SKF Copperhead Transmitter Unit (CMPT CTU) for Machinery Fault Detection

Part No. 32163100
Revision D

Instruction Manual

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1
Description

Figure 1-1: CMPT CTU (Copperhead Transmitter Unit)

This instruction manual provides detailed wiring connection and configuration information for the CMPT CTU (Copperhead Transmitter Unit) vibration and temperature transmitter. The CMPT CTU is configured by SKF when it is part of an assembled CMPT enclosure. The CMPT CTU must otherwise be properly installed and configured by the user. This instruction manual provides the user with information on how to properly install and configure the CTU and change the default configuration settings.

Please read this instruction manual and the cautionary notes thoroughly.

The SKF CTU is a digital vibration and temperature transmitter. It can be used as a part of a machinery fault detection system. The CTU performs three types of vibration signal process analysis – SKF Acceleration Enveloping (gE), Acceleration (g), or Velocity (mm/s or inch/s). The type of vibration analysis is user configurable. The CTU has analog output signals proportional to processed vibration analysis and temperature for connection to automation systems and SKF CMPT DCL monitors. The CTU is user configurable to process vibration signals from the SKF CMPT family of sensors or other industrial accelerometers.

Acceleration Enveloping vibration analysis is used to identify repetitive impact type vibrations generated by machinery faults due to loose components, gear faults, lack of lubrication and rolling bearing faults.

Acceleration vibration analysis is used to monitor overall machinery and structural vibration, including machinery having journal bearings. It can also be used to measure the overall operation of vibrating screens and other vibrating equipment.

Velocity vibration analysis is used to identify overall machinery vibration levels such as looseness and unbalance, including machinery support by journal bearings.

The CMPT CTU has unique features to monitor both high speed and low speed machinery (n <40 r/min).

2
Features

- Suitable with accelerometer sensors (10 mV/g to 230 mV/g).
- Temperature converter for accelerometers with integral temperature sensors.
- Three user selectable vibration process analyses:

  - SKF Acceleration Enveloping (ENV3), gE
  - Acceleration (RMS and Peak Hold), g
  - Velocity ISO, mm/s (inch/s)
- User configurable features on the front panel:
  - Vibration analyzer
  - Output Range
  - Optional sensor input or buffered vibration output input
  - Optional signal decay for Acceleration Enveloping Peak hold
  - Optional output signal averaging.
- Analog output signals - Processed vibration and temperature for interface with PLC/DCS and CMPT DCL alarm/display monitors.
- 35 mm DIN rail mounted with rugged steel retainer clip.
- Front panel mounted BNC connector for buffered vibration and temperature measurements.
- Front panel sensor OK/Overload lamp for detection of sensor and CTU faults.
- CAN-bus interface for connectivity of multiple numbers of CTU and remote monitoring via computer.
- Internal isolated DC/DC converter for grounding loop and reverse polarity protection.
- Auxiliary 24 V DC voltage output for optional powering of other sensor types (tachometer).

The software to process the vibration and temperature signals is embedded into the digital signal processing (DSP) card in the CTU. Calibration of the CTU is a part of the embedded software.

The CTU unit has two front panel rotary switches to set the configuration. There is no need to open the CTU enclosure to adjust pins or jumpers. The BNC connector is front panel switchable (BNC switch) to measure either the accelerometer sensor buffered (not processed) vibration output or the sensor temperature output. The buffered vibration output can be monitored with an SKF Microlog or equivalent device.

The CTU has a user configurable option to average the analog output signals so that rapid changes in vibration input do not cause annoying fluctuations in PLC/DCS or digital displays.

The CTU has a user configurable option of 1 second or 10 second signal decay time for Acceleration Enveloping Peak hold. The 10 second signal decay time is recommended for low speed (n <40 r/min) applications where the frequency of the mechanical impact vibration is low. Normal operation of the CTU is with the 1 second signal decay time.

The CTU can be user configured to accept a constant current signal from another CTU operating with an accelerometer sensor. This enables two CTUs having different configurations such as one Acceleration Enveloping and one Velocity to monitor the same accelerometer sensor signal.

The CTU has a front panel mounted SENSOR OK lamp to indicate that the sensor is correctly connected to the CTU and that the sensor (accelerometer and temperature) and the CTU are operating correctly.

- Green indicates that the system is OK (Correct).
- Red indicates that the system has a fault with the sensor or CTU, or that the vibration level or temperature exceeds the set RANGE (overload).

The CTU can be located up to 100 m (330 feet) from the sensor with suitable shielded cabling. The CMPT DCL display/alarm module can be used along with the CMPT CTU module to have a stand-alone monitoring of processed vibration. A second DCL module can be used to optionally monitor temperature from a CTU connected to a CMPT 2310T or CMPT 2323T sensor. The CMPT DCL is a single channel display/alarm module. It displays the live value from CTU on the front panel which is programmable. IT also has relay contacts for independent monitoring of the processed signals from the CTU. See the CMPT DCL data sheet.

Each CTU has a CAN-bus interface for remote communication with an industrial PC using an SKF protocol software. This enables remote configuration and monitoring of the CTU. The CAN-bus allows multiple numbers of CTU modules to be joined by a common CAN-bus connecting cable. This greatly reduces the wiring connections needed compared to the analog output signal cable requirements.

The CTU has an auxiliary 24 V DC power output for optional use to energize alternative sensors (20 mA maximum).

The CTU has an internal isolated DC/DC converter to avoid grounding loop problems. This isolates the 24 V power supply and the CAN-bus from the sensor input circuitry and the analog sensor output circuitry. The power input is protected from reverse polarity connections.

3
Specifications

Input signals

Industrial accelerometer	(2 wire, constant current source with voltage output)
Accelerometer sensitivity:	10 to 230 mV/g
Bias voltage:	12 V DC +/- 1 V
Supply current:	4 to 8 mA
Buffered acceleration signal output from another CTU	Buffered signal input mode
Supply voltage:	5 to 19 V
Temperature:	0 to 1,2 V DC @ 0,01 mV/°C

Environmental

Operating temperature:	0 to 70 °C (32 °F to 160 °F)
Storage temperature:	-40 °C to 85 °C (-40 °F to 185 °F)
Humidity:	95 % maximum
IP rating:	IP20
Vibration:	IEC68-2-6
Shock:	IEC68-2-27
Bump:	IEC68-2-29

Mechanical

Weight:	0,225 kg (0,102 lbs)
Enclosure:	Thermoplastic ABS
Color:	Gray
Connectors:	Two 8-pole pluggable screw clamp type
Wiring:	0,2 to 2,5 mm (24 to 12 AWG)
Mounting:	35 mm DIN-rail type EN50022 with steel retaining
clip	
Dimensions (H x W x D):	75 x 45 x 118 mm (2,95 x 1,77 x 4,65 inches)

Electrical

Power:	24 V DC (22 to 28 V DC) 250 mA current, maximum CTU is reverse power protected
Power consumption:	6 W

Vibration process analysis

Acceleration Enveloping, gE	
ENV3:	500 Hz – 10 kHz
Acceleration, g	
Accel RMS:	3 Hz – 10 kHz
Accel Peak Hold:	3 Hz – 10 kHz
Velocity, mm/s (inch/s)	
ISO:	10 Hz – 1 kHz 2 Hz – 1 kHz

Processed analog output signals

Vibration:	4 to 20 mA; 0 to 10 V DC Proportional to the input sensitivity of the accelerometer and the user defined signal processing method (Acceleration Enveloping, Acceleration or Velocity) and RANGE. See Section 3.
Temperature:	4 to 20 mA; 0 to 10 V DC Proportional to 0 °C to 120 °C

Analog signal less than 4 mA or greater than 20 mA indicates a system fault.

