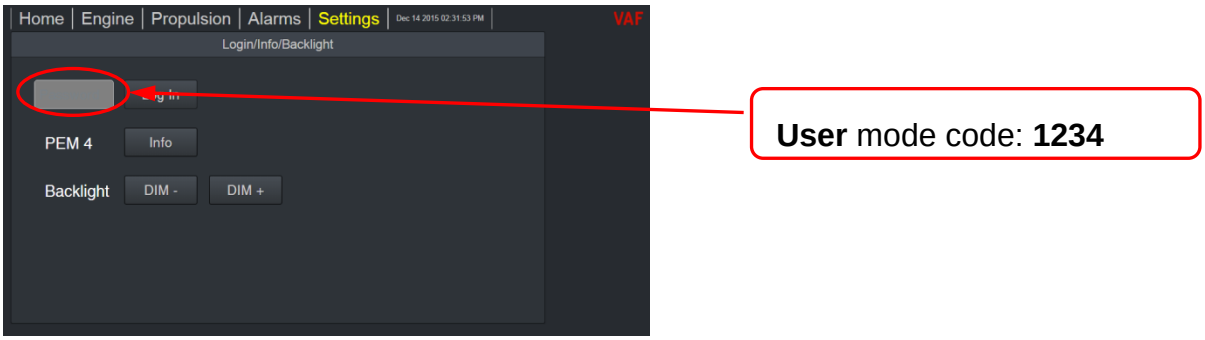


Figure 54 – Entering Settings menu screen

WARNING:
WRONG SETTINGS MAY RESULT IN SYSTEM FAILURE. VAF INSTRUMENTS B.V. WILL NOT TAKE ANY RESPONSIBILITY FOR OPERATIONS CARRIED OUT BY UNAUTHORIZED PERSONS.

Engine Fuels submenu

Figure 55 – Fuel type screen: **Manual** fuel selection

Figure 56 – Fuel type screen: **Automatic** fuel selection

In the *Engine Fuels submenu,* fuel types per engine/consumer will be allocated.
In case two different fuels are allocated to an engine/consumer the system can be switched manual or automatic to the actual fuel the engine/consumer is running on.
When set to “Manual” the type can be selected.
When set to “Automatic’ the Fuel High and Fuel Low can be selected. The system will switch automatically to specific fuel depending on the “Switching Temperature”.
Higher as switching temperature will select “Fuel High”. Lower as switching temperature will select “Fuel Low”.

The different fuel types will be entered in the *Fuel Type submenu*.

Fuel Type Settings submenu

Figure 57 – Fuel Type screen

In the *Fuel Type submenu* a maximum of six (6) fuel types can be set. Each fuel type is freely selectable per engine/consumer through the *Engine Fuels submenu*.
The following fuel parameters can be set per fuel type:

- Name of the fuel — e.g. HFO, MGO or other
- Density — default 0.998 kg/l
- Thermal expansion — default 0.070 %/°C
- Reference temperature — default 15.6 °C
- ROB (Remain on Board) — default 0 ton
- CO2 conversion factor for calculating the CO2 emissions per kg of fuel — default 3.1144 for HFO
- Caloric value of the fuel — default 40.87 MJ/kg
- Water percentage — default 0 %
- Sulfer percentage — default 0 %

Unifuel systems:
When a fuel change-over is done with an Unifuel system, please note that the type of fuel needs to be changed for both (sets of) engines.

The standard unit for fuel flow output at the PEM4 touch screen is kilogram. It is possible to read out all fuel consumption measurements in litres instead of kilograms. By selecting the “Consumption in kg/ litres” key at the right upper corner you can switch over from kg to litre and vice versa.

As a standard the PEM4 + SPU3 system monitors the fuel consumption per engine in kg/hour. In case you prefer to read out all fuel consumption data in litres/hour you can change the measurement unit. Please be aware that after switching from kg/hour to litres/hour and vice versa the value at the accumulated fuel consumption counter is not correct anymore.
The value at the Total Fuel consumption counter will be correct again after ticking the Reset key.

MRV Cargo submenu

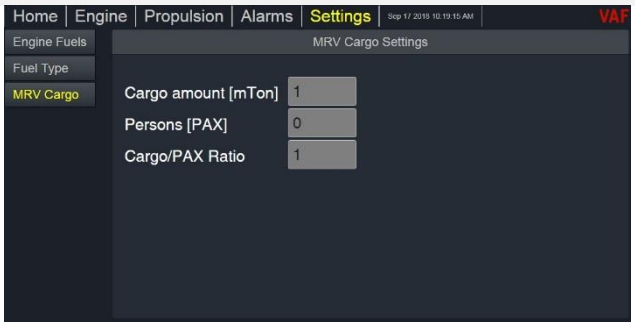


Figure 58 – MRV Cargo screen

In the *MRV Cargo submenu* the amount of cargo, amount of people on board and the cargo/person ratio can be set.

7.7 METHOD OF CALCULATIONS

Shaft power

Shaft power is calculated from the measured torque and the revolutions of the shaft.

$$\boldsymbol{P = M \cdot n \cdot \frac{2 \cdot \pi}{60}} \quad \text{(F1)}$$

P	*= Shaft power*	*[kW]*
M	*= Torque*	*[kNm]*
n	*= Rotations per minute*	*[rpm]*

Total energy

Total energy is calculated from the integrating shaft power over time

$$\boldsymbol{E = \sum_t P_t \cdot \Delta t} \quad \text{(F2)}$$

E	*= Total energy*	*[kWh]*
P_t	*= Power at time t*	*[kW]*
Dt	*= Sample rate*	*[sec]*

Specific gravity

The fuel oil specific gravity is a fixed or measured (ViscoSense®3D) value in the PEM4 + SPU3 system. The reference temperature (15.6ºC default) can be set per fuel type.

γ_T	*= Specific gravity at T temperature*	*[kg/l]*
$\gamma_{15.6}$	*= Specific gravity at reference temperature*	*[kg/l]*

Fuel oil consumption

Fuel oil volume flow measured by our VAF Series PT2 flowmeter is giving a fixed number of pulses per litre to the SPU3. Volume flow calculation is as follows:

$$\boldsymbol{\Delta V = \frac{\Delta p}{K\_factor}} \quad \text{(F3)}$$

DV	*= Volume from one measurement*	*[litres]*
Dp	*= Number of pulses*	*[p]*
K_factor	*= Pulses per litre from flowmeter*	*[p/l]*

Total volume flow

$$\boldsymbol{V = \sum \Delta V} \quad \text{(F4)}$$

V	*= Total Volume*	*[litres]*
DV	*= Volume from one measurement*	*[litres]*

Volume flow rate

$$\boldsymbol{Q = \frac{\Delta V}{\Delta t}} \quad \text{(F5)}$$

Q	*= Flow rate*	*[l/sec]*
DV	*= Volume from one measurement*	*[litres]*
Dt	*= Sample rate*	*[sec]*

$$\boldsymbol{Q_{tc} = Q \cdot \frac{\gamma_t}{\gamma_{15.6}}} \quad \text{(F6)}$$

Q_{tc}	*= Temperature compensated flow rate*	*[l/sec]*
Q	*= Flow rate*	*[l/sec]*
$\gamma_{15.6}$	*= Specific gravity at reference temperature*	*[kg/l]*
γ_t	*= Specific gravity heated to a temperature*	*[kg/l]*

or: $$\boldsymbol{Q_{tc} = Q \frac{1}{1+(\Delta T \cdot \frac{gc}{100})}} \quad \text{(F7)}$$

DT	*= Temperature difference*	*[°C]*
gc	*= Thermal expansion (Gravity change)*	*[%/°C]*

$$\boldsymbol{\Delta V_{tc} = \Delta V \cdot \frac{\gamma_t}{\gamma_{15.6}}} \quad \text{(F8)}$$

DV_{tc}	*= Temperature compensated volume*	*[litre]*
DV	*= Volume from one measurement*	*[litres]*
$\gamma_{15.6}$	*= Specific gravity at reference temperature*	*[kg/l]*
γ_t	*= Specific gravity heated to a temperature*	*[kg/l]*

or: $$\boldsymbol{\Delta V_{tc} = \Delta V \frac{1}{1+(\Delta T \cdot \frac{gc}{100})}} \quad \text{(F9)}$$

DT	*= Temperature difference*	*[°C]*
gc	*= Thermal expansion (Gravity change)*	*[%/°C]*

$$\Delta \boldsymbol{M} = \boldsymbol{\rho} \cdot \Delta \boldsymbol{V_{tc}} \quad \text{(F10)}$$

DM	*= Mass from one measurement*	*[kg]*
ρ	*= Density*	*[kg/l]*
DV_{tc}	*= Temperature compensated volume*	*[litre]*

$$\boldsymbol{M} = \sum \Delta \boldsymbol{M} \quad \text{(F11)}$$

M	*= Total Mass*	*[kg]*
DM	*= Mass from one measurement*	*[kg]*

$$\boldsymbol{G} = \frac{\Delta \boldsymbol{M}}{\Delta \boldsymbol{t}} \quad \text{(F12)}$$

