



GABLE IMUTM

EtherCAT[®] IMU + GPS + Compass



600 SERIES

PRODUCT DOCUMENTATION

SE610 | SE620 | SE630 | SE650 | SE670 | SE680



**MASTERING
MOTION**
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Document information

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C	21-09-2020	HCV	Added PDO mappings and configuration options. Minor other changes.
D	30-11-2020	SMB	Content updated.
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F	5-05-2022	HCV/SMB	Added section on EtherCAT P® injectors
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1 General information

This document provides information on the technical details and usage of the Gable-IMU™ 600 SERIES. The 600 SERIES are fully functional, easy to build-in Inertial Measurement Units (IMUs) which can be directly connected to or installed into an existing EtherCAT P® or EtherCAT® network.

An EtherCAT P®¹ networks combine EtherCAT® technology with power distribution into a one cable solution. Our EtherCAT P® variant of the 600 SERIES has therefore only two connectors opposed to three connectors of our EtherCAT® variant. This reduces the amount of cabling (communication, synchronization and power cables) compared to other IMU or navigation solutions. Using the 600 SERIES as the farthest node/slave of an EtherCAT P® network or branch allows for only one cable to be routed to the sensor.

Alternatively an EtherCAT P® variant of the 600 SERIES can also be easily integrated into a regular EtherCAT® network, using a simple converter module which injects power into the EtherCAT® network between the EtherCAT® master and the EtherCAT P® variant of the 600 SERIES. Please consult Gable Technologies for advice and/or support on these topics.

Gable Technologies B.V.

Website: www.gable-imu.nl

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1.1 Remarks on the documentation

1.1.1 Target audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the documentation and the following notes and explanations are followed when installing and commissioning 600 SERIES.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the devices described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

1.1.2 Disclaimer

The documentation has been prepared with care. The devices described are, however, constantly under development.

Gable Technologies reserves the right to revise and change the documentation at any point in time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

1.1.3 Trademarks

Gable-IMU™ is a trademark of Gable Technologies B.V.

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

EtherCAT P® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

XSENS® is a registered trademark of XSENS Technologies B.V. and/or its parent, subsidiaries and/or affiliates in The Netherlands, the USA and/or other countries.

1.1.4 Copyright

© Gable Technologies B.V., The Netherlands.

¹ <https://www.EtherCAT.org/en/EtherCAT®-p.html>

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1.2 Safety instructions

1.2.1 Safety regulations

The following safety instructions should be read and noted! Specific safety instructions can be found in subsections throughout this document.

1.2.2 Exclusion of liability

All the components are supplied in specific hardware and software configurations appropriate for the application. Hardware or software configuration modifications other than those described in this document are not permitted, and nullify the liability Gable Technologies B.V.

1.2.3 Personnel qualification

This description is only intended for trained specialists in control and automation familiar with the applicable national standards.

1.2.4 Description of symbols

In this documentation the following symbols are used with an accompanying safety instruction or note. Make sure to carefully read the instructions!



INFORMATION

This symbol indicates information that contributes to better understanding.



CAUTION

Makes the user alert to actions that could cause equipment damage, resulting in the equipment becoming unsafe, or to actions or operations that could have undesirable consequences.



WARNING

Makes the user aware of potentially hazardous events related to the 600 SERIES that may result in injury of persons interacting with the device.

1.3 Ordering information

When ordering Gable-IMU™ 600 SERIES, the following order code must be used. See Table 1
 You can also use our online product finder at www.gable-imu.nl to find the product that suits your demand.
 Please consult our sales department for production quantities, graduated prices and custom solutions.

Table 1: Order code 600 SERIES

SE610	-	HSD	-	P
↓		↓		↓
VARIANT: SE610 SE620 SE630 SE650 SE670 SE680		FORM: HSD = Housed variant OEM = PCB variant		INTERFACE: P = EtherCAT P® E = EtherCAT®

1.4 600 SERIES EtherCAT P® architecture

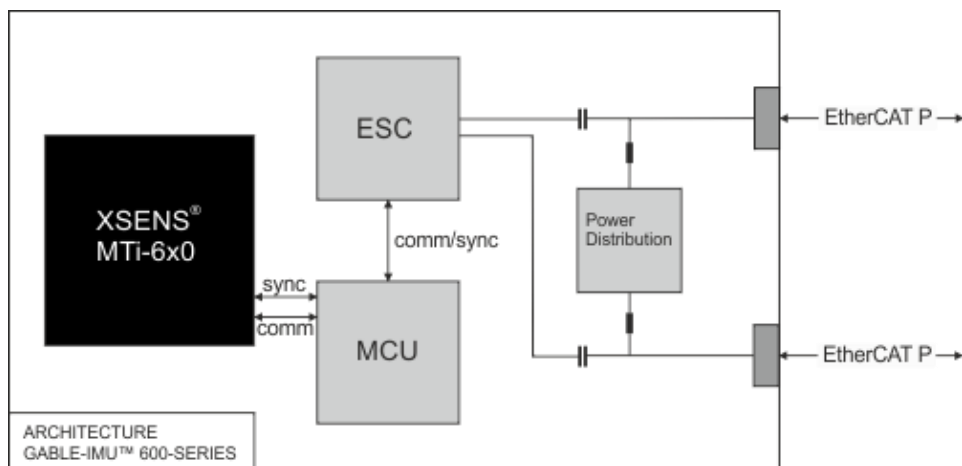


Figure 1: 600 SERIES EtherCAT P® Architecture

The schematic representation in Figure 1 shows the architecture of the 600 SERIES (EtherCAT P® variant). The 600 SERIES contains an XSENS®² MTi-6x0 IMU with a 3-axis gyroscope, 3-axis accelerometer and 3-axis magnetometer. The MTi-6x0 IMU is integrated in a fully functional EtherCAT P® slave which coordinates the communication between the EtherCAT P® network and the MTi-6x0 IMU. This is realized using a state of art EtherCAT® Slave Controller (ESC) and an industrial grade microcontroller (MCU).

