MANUAL

TCR180PEX-EL

Time Code Receiver

12th August 2020

Meinberg Funkuhren GmbH & Co. KG

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1 Imprint

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2 Safety instructions for building-in equipment

2.1 Used Symbols

Nr.	Symbol	Beschreibung / *Description*
1	===	IEC 60417-5031 Gleichstrom / *Direct current*
2	∿	IEC 60417-5032 Wechselstrom / *Alternating current*
3	⏚	IEC 60417-5017 Erdungsanschluss / *Earth (ground) Terminal*
4	⏚	IEC 60417-5019 Schutzleiterklemme / *Protective Conductor Terminal*
5	⚡	Vorsicht, Risiko eines elektrischen Schlages / *Caution, possibility of electric shock*
6	⚠	ISO 7000-0434 Vorsicht, Risiko einer Gefahr / *Caution, Danger*
7	🗑	2012/19/EU Dieses Produkt fällt unter die B2B Kategorie. Zur Entsorgung muss es an den Hersteller übergeben werden. *This product is handled as a B2B category product. In order to secure a WEEE compliant waste disposal it has to be returned to the manufacturer.*

CE label
This device follows the provisions
of the directives 93/68/EEC

$C\epsilon$

2.2 Safety Hints TCR180PEX-EL

This building-in equipment has been designed and tested in accordance with the requirements of Standard IEC60950-1 "Safety of Information Technology Equipment, including Electrical Business Equipment".

During installation of the building-in equipment in an end application (i.e. PC) additional requirements in accordance with Standard IEC60950-1 have to be taken into account.

General Safety instructions

- The building-in equipment has been evaluated for use in office environment (pollution degree 2) and may be only used in this environment. For use in rooms with a higher pollution degree more stringent requirements are applicable.
- The equipment/building-in equipment was evaluated for use in a maximum ambient temperature of 50°C.
- Protection against fire must be assured in the end application.

2.3 Additional Safety Hints

This manual contains important information for the installation and operation of this device as well as for your safety. Make sure to read carefully before installing and commissioning the device.

Certain operating conditions may require the observance of additional safety regulations not covered by this manual. Nonobservance of this manual will lead to a significant abatement of the security provided by this device. Security of the facility where this product is integrated lies in the responsibility of the installer.

The device must be used only for purpose named in this manual, any other use especially opteration above the limits specified in this document is considered as improper use.

Keep all documents provided with the device for later reference.

This manual is exclusively for qualified electricians or by a qualified electrician trained personnel who are familiar with the applicable national standards and specifications, in particular for the construction of high voltage devices.

2.4 Cabling

WARNING!
DANGER TO LIFE BY ELECTRICAL SHOCK! NO LIVE WORKING!
Wiring or any other work done the connectors particularly when connectors are opened may never be carried out when the installation is energized. All connectors must be covered to prevent from accidental contact to life parts.

ALWAYS ENSURE A PROPER INSTALLATION!

2.5 Replacing the Lithium Battery

Skilled/Service-Personnel only: Replacing the Lithium Battery
The life time of the lithium battery on the receiver boards is at least 10 years. If the need arises to replace the battery, the following should be noted:

There is a Danger of explosion if the lithium battery is replaced incorrectly. Only identical batteries or batteries recommended by the manufacturer must be used for replacement.

The waste battery has to be disposed as proposed by the manufacturer of the battery.

3 TCR180PEX-EL Features

The board TCR180PEX-EL has been designed as a "low profile" board for computers with PCI Express interface. Data transfer to the computer is done via a single PCI Express lane (x1 board). The TCR180PEX-EL card decodes modulated (AM) and unmodulated (DC Level Shift, DCLS) IRIG–A/B/G, AFNOR NF S87–500, IEEE C37.118, or IEEE 1344 time codes. AM codes are transmitted by modulating the amplitude of a sine wave carrier, unmodulated codes by variation of the width of pulses.

The TCR180PEX-EL is equipped with a TCXO oscillator which is disciplined as log as an input signal is available, and provides accurate time in holdover mode if the input signal is disconnected.

Receiver:
Automatic gain control within the receive circuit for unmodulated codes allows decoding of IRIG–A/B/G, AFNOR NF S87–500, IEEE C37.118 or IEEE 1344 signals with a carrier amplitude of 600 mVpp to 8 Vpp. The input stage is electrically insulated and has an impedance of either 50 Ω, 600 Ω or 5 kΩ, selectable by a jumper. Modulated input signals can be supplied via BNC connector in the TCR180PEX-EL's bracket.

Unmodulated (DC Level Shift, DCLS) time codes have to supplied via the card's 9 pin D-Sub connector. The receive circuit is insulated by an onboard photocoupler which can be driven by TTL or RS-422 signals for example. When the card is shipped the contacts of the D-Sub connector are not wired to the photocoupler. Two DIP switches have to be set to the 'ON' position to make the inputs available via the connector.

Optionally the TCR180PEX-EL can be delivered with an optical input. The card provides two configurable serial interfaces (RS–232) COM. COM0 is available via the Sub–D connector, COM1 is accessible via an extra ribbon cable connector on the board.

The extra ribbon cable connector on the board also provides two TTL inputs (CAP0 and CAP1) that can be used to time stamp external, asynchronous trigger slopes. The captured time stamps can be retrieved via the PCI-bus, or can be emitted as ASCII string via one of the serial interfaces.

4 Block diagram TCR180PEX-EL

The block diagram shows the following connections and components:

External signals (top): RS232 COM 0 / COM 1, fix pulses, time capture CAP0/CAP1

- SRAM data memory — connected via addr/data to microcontroller with RTC and Flash EPROM
- microcontroller with RTC and Flash EPROM — connected via dual Tx/Rx to RS232 drivers, and via addr/data/control to FPGA
- RS232 drivers — connect to RS232 COM 0 / COM 1
- fiber optic receiver (option) — unmodulated timecode optical input (option) — to FPGA
- programmable logic (inside FPGA)
- PCI Express interface (inside FPGA) — Tx, Rx, Refclk; PCI Express bus
- D/A-converter and driver — data to FPGA; control voltage and clock to master oscillator
- master oscillator — 10MHz, TTL output
- AGC-circuit and pulse shaper — modulated timecode input
- photocoupler — unmodulated timecode input
- internal power — power from PCI Express bus

5 Master oscillator

By default the TCR180PEX-EL is equipped with a TCXO (Temperature Compensated Xtal Oscillator) as master oscillator to provide a good time accuracy and frequency stability. As long as an input signal is supplied the frequency of the oscillator is adjusted from the input signal, and if the input signal is disconnected afterwards the card can still provide accurate time for a certain holdover interval.