G	*= Mass flow rate*	*[kg/sec]*
DM	*= Mass from one measurement*	*[kg]*
Dt	*= Sample rate*	*[sec]*

Specific Fuel Oil Consumption rate (S.F.O.C.)

$$\boldsymbol{SFOC} = \frac{\boldsymbol{G} \cdot \mathbf{1000}}{\boldsymbol{P}} \quad \text{(F13)}$$

SFOC	*= Specific Fuel Oil Consumption*	*[g/kWh]*
G	*= Mass flow rate to M/E*	*[kg/h]*
P	*= Shaft power*	*[kW]*

Specific Fuel Oil Consumption Corrected rate (S.F.O.C. corr)

$$\boldsymbol{SFOC\ corr} = \boldsymbol{SFOC} \cdot \frac{\boldsymbol{LCV\ fuel}}{\boldsymbol{LCV\ shop}} \quad \text{(F14)}$$

SFOC corr	*= Specific Fuel Oil Consumption Corrected*	*[g/kWh]*
SFOC	*= Specific Fuel Oil Consumption*	*[g/kWh]*
LCV fuel	*= Lower Calorific Value fuel*	*[MJ/kg]*
LCV shop	*= Lower Calorific Value shop*	*[MJ/kg]*

Specific Cylinder Oil Consumption rate (S.C.O.C.)

$$SCOC = \frac{G \cdot 1000}{P} \quad \text{(F15)}$$

SCOC	*= Specific Cylinder Oil Consumption*	*[g/kWh]*
G	*= Mass flow rate to M/E lubrication oil*	*[kg/h]*
P	*= Shaft power*	*[kW]*

Ship efficiency

$$FOC = \frac{G}{v} \quad \text{(F16)}$$

FOC	*= Fuel Oil Consumption*	*[kg/Nautical Mile]*
G	*= Mass flow rate to M/E*	*[kg/h]*
v	*= Ship speed*	*[knots]*

Thrust quotient

$$TQ = \frac{T}{P / 1000} \quad \text{(F17)}$$

TQ	*= Thrust quotient*	*[N/kW]*
T	*= Thrust*	*[kN]*
P	*= Shaft power*	*[kW]*

This quotient indicates the amount of thrust generated per MW propulsion power. The thrust quotient is an indicator of propeller efficiency. Be aware that propeller thrust and ship speed influence each other.

Propulsive Efficiency

$$\eta_P = \frac{P}{v} \quad \text{(F18)}$$

η_P	*= Propulsive efficiency*	*[kWh/NM]*
P	*= Shaft power*	*[kW]*
v	*= Ship speed*	*[Knots]*

Total CO2 Emission

$$\Delta C = \Delta M \cdot K_{CO2} \quad \text{(F19)}$$

$$CO2_{tot} = \sum \Delta C \quad \text{(F20)}$$

DC	*= CO2 Emission*	*[kg]*
DM	*= Mass fuel consumption from*	*[kg]*
K_{CO2}	*= CO2 conversion factor*	*[kg CO2 / kg fuel]*
$CO2_{tot}$	*= Total CO2 Emission*	*[kg]*

$$M_{CO2} = \frac{\Delta C}{\Delta t} \quad \text{(F21)}$$

M_{CO2}	*= Mass CO2 emission rate*	*[kg CO2 / h]*
DC	*= CO2 emission due to one measurement*	*[kg]*
Dt	*= Sample rate*	*[h]*

Fuel CO2 Emission (FCO2)

$$FCO2 = \frac{M_{CO2}}{v} \quad \text{(F22)}$$

FCO2	*= Fuel CO2 emission*	*[kg CO2/NM]*
M_{CO2}	*= Mass CO2 emission*	*[kg CO2 / h]*
v	*= Ship speed*	*[Knots]*

Specific Fuel CO2 Emission (SFCO2)

$$SFCO2 = \frac{M_{CO2} \cdot 1000}{P} \quad \text{(F23)}$$

SFCO2	*= Specific fuel CO2 emission per main engine*	*[g CO2/kW]*
M_{CO2}	*= Mass CO2 emission*	*[kg CO2 / h]*
P	*= Shaft power*	*[kW]*

Energy Efficiency Operational Indicator (EEOI)

$$EEOI = \frac{M_{CO2}}{Cargo \cdot Distance} \quad \text{(F24)}$$

EEOI	*[kgCO2 / ton·NM]*
M_{CO2}	*[kg CO2 / h]*
Cargo	*[ton or TEU or persons]*
Distance	*[NM]*

This quotient indicates the operational efficiency of your vessel. The EEOI is taking into account CO2 emissions from your consumers, which are monitored by the PEM4 + SPU3 system, the mass of cargo in DWT, number of TEU or number of persons and the distance sailed.

8. MAINTENANCE

No special maintenance is needed for the PEM4 equipment.
The touch screen can be cleaned with a dry and clean cloth.
Do not use any cleaning product or chemical on the screen.

When removing a PEM4 + SPU3 system precautions must be taken to prevent personal injuries and damage to the touch screen and SPU3.

9. REPAIR

Nothing on the PEM4 + SPU3 system can be repaired on site.

10. TAKE OUT OF SERVICE

Switch off the 24VDC and/or 115/230VAC power supply.

11. REMOVAL AND STORAGE OF EQUIPMENT

Switch off the 24VDC and 115/230VAC power supply.
Make sure that all wires that are connected to the PEM4 + SPU3 system are labelled correctly so that re-installation of the PEM4 + SPU3 system can be done without any errors.
Disconnect all the input and output wires.

Store the PEM4 + SPU3 system in a box in a cool and dry place, so that the PEM4 + SPU3 system cannot be damaged.

12. MALFUNCTION AND SEND FOR REPAIR

If the PEM4 + SPU3 system stops working completely contact VAF Instruments for instructions.
In the event the PEM4 + SPU3 system parts has to be sent back for repair, you can send it directly to:

VAF Instruments B.V.
Vierlinghstraat 24
NL-3316 EL Dordrecht
The Netherlands

13. ENVIRONMENT

The PEM4 equipment has no negative influence on the environment during normal operation.

14. DISPOSAL

The PEM4 equipment is made out of metal and electronics. It should be disposed according to local laws of the country.

15. TROUBLE SHOOTING

If the PEM4 + SPU3 system does malfunction, power down the PEM4 + SPU3 system, check all wiring and power up the PEM4 + SPU3 system back again. This will restart the program.

No torque signal
The connection between the SPU3 and the stator control box is broken

- Check wires for damage.
- Check the connections in the SPU3 or in the stator control box if applicable.

No signal from shaft generator
The connection between the SPU3 and the shaft generator sensor is broken.

- Check the wires for damage
- Check the connections to the backplane in the SPU3 (see section 17 Drawings)

Temperature sensor failure
The connection between the SPU3 and the temperature sensor is broken.

- Check the wires for damage
- Check all connections inside the temperature sensor.
- Check the connections to the backplane in the SPU3 (see section 17 Drawings)

Flowmeter alarms can occur when:

Flow meter 1 (supply) < Flow meter 2 (return)
Flow meter 1 (supply) > 0 and Flow meter 2 (return) = 0

- Check the wires for damage.
- Check all the connections at the flow meter side.
- Check the settings of the flow meters and relevant parameters and adjust them accordingly in cooperation with a VAF service engineer.

Temperature supply or return is too high
Adjust the temperature high set point of the alarm or adjust the maximum fuel temperature level(s) accordingly.

