QUAD THERMOCOUPLE CONDITIONER TO CAN BUS   TC4-C

TC4-C Quad channel Thermocouple Conditioner to CAN is designed to meet the latest automotive standards and by its ruggedized structure provide a reliable and accurate solution even under harsh motorsport conditions.

TC4-C is versatile Thermocouple probe conditioner that can be used for various Thermocouple Types (K, J, T, N, S, E, B, R) offering a wide range of temperatures and measurement accuracies. Typically used with common K-Type Thermocouples gives a full range from -100 to +1372°C. Each channel accommodates its own Cold-junction compensation reading to provide precise and error free Temperature measurement at the desired probe tip. The Voltage measurement is sourced from an up to 18-bit Analogue to Digital Converter offering high accuracy with fast response times. In addition, it integrates digital IIR Filter that can be configured to help reducing fast thermal transients or instabilities.

User can fully configure the Thermocouple conditioner behaviour with RS232 Setup Menu. This allows adjusting the settings for best required performance as well as modifying the CAN bus Communication properties to suit the application.

All the above is packaged inside a ruggedized, waterproof aluminium case. Flying leads give the option for selection of electrical connectors to suit individual requirements.

Description

Sensor	
Supported Types[1]	**K**, J, T, N, S, E, B, R
Number of channels	x4
Electrical	
Operating Voltage Range	6 – 40 V
Input current	~40 mA
Measurement (K-Type)	
Hot, Delta Junction Range	-100 – 1372°C
Cold Junction Range	-30 – 140 °C
Hot, Delta Junction Resolution[1]	0.0625, **0.125**, 0.25, 0.5 °C
Cold Junction Resolution[1]	**0.0625**, 0.25 °C
Digital IIR Filter[1]	**0** – 7 configurations
Communication	
CAN[1]	CAN 2.0**A**, B (**STANDARD**, EXTENDED)
Baud rate[1]	**1M**, 500k, 250k, 125k, 100k
Frame rate[1]	100Hz, **50Hz**, 20Hz, 10Hz, 2Hz, 1Hz
Base arbitration IDs[1]	0x555, 0x560, 0x570, 0x575
120Ω Termination[1]	**ON**, OFF

Environmental	
IP rating	IP67
Mechanical	
Operating Temperature	-30°C to +85°C
Dimensions	144 x 30 x 15 mm
Case material	Aluminium
Weight Controller	~50 g
Connector	Flying Leads 0,2m*

[1] User configurable in Setup Menu (RS-232)