All internal timing as well as the output signals are derived from the oscillator. The last known good oscillator adjustment value is stored in non-volatile memory, and is used as default after power-up. The oscillator's 10 MHz output frequency is also available with TTL level via at a ribbon cable connector.
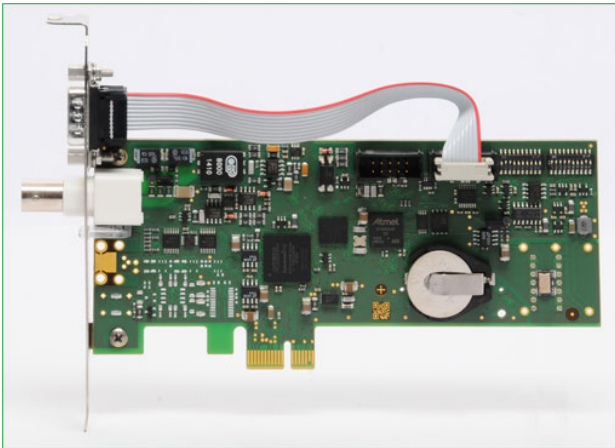

Figure: TCR180PEX-EL with TCXO oscillator

6 Functional description of receiver

After the received time code has passed a consistency check, the TCR180PEX-EL's on-board software clock and battery buffered real time clock are synchronized according to the external time reference. If an error or inconsistency is detected in subsequent time code frames, or the input signal is disconnected, the on-board clock switches to holdover mode, where the time is derived from the on-board high quality oscillator which has been disciplined before.

All IRIG and similar time codes provide the time-of-day, and a day-of-year number (1...365/366). When converting the day-of-year number from the incoming time code to a calendar date then the result is ambiguous unless the year number is not known: the day after February 28 can be March 1, but can also be February 29 in case the year is a leap year.

Unfortunately, most of the commonly used IRIG code formats don't include a year number, in which case the year number used for the computation of the calendar date is retrieved from the battery buffered on-board real time clock.

So care must be taken that the on-board clock has been set to the correct date. The on-board date and time can be adjusted by sending a Meinberg Standard Time string to the serial interface COM0, or via the PCI bus by using the utility programs included in the driver software package.

If the configured time code format does provide a year number (e.g. IEEE 1344, IEEE C37.118, IRIG-Bxx6/Bxx7) then the year number from the time code is used instead of the year number from the on-board real time clock, and the on-board date is set accordingly.

Most of the commonly used IRIG code formats also don't provide an indicator whether the transported time is UTC, or local time with some offset from UTC. However, the TCR180PEX-EL always needs to derive UTC time from the incoming time code since the card's on-board time is expected to run on UTC.

If no UTC offset is provided by the time code then a UTC offset parameter on the card first needs to be configured, depending on the time provided by the input signal. When the TCR180PEX-EL is shipped then the UTC parameter is set to "unconfigured", and as long as this is the case the card doesn't synchronize to the input signal. So the UTC offset has to be configured first when the card is put into operation. The tools that come with the driver software package given an appropriate hint if this is the case.

Only if the used time code format provides the UTC offset (e.g. IEEE 1344, IEEE C37.118) the card uses the UTC offset from the time code, and thus even synchronizes to the input signal if the card's UTC parameter is still set to "unconfigured".

Care must be taken, however, if one of the IEEE 1344 or IEEE C37.118 codes is used: The main difference between these formats is the way the UTC offset is to be applied: subtracted or added. Unfortunately there are 3rd party IRIG devices out there which claim to use a IEEE 1344 code, but in fact handle the UTC offset as specified in IEEE C37.118. This may result in a wrong UTC time derived from the time code if local time is transported. A simple fix is usually to switch the card from one of the IEEE codes to the other one.

The TCR180PEX-EL can automatically convert its on-board UTC time to some local time, including automatic switching to and from DST year by year according to configurable rules. This is independent from the

UTC offset of the incoming time code. The derived local time can be transmitted via the outgoing time code, the serial time strings, or can be read via the PCI interface.

The time zone is entered as offset of seconds from UTC, e.g. for Germany:
MEZ = UTC + 3600 sec, MESZ = UTC + 7200 sec

The specific date of beginning and end of daylight saving can be generated automatically for several years. The receiver calculates the switching times using a simple scheme, e.g. for Germany:

Beginning of daylight saving is the first sunday after March, 25th at two o'clock => MESZ
End of daylight saving is the first sunday after October, 25th at three o'clock => MEZ

The parameters for time zone and switching to/from daylight saving can be set by using the included monitor program. If the same values for beginning and end of daylight saving are entered then no switching to DST is made.

The associated settings can be changed using the configuration software shipped with the driver packages.

Most IRIG codes don't include an announcement flag for the DST change, or for the for the insertion of a leap second, so the TCR180PEX-EL will switch into free wheeling mode on such event, and resynchronize a few seconds later.

The board TCR180PEX-EL decodes the following formats:
Please note: all "**A**" und "**G**" **Timecodes** are only available **after** warmed up phase of the oscillator!