16. EMC CLASSIFICATIONS OF THE PEM4 + SPU3 SYSTEM

PEM4 + SPU3 system is tested in accordance with:

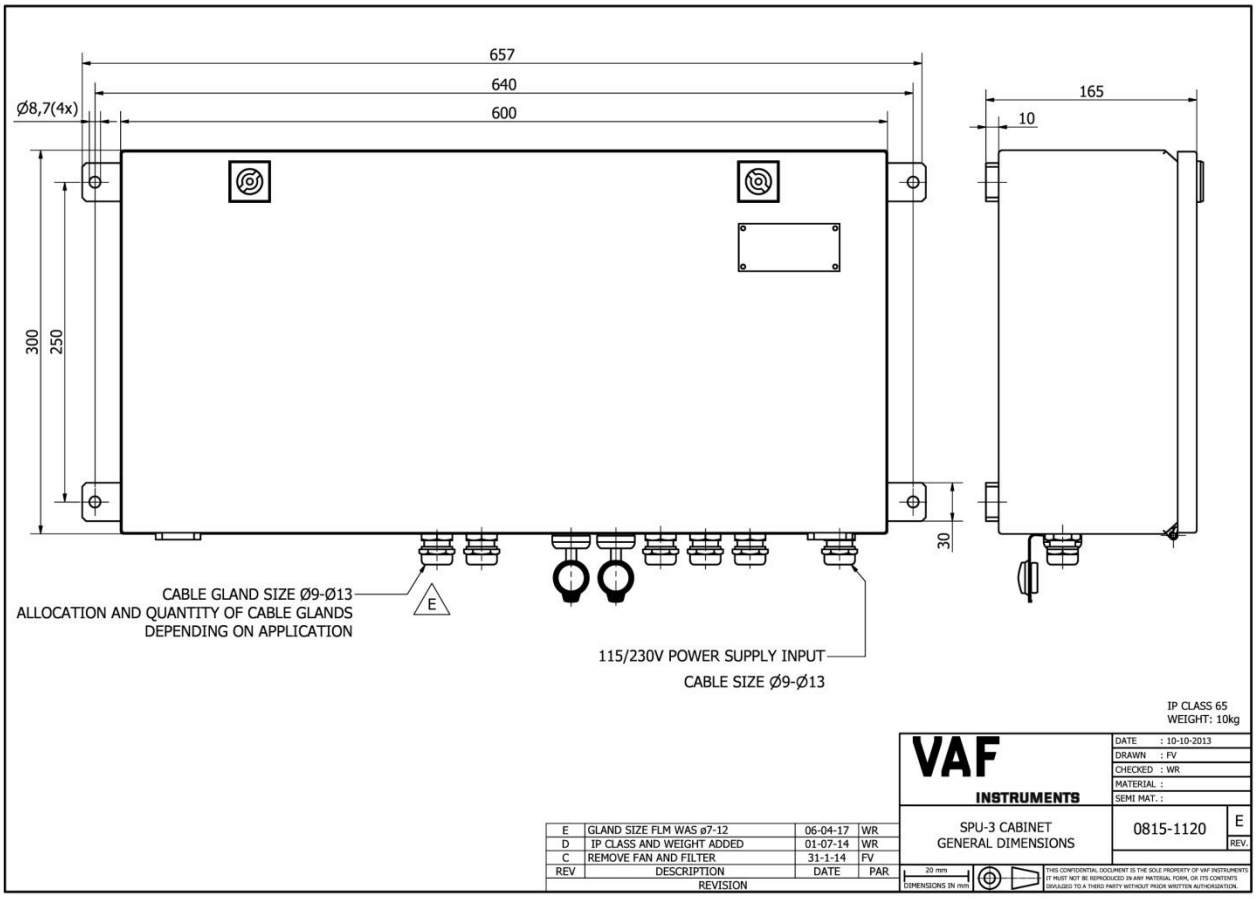
- General Vibration Strain, IEC publication 60068-2-6.
- Also complies with EMC and ESD tests according to EN61000.

16.1 CERTIFICATES

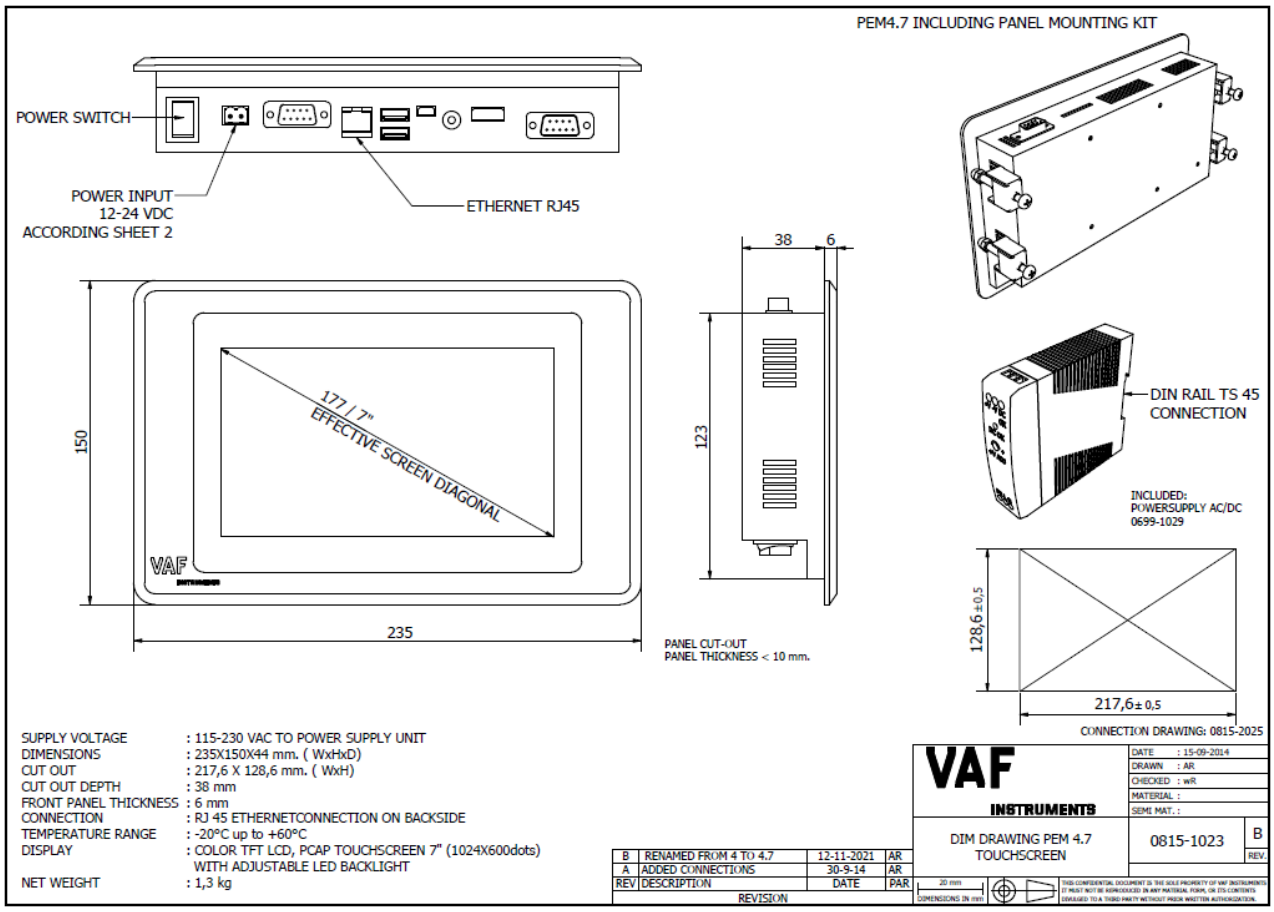
For a torque measuring system, no classification certificates are required.

17. DRAWINGS

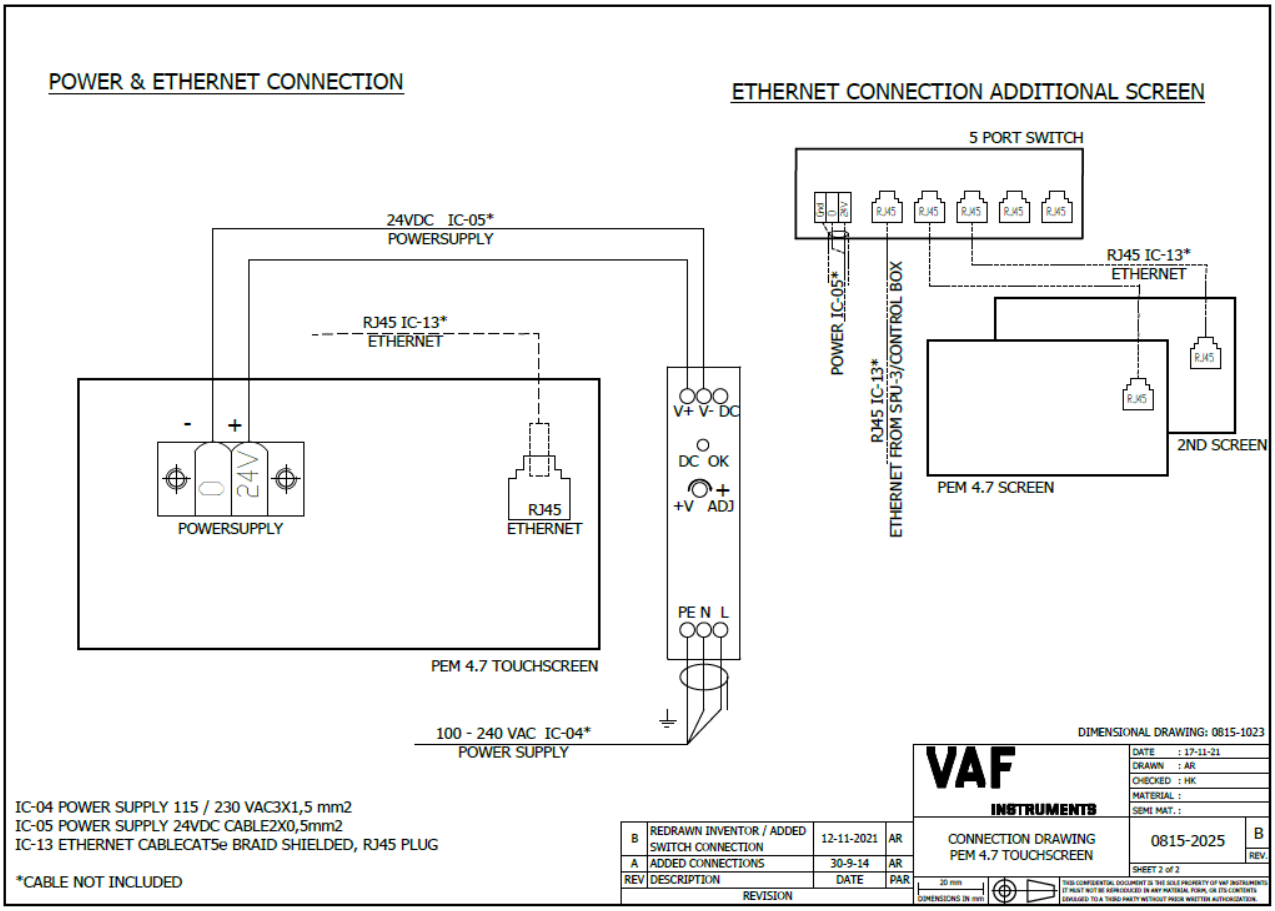
DWG#	DWG NAME	
0815-1120	SPU3 CABINET GENERAL DIMENSIONS	
0815-1023	DIM DRAWING PEM4.7 TOUCH SCREEN	
0815-2025	CONNECTIONS PEM4.7 TOUCH SCREEN	
0815-1125	DIM DRAWING PEM4.8 TOUCH SCREEN	
0815-2052	CONNECTIONS PEM4.8 TOUCH SCREEN	
0815-1026	DIM DRAWING PEM4.10 TOUCH SCREEN	
0815-2053	CONNECTIONS PEM4.10 TOUCH SCREEN	
0815-2020	CONN. DIAGRAM DATALOGGING U-PORT TO SPU3	
0815-2019	INTERCONN.DIAGRAM T&TT-SENSE SPU3 PEM4	3 SHEETS