Auxiliary power: +24 V DC / 20 mA maximum

Approvals: CE
Emission 50081-2
Immunity 50082-2

4
Dimensions/Front panel/Terminals

Front Panel Rotary Switches

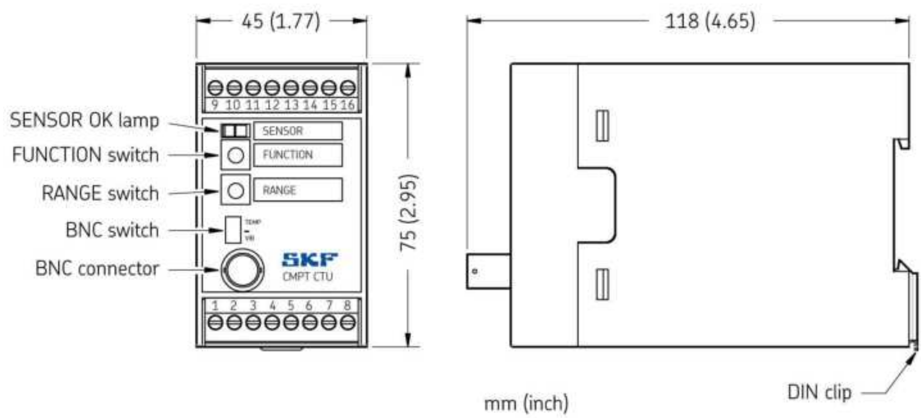


Figure 4-2: Dimensions and front panel

FUNCTION switch legend

0	Velocity (ISO), 10 Hz – 1 kHz
1	Velocity, 2 Hz – 1 kHz
4	Acceleration Peak Hold, 1 second decay
5	Acceleration Peak Hold, 10 seconds decay
6	Acceleration RMS, 1 second decay
7	Acceleration RMS, 10 seconds decay
C	Acceleration Enveloping 3 (ENV3), 1 second decay
D	Acceleration Enveloping 3 (ENV3), 10 second decay

RANGE switch legend

0	Range 0, Accelerometer sensor input ON, Output averaging OFF
1	Range 1, Accelerometer sensor input ON, Output averaging OFF
2	Range 2, Accelerometer sensor input ON, Output averaging OFF
3	Range 3, Accelerometer sensor input ON, Output averaging OFF
4	Range 0, Accelerometer sensor input ON, Output averaging ON
5	Range 1, Accelerometer sensor input ON, Output averaging ON
6	Range 2, Accelerometer sensor input ON, Output averaging ON
7	Range 3, Accelerometer sensor input ON, Output averaging ON
8	Range 0, Buffered signal input ON, Output averaging OFF
9	Range 1, Buffered signal input ON, Output averaging OFF
A	Range 2, Buffered signal input ON, Output averaging OFF
B	Range 3, Buffered signal input ON, Output averaging OFF
C	Range 0, Buffered signal input ON, Output averaging ON
D	Range 1, Buffered signal input ON, Output averaging ON
E	Range 2, Buffered signal input ON, Output averaging ON
F	Range 3, Buffered signal input ON, Output averaging ON

SENSOR OK lamp

Green	Accelerometer and temperature sensor and CTU are operating correctly
Green (flashing)	CTU is settling output because of change in rotary switch setting
Red	Fault with sensors or vibration exceeds set RANGE *
Red (flashing)	Vibration or temperature input signal exceeds full Scale
Red/Green (flashing)	Unit failure (return to SKF for repair)

* The SENSOR OK lamp will be red if the temperature sensor is not connected. A 100 Ω or a 120 Ω resistor is required between CTU terminals 2 and 3 to avoid the red SENSOR OK lamp.

Connector Assignment

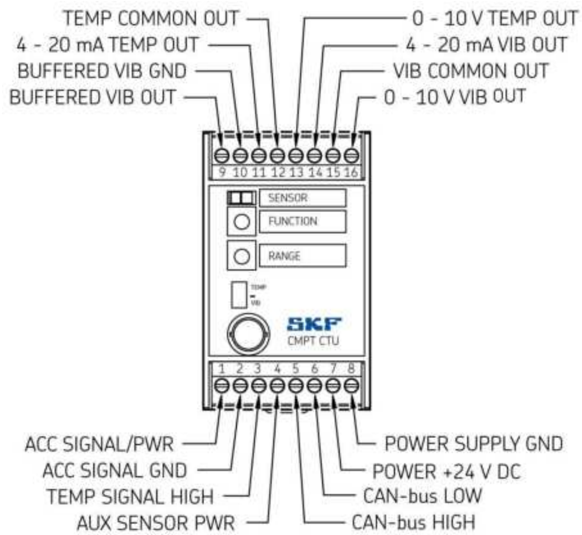


Figure 4-3: CMPT CTU connector assignment

Pin Number	Connection	Description
1	ACC SIGNAL/PWR	Accelerometer signal
2	ACC SIGNAL GND	Accelerometer ground
3	TEMP SIGNAL High	Temperature signal (optional)
4	AUX SENSOR PWR	Powering of auxiliary sensor (optional)
5	CAN-bus HIGH	See CTU CAN-bus
6	CAN-bus LOW	See CTU CAN-bus
7	POWER +24 V DC	Power supply for CTU
8	POWER SUPPLY GND	Power supply ground
9	BUFFERED VIB OUT	Buffered (not processed) vibration signal
10	BUFFERED VIB GND	Buffered vibration signal ground
11	4–20 mA TEMP OUT	Analog signal for temperature
12	TEMP COMMON OUT	Common (ground) for temperature
13	0–10 V TEMP OUT	Analog signal for temperature
14	4–20 mA VIB OUT	Analog signal for processed vibration
15	VIB COMMON OUT	Analog signal common (ground) for vibration
16	0–10 V VIB OUT	Analog signal for processed vibration

5 Caution

Read and understand these instructions thoroughly before working with the CMPT CTU. The CMPT CTU should be installed by persons qualified to work with electrical instrumentation.

Caution - Damage or injury can result

- *The CMPT CTU is powered by 24 V DE. Do not apply higher voltage.*
- *Higher voltage (110–240 V AC) power may exist in the same proximity as the CMPT CTU. Use caution to avoid contact with any voltage source.*
- *Make sure that the CMPT CTU is installed in an environment within its specifications (see section "Specifications")*

Lightning strikes, power surges and other electrical anomalies can damage this device. For the protection of your equipment, SKF recommends the power connections be made through a surge protector.