The 600 SERIES offers the possibility to time synchronize multiple 600 SERIES based on the principle of distributed clocks. All nodes or slaves within an EtherCAT P® network can be time synchronized within a window of 1 microsecond (us).

Optimally estimated orientation, position and velocity are available with output data rates up to 400Hz. Gyroscope and acceleration data are available at data rates up to 1600 and 2000 Hz respectively.

1.5 600 SERIES variants

The 600 SERIES is available with an EtherCAT P® or EtherCAT® interface and in the following variants:

- SE610 Inertial Measurement Unit (IMU)

² <https://www.xsens.com/>

- SE620 IMU + Vertical Reference Unit (VRU)
- SE630 IMU + VRU + Altitude and Heading Reference System (AHRS)
- SE650 Global Navigation Satellite System (GNSS) Real Time Kinematic (RTK)
- SE670 IMU + VRU+ AHRS+GNSS + Inertial Navigation System (INS)
- SE680 IMU + VRU+ AHRS+GNSS + INS + RTK

Depending on the 600 SERIES variant, output data can be different which is explained in the following sections. The specific variant can be found on the label placed on the housing or PCB.

1.5.1 SE610 IMU

The SE610 is an IMU that outputs calibrated 3D rate of turn, 3D acceleration and 3D magnetic field. The SE610 also outputs coning and sculling compensated orientation increments and velocity increments (Δq and Δv). Advantages over a simple gyroscope-accelerometer combo-sensor are the inclusion of synchronized magnetic field, on-board signal processing and the easy-to-use synchronization and communication protocol. The signal processing pipeline and the suite of output options allow access to the highest possible accuracy at any output data rate up to 2000 Hz. Moreover, the testing and calibration is already performed by XSENS® and ensures a robust and reliable product, which enables a short time to market.

Source: MTi 600 SERIES Datasheet

1.5.2 SE620 VRU/AHT

The SE620 is a 3D VRU. On top of the functionality of the SE610 IMU, its algorithm computes 3D orientation data with respect to a gravity referenced frame: drift-free roll, pitch and unreferenced yaw. Although the yaw is unreferenced, it is superior to only gyroscope integration as a result of advanced on-board sensor fusion. The 3D acceleration is also available as so-called free acceleration, which has the local-gravity subtracted. The drift in unreferenced heading can be limited by using the Active Heading Stabilization (AHS) functionality. The raw sensor signals are combined and processed at a high frequency to produce a real-time data stream with device's 3D orientation (roll, pitch and yaw) up to 400 Hz.

Source: MTi 600 SERIES Datasheet

1.5.3 SE630 AHRS

The SE630 supports all features of the SE610 and SE620, and in addition is a full magnetometer-enhanced AHRS. In addition to the roll and pitch, it outputs a true magnetic North referenced yaw (heading) and calibrated sensors data: 3D acceleration, 3D rate of turn, 3D orientation and velocity increments (Δq and Δv) and 3D earth-magnetic field data. The raw sensor signals are combined and processed at a high frequency to produce a real-time data stream with device's 3D orientation (roll, pitch and yaw) up to 400 Hz.

Source: MTi 600 SERIES Datasheet

1.5.4 SE650 RTK/GNSS

The SE650 is a low-cost solution to enable EtherCAT P® Global Navigation Satellite System (GNSS) solution. This variant of our 600 SERIES does not contain an IMU and therefore can only be used for GNSS measurements.

1.5.5 SE670 GNSS/INS

The SE670 supports all features of the SE610, SE620 and SE630, and in addition the SE670 combines orientation data with position data supplied by an internal GNSS receiver. The SE670 represents the highest standard in GNSS/INS. This all-in-one navigation solution is lightweight and robust, as well as cost-effective and easy to integrate.

Source: MTi 600 SERIES Datasheet

1.5.6 SE680 RTK/GNSS/INS

The SE680 supports all features of the SE610, SE620, SE630 and SE670, and in addition the internal integrated Real-Time Kinematic receiver (RTK). With the RTK you can improve your positional data from meter-level to centimeter-level accuracy. You also benefit from sub 0.5 degree orientation estimates.

Source: MTi 600 SERIES Datasheet

2 600 SERIES specifications

This section presents the performance and the sensor component specifications for the 600 SERIES, based on the performance of the IMU (MTi-6x0) .

2.1 XSENS® MTi-600 series performance specifications

Each XSENS® MTi-6x0, inside the Gable IMU™ 600 SERIES, has passed the XSENS® calibration process individually. The XSENS® calibration procedure calibrates for many parameters, including bias (offset), alignment of the sensors with respect to the PCB and to each other, and gain (scale factor). All calibration values are temperature dependent and temperature calibrated. The calibration values are stored in the non-volatile memory of the XSENS® MTi-6x0.

In addition, some calibration parameters are continuously improved and/or re-estimated through the on-board sensor fusion algorithms during normal operation.

Source: MTi 600 SERIES Datasheet

Table 2: Orientation performance specifications

Parameter	Condition	SE610 IMU	SE620 VRU	SE630 AHRS	SE670 GNSS/INS	SE680 RTK
Roll/Pitch	Static	N/A	0.2°	0.2°	0.2	0.2
	Dynamic	N/A	0.25°	0.25°	0.25	0.25
Yaw	Dynamic	N/A	Unreferenced	1°	0.8	0.5
Position (Horizontal)		N/A	N/A	N/A	<1.0 m CEP	1 cm + 1ppm ³ CEP
Position (Vertical)		N/A	N/A	N/A	2.0 m CEP	0.1 m + 1ppm CEP ³
Velocity 3D		N/A	N/A	N/A	0.05 m/s	0.05 m/s

All above specifications are RMS values based on typical application scenarios.