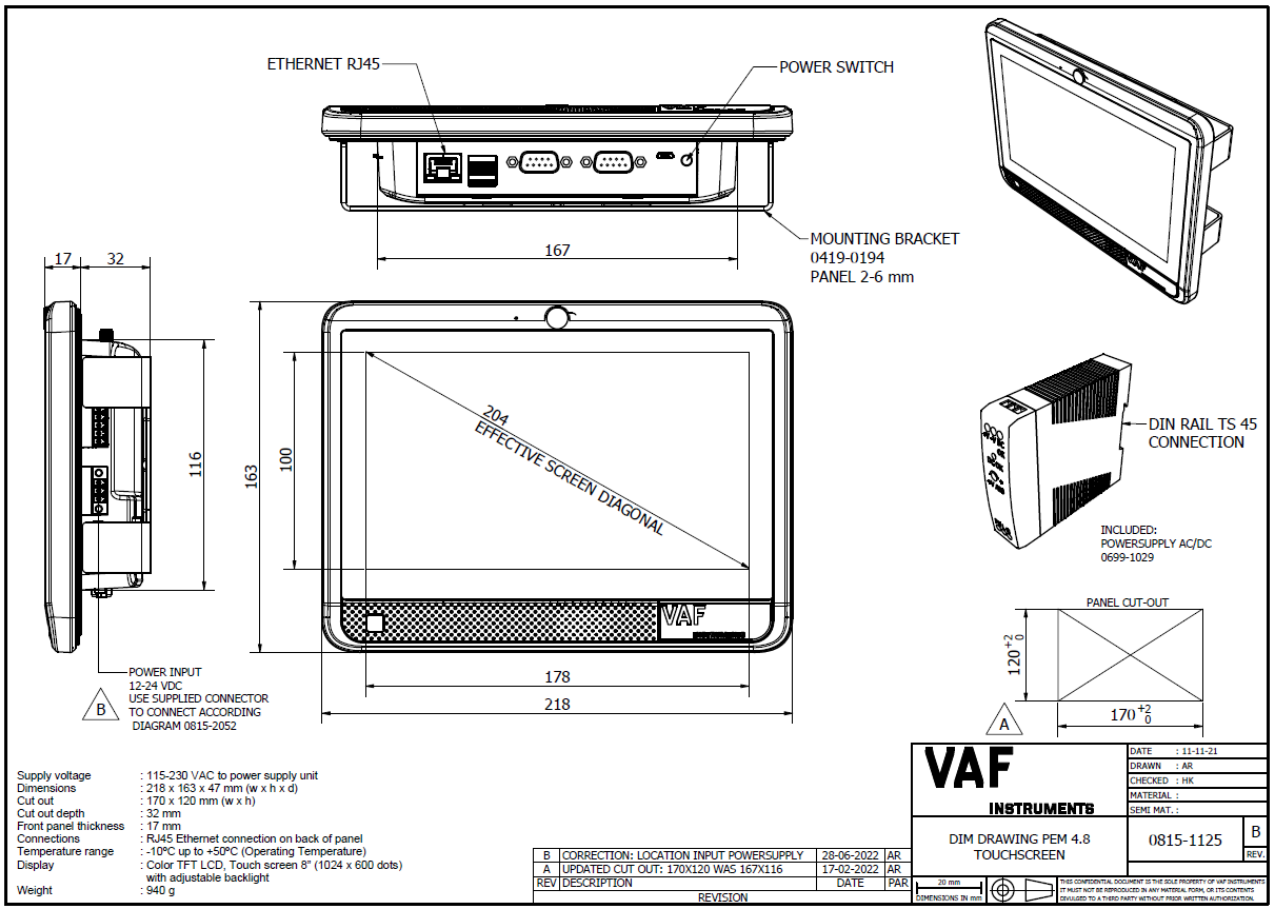
Drawing 0815-1120 SPU-3 Cabinet General Dimensions



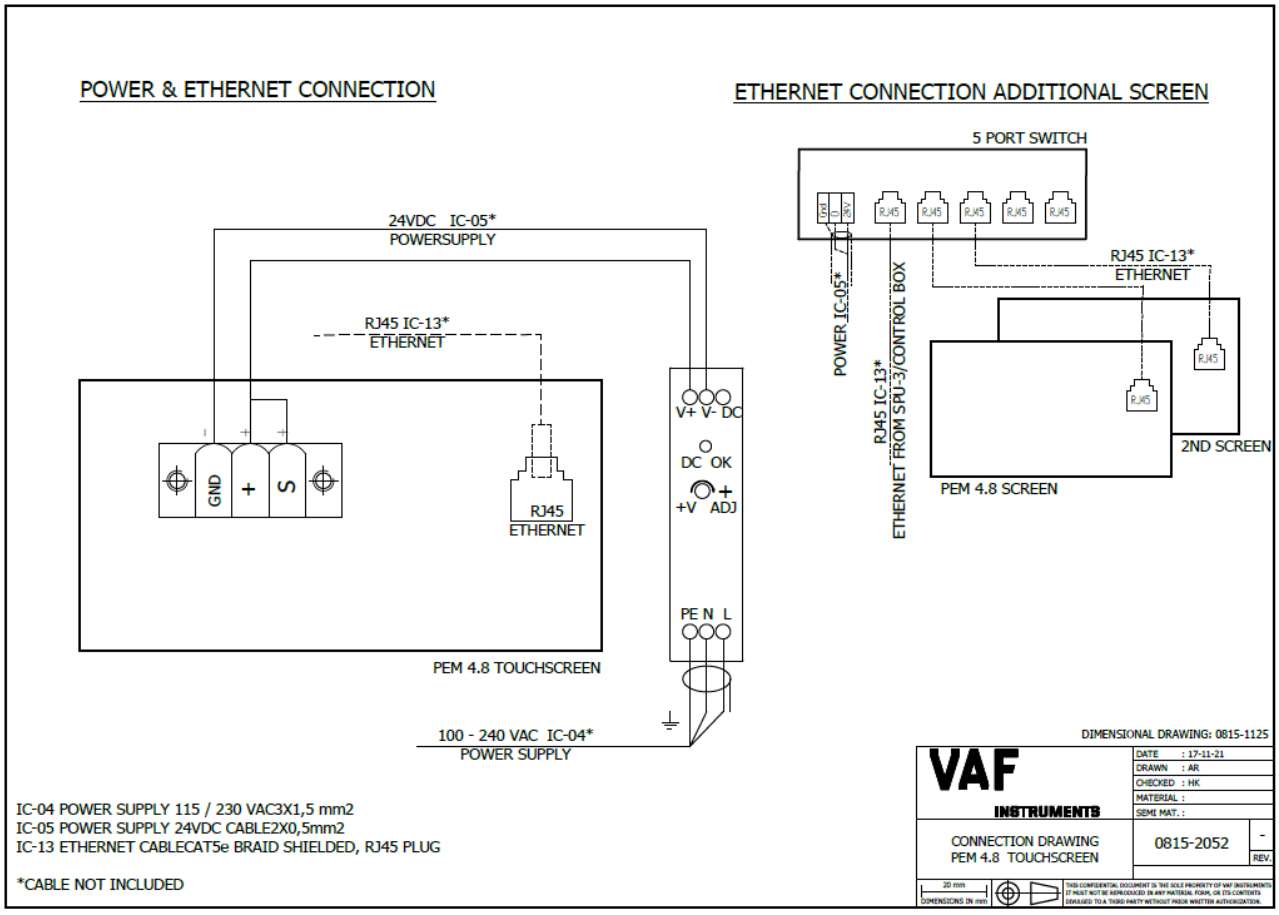
Drawing 0815-1023 Dimensional Drawing PEM4.7 Touch Screen