6

CMPT CTU Output Signal Scales

Vibration

The accelerometer sensor and CMPT CTU unit provide processed vibration and temperature (optional) analog signals for use with a CTU module and for PLC/DCS systems for continuous monitoring. The scale of the CTU vibration analog output signal in engineering units (gE, g, mm/s or inch/s (IPS)) depends on the setting of the rotary FUNCTION and RANGE switches and the sensitivity of the selected accelerometer sensor. See Table 6-1 and Table 6-2 below for the full scale (RANGE) values of the CTU depending on the type of vibration analysis mode, sensor sensitivity, and selected CTU RANGE.

Examples for the setting of the FUNCTION and RANGE:

Example 1

Sensor		100 mV/g	
CTU settings			
	FUNCTION switch	C	(Acceleration Enveloping ENV 3)
	RANGE switch	2	(full Scale = 30 gE)
Output signal scale			
	Vibration	0–30 gE3	(4 to 20 mA and 0 to 10 V DC)
	Temperature	0–120 °C	(4 to 20 mA and 0 to 10 V DC)

Example 2

Sensor		100 mV/g	
CTU settings			
	FUNCTION switch	0	(Velocity ISO)
	RANGE switch	2	(full Scale = 15 mm/s)
Output signal scale			
	Vibration	0–15 mm/s	(4 to 20 mA and 0 to 10 V DC)
	Temperature	0–120 °C	(4 to 20 mA and 0 to 10 V DC)

Example 3

Sensor		230 mV/g	
CTU settings			
	FUNCTION switch	C	(Acceleration Enveloping)
	RANGE switch	0	(full Scale = 1,3 gE3)
Output signal scale			
	Vibration	0–1,3 gE3	(4 to 20 mA and 0 to 10 V DC)
	Temperature	0–120 °C	(4 to 20 mA and 0 to 10 V DC)

The following Table 6-1 lists the vibration gain (unit/V) and scale values of Velocity mode, ISO and Non-standard ISO.

Sensor (RMS)		**RANGE 0**	**RANGE 1**	**RANGE 2**	**RANGE 3**
230 mV/g Metric (RMS)	Gain Scale	0,065 mm/s/V 0 to 0,65 mm/s	0,22 mm/s/V 0 to 2,17 mm/s	0,65 mm/s/V 0 to 6,5 mm/s	2,2 mm/s/V 0 to 21,74 mm/s
100 mV/g Metric (RMS)	Gain Scale	0,15 mm/s/V 0 to 1,50 mm/s	0,50 mm/s/V 0 to 5,00 mm/s	1,5 mm/s/V 0 to 15,00 mm/s	5,0 mm/s/V 0 to 50 mm/s
30 mV/g Metric (RMS)	Gain Scale	0,5 mm/s/V 0 to 5 mm/s	1,67mm/s/V 0 to 16,7 mm/s	5,0 mm/s/V 0 to 50 mm/s	16,7 mm/s/V 0 to 167 mm/s
10 mV/g Metric (RMS)	Gain Scale	1,5 mm/s/V 0 to 15 mm/s	5,0 mm/s/V 0 to 50 mm/s	15 mm/s/V 0 to 150 mm/s	50 mm/s/V 0 to 500 mm/s
Sensor (Peak)		**RANGE 0**	**RANGE 1**	**RANGE 2**	**RANGE 3**
230 mV/g English (IPS Ps. PK)	Gain Scale	0,0036 IPS/V 0 to 0,036 IPS	0,012 IPS/V 0 to 0,12 IPS	0,036 IPS/V 0 to 0,36 IPS	0,121 IPS/V 0 to 1,21 IPS
100 mV/g English (IPS Ps. PK)	Gain Scale	0,008 IPS/V 0 to 0,08 IPS	0,027 IPS/V 0 to 0,27 IPS	0,084 IPS/V 0 to 0,84 IPS	0,28 IPS 0 to 2,78 IPS
30 mV/g English (IPS Ps. PK)	Gain Scale	0,028 IPS/V 0 to 0,28 IPS	0,093 IPS/V 0 to 0,93 IPS	0,28 IPS/V 0 to 2,8 IPS	0,93 IPS/V 0 to 9,3 IPS
10 mV/g English (IPS Ps. PK)	Gain Scale	0,084 IPS/V 0 to 0,84 IPS	0,28 IPS/V 0 to 2,8 IPS	0,84 IPS/V 0 to 8,4 IPS	2,8 IPS/V 0 to 28 IPS

Table 6-1: Velocity mode, ISO and Non-standard ISO

The following Table 6-2 lists the vibration gain (unit/V) and scale values of Acceleration (g) and Acceleration Enveloping (gE).

Sensor		**RANGE 0**	**RANGE 1**	**RANGE 2**	**RANGE 3**
230 mV/g	Gain Scale	0,13 gE/V 0 to 1,3 gE	0,44 gE/V 0 to 4,4 gE	1,3 gE/V 0 to 13 gE	4,4 gE/V 0 to 43,5 gE
100 mV/g	Gain Scale	0,3 gE/V 0 to 3 gE	1,0 gE/V 0 to 10 gE	3,0 gE/V 0 to 30 gE	10,0 gE/V 0 to 100 gE
30 mV/g	Gain Scale	1,0gE/V 0 to 10 gE	3,3 gE/V 0 to 33,3 gE	10,0 gE/V 0 to 100 gE	33,3 gE/V 0 to 333 gE
10 mV/g	Gain Scale	3,0 gE/V 0 to 30 gE	10,0 gE/V 0 to 100 gE	30,0 gE/V 0 to 300 gE	100,0 gE/V 0 to 1 000 gE

Table 6-2: Acceleration (g) and Acceleration Enveloping (gE)

Values of vibration (V) in the machinery being monitored can be calculated from the measured analog output current signal of the CTU (terminals 14 and 15) using the following equation:

$$L = \frac{S\,(C - 4)}{16}$$

Where as;
L = vibration level in machine (gE, g, mm/s, IPS)
S = full RANGE scale (gE, g, mm/s, IPS) of the CTU
C = measured current output from CTU (mA) between 4 and 20 mA

The vibration level (L) in the machinery being monitored can be calculated from the measured analog DC voltage signal of the CTU (terminals 15 and 16) using the following equation:

$$L = \frac{V \times S}{10}$$

Where as;
L = vibration level in machine (gE, g, mm/s, IPS)
V = measured voltage output from CTU (V) between 0 and 10 V DC
S = full RANGE scale (gE, g, mm/s, IPS) of the CTU

Temperature

The CTU temperature analog output signals is constant at 0 °C to 120 °C (32 °F to 248 °F) equal to 4 to 20 mA and 0 to 10 V DC.