2.2 Individual component specifications

Table 3: 600 SERIES gyroscope specifications

Gyroscope Specifications ⁴	Unit	Value
Standard full range	[°/s]	±2000
In-run bias stability	[°/h]	8
Bandwidth (-3dB)	[Hz]	520
Noise density	[°/s/√Hz]	0.007
g-sensitivity (calibrated)	[°/s/g]	0.001
Non-linearity	[%FS]	0.1
Scale Factor variation	[%]	0.5(typical) 1.5 (over life)

Table 4: 600 SERIES accelerometer specifications

Accelerometer ⁴	Unit	Value
Standard full range	[g]	±10
In-run bias stability	[μg]	10(x,y), 15(z)
Bandwidth (-3dB)	[Hz]	500
Noise density	[μg/√Hz]	60
Non-linearity	[%FS]	0.1

Table 5: 600 SERIES magnetometer specifications

Magnetometer ⁴	Unit	Value
Standard full range	[G]	±8
Non-linearity	[%]	0.2
Total RMS noise	[mG]	1

³ 1 ppm = 1 part per million, e.g. an additional 1 mm of error for every kilometer distance from the RTK base station. Position accuracies are assuming proper GNSS reception/circumstances.

⁴ As XSENS® continues to update the MTi-600 series, these specifications are subject to change

Resolution	[mG]	0.25
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Table 6: 600 SERIES orthogonality specifications

Parameter ⁴	Unit	Value
Non-orthogonality (accelerometer)	[°]	0.05
Non-orthogonality (gyroscope)	[°]	0.05
Non-orthogonality (magnetometer)	[°]	0.05

3 Wiring of the 600 SERIES

This section describes the mounting and wiring options for the 600 SERIES.



CAUTION | Risk of damage to the device!

Bring the EtherCAT P®/EtherCAT® system into a safe, powered down state before starting installation, disassembly or wiring of the 600 SERIES.

3.1 General wiring information

3.1.1 Cabling conductor losses

Power cables and EtherCAT P® cables should be designed in such a way that their length prevents a voltage drop which is too large for the 600 SERIES to still operate reliably. Current draw from other nodes connected to the OUT port of the 600 SERIES also need to be taken into account. At a control voltage U_S of 24V, reliable operation cannot be guaranteed anymore when the voltage drop exceeds 12 V.

Figure 2 shows the different cable lengths and their relation to the voltage drop at a specific current draw.

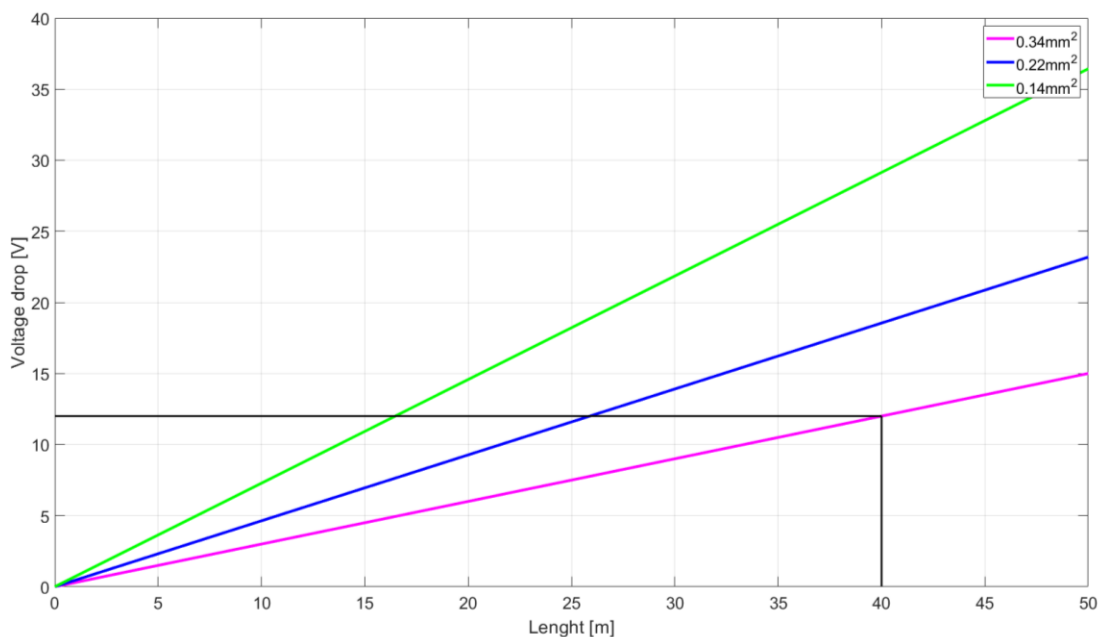


Figure 2: Voltage drop vs conductor cross sections

Example: An EtherCAT P® cable of 40m with (copper) conductor cross section of 0.34mm² has a voltage drop of ~12V @ 3A.

3.1.2 Control voltage U_S 24 VDC

Power is supplied to the fieldbus, the processor logic, the inputs and the sensors from the 24 VDC control voltage U_S .

3.1.3 Auxiliary voltage U_P 24 VDC (EtherCAT P®)

The Auxiliary voltage U_P supplies the digital outputs; it can be brought in separately. If the load voltage is switched off, the fieldbus functions and the power supply and functionality of the inputs are retained.

3.2 Connecting EtherCAT P® variants

The feeding and forwarding of EtherCAT P® is done via two EtherCAT P® p- coded M8 connectors at the front of the 600 SERIES:

- IN: left M8 connector with EtherCAT®-P p-coding for feeding EtherCAT P®
- OUT: right M8 connector with EtherCAT P® for forwarding the supply voltages and EtherCAT® communication

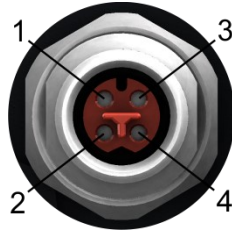


Figure 3: EtherCAT P® pinout

Table 7: EtherCAT P® pin assignment

Pin	Signal	Voltage
1	Tx+	GNDs
2	Rx+	GNDp
3	Rx-	Auxiliary voltage UP, +24 V _{DC}
4	Tx-	Control voltage US, +24 V _{DC}
Housing	Shield	Shielding

The pins of the M8 connectors can carry a maximum current of 3 A.