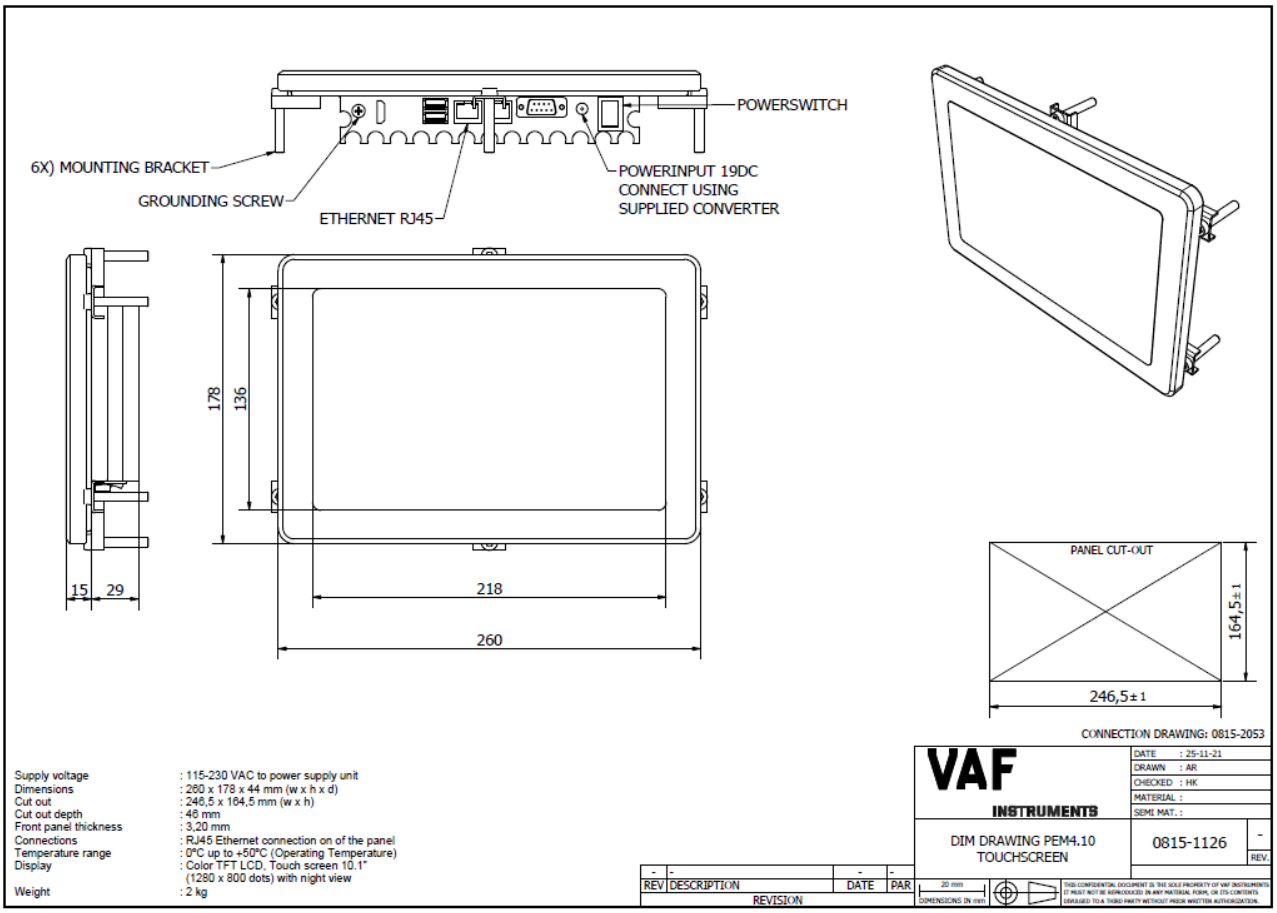
Drawing 0815-2025 Connection Drawing PEM4.7 Touch Screen



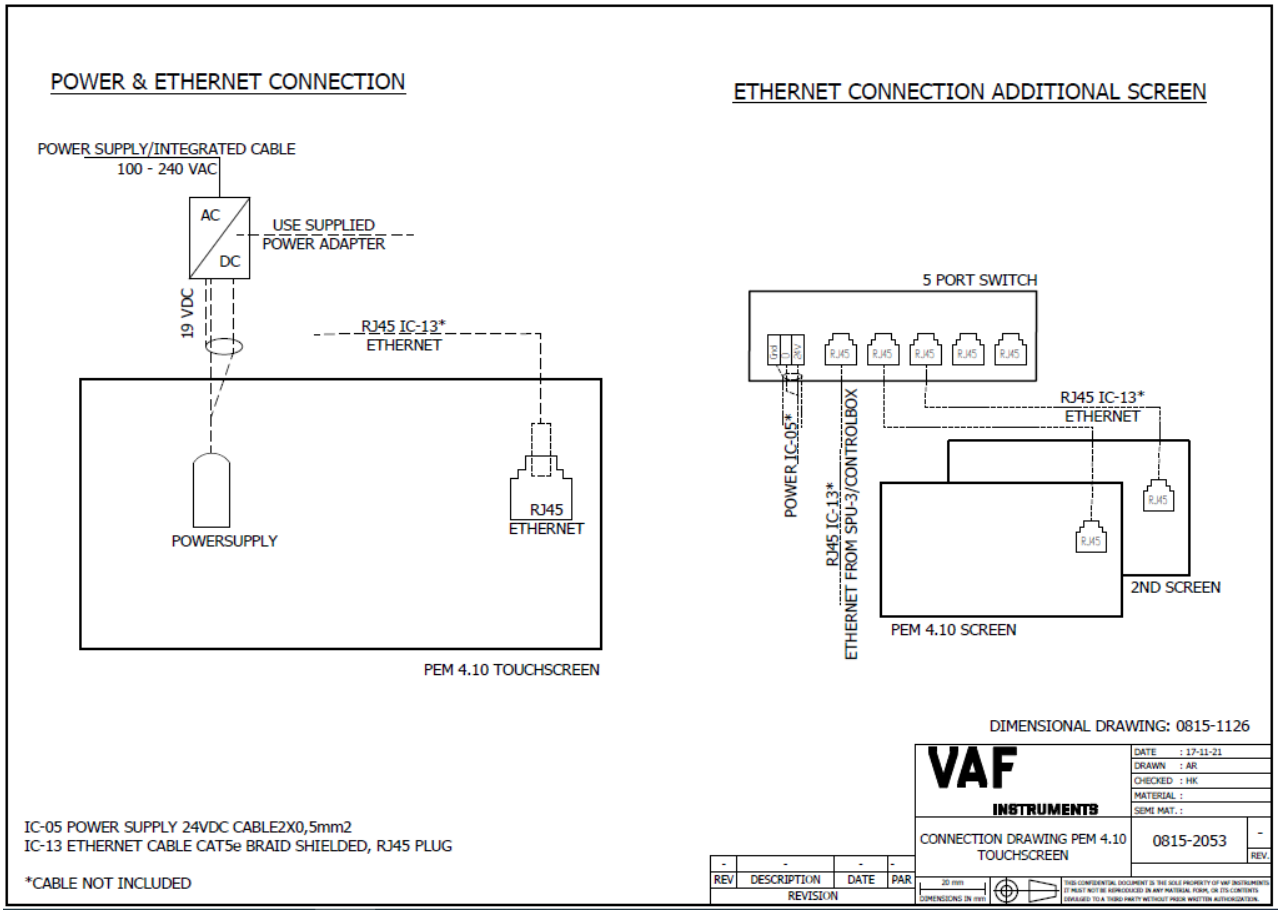
Drawing 0815-1125 Dimensional Drawing PEM4.8 Touch Screen