*Other variants on request

Circuit Layout
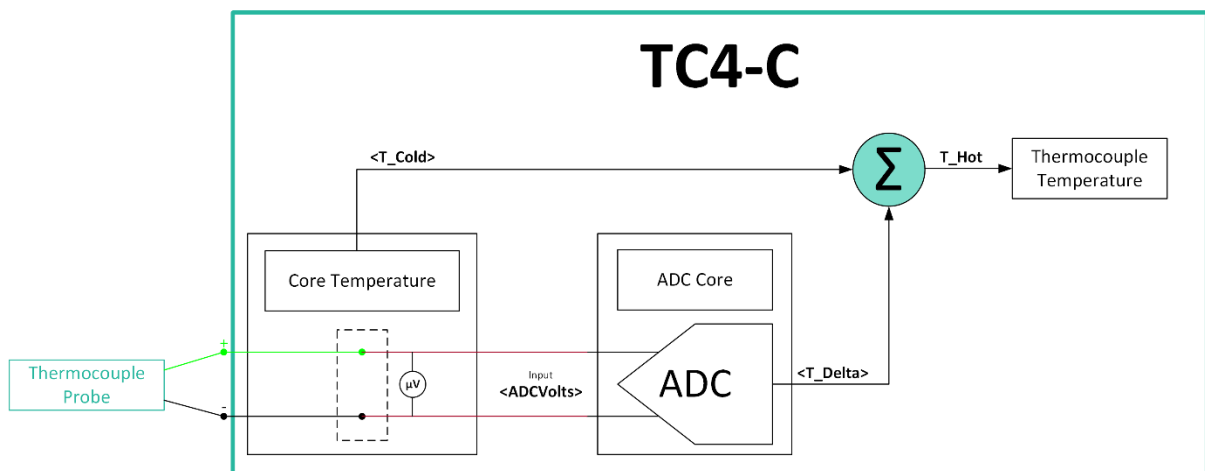
Digital Filter

The device integrates a first order recursive Infinite Impulse Response (IIR) filter, also known as Exponential Moving Average (EMA). This feature can be used to filter out fast thermal transients or thermal instability at the thermocouple Hot junction temperature.

$$Y_{curr} = k \times X_{curr} + (1 - k) \times Y_{prev}$$

$$k = \frac{2}{(2^n + 1)}$$

Where:	
Y_{curr}	New filtered Temperature
X_{curr}	Current unfiltered Temperature
Y_{prev}	Previous filtered Temperature
n	User-selectable filter coefficient (0 – 7)

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Temperature Resolution vs. Update rate

The temperature resolution is user-selectable for both measured points, Cols and Delta Junction. The higher the resolution the slower is the conversion time to process the measurement. The Resolution and Update Rate relation is described below:
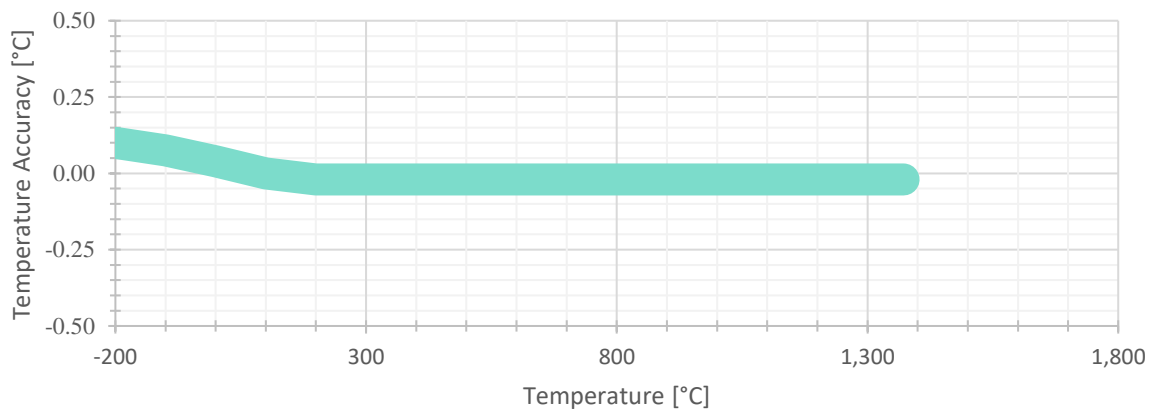
Delta/Hot Junction ADC Resolution:

ADC	Temperature	Update Rate
18-bit	0.0625°C	2Hz
16-bit	0.125°C	10Hz
14-bit	0.25°C	20Hz
12-bit	0.5°C	50Hz

Cold Junction ADC Resolution:

ADC	Temperature	Update Rate
18-bit	0.0625°C	2Hz
14-bit	0.25°C	10Hz

Typical Performance

Typical Temperature Accuracy from NIST ITS-90 Database
K-Type

Typical Temperature Sensitivity with 18-bit Resolution
K-Type
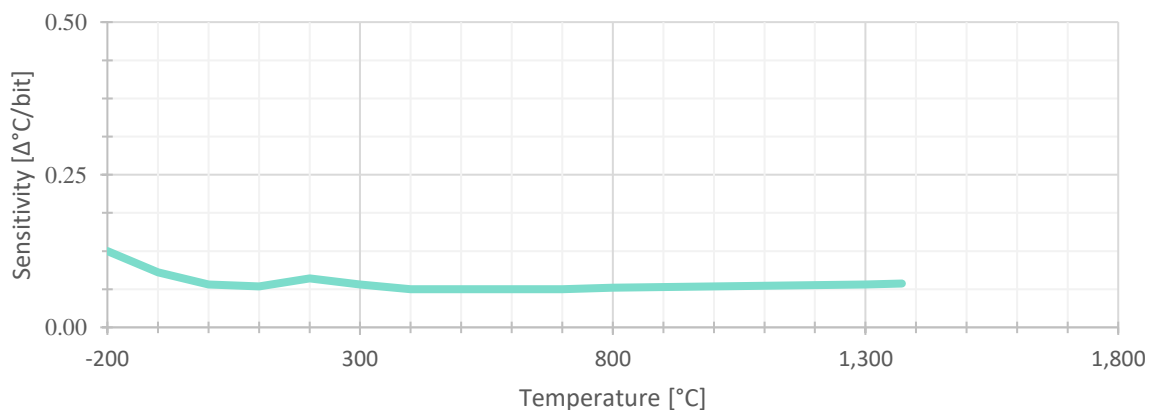
TC4-C

Pinout

TC4-C Output – Deutsch AS		TC4-C Output – Deutsch DT	
Connector	DEUTSCH AS610-98PN	Connector	DEUTSCH DTM04-6P
Mating	DEUTSCH AS110-98SN	Mating	DEUTSCH DTM06-6S
Pin	**Signal (TC4-C)**	**Pin**	**Signal (TC4-C)**
A	+VBATT (+12V)	1	+VBATT (+12V)
B	GND	2	GND
C	CAN-L	3	CAN-L
D	RS-232 Tx	4	CAN-H
E	CAN-H	5	RS-232 Tx
F	RS232 Rx	6	RS232 Rx

TC4-C Output – Deutsch ASL**		TC4-C Output – Deutsch ASC	
Connector	DEUTSCH ASL006-05PB	Connector	DEUTSCH ASC105-06PN
Mating	DEUTSCH ASL606-05SB	Mating	DEUTSCH ASC605-06SN
Pin	**Signal (TC4-C)**	**Pin**	**Signal (TC4-C)**
1	+VBATT (+12V)	1	+VBATT (+12V)
2	CAN-H	2	CAN-L
3	N/C	3	RS-232 Tx
4	CAN-L	4	RS232 Rx
5	GND	5	CAN-H
-	N/C	6	GND

TC4-C Output – Flying lead			
Connector	Flying leads		
Mating	Flying leads		
Pin	**Signal (TC4-C)**	**AWG**	
Rd	+VBATT (+12V)	22	
Bl	GND	22	
Bk	CAN-L	22	
Wt	CAN-H	22	
Wt	RS-232 Tx	22	
Bk	RS232 Rx	22	