Values of temperature (T) in the machinery being monitored can be calculated from the measured analog current (mA) output signal of the CTU (terminals 11 and 12) using the following equation:

$$T = \frac{120\ (C - 4)}{16}$$

Where as;
T = temperature level in machine (°C)
C = measured current output from CTU (mA) between 4 and 20 mA

Or

$$T = \frac{216\ (C - 4)}{16} + 32$$

Where as;
T = temperature level in machine (°F)
V = measured current output from CTU (mA) between 4 and 20 mA

The temperature (T) in the machinery being monitored can be calculated from the measured analog DC voltage signal of the CTU (terminals 12 and 13) using the following equation:

$$T = 12 \times V$$

Where as;
T = temperature level in machine (°C)
V = measured voltage output from CTU (V) between 0 and 10 V DC

Or

$$T = (21.6 \times V) + 32$$

Where as;
T = temperature level in machine (°F)
V = measured voltage output from CTU (V) between 0 and 10 V DC

7
Basic Instructions and Wiring Connections

General Instructions

The accelerometer sensor and CMPT CTU should be located within 100 m (300 feet) of each other. A suitable twisted and shielded pair of wires (22 AWG with 100 pF/m) should be used to connect the CMPT 2310 and CMPT 2323 accelerometer sensors to the CTU. Three wires are needed for the CMPT 2310T and CMPT 2323T sensors.

Set the CTU rotary FUNCTION and RANGE switches to configure the transmitter for the desired vibration analysis mode and the desired output signal scale. The FUNCTION switch setting defines the type of vibration analysis (Acceleration Enveloping, Acceleration, or Velocity) and the RANGE setting defines the output signal scale. The RANGE setting also defines the type of input source (accelerometer sensor or a buffered signal input from another CTU).

The CTU can be mounted horizontally or vertically on a DIN rail. It is advisable to use DIN spacers between the CTU modules. The CTU must be installed in an area with sufficient cooling.

The following Table 7-3 shows general recommendations on the selection of the vibration accelerometer and the RANGE and signal decay settings for the CTU depending on the speed of the application.

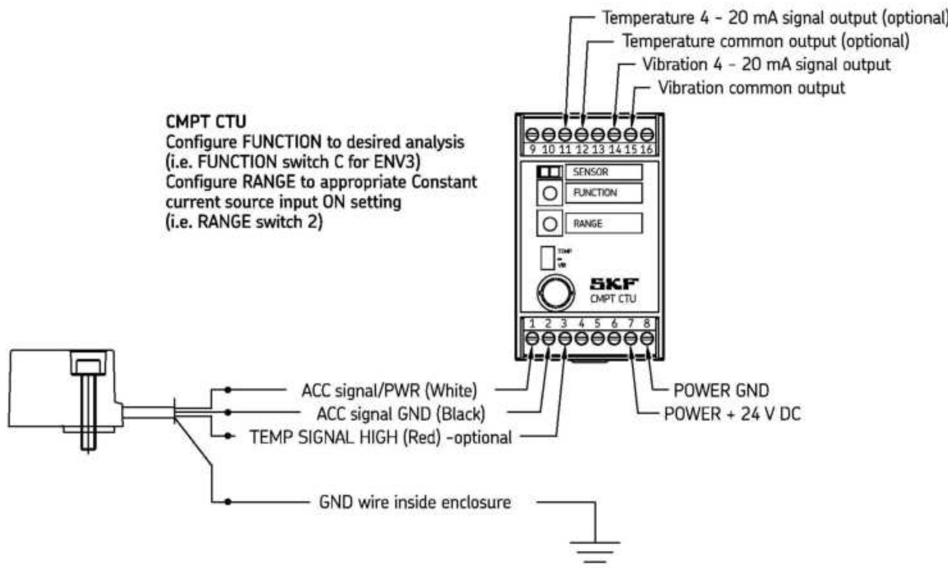
	Application conditions	
	Normal speed	Low speed (n < 40 r/min)
Sensor	CMPT 2310 or CMPT 2310T	CMPT 2323 or CMPT 2323T
CMPT CTU settings		
Output RANGE	1, 2 or 3	0 or 1
Vibration signal decay	1 second	10 seconds

Table 7-3: CTU application conditions

The analog output signals can be averaged using the appropriate RANGE switch setting. This will reduce the variation of the signal display for visual observation with a CMPT DCL display/alarm module or in the PLC/DCS system.

After the CTU FUNCTION and RANGE switches are set, apply the self-adhesive stickers provided with the CTU to the front panel of the CTU corresponding to the selected FUNCTION and RANGE settings.

Normal Wiring as Vibration and Temperature (optional) Transmitter



This applies to SKF CMPT sensors 2310, 2310T, 2323 and 2323T.
The sensor ground wire is connected to the inner shield of the sensor cable. This wire should be connected to ground (earth) inside the CMPT CTU enclosure. The sensors have a stainless steel over braid. The braid is for mechanical protection of the cable. The braid also acts as an outer shield. It is advised to isolate (shield) the sensor ground wire from the braid and local ground. The cable braid and the sensor ground wire should not contact each other or else a “ground loop” may occur causing signal interference.

Figure 7-4: Basic CMPT CTU with wiring

The CMPT accelerometer sensor is connected to the CMPT CTU according to the wiring diagram in Figure 7-4.

The CTU can directly interface with a plant automation system via a Programmable Logic Controller (PLC) / Distributed Control System (DCS) using both the processed vibration and temperature analog output signals. The accelerometer and CTU can be located up to 1,6 km (1 mile) away from the PLC/DCS when using the 4–20 mA current signal outputs and recommended wire size (2,5 mm (22 AWG) at 100 pF/m).

The processed vibration signals of the CTU can be “averaged” to dampen the change in processed vibration output signal. This feature is useful if the vibration level in the machine is dynamic making the setting of alarm(s) in the PLC/DCS difficult or the observation of the PLC / DCL digital display uncomfortable for the operator. Use RANGE settings 4 to 7 or C to F to enable the “Output averaging ON” configuration.

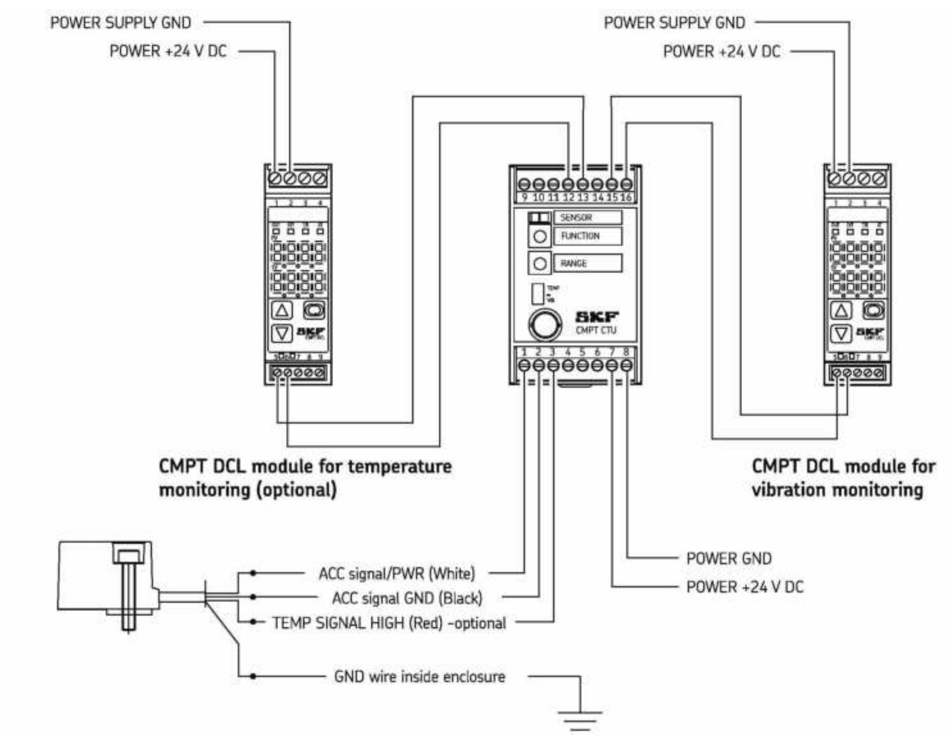
The SENSOR OK lamp will be red if the temperature sensor is not connected. A 100 Ω or a 120 Ω resistor is required between CTU terminals 2 and 3 to avoid the red SENSOR OK lamp.