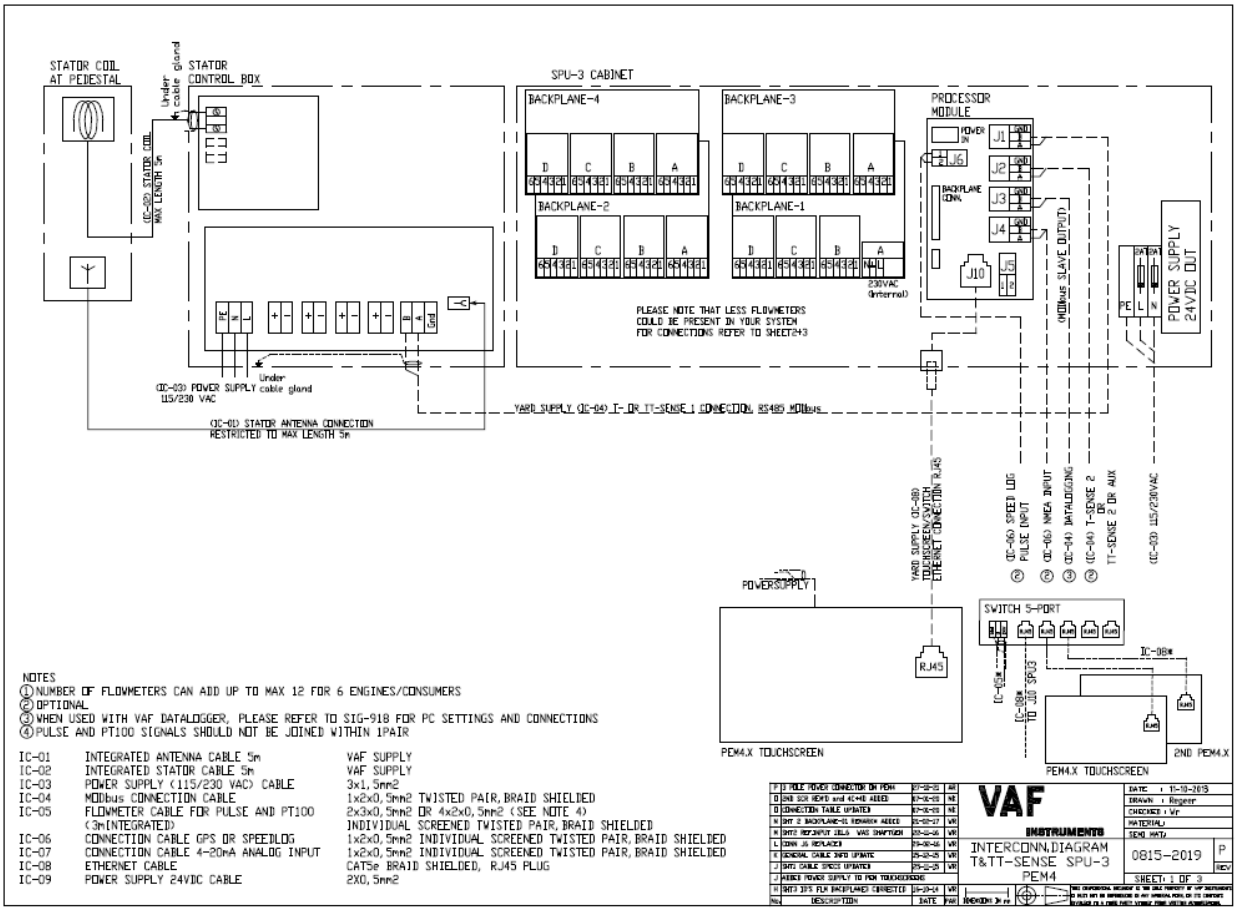
Drawing 0815-2052 Connection Drawing PEM4.8 Touch Screen



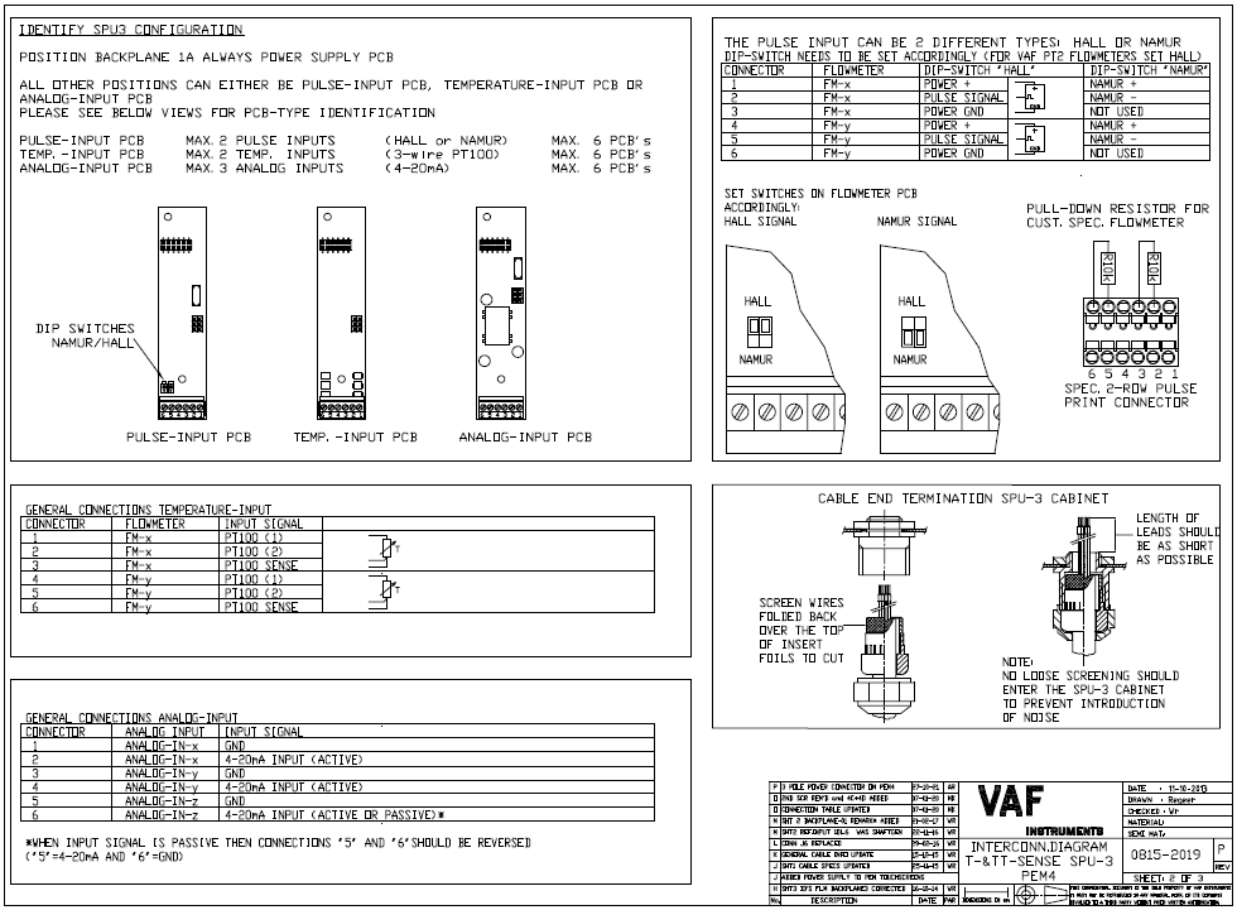
Drawing 0815-1126 Dimensional Drawing PEM4.10 Touch Screen