* Other variants on request
** RS-232 Setup Menu not available

Drawing
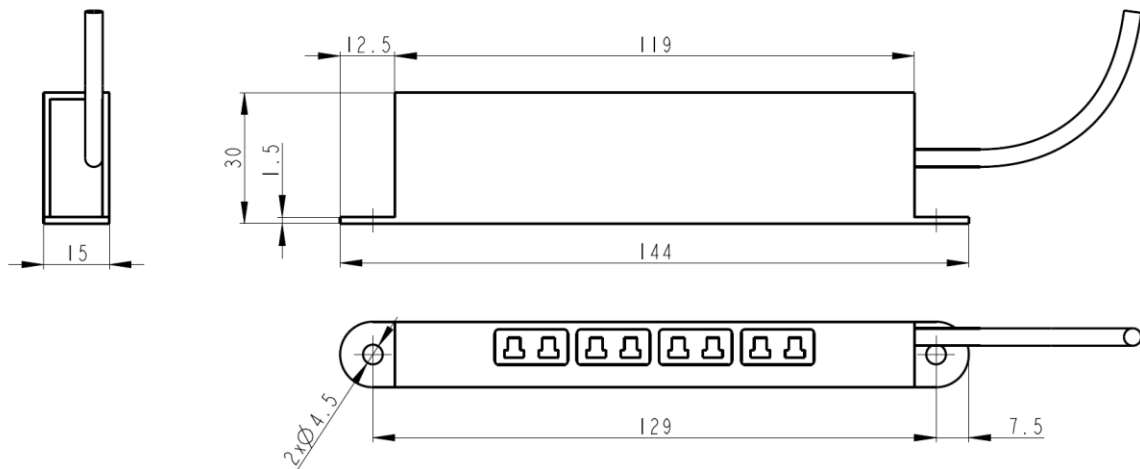
Ordering information

TC4-C Quad Channel Thermocouple Conditioner

TC4-C-XX

TC4-C -> Thermocouple Type	**TC4-C -> Connector**
K – K Type	A – DEUTSCH AS610-98PN
J – J Type	**D – DEUTSCH DTM04-6P**
T – T Type	G – DEUTSCH ASL006-05PB
N – N Type	C – DEUTSCH ASC105-06PN
S – S Type	F – Flying leads
E – E Type	
B – B Type	
R – R Type	
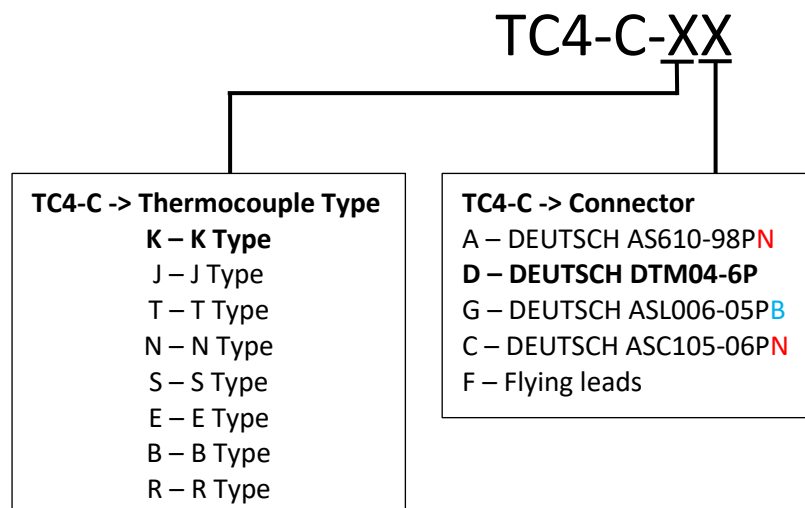
NOTE: Custom variants available on request

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CAN Communication

All CAN Identifiers and parameters can be changed to customer requirements using Setup Menu via RS-232. The CAN description below is defined using a bit index from start of the data field in the message. All "multi-byte" channels are in **BIG-ENDIAN** (**Motorola**) format.
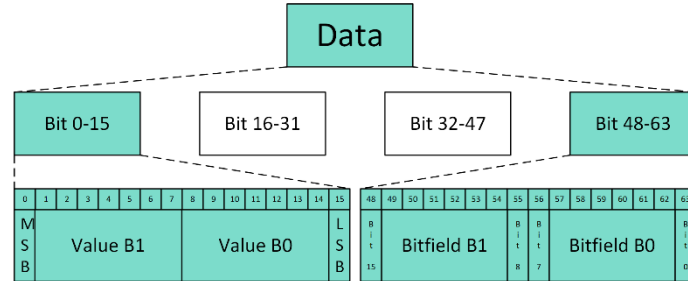
Transmit