Basic connections (Basic CMPT CTU with wiring):

Accelerometer	**CTU terminal**
ACC Signal / Power (White)	1
ACC / TEMP signal Ground (Black)	2
TEMP signal High (Red)	3
Power +24 V DC	7
Power Ground	8
Analog output (current)	
Vibration	
4 to 20 mA	14
Vibration common	15
Temperature	
4 to 20 mA	11
TEMP common	12
Alternative analog output (voltage)	
Vibration	
0 to 10 V DC	16
Vibration common	15
Temperature	
0 to 10 V DC	13
TEMP common	12

Normal Wiring as Vibration and Temperature (optional) Transmitter with CMPT DCL Modules for Stand Alone Monitoring

An accelerometer sensor and CMPT CTU can be connected to a CMPT DCL module for stand alone vibration monitoring. A second DCL module may be used for optional temperature monitoring. The DCL module provides a digital display of the processed vibration (or optional temperature) signal and has a single alarm and relay function for local annunciation of a change in vibration or temperature. See the wiring diagram in Figure 7-5 and refer to the CMPT DCL Instruction Manual for wiring and setting details.



This applies to SKF CMPT sensors 2310, 2310T, 2323 and 2323T.
The sensor ground wire is connected to the inner shield of the sensor cable. This wire should be connected to ground (earth) inside the CMPT CTU enclosure. The sensors have a stainless steel over braid. The braids for mechanical protection of the cable. The braid also acts as an outer shield. It is advised to isolate (shield) the sensor ground wire from the braid and local ground (earth). The cable braid and the sensor ground wire should not contact each other or else a “ground loop” may occur causing signal interference.

Figure 7-5: CMPT sensor and CTU connected with two CMPT DCL display/alarm modules for stand alone monitoring with a temperature sensor

The SENSOR OK lamp will be red if the temperature sensor is not connected. A 100 Ω or a 120 Ω resistor is required between CTU terminals 2 and 3 to avoid the red SENSOR OK lamp.

Parallel Wiring with Secondary CTU

To monitor a machine with two of the three possible analysis types – Acceleration Enveloping, Acceleration or Velocity – one accelerometer sensor and two CMPT CTU modules are wired parallel to one another. A secondary CTU module is wired parallel to a primary CTU. The RANGE switch of the secondary CTU is set to the appropriate buffered signal input ON selection. See the wiring diagram below. The CTU(s) analog output signals can be connected to a PLC/DCS or CMPT DCL module for monitoring.

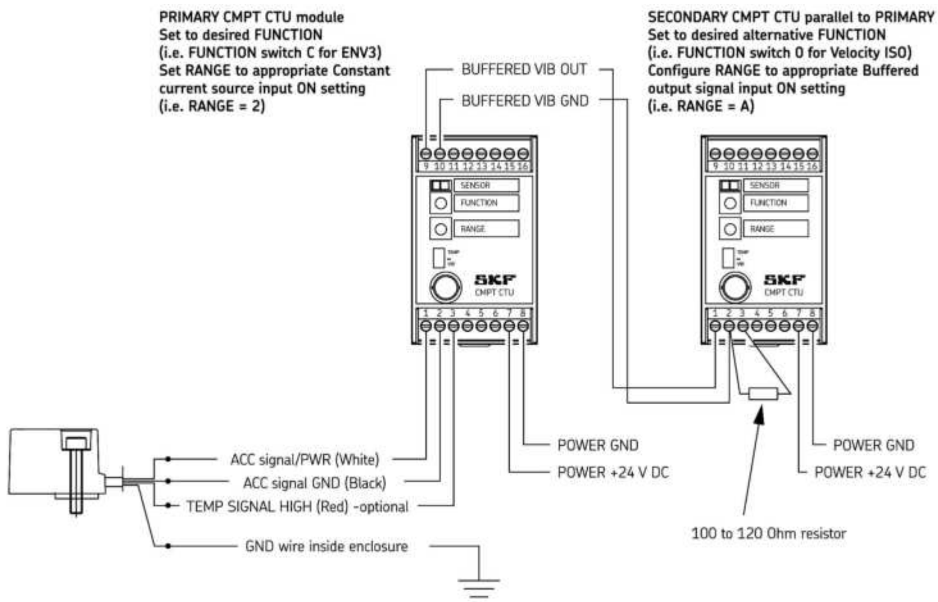


Figure 7-6: Secondary CTU connected to sensor and primary CTU

The SENSOR OK lamp will be red if the temperature sensor is not connected. A 100 Ω or a 120 Ω resistor is required between CTU terminals 2 and 3 to avoid the red SENSOR OK lamp.

Connections		
	Primary CTU	Secondary CTU
Buffered VIB OUT	9	1
Buffered VIB GND	10	2

Table 7-4: Connections

Set the secondary CTU to the desired RANGE having a buffered input signal ON (RANGE 8 to F). A 100 to 120 Ω resister is required between the secondary CTU terminals 2 and 3 since a temperature input is not used.

8
CMPT CTU Output

Each machine has its own normal vibration level depending on its function and design, supporting structure, and environment. The CMPT CTU is particularly useful for continuous detection of changes in machinery vibration and temperature. The CTU analog output signals can be monitored either by the PLC/DCS system or the CMPT DCL modules. For new machinery or for machinery known not to have any preexisting faults, the alarm levels in PLC/DCS or DCL modules can be set at 50 % to 100 % (1,5 to 2 X) over the normal machine vibration level. Lower vibration alarm levels should be used if the condition of the machinery is not known. Table 8-6 and Table 8-7 below can be used to judge the severity of vibration in a machine. Generally, Acceleration Enveloping vibration (gE3) values above 12 to 15 gE3 are indications of faults such as mechanical looseness, lack of lubrication, and bearing defects. Consult SKF for additional details about vibration levels.

Alarm limits for temperature monitoring can be established based on experience of the original equipment manufacturer (OEM) or the machinery operator.

When high vibration or temperature levels are detected, it is advisable for the plant operator or maintenance personnel to inspect the machine. Very often, these personnel can detect faults based on unusual sounds or noise. Procedures are available to help diagnose faults in machinery. If the cause of the fault cannot be identified, it is advisable to use the experience of a vibration analyst to perform a complete vibration spectrum analysis of the machine.