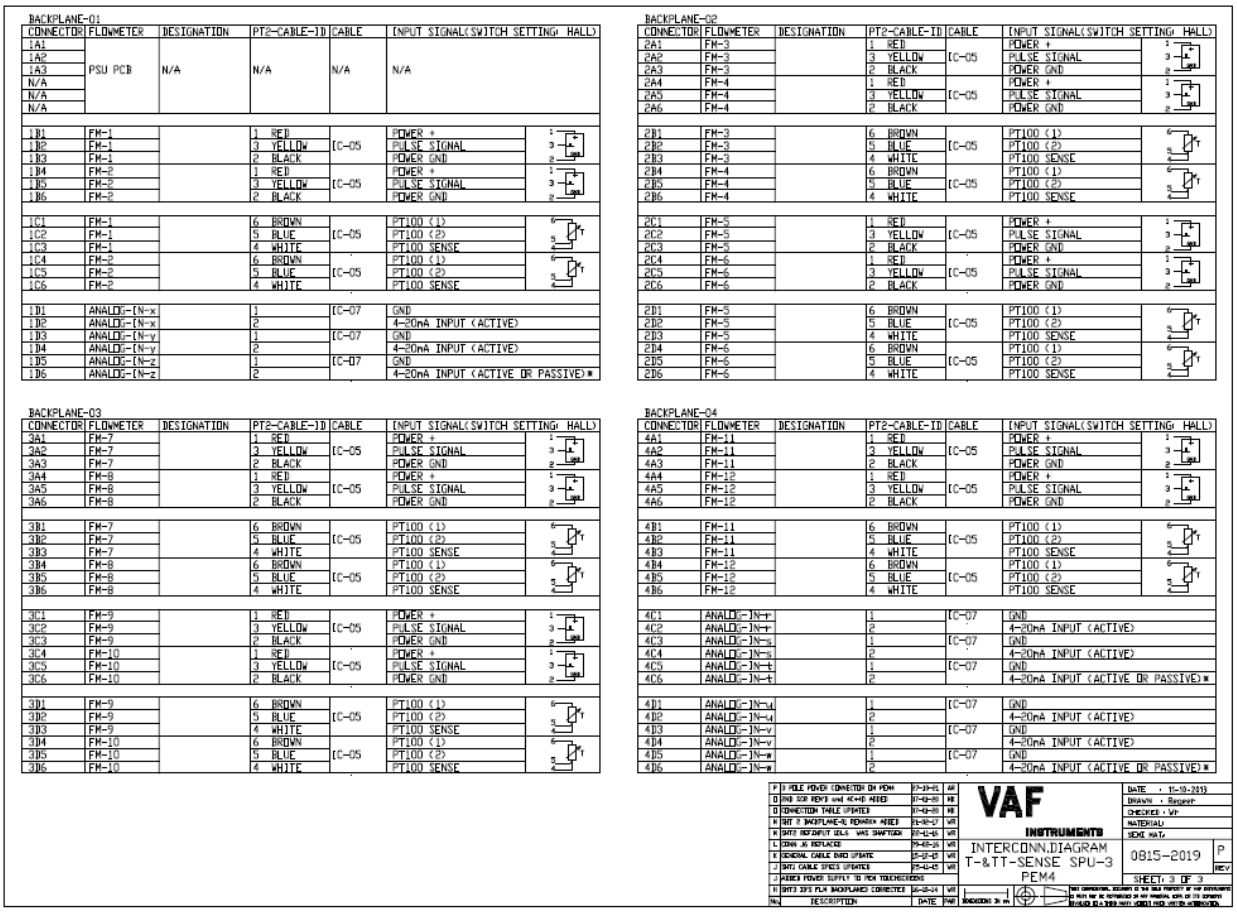
Drawing 0815-2053 Connection Drawing PEM4.10 Touch Screen



Drawing 0815-2019 Sheet 1 of 3 Connection diagram T&TT-sense SPU-3 PEM4.x



Drawing 0815-2019 Sheet 2 of 3 Connection diagram T&TT-sense SPU-3 PEM4.x



BACKPLANE-01

CONNECTOR	FLOWMETER	DESIGNATION	PT2-CABLE-ID	CABLE	INPUT SIGNAL(SWITCH SETTING, HALL)
1A1					
1A2					
1A3	PSU PCB	N/A	N/A	N/A	N/A
N/A					
N/A					
N/A					
1B1	FM-1		1 RED		POWER +
1B2	FM-1		3 YELLOW	(C-05	PULSE SIGNAL
1B3	FM-1		2 BLACK		POWER GND
1B4	FM-2		1 RED		POWER +
1B5	FM-2		3 YELLOW	(C-05	PULSE SIGNAL
1B6	FM-2		2 BLACK		POWER GND
1C1	FM-1		6 BROWN		PT100 (1)
1C2	FM-1		5 BLUE	(C-05	PT100 (2)
1C3	FM-1		4 WHITE		PT100 SENSE
1C4	FM-2		6 BROWN		PT100 (1)
1C5	FM-2		5 BLUE	(C-05	PT100 (2)
1C6	FM-2		4 WHITE		PT100 SENSE
1D1	ANALOG-IN-x		1	(C-07	GND
1D2	ANALOG-IN-x		2		4-20mA INPUT (ACTIVE)
1D3	ANALOG-IN-y		1	(C-07	GND
1D4	ANALOG-IN-y		2		4-20mA INPUT (ACTIVE)
1D5	ANALOG-IN-z		1	(C-07	GND
1D6	ANALOG-IN-z		2		4-20mA INPUT (ACTIVE OR PASSIVE)*

BACKPLANE-02

CONNECTOR	FLOWMETER	DESIGNATION	PT2-CABLE-ID	CABLE	INPUT SIGNAL(SWITCH SETTING, HALL)
2A1	FM-3		1 RED		POWER +
2A2	FM-3		3 YELLOW	(C-05	PULSE SIGNAL
2A3	FM-3		2 BLACK		POWER GND
2A4	FM-4		1 RED		POWER +
2A5	FM-4		3 YELLOW	(C-05	PULSE SIGNAL
2A6	FM-4		2 BLACK		POWER GND
2B1	FM-3		6 BROWN		PT100 (1)
2B2	FM-3		5 BLUE	(C-05	PT100 (2)
2B3	FM-3		4 WHITE		PT100 SENSE
2B4	FM-4		6 BROWN		PT100 (1)
2B5	FM-4		5 BLUE	(C-05	PT100 (2)
2B6	FM-4		4 WHITE		PT100 SENSE
2C1	FM-5		1 RED		POWER +
2C2	FM-5		3 YELLOW	(C-05	PULSE SIGNAL
2C3	FM-5		2 BLACK		POWER GND
2C4	FM-6		1 RED		POWER +
2C5	FM-6		3 YELLOW	(C-05	PULSE SIGNAL
2C6	FM-6		2 BLACK		POWER GND
2D1	FM-5		6 BROWN		PT100 (1)
2D2	FM-5		5 BLUE	(C-05	PT100 (2)
2D3	FM-5		4 WHITE		PT100 SENSE
2D4	FM-6		6 BROWN		PT100 (1)
2D5	FM-6		5 BLUE	(C-05	PT100 (2)
2D6	FM-6		4 WHITE		PT100 SENSE

BACKPLANE-03

CONNECTOR	FLOWMETER	DESIGNATION	PT2-CABLE-ID	CABLE	INPUT SIGNAL(SWITCH SETTING, HALL)
3A1	FM-7		1 RED		POWER +
3A2	FM-7		3 YELLOW	(C-05	PULSE SIGNAL
3A3	FM-7		2 BLACK		POWER GND
3A4	FM-8		1 RED		POWER +
3A5	FM-8		3 YELLOW	(C-05	PULSE SIGNAL
3A6	FM-8		2 BLACK		POWER GND
3B1	FM-7		6 BROWN		PT100 (1)
3B2	FM-7		5 BLUE	(C-05	PT100 (2)
3B3	FM-7		4 WHITE		PT100 SENSE
3B4	FM-8		6 BROWN		PT100 (1)
3B5	FM-8		5 BLUE	(C-05	PT100 (2)
3B6	FM-8		4 WHITE		PT100 SENSE
3C1	FM-9		1 RED		POWER +
3C2	FM-9		3 YELLOW	(C-05	PULSE SIGNAL
3C3	FM-9		2 BLACK		POWER GND
3C4	FM-10		1 RED		POWER +
3C5	FM-10		3 YELLOW	(C-05	PULSE SIGNAL
3C6	FM-10		2 BLACK		POWER GND
3D1	FM-9		6 BROWN		PT100 (1)
3D2	FM-9		5 BLUE	(C-05	PT100 (2)
3D3	FM-9		4 WHITE		PT100 SENSE
3D4	FM-10		6 BROWN		PT100 (1)
3D5	FM-10		5 BLUE	(C-05	PT100 (2)
3D6	FM-10		4 WHITE		PT100 SENSE

BACKPLANE-04

CONNECTOR	FLOWMETER	DESIGNATION	PT2-CABLE-ID	CABLE	INPUT SIGNAL(SWITCH SETTING, HALL)
4A1	FM-11		1 RED		POWER +
4A2	FM-11		3 YELLOW	(C-05	PULSE SIGNAL
4A3	FM-11		2 BLACK		POWER GND
4A4	FM-12		1 RED		POWER +
4A5	FM-12		3 YELLOW	(C-05	PULSE SIGNAL
4A6	FM-12		2 BLACK		POWER GND
4B1	FM-11		6 BROWN		PT100 (1)
4B2	FM-11		5 BLUE	(C-05	PT100 (2)
4B3	FM-11		4 WHITE		PT100 SENSE
4B4	FM-12		6 BROWN		PT100 (1)
4B5	FM-12		5 BLUE	(C-05	PT100 (2)
4B6	FM-12		4 WHITE		PT100 SENSE
4C1	ANALOG-IN-t		1	(C-07	GND
4C2	ANALOG-IN-t		2		4-20mA INPUT (ACTIVE)
4C3	ANALOG-IN-t_2		1	(C-07	GND
4C4	ANALOG-IN-t_2		2		4-20mA INPUT (ACTIVE)
4C5	ANALOG-IN-t		1	(C-07	GND
4C6	ANALOG-IN-t		2		4-20mA INPUT (ACTIVE OR PASSIVE)*
4D1	ANALOG-IN-t_4		1	(C-07	GND
4D2	ANALOG-IN-t_4		2		4-20mA INPUT (ACTIVE)
4D3	ANALOG-IN-v		1	(C-07	GND
4D4	ANALOG-IN-v		2		4-20mA INPUT (ACTIVE)
4D5	ANALOG-IN-*		1	(C-07	GND
4D6	ANALOG-IN-*		2		4-20mA INPUT (ACTIVE OR PASSIVE)*