Packet	TC4C_Tx1_Status				
ID	0x555				
Direction	TC4-C Tx				
Rate	5Hz				
Bits	**Name**	**Data Type**	**Gain**	**Offset**	**Notes**
0-15	TC4_VBatt	U16	0.1	0	[V]
16-23	TC4_CPUTemp	U8	1	0	[°C]
24-27	TC4_SWMajorVersion	U8	1	0	[-]
28-31	TC4_SWMinorVersion	U8	1	0	[-]
32-39	TC4_SerialNumber	U8	1	0	[-]
40-42	TC4_Filter	U8			Enum
43-45	TC4_TCType	U8			Enum
46-47	TC4_HotResolution	U8			Enum
48-51	TC4_InitFail	U8			Enum
52-55	TC4_Timeout	U8			Enum
56-59	TC4_SCFail	U8			Enum
60-63	TC4_OCFail	U8			Enum

Filter

Code (dec)	Description
0	OFF
1	1_MIN
2	2
3	3
4	4_MID
5	5
6	6
7	7_MAX

TCType

Code (dec)	Description
0	K
1	J
2	T
3	N
4	S
5	E
6	B
7	R

HotResolution

Code (dec)	Description
0	0.0625°C
1	0.125°C
2	0.25°C
3	0.5°C

InitFail, Timeout, SCFail, OC, Fail

Code (dec)	Description
0	FAILED TC1
1	FAILED TC2
2	FAILED TC3
3	FAILED TC4

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Packet	TC4C_Tx2_HotJunc				
ID	0x560				
Direction	TC4-C Tx				
Rate	50Hz				
Bits	**Name**	**Data Type**	**Gain**	**Offset**	**Notes**
0-15	TC4_Hot1	U16	0.0625	-100	[°C]
16-31	TC4_Hot2	U16	0.0625	-100	[°C]
32-47	TC4_Hot3	U16	0.0625	-100	[°C]
48-63	TC4_Hot4	U16	0.0625	-100	[°C]

Packet	TC4C_Tx3_DeltaJuncs				
ID	0x565				
Direction	TC4-C Tx				
Rate	50Hz				
Bits	**Name**	**Data Type**	**Gain**	**Offset**	**Notes**
0-15	TC4_Delta1	U16	0.0625	-100	[°C]
16-31	TC4_Delta2	U16	0.0625	-100	[°C]
32-47	TC4_Delta3	U16	0.0625	-100	[°C]
48-63	TC4_Delta4	U16	0.0625	-100	[°C]

Packet	TC4C_Tx4_ColdJunc				
ID	0x570				
Direction	TC4-C Tx				
Rate	50Hz				
Bits	**Name**	**Data Type**	**Gain**	**Offset**	**Notes**
0-15	TC4_Cold1	U16	0.0625	-100	[°C]
16-31	TC4_Cold2	U16	0.0625	-100	[°C]
32-47	TC4_Cold3	U16	0.0625	-100	[°C]
48-63	TC4_Cold4	U16	0.0625	-100	[°C]

Packet	TC4C_Tx4_ADCVolts				
ID	0x575				
Direction	TC4-C Tx				
Rate	50Hz				
Bits	**Name**	**Data Type**	**Gain**	**Offset**	**Notes**
0-15	TC4_Volts1	U16	0.0625	-32	[mV]
16-31	TC4_Volts2	U16	0.0625	-32	[mV]
32-47	TC4_Volts3	U16	0.0625	-32	[mV]
48-63	TC4_Volts4	U16	0.0625	-32	[mV]

RS232 Setup Menu

RS232 Device Setup Menu can be accessed using the RS232 connection available. The connection to a computer is utilized via Serial port (e.g. USB to Serial interface). PC Terminal software such as HyperTerminal or PuTTy (http://www.extraputty.com/) is used to communicate with the device CPU.