INFORMATION

Always note the orientation of the T-shaped structure in the connector center to prevent mismatch in pinout during cable confection!

3.2.1 EtherCAT P® Mating connectors

The following connectors from CONEC⁵ can be used to connect to the 600 SERIES EtherCAT P® variants. Note, a standard SMA connector can be used to connect to the internal GNSS receiver (if applicable).

Table 8: EtherCAT P® Mating connectors 600 SERIES

Connector	Number	Manufacturer	Remark
Male connector Axial AWG26-20	42-00132	CONEC	Field Attachable, IP67
Male connector Axial AWG28-22	42-00134	CONEC	Field Attachable, IP67



Figure 4: CONEC field assembly EtherCAT P® connector



CAUTION | Risk of mechanical damage to the device!

Tighten the M8 connectors with torque of at most 0.4 Nm.



CAUTION Pay attention to the maximum permissible current!

Pay attention for the forwarding of EtherCAT P®, the maximum permissible current of 3 A must not be exceeded at any connection point!

⁵ <https://www.conec.com/en/>

3.3 Connecting EtherCAT® variants

The feeding and forwarding of EtherCAT® is done via two EtherCAT® d-coded M8 connectors at the front of the 600 SERIES:

- IN: left M8 connector with EtherCAT® d-coding for feeding EtherCAT®
- OUT: right M8 connector with EtherCAT® d-coding for forwarding the EtherCAT® communication.

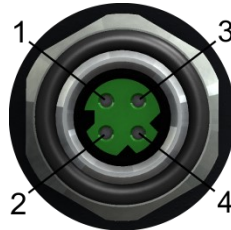


Figure 5: EtherCAT® pinout

Table 9: EtherCAT® pin assignment

Pin	Signal	Voltage
1	Tx+	Transmit Data+
2	Rx+	Receive Data+
3	Rx-	Receive Data-
4	Tx-	Transmit Data-
Housing	Shield	Shielding

For non EtherCAT® P variants an additional power port is present. The pinout can be found in Figure 6

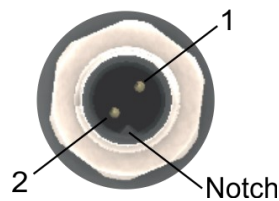


Figure 6: Power pinout

Table 10: Power pin assignment

Pin	Signal	Voltage
1	Vs	5 - 24V
2	PR	0V (GND)



INFORMATION

Always note the orientation of the structure in the connector center to prevent mismatch in pinout during cable confection!



INFORMATION

The pin-out is different opposed to standard industrial EtherCAT® d-coded connectors!

3.3.1 EtherCAT® and Power mating connectors

The following connectors from CONEC⁶ and Norcomp⁷ can be used to connect to the 600 SERIES EtherCAT® variants. Note, a standard SMA connector can be used to connect to the internal GNSS receiver (if applicable).

Table 11: EtherCAT® Mating connectors 600 SERIES

Connector	Number	Manufacturer	Remark
Male connector Axial 0.14 – 0.5 mm ²	42-00140	CONEC	Field Attachable, IP67
Male connector Axial 0.08-0.34mm ²	42-00138	CONEC	Field Attachable, IP67
Female connector M5 Vulcon™ series 2P	850-002-203RSS4	NORCOMP	Solder pin assembly, IP67



Figure 7: CONEC field assembly EtherCAT® connector



CAUTION | Risk of mechanical damage to the device!

Tighten the M8 connectors with torque of at most 0.4 Nm.



Figure 8: Norcomp VULCON™ connector (image for illustrative purpose only, pin out can be different)

3.4 LED indicators

The 600 SERIES has 6 LEDs to inform the user about the status of the device. In the following table the different LEDs and their function are explained.

Table 12: 600 SERIES LED IDs and states

LED	Color	State
-----	-------	-------

⁶ <https://www.conec.com/en/>

⁷ <https://www.norcomp.net/>

IN	Green	Flashing: EtherCAT® communication
OUT	Green	Flashing: EtherCAT® communication
Us	Green	On: Control Voltage Us ok
Up	Green	On: Auxiliary voltage Up ok (only for EtherCAT P®)
RUN	Green	Off: Device in INIT/unknown state On: Device in Run mode
ERR	Red	Flashing: Device in SAFEOP or PREOP state Off: ok Flashing: Internal communication error



Figure 9: SE600 top view showing LED IDs and location

3.5 Integration of EtherCAT P® variants into EtherCAT® networks

It is possible to integrate the 600 SERIES EtherCAT P variant into an existing EtherCAT® network. For this, several components can be used. The components in Table 13 are possible candidates.

Table 13 components for 600 SERIES EtherCAT P® to EtherCAT® integration

Component	Supplier	Description
EK1310	Beckhoff	1-port EtherCAT P® extension with feed-in
EK1322	Beckhoff	2-port EtherCAT P® junction with feed-in
EPP1321-0060	Beckhoff	1-channel EtherCAT® to EtherCAT P® supply module

3.6 GNSS connection (if applicable)

3.6.1 HSD version and GNSS

If applicable, any standard SMA mating connector can be used to attach to the internal GNSS receiver.

3.6.2 OEM (PCB) version and GNSS

A cable assembly with PCB to SMA panel mount connector is provided for the SE650, SE670 and SE680 OEM variants only. see 4.2 Mounting of PCB version (OEM). Any standard SMA mating connector can be used to connect to the SMA panel mount connector.

4 Mounting 600 SERIES

4.1 Mounting of housed version (HSD)

The housed version of the 600 SERIES is supplied with two hexagon head bolts DIN 916 A2 M3x12 (Allen key 2.5) which need to be used to fix the sensor to another system or device. The dimensions and location of the mounting holes can be found in Figure 10.

4.1.1 Origin of measurement

The origin of measurement of the housed version can be found in Figure 10 and is dimensioned in relation to its mounting holes.



CAUTION | Risk of mechanical damage to the device!

Tighten the M3 bolts with a maximum tightening torque of 0.6 Nm.