A002:	1000pps, DC Level Shift pulse width coded, no carrier BCD time of year
A132:	1000pps, amplitude modulated sine wave signal, 10 kHz carrier frequency BCD time of year
A003:	1000pps, DC Level Shift pulse width coded, no carrier BCD time of year, SBS time of day
A133:	1000pps, amplitude modulated sine wave signal, 10 kHz carrier frequency BCD time of year, SBS time of day
B002:	100pps, DC Level Shift pulse width coded, no carrier BCD time of year
B122:	100pps, amplitude modulated sine wave signal, 1 kHz carrier frequency BCD time of year
B003:	100pps,DC Level Shift pulse width coded, no carrier BCD time of year, SBS time of day
B123:	100pps, amplitude modulated sine wave signal, 1 kHz carrier frequency BCD time of year, SBS time of day
B006:	100 pps, DC Level Shift, no carrier BCD time-of-year, Year
B126:	100 pps, AM sine wave signal, 1 kHz carrier frequency BCD time-of-year, Year
B007:	100 pps, DC Level Shift, no carrier BCD time-of-year, Year, SBS time-of-day
B127:	100 pps, AM sine wave signal, 1 kHz carrier frequency BCD time-of-year, Year, SBS time-of-day
G002:	10 k pps, DC Level Shift, no carrier BCD time-of-year
G142:	10 k pps, AM sine wave signal, 100 kHz carrier frequency BCD time-of-year
G006:	10 k pps, DC Level Shift, no carrier BCD time-of-year, Year
G146:	10 k pps, AM sine wave signal, 100 kHz carrier frequency BCD time-of-year, Year

AFNOR: Code according to NF S–87500, 100 pps, wave signal,
                    1kHz carrier frequency, BCD time–of–year, complete date,
                    SBS time–of–day, Signal level according to NF S–87500

IEEE 1344:   Code according to IEEE 1344-1995, 100 pps, AM sine wave signal,
                    1kHz carrier frequency, BCD time–of–year, SBS time–of–day,
                    IEEE 1344 extensions for date, timezone, daylight saving and
                    leap second in control functions (CF) segment.
                    (also see table 'Assignment of CF segment in IEEE 1344 mode')

IEEE C37.118:   Like IEEE 1344 – with UTC offset to be applied reversely

6.1 Input signals

The time code format has to be configured using the monitor software: if an amplitude–modulated signal (IRIG–A/B/G, AFNOR NF S–87500, IEEE C37.118 oder IEEE 1344) is configured then the input signal has to be supplied to the upper BNC connector in the TCR180PEX-EL's bracket. A coaxial, shielded or twistet pair cable should be used.

A pulse width modulated (DC Level Shift, DCLS) signal has to be supplied via the 9-pin D–SUB connector. Two DIP switches have to be set to the "ON" position to wire the contacts of the D–Sub connector to the onboard photocoupler, and an appropriate DCLS time code format has to be configured using the monitor program.

Optionally an optical input can be equipped instead of the modulated input. It is available as ST-connector for GI 50/125 μm or GI 62,5/125 μm gradient fiber.

The board TCR180PEX-EL can't be used to decode amplitude modulated and DC Level Shift signals simultaneously. Depending on the selected code format, only the signal at the BNC-connector or the D–Sub connector is decoded.

6.2 Input impedance for modulated signals

Except the AFNOR NF S87-500 standard there are no time code specifications for modulated signals which define the output impedance of a generator, or the input impedance of a receiver, so care must be taken that the specifications of this card meet the requirements of 3rd party devices.

The TCR180PEX-EL provides a jumper to set the input impedance for modulated codes to 50 Ω, 600 Ω, or 5 kΩ.

Time code outputs provided by Meinberg devices provide a 50 Ω output impedance to match the transmission requirements with coaxial cable, so the receiver should be set to 50 Ω input impedance if only a single receiver is connected to a generator.

If T-connectors are used to provide several receivers with a single output signal from a generator then the resulting load impedance for the generator may be too low if all receivers have a low input impedance, so it's more appropriate to set the input impedance of all receivers to 600 Ω. This also meets the requirement of the AFNOR standard, so this is the default setting when the TCR180PEX-EL is shipped.

Only if the external time code generator has a high output impedance (see specifications of the external time code generator) it may be required to set the input impedance to 5 kΩ.

The driver software shows a bar chart for evaluation of the signal level at the receiver input. The following detail of the TCR180PEX-EL's placeplan of shows the possible jumper settings and the associated input impedance:
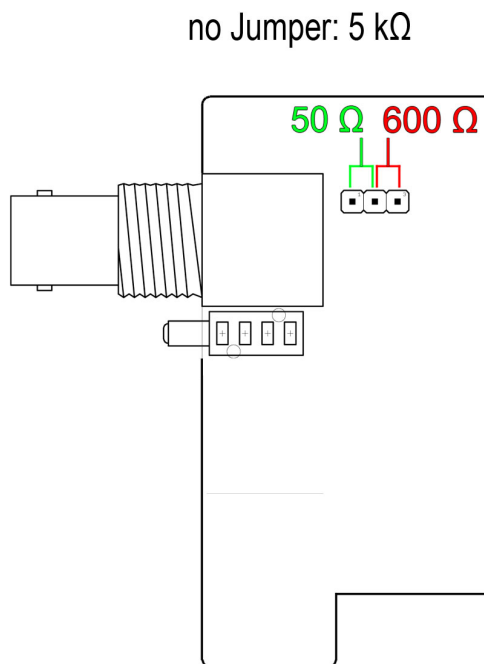
6.3 Photocoupler input

Pulse width modulated (DC Level Shift) codes are insulated by an onboard photocoupler. The connection scheme is shown below:
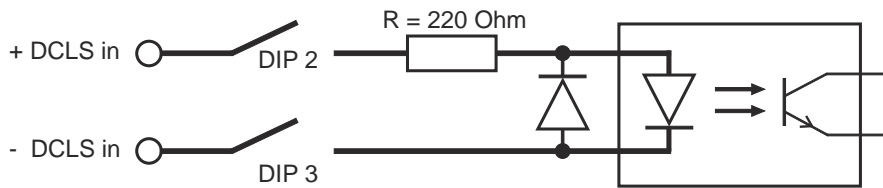
MultiRef-Port: Pin Assignment of the D-SUB 9 connecor
(see chapter D-SUB Pin Assignment of MultiRef Port)

The internal series resistance allows direct connection of input signals with a maximum high level of +12 V (TTL or RS-422 for example). If signals with a higher amplitude are used, an additional external series resistance has to be applied to not exceed the limit of the forward current of the input diode (60 mA). The forward current should not be limited to a value of less than 10 mA to ensure safe switching of the photocoupler.