Class I (Small machines) Machines may be separated driver and driven, or coupled units comprising operating machinery up to approximately 15 kW (approx. 20 hp). Class II (Medium machines) Machinery (electrical motors 15 kW (20 hp) to 75 kW (100 hp), without special foundations, or rigidly mounted engines or machines up to 300 kW (400 hp) mounted on special foundations Class III (Large machines) Machines are large prime movers and other large machinery with large rotating assemblies mounted on rigid and heavy foundations which are reasonably stiff in the direction of vibration. Class IV (Large machines) Includes large prime movers and other large machinery with large rotating assemblies mounted on foundations which are relatively soft in the direction of the measured vibration such as turbine generators and gas turbines greater than 10 MW (approximately 13 500 hp) output.

Table 8-5: ISO 10816-1 Machine classifications

<table>
<tr><th colspan="2">Velocity Severity</th><th colspan="4">Velocity Range Limits and Machine Classes</th></tr>
<tr><th rowspan="2">mm/s RMS</th><th rowspan="2">in/s Peak</th><th rowspan="2">Small Machines Class I</th><th rowspan="2">Medium Machines Class II</th><th colspan="2">Large Machines</th></tr>
<tr><th>Rigid Supports Class III</th><th>Less Rigid Supports Class IV</th></tr>
<tr><td>0,28</td><td>0.02</td><td rowspan="3">Good</td><td rowspan="4">Good</td><td rowspan="5">Good</td><td rowspan="6">Good</td></tr>
<tr><td>0,45</td><td>0.03</td></tr>
<tr><td>0,71</td><td>0.04</td></tr>
<tr><td>1,12</td><td>0.06</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>1,8</td><td>0.10</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>2,8</td><td>0.16</td><td rowspan="2">Unsatisfactory (alert)</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>4,5</td><td>0.25</td><td rowspan="2">Unsatisfactory (alert)</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>7,1</td><td>0.40</td><td rowspan="5">Unacceptable (danger)</td><td rowspan="2">Unsatisfactory (alert)</td></tr>
<tr><td>11,2</td><td>0.62</td><td rowspan="4">Unacceptable (danger)</td><td rowspan="2">Unsatisfactory (alert)</td></tr>
<tr><td>18</td><td>1.00</td><td rowspan="3">Unacceptable (danger)</td></tr>
<tr><td>28</td><td>1.56</td><td rowspan="2">Unacceptable (danger)</td></tr>
<tr><td>45</td><td>2.51</td></tr>
</table>

Table 8-6: ISO 10816-1 Velocity Range Limits

<table>
<tr><th>Enveloping Severity</th><th colspan="3">Shaft Diameter & Speed</th></tr>
<tr><th>gE peak-to-peak</th><th>Diameter between 200 and 500 mm and Speed < 500 r/min</th><th>Diameter between 50 and 300 mm and Speed between 500 and 1 800 r/min</th><th>Diameter between 20 and 150 mm and Speed is either 1 800 or 3 600 r/min</th></tr>
<tr><td>0.1</td><td>Good</td><td rowspan="2">Good</td><td rowspan="3">Good</td></tr>
<tr><td>0.5</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>0.75</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>1</td><td>Unsatisfactory (alert)</td><td>Satisfactory</td></tr>
<tr><td>2</td><td rowspan="3">Unacceptable (danger)</td><td>Unsatisfactory (alert)</td><td>Unsatisfactory (alert)</td></tr>
<tr><td>4</td><td rowspan="2">Unacceptable (danger)</td><td rowspan="2">Unacceptable (danger)</td></tr>
<tr><td>10</td></tr>
</table>

Table 8-7: Enveloped Acceleration Limits

9

Interface with Dataloggers and Vibration Systems

The CMPT CTU is equipped with a front panel BNC connector to enable connection to the buffered output signal of the connected accelerometer sensor. This enables use of the SKF MarlinVIBPAK and SKF Microlog dataloggers, or an equivalent vibration spectrum datalogger to safely and easily connect to the sensor without interference. The BNC connector can be switched to "TEMP" to enable measurement of the sensor temperature signal (optional).

The CTU also has screw terminals (numbers 9 and 10) for connection of the buffered output signal to other vibration monitoring devices.

The processed Acceleration Enveloping, Acceleration and Velocity output signals from the CTU will likely be different than the values obtained directly with the SKF Microlog datalogger owing to slight differences in the way the signal is processed and how the frequency point in the datalogger is configured.

10
CTU CAN-bus

CTU CAN-bus Connection

Multiple CTUs can be connected together to allow an efficient transfer of measurement values over a digital communication bus. CAN-bus (Controller Area Network) is an industry standard and is used in many plant automation applications. As many as 64 CTU can simultaneously cooperate on the bus.

Characteristics:

Frame format: CAN 2.0B
CAN massage ID (hex): Uses 12000000 to 13FFFFFF
Communication speed: 250 kBps
Maximum bus length: 250 meters (depends on cable quality, number of nods, stub length, etc…)

CTU has an integrated 120 Ω resistor which can be disabled by removing the jumper shown in Figure 10-7, below.

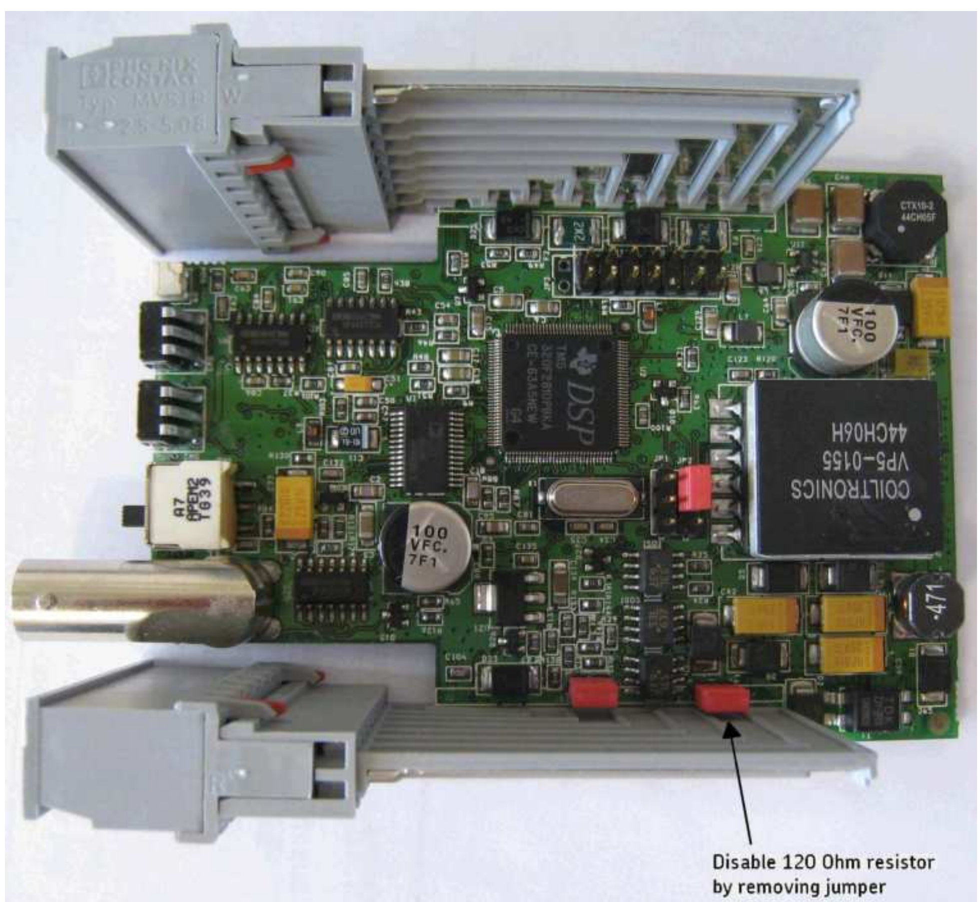


Figure 10-7: Location of jumper which can be removed to disable resistor

The CAN-Bus has to be terminated with 120 Ω on both ends as shown in Figure 10-8, below. The can-bus cable should be a two-wire twisted pair. Wires between each unit must be as short as possible. If wires are too long, perturbation may appear on the bus and alter the data.