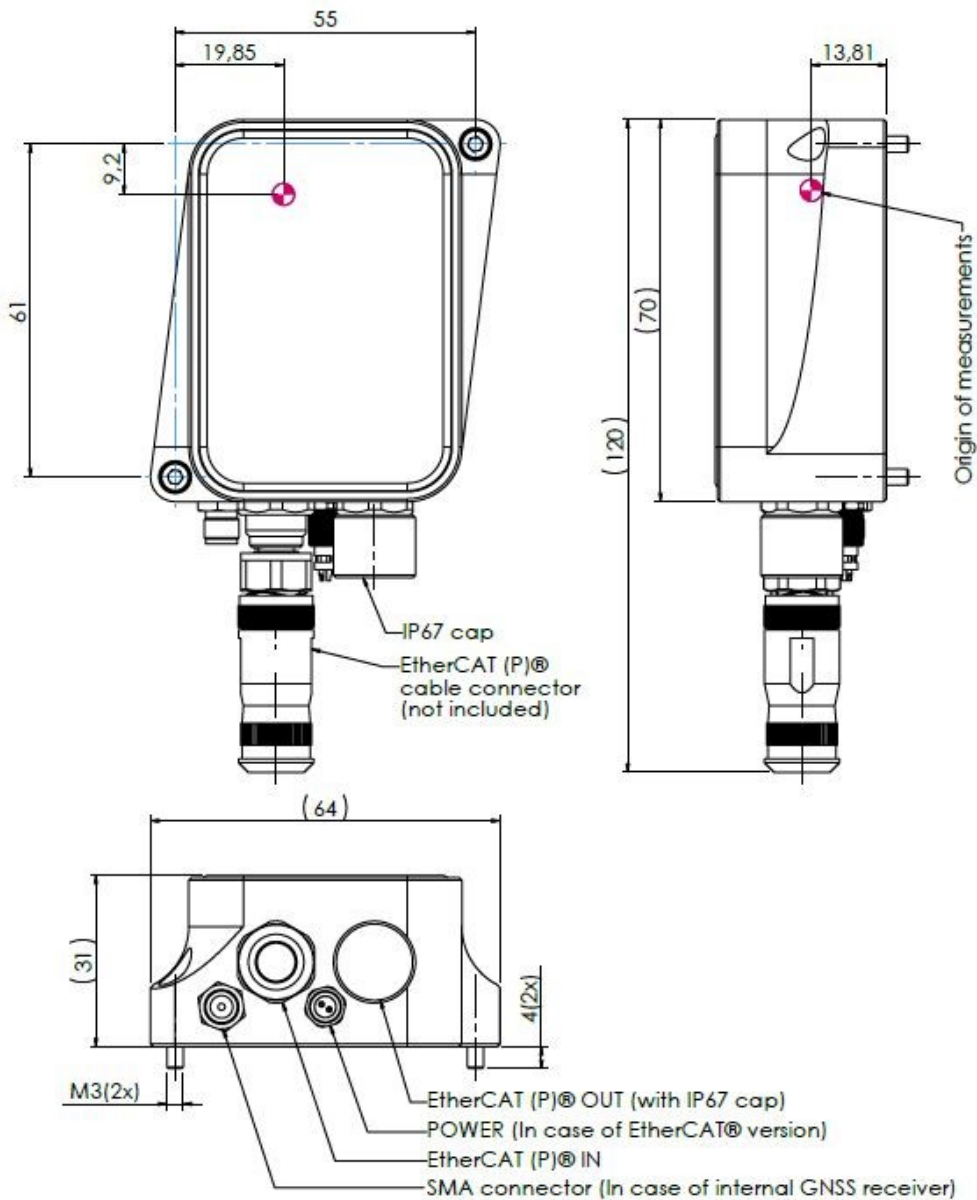


Figure 10: 600 SERIES HSD drawing

4.2 Mounting of PCB version (OEM)



CAUTION | Risk of mechanical damage to the device!
A static free-workstation must be used when handling the 600 SERIES PCB-version.

The PCB version of the 600 SERIES can be mounted according to the dimensions per drawing of Figure 11 and the following instructions:

- Ensure a static free-workstation before unpacking and handling the PCB and electronic components. A electro static discharge (ESD) can damage electronic components.
- Ensure bottom PCB clearance into your design, with washer or threaded pillars.
- Use non-ferro M2 fasteners to mount the PCB.

- A thicker panel thickness than 2,6mm is allowed. However, it will make the use of the supplied IP67 screw cap impossible. In this situation both M8 connectors need to be connected to maintain the ingress protection (IP67).
- The panel mount connectors allow some sliding in axial direction. This allows the dimension 57,4 to be increased to 58,4mm and gives some assembly freedom.
- The device is internally shielded through the EtherCAT P® connectors, no additional shielding/earthing is required.
- On request, a GradConn IP67 SMA cable assembly can be provided, Figure 12, to connect to the internal GNSS receiver of OEM-versions of variants SE650, SE670 and SE680. The assembly consists out of a SMA panel mount connector with a 200mm cable and I-PEX MHF 4L LK plug that can be connected to the PCB. Please consult the manufacturer information for mounting instructions of the SMA panel connector. Part number CAB442RF.



CAUTION | Risk of mechanical damage to the device!

Follow the mounting instructions and recommendations to prevent damage and undesirable effects.



CAUTION | Risk of mechanical damage to the device!

It is recommended to tighten the PCB fasteners hand tight (0.2 Nm) to prevent damage to the PCB.

4.2.1 Origin of measurement

The origin of measurement of the OEM version can be found in Figure 11 and is dimensioned in relation to its mounting holes.

IMPORTANT

- Panel connectors must always be fixated to a panel or housing.
- The PCB must be fixated with respect to the panel connectors.