6.4 Pulse outputs

PO0:   Pulse each second (PPS), active HIGH, pulse duration 200 msec
PO1:   Pulse each minute (PPM), active HIGH, pulse duration 200 msec

6.5 Asynchronous serial port

Two asynchronous serial interfaces (RS-232) labelled COM0 and COM1 are provided by the TCR180PEX-EL. Only COM0 is available at the rear panel slot cover, COM1 is accessible via the second ribbon cable connector on the card. The monitor program can be used to configure the outputs. In the default mode of operation, the serial outputs are disabled until the receiver has synchronized after power-up. However, they can be configured to be enabled immediately after power-up.

Transmission speed, framing and mode of operation can be configured individually for each port. Both of the ports can be configured to transmit either time strings (once per second, once per minute, or on request with ASCII "?" only), or to transmit capture strings (automatically when available, or on request). The format of the output strings is ASCII, see the technical specifications at the end of this document for details.

Please note: If a serial interface sends capture events automatically, they can't be read via PCI-bus, because they are deleted from the buffer memory after transmission.

6.6 Enabling of outputs

By default the pulse outputs and the the serial outputs are disabled after power up until the receiver is synchronized. However, the monitor software can be used to configure each group of outputs so that they are always enabled immediately after power–up.

6.7 Time capture inputs

The TCR180PEX–EL provides two time capture inputs called User Capture 0 and 1 (CAP0 and CAP1) which can be mapped to pins at the 9 pin connector in the rear panel. These inputs can be used to time stamp trigger slopes of asynchronous external hardware signals. A falling TTL slope at one of these inputs lets the card save the current on–board time in its on–board FIFO buffer which can hold up to more than 500 entries.

Capture events can be retrieved from the FIFO buffer either as ASCII string sent automatically or on request via one of the card's serial ports, or via the PCI bus using an API call, which is much faster than serial output and thus allows for higher continuous capture rates.

The format of the output string is described in the technical specifications at the end of this document. If the capture buffer is full a message "** capture buffer full" is transmitted, if the interval between two captures is too short the warning "** capture overrun" is being sent via the serial port.

7 Connectors and LEDs in the bracket
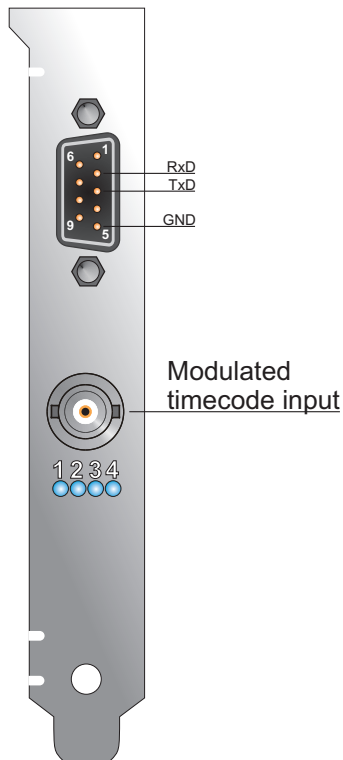
The bracket of the board includes the BNC connector for the amplitude modulated time codes, four LEDs and a 9 pin D–Sub–plug.

Pressing the hidden key BSL is required for activating the Bootstrap–Loader before updating the firmware.

The 9 pin D–Sub–connector is wired to the board's serial port. Pin assignment can be seen from the figure below. This port can not be used as serial port for the computer. Instead, the clock uses the port to send out Meinberg's standard time string in order to control an external display or some other external device. The string is sent out once per second, once per minute or if requested by an incoming ASCII "?".

It is also possible to change the board time by sending such a string towards the clock. Transmission speed, framing and mode of operation can be modified using the monitor software. The string format is described in the section 'Technical Specifications' at the end of this manual.

RxD
TxD
GND

Modulated
timecode input

1 2 3 4

LED Indicators

1.	blue:	During the TCR180PEX–EL initialization phase
	off:	Oscillator not warmed up
	green:	Oscillator warmed up
2.	green:	Correct time code detected
	red:	No correct time code detected
	yellow:	TCR180PEX–EL synchronized by Multi.Ref. source
	yellow/green (flashing):	Holdover mode (Multi.Ref.), Time Code available
	yellow/red (flashing):	Holdover mode (Multi.Ref.), Time Code not available
3.	green:	Telegramm consistent
	red:	Telegramm inconsistent
	yellow (flashing):	Jitter to large
4.	red:	The internal timing of TCR180PEX–EL is in holdover mode
	off:	The internal timing of TCR180PEX–EL is synchronized to the received time code (Lock)

7.1 Pin assignments of the D-Sub-connector

By default only the signals needed for the serial port COM0 are mapped to the pins of the connector. Whenever one of the additional signals is to be used the signal must be wired to a pin by putting the appropriate lever of a DIP switch to the ON position.
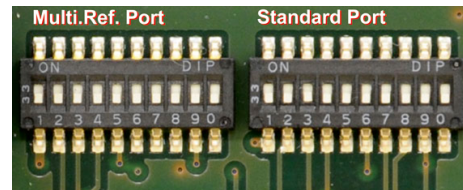
The table below shows the pin assignment of the connector and the assignment of the individual switches in the "Standard Port" block. Please note that
Pin 1 and Pin 4 of the connector can be assigned to two different signals. Only one switch at a time may then be set to the ON position:

Standard Port

9pin D-SUB	Signal	Signal Level	DIP-Switch ON	
1	VCC out	+5 V	**1**	*DIP 8 must be OFF*
1	PO_0 (PPS) out	RS232	**8**	*DIP 1 must be OFF*
2	RxD 0 in	RS232	-	
3	TxD 0 out	RS232	-	
4	PO_1 (PPM) out	TTL	**5**	*DIP 10 must be OFF*
4	10 MHz out	TTL	**10**	*DIP 5 must be OFF*
5	GND	-	-	
6	CAP 0 in	TTL	**2**	
7	CAP 1 in	TTL	**3**	*DIP 7 must be OFF*
8	PO_0 (PPS) out	TTL	**4**	
9	not used	-	-	*only PEX-EL version*
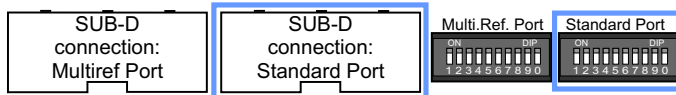
7.2 D-SUB Pin Assignment of MultiRef Port
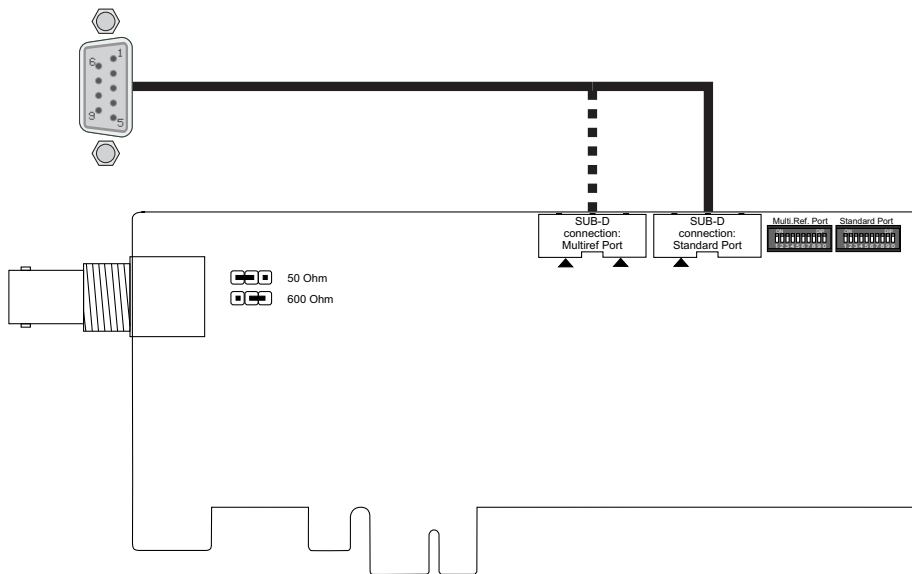
Connection of ribbon cable

To lead the "Multiref" signals through the SUB-D connector, the ribbon cable must be plugged to the appropriate boxed header:

The table below shows the pin assignment of the connector and the assignment of the individual switches in the "Multiref Port" block. Please note that **pin 4** of the connector can be assigned with two different signals. Only one switch at a time should be set to the ON position:

Multi.Ref. Port

9pin D-SUB	Signal	Signal Level	DIP-Switch ON	
1	VCC out	+5 V	**1**	*DIP 7 must be OFF*
2	RxD 1 in	RS232	-	
3	TxD 1 out	RS232	-	
4	PO_1 (PPM) out	TTL	**5**	*DIP 10 must be OFF*
4	10 MHz out	TTL	**10**	*DIP 5 must be OFF*
5	GND	-	-	
6	+ DCLS in	photocoupler	**2**	
7	- DCLS in	photocoupler	**3**	
8	PO_0 (PPS) out	TTL	**4**	
9	not used	-	-	*only PEX-EL version*
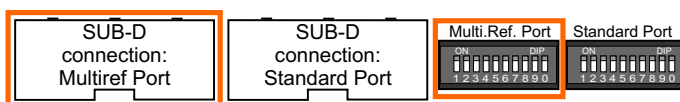
8 Putting into operation

To achieve correct operation of the board, the following points must be observed.

8.1 Installing the TCR180PEX-EL in your computer

Every PCI Express board is a plug & play board. After power-up, the computer's BIOS assigns resources like I/O ports and interrupt numbers to the board, the user does not need to take care of the assignments. The programs shipped with the board retrieve the settings from the BIOS.

The computer has to be turned off and its case must be opened. The radio clock can be installed in any PCI Express slot not used yet. The rear plane must be removed before the board can be plugged in carefully. The computer's case should be closed again and the time code signal can be connected to the coaxial plug at the clock's rear slot cover. After the computer has been restarted, the monitor software can be run in order to check the clock's configuration. The computer's case should be closed again and the time code signal must be connected to the appropriate connector.

After the board has been mounted and connected, the system is ready to operate. About 10 seconds after power-up the receiver's TCXO operates with the required accuracy.

8.2 Power supply

All power supplies needed by TCR180PEX-EL are delivered by the PCI-(Express) bus.

8.3 Configuration of TCR180PEX-EL

The selection of the time code, configuration of the serial interface and a possible offset of the received time to UTC must be set up by the monitor software via the PCIExpress bus. In contrast to AFNOR NF S87-500 the IRIG telegram containes only the day of year (1...366) instead of a complete date. To ensure correct function of TCR180PEX-EL, the date stored in the realtime clock of the board must be set when using IRIG codes therefore. This setting can be done by a terminal software also.

If the time zone of the received time code is not UTC, the local offset to UTC must be configured to ensure correct function of the driver software. If the local time zone is MEZ for example, the board must be set to a local offset of '+60min' (MEZ = UTC + 1 h).

The serial interface COM0 can be configured to send a time telegram with reference to UTC or to the received local time.

9 Firmware Updates

Whenever the on-board software must be upgraded or modified, the new firmware can be downloaded to the internal flash memory via the clock's serial port COM0. There is no need to open the computer case and insert a new EPROM.

A loader program shipped together with the file containing the image of the new firmware sends the new firmware from one of the computer's serial ports to the clock's serial port COM0. The bootstrap loader does not depend on the contents of the flash memory, so if the update procedure is interrupted, it can easily be repeated.

The contents of the program memory will not be modified until the loader program has sent the command to erase the flash memory. So if the button has been pressed accidentally, the system will be ready to operate again after the computer has been turned off and then on again.