REV	DESCRIPTION	DATE	PAR
P	3 POLE POWER CONNECTOR ON PCB#	23-03-15	AR
O	END SCR REV'S and 4C-4E ADDED	20-02-20	MB
O	CONNECTION TABLE UPDATED	20-02-20	MB
N	SHT 2 BACKPLANE-01 REMARKS ADDED	19-08-27	VR
N	SHT2 REF.INPUT SELS WAS SWAPTOM	19-11-13	VR
L	CONN J6 REPLACED	19-05-16	VR
K	GENERAL CABLE SHEET UPDATE	19-03-27	VR
J	SHT1 CABLE SPECS UPDATED	19-01-25	VR
J	ADDED POWER SUPPLY TO PCB TOUCHSCREENS		
H	SHT3 XP5 FLH BACKPLANE1 CORRECTED	16-12-14	VR

VAF INSTRUMENTS

INTERCONN.DIAGRAM T-&TT-SENSE SPU-3 PEM4

0815-2019 P

SHEET: 3 OF 3

DATE : 11-10-2019
DRAWN : Rapaet
CHECKED : VR
MATERIAL:
SEMI MAT.

Drawing 0815-2019 Sheet 3 of 3 Connection diagram T&TT-sense SPU-3 PEM4.x

18. ABBREVIATIONS

AMS	Alarm and Monitoring System
CPU	Central Processing Unit
ECR	Engine Control Room
EEOI	Energy Efficiency Operational Indicator
ER	Engine Room
LCD	Liquid Crystal Display
LCV	Lower Calorific Value
LED	Light Emitting Diode
NMEA 0183	National Marine Electronics Association protocol 0183 for serial data transfer
PCAP	Projected Capacitive
PEM4	Propulsion Efficiency Monitor touch screen
PT100	Temperature sensor type PT100
PT2	Type of flowmeter with Hall sensor and PT100 output
PTO	Power Take Off
ROB	Remain on Board
RS485	Serial interface for long distance data communication
SFOC	Specific Fuel Oil Consumption
SFOC Corr	Specific Fuel Oil Consumption Corrected
SI	Système International d'Unités
SPU3	Signal Processing Unit
TFT	Thin Film Transistor - Liquid Crystal Display
T-Sense®	Optical Torque Measuring System
TT-Sense®	Optical Thrust and Torque Measuring System

19. SPARE PARTS

A recommended spare parts list is not applicable, but for reference purposes, please find below main part numbers. Since SPU3 / PEM4 systems are configured for each application, not all parts are applicable for each individual situation.

Part name	Part number
PEM4.7 Screen	0379-0401
PEM4.8 Screen	0379-0436
PEM4.10 Screen	0379-0437
SPU3 Power supply 24VDC	0699-1029
Back-plane Base	0397-0383
Back-plane Power pcb	0397-0384
Pulse pcb	0397-0385
PT100 pcb	0397-0386
Analogue-in pcb	0397-0387
Processor Module	0379-0391

20. WARRANTY CONDITIONS

1. Without prejudice to the restrictions stated hereinafter, the contractor guarantees both the soundness of the product delivered by him and the quality of the material used and/or delivered for it, insofar as this concerns faults in the product delivered which do not become apparent during inspection or transfer test, which the principal shall demonstrate to have arisen within 12 months from delivery in accordance with sub article 1A exclusively or predominantly as a direct consequence of unsoundness of the construction used by the contractor or as a consequence of faulty finishing or the use of poor materials.

   1A. The product shall be deemed to have been delivered when it is ready for inspection (if inspection at the premises of the contractor has been agreed) and otherwise when it is ready for shipment.

2. Articles 1 and 1a shall equally apply to faults which do not become apparent during inspection or transfer test which are caused exclusively or predominantly by unsound assembly/installation by the contractor. If assembly/installation is carried out by the contractor, the guarantee period intended in article 1 shall last 12 months from the day on which assembly/installation is completed by the contractor, with the understanding that in this case the guarantee period shall end not later than 18 months after delivery in accordance with the terms of sub article 1A.

3. Defects covered by the guarantee intended under articles 1, 1a and 2 shall be remedied by the contractor by repair or replacement of the faulty component either on or off the premises of the contractor, or by shipment of a replacement component, this remaining at the discretion of the contractor. Subarticle 3A shall equally apply if repair or replacement takes place at the site where the product has been assembled/installed. All costs accruing above the single obligation described in the first sentence, such as are not restricted to shipment costs, travelling and accommodation costs or disassembly or assembly costs insofar as they are not covered by the agreement, shall be paid by the principal.

   3A. If repair or replacement takes place at the site where the product has been assembled/installed, the principal shall ensure, at his own expense and risk, that:

   a. the employees of the contractor shall be able to commence their work as soon as they have arrived at the erection site and continue to do so during normal working hours, and moreover, if the contractor deems it necessary, outside the normal working hours, with the proviso that the contractor informs the principal of this in good time;

   b. suitable accommodation and/or all facilities required in accordance with government regulations, the agreement and common usage, shall be available for the employees of the contractor;

   c. the access roads to the erection site shall be suitable for the transport required;

   d. the allocated site shall be suitable for storage and assembly;

   e. the necessary lockable storage sites for materials, tools and other goods shall be available;

   f. the necessary and usual auxiliary workmen, auxiliary machines, auxiliary tools, materials and working materials (including process liquids, oils and greases, cleaning and other minor materials, gas, water, electricity, steam, compressed air, heating, lighting, etc.) and the measurement and testing equipment usual for in the business operations of the principal, shall be available at the correct place and at the disposal of the contractor at the correct time and without charge;

   g. all necessary safety and precautionary measures shall have been taken and adhered to, and all measures shall have been taken and adhered to necessary to observe the applicable government regulations in the context of assembly/installation;

   h. the products shipped shall be available at the correct site at the commencement of and during assembly.

4. Defects not covered by the guarantee are those which occur partially or wholly as a result of:

   A. non-observance of the operation and maintenance instructions or other than foreseeable normal usage;

   B. normal wear and tear;

   C. assembly/installation by third parties, including the principal;

   D. the application of any government regulation regarding the nature or quality of the material used;

   E. materials or goods used in consultation with the principal;

   F. materials or goods provided by the principal to the contractor for processing;

   G. materials, goods, working methods and constructions insofar as are applied at the express instruction of the principal, and materials or goods supplied by or on behalf of the principal;

   H. components obtained from third parties by the contractor insofar as that party has given no guarantee to the contractor.

5. If the principal fails to fulfil any obligation properly or on time ensuing from the agreement concluded between the principal and the contractor or any agreement connected to it, the contractor shall not be bound by any of these agreements to any guarantee regardless of how it is referred to. If, without previous written approval from the contractor, the principal commences disassembly, repair or other work on the product or allows it to be commenced, then every agreement with regard to guarantee shall be void.

6. Claims regarding defects must be submitted in writing as quickly as possible and not later than 14 days after the discovery of such. All claims against the contractor regarding faults shall be void if this term is exceeded. Claims pertaining to the guarantee must be submitted within one year of the valid complaint on penalty of invalidity.

7. If the contractor replaces components/products under the terms of his guarantee obligations, the replaced components/products shall become the property of the contractor.

8. Unless otherwise agreed, a guarantee on repair or overhaul work carried out by the contractor or other services shall only be given on the correctness of the manner in which the commissioned work is carried out, this for a period of 6 months. This guarantee only covers the single obligation of the contractor to carry out the work concerned once again in the event of unsound work. In this case, sub article 3A shall apply equally.

9. No guarantee shall be given regarded the inspection conducted, advice given and similar matters.

10. Alleged failure to comply with his guarantee commitments on the part of the contractor shall not absolve the principal from his obligations ensuing from any agreement concluded with the contractor.

11. No guarantee shall be given on products which form a part of, or on work and services on, goods older than 8 years.

Revision 1014(2)
Section 17, drawing 0815-2019 corrected

Revision 0315
Section 17, drawing 0815-2022 added

Revision 0116
Section 3, Technical specifications updated
Section 7, Operating information updated conform firmware version 0.3.16
Section 17, Drawings updated
Section 18, List of abbreviations updated

Revision 0117
Section 3 analog input specs updated
Section 6.6 and 6.7 updated with backplane-X
Section 6.8, 6.9 and 6.10 added
Drawings updated with latest version

Revision 0817
Section 6.12 Additional slave addresses added

Revision 0418
Chapter 1.1 warnings added

Revision 0918
Initial release: PEM4 + SPU3 firmware version 4.31.