After device is powered up the main screen looks as follows:

```
=================================================================
=                        ||   ||                               =
=                   ||   ||   ||   ||                           =
=                   ||   ||   ||   ||                           =
=                   ||   ||   ||   ||                           =
=                   ||   ||   ||   ||                           =
=                        ||   ||                               =
=================================================================
=                   ||              ||                         =
=                   ||  |Per|Sys|Tec|   ||                      =
=                   ||       s.r.o       ||                     =
=                   ||              ||                          =
=================================================================
=                  >> support@persystec.cz <<                  =
=================================================================
=                       TC4-C   v0.0a                          =
=================================================================


   Running...
```

- Pressing <Esc> key will Halt the Application and display the Setup Menu:

```
   <Esc> Pressed.

   ===================================== TC4-C   v0.0a ====
   ================= Setup Menu ===========================
   ========================================================

      CAN Communication ----------------------------------- C

      Hardware Information -------------------------------- H

      Thermocouple Configuration ------------------------- T

      Reset to Factory Defaults -------------------------- R

      Save Settings to NVRAM ----------------------------- U

      Watch Live ----------------------------------------- W

      Exit Menu and return to Run Mode ------------------- X

      Go to Sleep and wait for reset --------------------- Z

      Reload this menu ----------------------------------- ?


   ========================================================

          Selection: █
```

- To reconfigure the CAN Communication settings press <C>:

The available options are displayed in brackets (On or Off) and the current settings in square brackets [Off]. The user can change the setting by typing the desired command and acknowledging by <Enter>.

```
        Selection:  c

CAN Communication
   CAN Baud rate (1000, 500, 250, 125, 100 kbps) [ 1000 ] :
   CAN Extended (On or Off) [ Off ] :
   CAN Termination (On or Off) [ On ] :
   CAN Tx Status    ID [ 0x0555 ] :
   CAN Tx HotJunc   ID [ 0x0560 ] :
   CAN Tx DeltaJunc ID [ 0x0565 ] :
   CAN Tx ColdJunc  ID [ 0x0570 ] :
   CAN Tx ADCVolts  ID [ 0x0575 ] :
   CAN Tx Status    Rate (T, 0, 1, 2, 5, 10, 20, 50, 100 Hz) [ 5 ] :
   CAN Tx HotJunc   Rate (T, 0, 1, 2, 5, 10, 20, 50, 100 Hz) [ 50 ] :
   CAN Tx DeltaJunc Rate (T, 0, 1, 2, 5, 10, 20, 50, 100 Hz) [ 50 ] :
   CAN Tx ColdJunc  Rate (T, 0, 1, 2, 5, 10, 20, 50, 100 Hz) [ 50 ] :
   CAN Tx ADCVolts  Rate (T, 0, 1, 2, 5, 10, 20, 50, 100 Hz) [ 50 ] :
```

NOTE:
T – transmission rate for triggered messages. When the internal temperature conversion is finished.

- Thermocouple Sensor Settings can be accessed by pressing <T>:

```
        Selection:  t

Thermocouple Configuration
   TC Type (K, J, T, N, S, E, B, R) [ K ] :
   TC Filter (0->OFF, 1->MIN, 2, 3, 4->MID, 5, 6, 7->MAX) [ 0 ] :
   TC Resolution Hot (0->0.0625, 1->0.125, 2->0.25, 3->0.5 °C) [ 0.125°C ] :
   TC Resolution Cold (0->0.0625, 1->0.25 °C) [ 0.0625°C ] :
   TC Timeout (100 – 50 000 ms) [ 1000 ] :
```

- Hardware Information can be displayed by pressing <H>:

```
        Selection:  h

Hardware Information
   PCB Part Number [ TC4-C ] :
   PCB Serial Number [ 3 ] :
   PCB Issue [ 0 ] :
   PCB Mod State [ 0 ] :
```

- Live values can be watched by pressing <W>:

```
                Selection:   w




   CAN Mess Try:         27        T_CPU:              39.1 °C
   CAN Mess Fail:         0        V_Bat:              12.4 V
   Status1:            0x00        Status2:         0x00
   Status3:            0x4F        Status4:         0x00
   T_Hot1:           -100.6 °C     T_Hot2:            -100.6 °C
   T_Hot3:             23.0 °C     T_Hot4:            -100.6 °C
   T_Delta1:         -100.6 °C     T_Delta2:          -100.6 °C
   T_Delta3:            0.1 °C     T_Delta4:          -100.6 °C
   T_Cold1:          -100.6 °C     T_Cold2:           -100.6 °C
   T_Cold3:            23.5 °C     T_Cold4:           -100.6 °C
   V_Delta1:       -32000.6 µV     V_Delta2:        -32000.6 µV
   V_Delta3:          -24.6 µV     V_Delta4:        -32000.6 µV
```