10 Technical specification TCR180PEX-EL

RECEIVER INPUT: AM-input (BNC-connector):
insulated by a transformer
impedance settable 50 Ω, 600 Ω, 5 kΩ
input signal: 600 mV_{pp} to 8 V_{pp} (Mark)
other ranges on request

DC Level Shift input (D-Sub-connector):
insulated by photocoupler
internal series resistance: 220 Ω
maximum forward current: 60 mA
diode vorward voltage: 1.0 V...1.3 V

optional input(option):
optical receive power: min. 3μW
optical connector: ST-connector
for GI 50/125μm
or GI 62,5/125μm
gradient fiber

DECODING: decoding of the following telegrams possible:
IRIG-A002 / A132 / A003 / A133 / A006 / A136 / A007 / A137
IRIG-B002 / B122 / B003 / B123 / B006 / B126 / B007 / B127
IRIG-G002 / G142 / G006 / G146
AFNOR NF S87-500
IEEE C37.118
IEEE 1344

ACCURACY OF TIME BASE: $\pm$ 750 nsec compared to IRIG reference marker

REQUIRED ACCURACY OF
TIME CODE SOURCE: $\pm$ 100ppm

HOLDOVER MODE: automatic switching to crystal time base
accuracy approximately $1*10^{-8}$
if decoder has been synchronous for more than 1h

BACKUP-BATTERY: if the power supply fails, an onboard realtime
clock keeps time and date information
important system parameters are stored in the
RAM of the system lifetime of the Lithium battery
at least 10 years

PULSE OUTPUTS: active only 'if sync'
PO_0:   change of seconds (PPS)
pulse duration 200 msec
valid on rising edge
PO_1:   change of minute (PPM)
pulse duration 200 msec
valid on rising edge

ACCURACY OF PULSES: better than $\pm$ 1 μsec after synchronization and 20 minutes of operation

SERIAL PORT: configurable RS-232 interface
baudrates: 300 Bd...115200 Bd

	framing: 7N2, 7E1, 801	7E2, 8N1, 8N2, 8E1
	mode of operation:	string per second string per minute string on request
	time telegram:	Meinberg Standard Uni Erlangen, SAT
	Meinberg Capture, ION Computime, SPA, RACAL	

CAPTURE INPUTS:

triggered by falling TTL slope
pulse repetition time: 1.5 msec min.
resolution: 800 nsec
output of trigger event via PCI–bus or serial interface

MASTER OSCILLATOR:

TCXO
(Temperature Compensated Xtal Oscillator)

accuracy compared to IRIG–reference:
sync. and 20 min. of operation: $\pm 5(10^{-9})$
first 20 min. after sync.: $\pm 1(10^{-8})$

accuracy of oscillator:
holdover, 1 day: $\pm 1(10^{-7})$
holdover, 1 year: $\pm 1(10^{-6})$

short term stability:
≤ 10 sec, synchronized: $\pm 2(10^{-9})$
≤ 10 sec, holdover: $\pm 5(10^{-9})$

temperature dependant drift:
holdover: $\pm 1(10^{-6})$

RELIABILITY OF OPERATION:

microprocessor supervisory circuit provides watchdog timer,
power supply monitoring and backupbattery
switchover software watchdog monitors correct program
flow and generates a reset in case of error detection

INITIALIZATION:

software and realtime clock can be set by a serial Meinberg
Standard Telegram via COM0 or the PCI–Express bus

BUS–INTERFACE:

Single lane (x1) PCI Express (PCIe) Interface
compatible to PCI Express specification r1.0a

DATA FORMAT:

binary, byte serial

POWER REQUIREMENT:

+3.3V: $\approx$ 250 mA
+12V : $\approx$ 90 mA
power supplies provided by PCI Express interface

Board DIMENSION:

"low profile" slot card (69 mm x 150 mm)

AMBIENT TEMPERATURE:

0 ... 50°C

HUMIDITY:

max. 85 %

11 Technical appendix TCR180PEX-EL

11.1 Abstract of Time Code

The transmission of coded timing signals began to take on widespread importance in the early 1950's. Especially the US missile and space programs were the forces behind the development of these time codes, which were used for the correlation of data. The definition of time code formats was completely arbitrary and left to the individual ideas of each design engineer. Hundreds of different time codes were formed, some of which were standardized by the "Inter Range Instrumentation Group" (IRIG) in the early 60's.

The TCR180PEX-EL supports decoding and generating of IRIG-A, IRIG-B, IRIG-G, AFNOR NF S87-500, IEEE C37.118 and IEEE 1344.

11.1.1 Description of IRIG-Codes

Format:

Format A	1 k pps
Format B	100 pps
Format D	1 ppm
Format E	10 pps
Format G	10 k pps
Format H	1 pps

Modulation Frequency:

0	Pulse width code
1	Sine wave, amplitude modulated
2	Manchester modulated

Frequency/Resolution:

0	No carrier/index count interval
1	100 Hz/10 ms
2	1 kHz/1 ms
3	10 kHz/0.1 ms
4	100 kHz/10 ms
5	1 MHz/1ms

Coded Expressions:

0	BCD_{TOY}, CF, SBS
1	BCD_{TOY}, CF
2	BCD_{TOY}
3	BCD_{TOY}, SBS
4	BCD_{TOY}, BCD_{YEAR}, CF, SBS
5	BCD_{TOY}, BCD_{YEAR}, CF
6	BCD_{TOY}, BCD_{YEAR}
7	BCD_{TOY}, BCD_{YEAR}, SBS

A 1 3 7

The signal designated as A137 is deciphered as follows: Format A, Sine wave (amplitude modulated), 10 kHz carrier/0.1 ms resolution, and Coded expressions BCD_{TOY}, BCD_{YEAR}, and SBS.