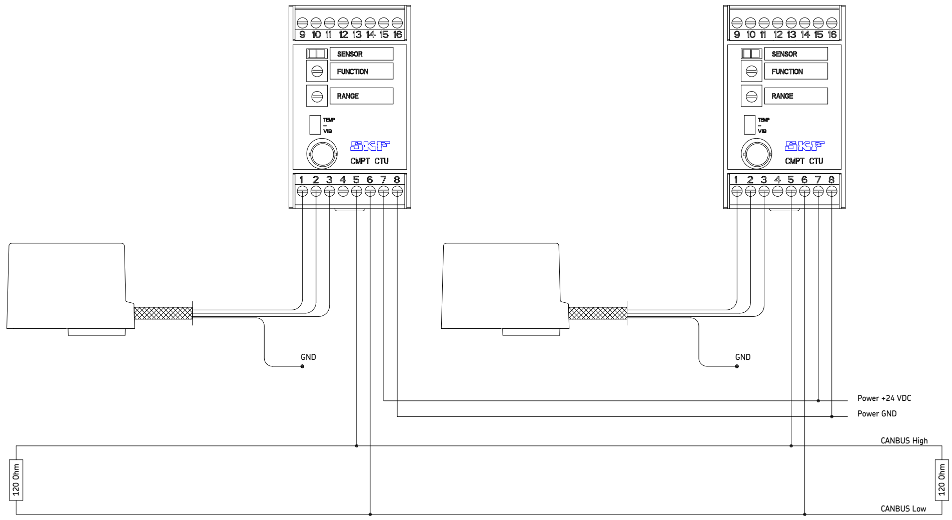


Figure 10-8: Two CTU transmitters wired for CAN-bus connectivity

Network problems are often caused by not using proper termination at both ends, wrong bit rates for cable lengths, incorrectly installed cables and/or poor signal quality.

For more information, refer to:
"Controller Area Network", by Konrad Etschberger, ISBN N 3-00-007376-0
http://en.wikipedia.org/wiki/Controller%E2%80%93area_network

CTU CAN Protocol

The CTU protocol will be specified in the following sections. Note that the OSI layer descriptions are an indication of where the protocols must be specified according to the 7-layer model.

CTU's are defined to operate on 250 kBit/s and this cannot be changed.

Used CAN message contains following information:

Parameter	Type	Description
ID	29 bits	CAN message ID Lower 29 bits are used for extended frame format messages. Bits 29 – 19 are used for standard frame format messages.
IDE	1-bit	0 = standard frame format (11-bit ID) 1 = extended frame format (29-bit ID)
DLC	4-bits	Data Length Code, length of the Data field in bytes (min 0, max 8)
Data	byte[8] (array)	Message data bytes. Byte send order is Data[0], Data[1], ..., Data[7].

Table 10-8: Used CAN messages

CTU uses the extended frame format.

The CAN extended frame ID format consisting of 29-bits is as following:

ID[28-25]	ID[24-17]	ID[16]	ID[15-8]	ID[7-0]
FNC (4 bits)	Command (8 bits)	RR (1 bit)	Source	Destination
Network	*CTU Service*		*Network*	

Table 10-9: CAN extended frame ID fromat consisting of 29-bits

As shown in Table 10-9 above, the network layer uses the ID bits [28-25] and [15-0] for protocol communication. The CTU service layers (higher layers) use bits [24-16] and the DLC and Data bytes from the CAN message.

Services

As specification indicates, your application should act as the host node with address in between 0x00 and 0x0F.This ID is used to communicate with CTUs. The default address for each CTU is 0xEF.

Predefined special addresses:

- **0xFF** all nodes (hosts and CTUs)
- **0xF0** all hosts
- **0xF1** all CTUs

Identify Unit:

The first thing is to identify the CTUs in the network. As it was mentioned, all CTUs have the default address 0xEF. If you have multiple CTUs in the same network, you will need to first identify all CTUs and then change their address if needed.

Identification can be done with Identify message. When host application starts, the default address 0xEFshould be sent with the broadcast address as the destination (see Request below). For just CTUs you can use 0xF1 as the destination, which will return serial number of CTUs. The destination ID 0xFF will return serial numbers of all the hosts and CTUs . When CTU is powered, it will also send identify response message.

Request:

Command	RR	Source	Dest	Data	Remarks
0xE0	0	Source ID	Dest ID/ Broadcast	-	

Table 10-10: Services request

Boot-loader response:

Command	RR	Source	Dest	Data	Remarks
0xE0	1	Dest ID	Source ID	[0-5] Serial	Serial number

Table 10-11: Services boot-leader response

Application response:

Command	RR	Source	Dest	Data	Remarks
0x80	1	Dest ID	Source ID	[0-5] Serial	Serial number

Table 10-12: Services application response

Example:

Using PCANView application to send and receive messages, I sent message 13C001F1 with data set to 0. The ID of PCANView (acts like host) is 1.

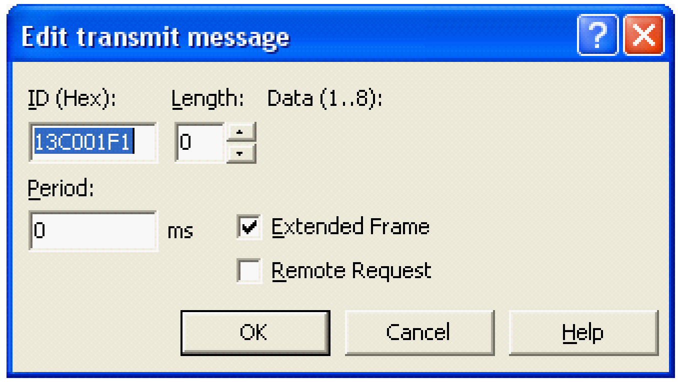


Figure 10-9: Example of Edit transmit message

The bit representation (32 bit) of message and response is as the following:

1. Yellow: Extra bits not used
2. Green: FNC (always 0x09)
3. Turquoise: Command (0xE0)
4. Pink: RR
5. Blue: Source (1), sender address
6. Red: Destination (Broadcast to all CTUs 0xF1)

The **message** in bitwise:

1 2 3 4 5 6
00010011110000000000000111110001

Response from CTU in application mode with serial number 0002-001746:

1301EF01 with 6 data bytes [0x00,0x02,0x00,0x00,0x06,0xD2]

1 2 3 4 5 6
00010011000000011110111100000001
0x09 0x80 0xEF 0x01

Unit Address

As all CTUs have the same address by default, the next thing to do is to set a new address to CTU. This can be done by using unit's serial number as the identifier when setting a new address. The valid address for CTU is between 0x10 and 0x4F. To set the address, the following request as in Table 10-13 is used and the response as in Table 10-14 will be sent back.