- When finished the chosen settings can be saved to Non-volatile memory to be kept even after the power is removed from the device by pressing <U>:

```
                Selection:   u

   Some settings have been changed.
   Update System NVRAM? (Y or N) :   Y

   Settings saved to NVRAM.
```

NOTE: This menu is also displayed after completion of each sub-section if a setting was changed.

- Factory Defaults will be Reset after pressing <R> and confirmed by <Y>:

```
                Selection:   r

   Factory Defaults Restored.

   Some settings have been changed.
   Update System NVRAM? (Y or N) :   Y

   Settings saved to NVRAM.
```

- To Exit this Menu press <X>:

```
                Selection:   x

   Running...
     + To go to Setup Mode again
           > Hit <Esc> key
     + To Re-Load the Application
           > Power cycle with <Control-R> Pressed
```

RS232 Software Reflash

The internal software application can be updated using embedded RS232 Bootloader. PC connected via Terminal application as per the Setup Menu above can be used to access the Booloader Menu and sending the binary file.

- Hold <Ctrl> + <R> whilst the device is being powered up and Bootloader Menu will appear:

```
=========================================================================
=                              ||  ||                                   =
=                              ||  ||  ||  ||                           =
=                              ||  ||  ||  ||                           =
=                              ||  ||  ||  ||                           =
=                              ||  ||  ||  ||                           =
=                              ||  ||                                   =
=========================================================================
=                        ||                 ||                         =
=                        ||  |Per|Sys|Tec|  ||                         =
=                        ||       s.r.o     ||                         =
=                        ||                 ||                         =
=========================================================================
=              (C) COPYRIGHT 2015 STMicroelectronics                   =
=                                                                      =
=  STM32F1xx In-Application Programming Application  (Version 1.0.0) =
=                                                                      =
=                             By MCD Application Team                  =
=========================================================================

-* Reprogram requested *-

================= Main Menu ============================

  Download image to the internal Flash ---------------- 1

  Execute the loaded application --------------------- 3

  Disable the write protection ----------------------- 4


========================================================
```

- First, disable the Flash Write Protection by selecting <4>:
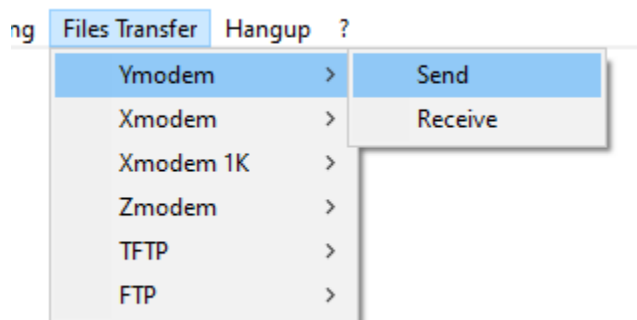
```
  Write Protection disabled...

  System will now restart...
     + To Re-Enter this Menu
          > Power cycle with <Control-R> Pressed
```

- The device is reset and the Bootloader Menu must be entered again as per above.
- In the Bootloader Menu select <1> to send the Application Binary file.

- In the Terminal SW use Ymodem to transfer the file:

- After the file is transferred the Flash is set to Protected Mode again and the device automatically reboots and starts the Application.

```
Waiting for the file to be sent ... (press 'a' to abort)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCted Successfully!
-------------------------------
 Name: TC4.bin
 Size: 59668 Bytes
-------------------
Write Protection enabled...

System now Restarts and Runs the Application...
    + To Re-Enter this Menu
           > Power cycle with <Control-R> Pressed
```