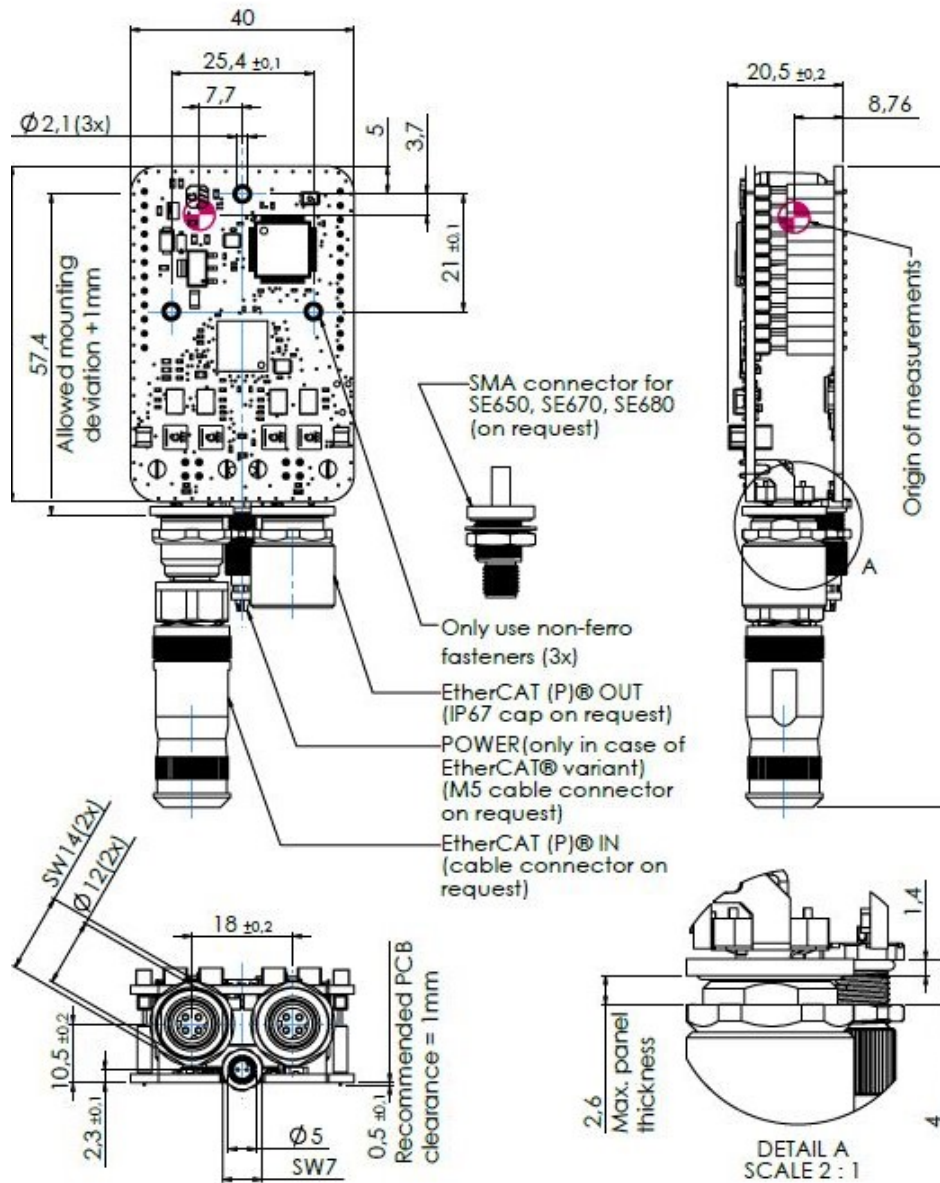


Figure 11: 600 SERIES OEM drawing

4.3 Cable assemblies and accessories

The following cable assemblies and accessories are recommended and can be ordered directly from the specified manufacturer and/or through Gable Technologies BV see Table 14.

Table 14: Connectors and accessories

Item	Manufact.	Number	Required 610/20/30 OEM	Required 610/20/30 HSD	Required 650/70/80 OEM	Required 650/70/80 HSD
M5 mating connector with flying lead	Gable Technologies	2pM5plug	1	1	1	1

(power cable assembly 500mm), Figure 13						
PCB to SMA panel mount cable assembly 200mm, Figure 12	GradConn	CAB442RF			1	
Multi-band active GNSS antenna IP67 with SMA connector, Figure 14	Ublox	ANN-MB-00-00			1	1



Figure 12: GradConn SMA cable assembly



Figure 13: Norcomp VULCON™ series connectors (image for illustrative purpose only, pin out can be different)



Figure 14: multi-band active GNSS antenna

5 Electrical and mechanical specifications

This section describes the electrical operating conditions and mechanical specifications of the 600 SERIES variants.

5.1 Supply voltage and power consumption

The 600 SERIES operates on the control voltage U_s provided over the EtherCAT P® or power connection. The following table specifies the range of voltages and power consumption.

Table 15: Supply voltage range 600 SERIES

Symbol	Minimal	Typical	Maximal	Unit
U_s	12	24	30	V

Table 16: Power consumption 600 SERIES

Variant	Typical	Unit	Description
SE610/20/30	1 ⁸	W	At 24V U_s
SE670/680	TBD	W	At 24V U_s

5.2 Mechanical characteristics

Table 17: Mechanical characteristics 600 SERIES

Variant	Weight	Dimensions	Protection
OEM	55 grams	60x40x20,5 mm (2.36x1.58x0.81 inches)	None
HSD	180 grams	70x64x31 mm (2.76x2.52x1.22 inches)	IP67

5.3 Ingress protection (HSD variants)

The 600 SERIES HSD has a two part robust machined aluminium housing which is completely sealed to achieve an ingress protection (IP) of 67. In case the EtherCAT® OUT port is not used, the IP67 screw cap needs to be installed to maintain ingress protection. The screw cap is included for the HSD-versions only, but can be ordered for the OEM-versions as well.



CAUTION | Ingress protection

In case the EtherCAT® OUT port is *not* used, the screw cap needs to be installed to maintain IP67 rating. The screw cap is installed by default.

⁸ Preliminary value



Figure 15: Screw Cap Mounting for IP67 rating

Note: Warranty rights will be lost immediately after attempts to open the housing or otherwise tamper with it.