Request:

Command	RR	Source	Dest	Data	Remarks
0xEF	0	Source ID	Dest ID	[0-5] Serial [6-7] Node ID	Serial number The new node ID

Table 10-13: Unit address request

Response:

Command	RR	Source	Dest	Data	Remarks
0xEF	1	Dest ID	Source ID	[0-1] Result	Result = 0: OK Result > 0: Error

Table 10-14: Unit address response

Warning - CTU will use the old address when responding. After sending response it will change the address.

Example:

Using PCANView application to send and receive messages, I sent message 13C001F1 (ID in hex) with data set to 00 02 00 00 06 D2 00 10. The ID of PCANView (acts like host) is 1.

The bytes 1 to 6 (starting from left most) of the data represent the serial number and bytes 7 and 8 represent the new address for CTU (in this case 0x0010)

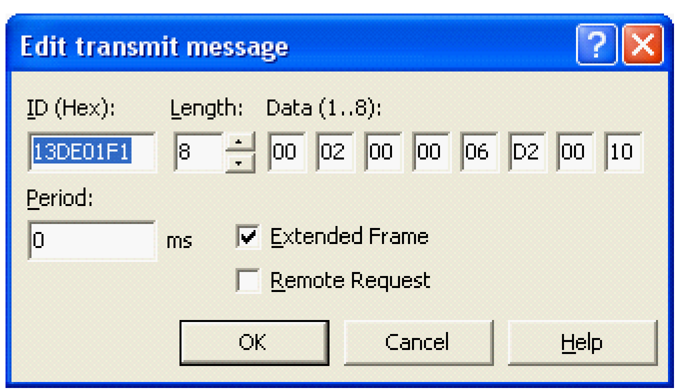


Figure 10-10: Example of Edit transmit message

The bit representation (32 bit) of message and response is as the following:

1. Yellow: Extra bits not used
2. Green: FNC (always 0x09)
3. Turquoise: Command (0xEF)
4. Pink: RR
5. Blue: Source (1), sender address
6. Red: Destination (Broadcast to all CTU's 0xF1)

The **message** in bitwise (32 bit):

1	2	3	4	5	6
000	1001	11101111	0	00000001	11110001

Response from CTU in application mode with serial number 0002-001746:
13DFEF01 with 6 data bytes [0x00,0x00]

1	2	3	4	5	6
000	1001	11101111	1	11101111	00000001
	0x09	0xEF		0xEF	0x01

Overall Measurement Values

If overall values are needed the following request as in Table 10-15 can be used. This will get the value from parameters that save the values.

Request:

Command	RR	Source	Dest	Data	Remarks
0x48	0	Client ID	Server ID	[0-1] Parameter ID [2-3] Elem Index	ID of parameter Element index

Table 10-15: Unit address response

Response:

Comman d	RR	Source	Dest	Data	Remarks
0x48	1	Server ID	Client ID	[0-1] Result [2-5] Value	Result = 0: OK Result >0: Error 32-bit aligned value

Table 10-16: Unit address response

Parameter ID with default Elem Index (value 0) for getting temperature and different vibration values:

Current measured temperature (°C)	**204 (0x00, 0xCC)**
Acceleration RMS output	**266 (0x01, 0x0A)**
Acceleration PH output	**267 (0x01, 0x0B)**
Velocity RMS output	**268 (0x01, 0x 0C)**
Enveloper PH output	**269 (0x01, 0x0D)**
Current measured Bias offset voltage	**209 (0x00, 0xD1)**

Response will return a result code and 32 bit aligned value. Overall value will be 32 bit floating point IEEE 754 format. When calling these values you should know the dial setup of the unit and the kind of sensor you have. If you call for example Velocity RMS when you measure Envelope according to CTU dial selector, you will receive value 0.

Result codes:

Result code (hex)	Description
0x0000	Ok
0x0001	Invalid parameter
0x0002	No write access
0x0003	Invalid condition
0x0004	Invalid state
0x0005	Zero sample rate
0x0006	No read access
0x0007	Invalid mode
0x0008	Invalid parameter value
0x0009	Algorithm not active

Result code (hex)	Description
0x000A	Measurement locked
0x000B	Invalid frame size
0x000C	Algorithm not available

Table 10-17: Unit address response

Example:

Using PCANView application to send and receive messages, I sent message 12900110 with data set to 01 0D 00 00. The ID of PCANView (acts like host) is 1 and the CTU is 0x10. This will get Envelope value from CTU.

The bytes 1 and 2 (starting from left most) of the data represent the parameter ID and bytes 3 and 4 represent the element index.

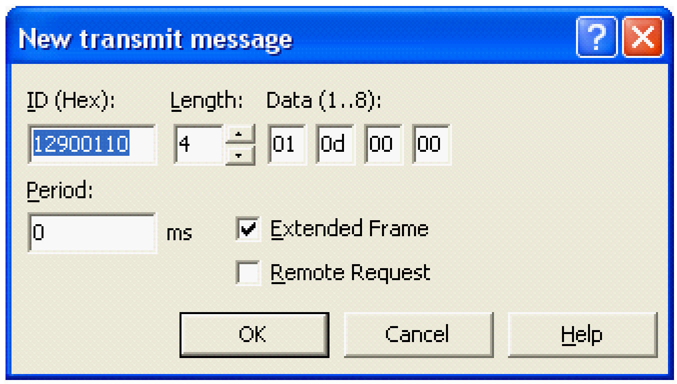


Figure 10-18: Example of New transmit message

The bit representation (32 bit) of message and response is as the following:

1. Yellow: Extra bits not used
2. Green: FNC (always 0x09)
3. Turquoise: Command (0x48)
4. Pink: RR
5. Blue: Source (1), sender address
6. Red: Destination

The **message** in bitwise:

1 2 3 4 5 6
00010010100100000000000100010000

Response from CTU in application mode with serial number 0002-001746:

12911001 with 6 data bytes [0x00,0x00,0x3D,0x9A,0xF3,0xC0]
|-- data value -|

1 2 3 4 5 6
00010010100100010001000000000001
0x09 0x48 0xEF 0x01

The bit representation of **data value** (hex number 3D9AF3C0) is as the following:

00111101100110101111001111000000
S Exponent Fraction

Sign (1 bit): bit position 31.
Exponent (8 bit): bit position 23 to 30.
Fraction (23 bit): bit position 22 to 0.

Equation = (-1)^s*(1+Significand)*2^(E-127)

$$\text{Significand} = \sum_{i=22}^{0} bit(i) * 1/2^{(23-i)}$$

So in this case the equation could look like following:

(-1)^0 * (1+1/8+1/16+1/64+1/256+1/512+1/1024+1/2048+1/8192+1/16384+1/3276 + 1/65536) * 2^(123-127) = 1 * 1,210678 * 2^-4

This represents value 0,075667375.