11.2 Time code Format

11.2.1 IRIG Standard Format
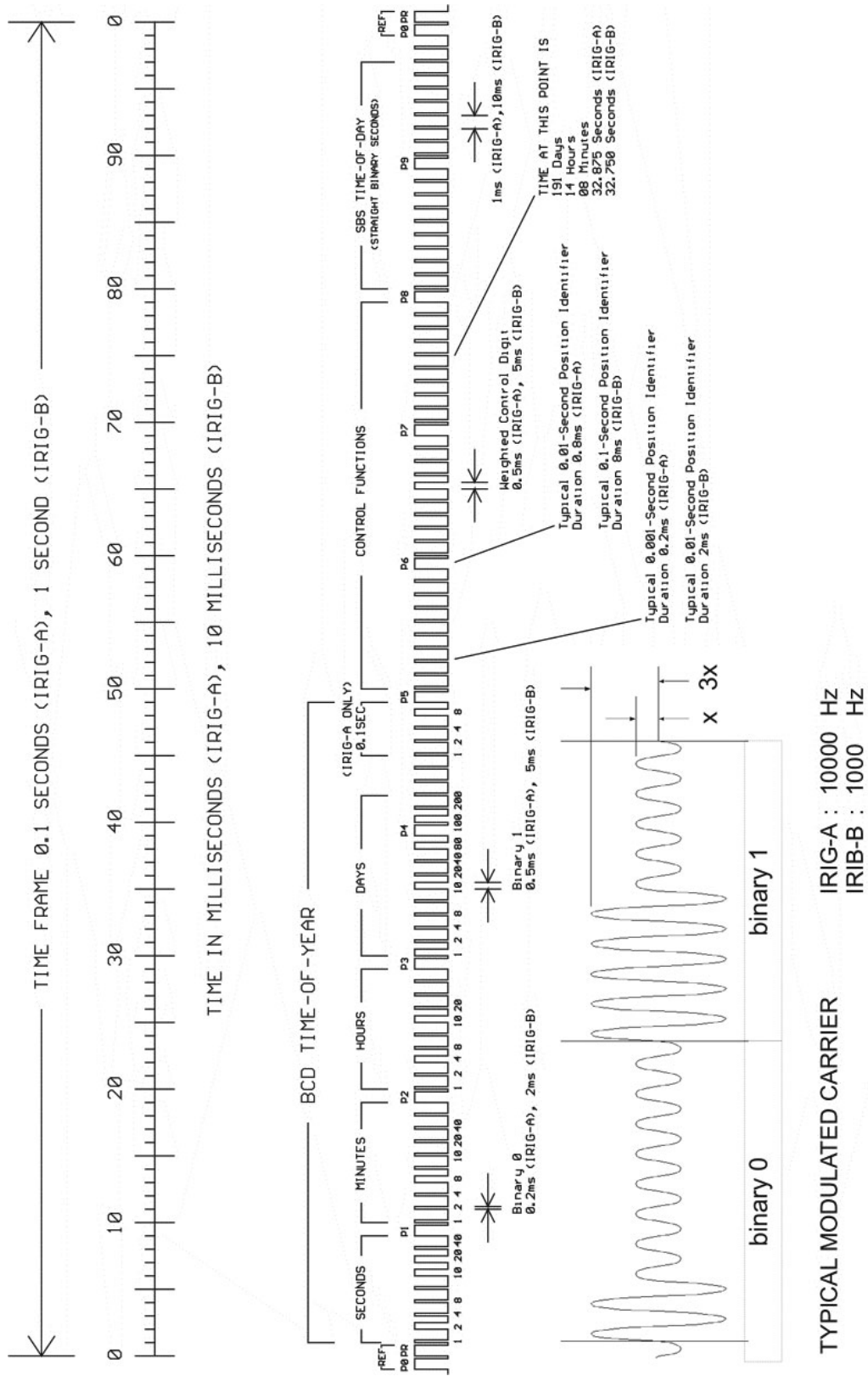
11.2.2 AFNOR Standard Format

11.3 Time Strings

11.3.1 Format of the Meinberg Standard Time String

The Meinberg Standard Time String is a sequence of 32 ASCII characters starting with the STX (start–of–text) character and ending with the ETX (end–of–text) character. The format is:

<STX>D:*dd.mm.yy;T:w;U:hh.mm.ss;uvxy*<ETX>

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<STX>	Start-Of-Text, ASCII Code 02h		
	sending with one bit accuracy at change of second		
dd.mm.yy	the current date:		
	dd	day of month	(01..31)
	mm	month	(01..12)
	yy	year of	
	the century (00..99)		

w	the day of	
	the week	(1..7, 1 = Monday)

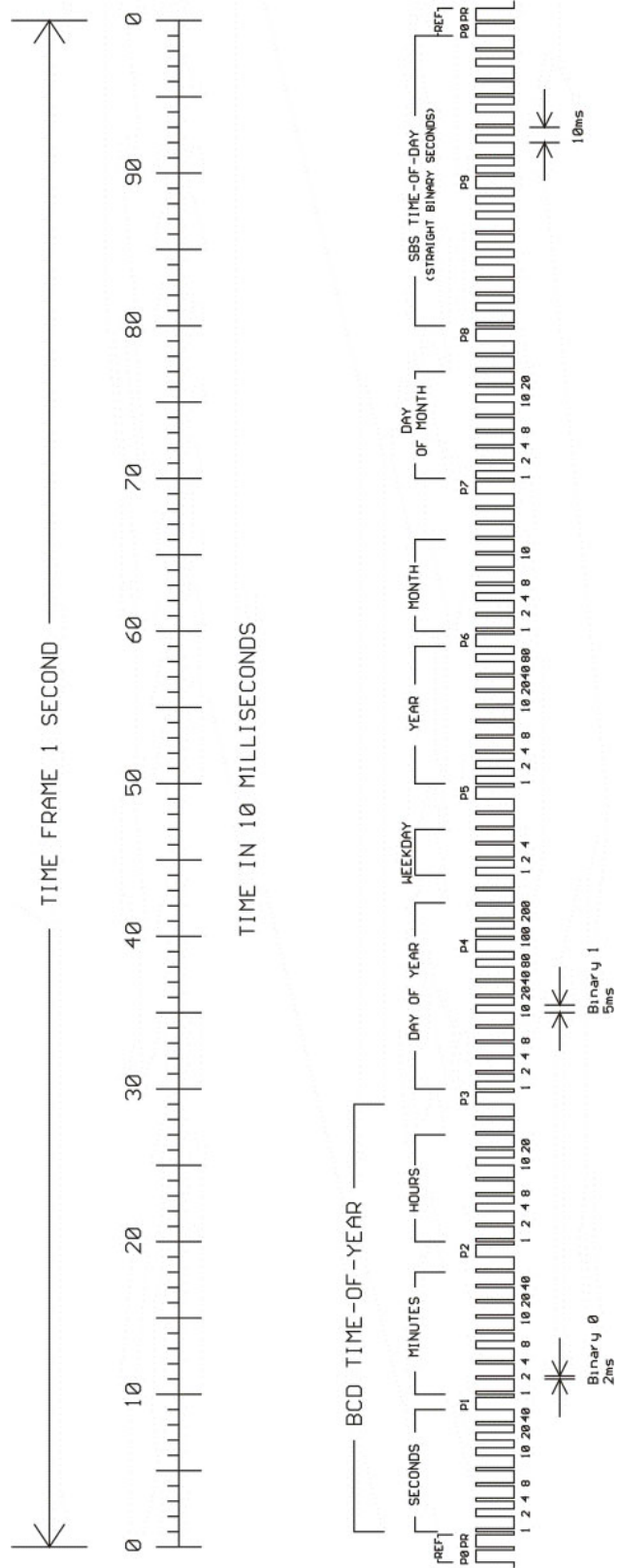|			
hh.mm.ss	the current time:		
	hh	hours	(00..23)
	mm	minutes	(00..59)
	ss	seconds	(00..59, or 60 while leap second)
uv	clock status characters (depending on clock type):		