6 Configuration and settings

The EtherCAT® communication between the 600 SERIES and the EtherCAT® master goes through its PDO's (No CoE parameters).

6.1 PDO mappings

The PDO mappings for each 600 SERIES can be found in Table 18 and Table 19.

Table 18: PDO mappings SE610, SE620 and SE630

PDO	Data format	Usage
FilterProfile^{9,10}	Array with entries being USINT.	The FilterProfile Array is shows the configured filter profile of the MTi-6XX, and can be mapped to EtherCAT® master outputs with matching data format.
DeviceID	Array with entries being USINT.	The DeviceID Array shows the device ID/ serial number of the MTi-6XX, and can be mapped to EtherCAT® master outputs with matching data format.
Quaternions¹⁰	Structure with {qw, qx, qy, qz} each field being a REAL.	The <i>Quaternion fields</i> can be mapped to EtherCAT® master inputs of matching data format.
Euler Angles¹⁰	Structure with {ex, ey, ez} each field being a REAL.	The <i>Euler Angles</i> can be mapped to EtherCAT® master inputs of matching data format.
Gyroscope	Structure with {gx, gy, gz} each field being a REAL.	The <i>Gyroscope fields</i> can be mapped to EtherCAT® master inputs of matching data format.
Acceleration	Structure with {ax, ay, az} each field being a REAL.	The <i>Acceleration fields</i> can be mapped to EtherCAT® master inputs of matching data format.
MagneticField	Structure with { magX, magY, magZ} each field being a REAL.	The <i>MagneticField fields</i> can be mapped to EtherCAT® master inputs of matching data format.
GyroscopeHR	Structure with { gxHR, gyHR, gzHR} each field being a REAL.	The <i>GyroscopeHR fields</i> can be mapped to EtherCAT® master inputs of matching data format. These signals are available at rates up to 1000Hz ¹¹ (not synchronized to the internal XSENS® clock). See Table 16 and 22 MT_Low-Level_Documentation.pdf.
AccelerationHR	Structure with { axHR, ayHR, azHR} each field being a REAL.	The <i>AccelerationHR fields</i> can be mapped to EtherCAT® master inputs of matching data format. These signals are available at rates up to 1000Hz ¹¹ (not synchronized to the internal XSENS® clock). See Table 16 and 22 MT_Low-Level_Documentation.pdf.
Status	Structure with: { CRC errors – UDINT, Wakeup – BIT, Command_Response – USINT, Communication_Errors - UDINT, PacketCounter – UINT, StatusWord – UDINT,	The <i>Status fields</i> can be mapped to EtherCAT® master inputs of matching data format. <i>CRC errors</i> : Number of CRC errors due to invalid XBus ¹² frame CRC. <i>Wakeup</i> : Sensor is ready to use <i>Command_Response</i> : Response message after sending an XBus message to the XSENS® IMU

⁹ Convert decimal values to ASCII for filter profile text representation.

¹⁰ Not available for the SE610.

¹¹ Due to the internal microcontroller and ESC the output rate is limited to 1000Hz.

¹² XBus: Xsens digital data bus system.

Info	CMD_ACK – USINT, MID_ACK - USINT} Structure with: { Baudrate – USINT, Firmware major version – SINT, Hardware major version – SINT}	<i>Communication_Errors</i> : Number of communication error(s) between the XSENS® IMU and the microcontroller. The <i>Status fields</i> can be mapped to EtherCAT® master inputs of matching data format. <i>Baudrate</i> : Baudrate between XSENS® Mti-6XX and microcontroller. <i>Firmware major version</i> : Major firmware version of the XSENS® Mti-6XX <i>Hardware major version</i> : Major hardware version of the XSENS® Mti-6XX
Command	Field being USINT.	The <i>Command</i> field is part of a XBus message used to configure the XSENS® IMU, and can be mapped to an EtherCAT® master output with matching data format. The following preconfigured messages are defined: 0 – Default return value 1 – Custom/Xbus message 2 – Config mode 3 – Measurement mode 4 – Software Reset 5 – Alignment Reset (Code 0x0004, see <i>MT_LowLevelCommunicationProtocol_Documentation.pdf</i>) 6 – SetFilter
Data	Array with entries being USINT.	The <i>Data</i> Array is part of a XBus message used to configure the XSENS® IMU, and can be mapped to EtherCAT® master outputs with matching data format.
MID	Field being USINT.	The <i>MID (Message ID)</i> field is part of a XBus message used to configure the XSENS® IMU, and can be mapped to an EtherCAT® master output with matching data format.
DataLenght	Field being USINT.	The <i>DataLenght</i> field is part of a XBus message used to configure the XSENS® IMU, and can be mapped to an EtherCAT® master output with matching data format.

Table 19: PDO mappings specific to the SE670 and SE680

PDO	Data format	Usage
GNSSpvt	Structure with: { itow – UDINT, year – UINT, month – USINT, day – USINT, hour – USINT, minute – USINT, second – USINT, valid – USINT, tAcc – UDINT, nano – DINT, fixtype – USINT, flags – USINT numSV – USINT, lon – DINT, lat – DINT,	The individual GNSSpvt fields can be mapped to EtherCAT® master inputs of matching data format.

```

height – DINT,
hMSL – DINT,
hAcc – UDINT,
vAcc – UDINT,
velN – DINT,
velE – DINT,
velD – DINT,
gSpeed – DINT,
headMot – DINT,
sAcc – UDINT,
headAcc – UDINT,
hadVeh - DINT}

```

6.2 Sending commands to the 600 SERIES for configuration

This section describes the commands which need to be send over EtherCAT® to change for example the filter settings or output data on a 600 SERIES. All values from the XSENS® low level communication manual for MID, Data[] and DataLength should be converted from Hexadecimal to decimal before sending.

Table 20: Example command to change filter setting

Step	EtherCAT® Message	Result	Comment
Go to config mode	Send: Command = 2	Acceleration, Gyroscope etc. will stop being updated (freeze)	-
Set Filter ¹³	Send in one cycle: Command = 1 MID = 100 Data[0..61] = 0 (See filter options Mti-6XX, page 59 low level communication protocol) DataLength = 1..62 bytes	Status.Command_Response should show '101' as a response to MID '100'. Data array fields should contain the decimal representation of each ASCII symbol, e.g. 'Responsive/VRU' -> [82 101 115 112 111 110 115 105 118 101 47 86 82 85 32]	-
Reset sensor	Send: Command = 4		Sensor is being reset and starts in measurement mode again.

An XSENS® XBus message also consist of header bytes (Preamble and BID) and a CRC byte, but these will be generated internally by the 600 SERIES and should not be included in any message. Only the light blue fields (see Table 21) should be send combined with the correct *Command* (see Table 20).

Table 21: Complete Xbus message to change filter type to Responsive/VRU

Preamble	BID	MID	DataLength	Data	CRC
0xFA	0xFF	0x64 (Decimal 100)	0x0F (Decimal 15)	[0x52 0x 65 0x 73 0x 70 0x 6F 0x 6E 0x 73 0x 69 0x 76 0x 65 0x 2F 0x 56 0x 52 0x 55 0x 20] (Decimal [82 101 115 112 111 110 115 105 118 101 47 86 82 85 32])	0x14 (Decimal 20)

¹³ The command to change for example the filter settings need to be send in one EtherCAT® frame.

The default configuration of the 600 SERIES does not include the *GyroscopeHR* and *AccelerationHR* PDOs. This is because the time synchronized and processed data at 400Hz is most commonly used. These PDOs can be activated separately by sending the correct command (see Table 22). To have both the processed data and the *GyroscopeHR* and *AccelerationHR* PDOs a message similar to the message in Table 15 needs to be send including the other PDO identifiers (MT_LowLevelCommunicationProtocol_Documentation.pdf).

Table 22: Example Command to get both HR (High Rate) PDOs only

Step	EtherCAT® Message	Result	Comment
Go to config mode	Send: Command = 2	Acceleration, Gyroscope etc. will stop being updated (freeze)	-
Set PDOs ¹⁴	Send in one cycle: Command = 1 MID = 192 Data[0.....7] = [128, 64, 0, 0, 64, 64, 0, 0] DataLength = 8	Status.Command_Response should show '193' as a response to MID '192' .	-
Go to measurement mode	Send: Command = 3	Only the <i>GyroscopeHR</i> and <i>AccelerationHR</i> PDOs are active.	Sensor starts in measurement mode again.

6.3 Filter profiles

The SE620 and SE630 can be used with several filter settings depending on the environment and application. TABLE 23 and TABLE 24 provide guidelines on selecting appropriate filter settings for your specific application or use case. The filter setting consist of a 'base filter' and a 'heading behavior filter'. The base filter affects the general dynamic behavior whereas the heading behavior filter affects the heading/yaw output (mainly how the magnetometer measurements are interpreted).

Table 23: Base filters for the SE620 and SE630 Variants

Name	Variant	Typical applications
Responsive	SE620	– Outdoor/Indoor handling objects
	SE630	– Indoor ground vehicles – Indoor mapping – Industrial robotic arms
Robust	SE620	– Ships/vessels
	SE630	– Automotive – Ground vehicles outdoor – Outdoor mapping with vehicles
General	SE620	– Automotive
	SE630	– Ground vehicles outdoor – Outdoor mapping with vehicles

¹⁴ The command to change for example the configuration settings need to be send in one EtherCAT® frame.

Table 24: Heading behavior filter

Name	Variant	Typical applications
NorthReference	SE630	All applications that require a North reference heading and are used in a homogeneous magnetic field.
FixedMagRef	SE630	All applications in environments where different magnetic fields are present (e.g. mixed indoor/outdoor applications).
VRU	SE620 SE630	Applications where only roll/pitch is of interest and/or applications that are used in environments where the magnetic field cannot be trusted (e.g. stabilized antenna platforms or pipeline inspection tools).
VRU/AHRS	SE620 SE630	Scenarios where the magnetic field cannot be trusted completely, but a stable yaw is needed.

An example for setting the filter to 'Responsive/VRU' can be found in section 0.

6.4 Timing and synchronization

The default mode for the 600 SERIES is Free Run. In this mode data is presented in the EtherCAT® frames without time synchronization between the 600 SERIES, other slaves in the same EtherCAT® network and the EtherCAT® master. The 600 SERIES supports Distributed clocks¹⁵ (DC) in which the internal clocks of the IMU/VRU/AHRS can be time synchronized through an ESC sync event with other slaves and the EtherCAT® master in the same EtherCAT® network. Configuration of the synchronization mode needs to be done inside the EtherCAT® master of choice.

¹⁵ Available from firmware version 2.0. Please contact Gable Technology for further assistance.

7 Packaging information

600 SERIES are packaged and shipped as single or multiple units.

7.1 Package content

The following contents are shipped

Table 25: Package contents

Package	Content	Qty	Information
6XX-OEM-P	– 600 SERIES PCB Assembly (Pre-installed M8 panel mount connectors)	1	
	– <i>On request connector set and/or accessories.</i>	→	4.3 Cable assemblies and accessories
6XX-OEM-E	– 600 SERIES PCB Assembly (Pre-installed M8 and M5 panel mount connectors)	1	
	– <i>On request connector set and/or accessories.</i>	→	4.3 Cable assemblies and accessories
6XX-HSD-P	– 600 SERIES in IP67 housing	1	
	– IP67 screw cap on OUT port	1	
	– Bag with 2 hexagon socket head screws	1	
	– <i>On request connector set and/or accessories.</i>	→	4.3 Cable assemblies and accessories
6XX-HSD-E	– 600 SERIES in IP67 housing	1	
	– IP67 screw cap on OUT port	1	
	– Bag with 2 hexagon socket head screws	1	
	– <i>On request connector set and/or accessories.</i>	→	4.3 Cable assemblies and accessories