	u:	'#'	GPS: clock is running free (without exact synchr.)
			PZF: time frame not synchronized
			DCF77: clock has not synchronized after reset
		' '	(space, 20h)
			GPS: clock is synchronous (base accuracy is reached)
			PZF: time frame is synchronized
			DCF77: clock has synchronized after reset
	v:	'*'	GPS: receiver has not checked its position
			PZF/DCF77: clock currently runs on XTAL
		' '	(space, 20h)
			GPS: receiver has determined its position
			PZF/DCF77: clock is syncronized with transmitter

x	time zone indicator:		
	'U'	UTC	Universal Time Coordinated, formerly GMT
	' '	CET	European Standard Time, daylight saving disabled
	'S'		(CEST) European Summertime, daylight saving enabled

y	anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:	
	'!'	announcement of start or end of daylight saving time
	'A'	announcement of leap second insertion
	' '	(space, 20h) nothing announced

<ETX>	End-Of-Text, ASCII Code 03h

11.3.2 Format of the Meinberg Capture String

The Meinberg Capture String is a sequence of 31 ASCII characters terminated by a CR/LF (Carriage Return/-Line Feed) combination. The format is:

CH*x_tt.mm.jj_hh:mm:ss.fffffff*<CR><LF>

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

x   0 or 1 corresponding on the number of the capture input
_   ASCII space 20h

dd.mm.yy the capture date:

dd	day of month	(01..31)
mm	month	(01..12)
yy	year of the century	(00..99)

hh:mm:ss.fffffff the capture time:

hh	hours	(00..23)
mm	minutes	(00..59)
ss	seconds	(00..59, or 60 while leap second)
fffffff	fractions of second, 7 digits	

<CR>   Carriage Return, ASCII Code 0Dh

<LF>   Line Feed, ASCII Code 0Ah

11.3.3 Format of the Uni Erlangen String (NTP)

The time string Uni Erlangen (NTP) of a GPS clock is a sequence of 66 ASCII characters starting with the STX (start-of-text) character and ending with the ETX (end-of-text) character. The format is:

<STX>*tt.mm.jj; w; hh:mm:ss; voo:oo; acdfg i;bbb.bbbbn lll.lllle hhhhm*<ETX>

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<STX>	Start-Of-Text, ASCII Code 02h sending with one bit occuracy at change of second	

dd.mm.yy	the current date:		
	dd	day of month	(01..31)
	mm	month	(01..12)
	yy	year of the century	(00..99)
	w	the day of the week	(1..7, 1 = Monday)

hh.mm.ss	the current time:		
	hh	hours	(00..23)
	mm	minutes	(00..59)
	ss	seconds	(00..59, or 60 while leap second)

v	sign of the offset of local timezone related to UTC
oo:oo	offset of local timezone related to UTC in hours and minutes

ac	clock status characters:		
	a:	'#'	clock has not synchronized after reset
		' '	(space, 20h) clock has synchronized after reset
	c:	'*'	GPS receiver has not checked its position
		' '	(space, 20h) GPS receiver has determined its position

d	time zone indicator:		
	'S'	CEST	European Summertime, daylight saving enabled
	' '	CET	European Standard Time, daylight saving disabled

f	anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:	
	'!'	announcement of start or end of daylight saving time
	' '	(space, 20h) nothing announced

g	anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:	
	'A'	announcement of leap second insertion
	' '	(space, 20h) nothing announced

i	leap second insertion	
	'L'	leap second is actually inserted (active only in 60th sec.)
	' '	(space, 20h) no leap second is inserted

bbb.bbbb	latitude of receiver position in degrees leading signs are replaced by a space character (20h)

n	latitude, the following characters are possible:	
	'N'	north of equator

          'S'   south d. equator

lll.lllll   longitude of receiver position in degrees
              leading signs are replaced by a space character (20h)

e   longitude, the following characters are possible:
              'E'   east of Greenwich
              'W'   west of Greenwich

hhhh   altitude above WGS84 ellipsoid in meters
              leading signs are replaced by a space character (20h)

<ETX>   End–Of–Text, ASCII Code 03h

11.3.4 Format of the SAT Time String

The SAT Time String is a sequence of 29 ASCII characters starting with the STX (start–of–text) character and ending with the ETX (end–of–text) character. The format is:

<STX>*dd.mm.yy/w/hh:mm:ssxxxxuv*<ETX>

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<STX> Start–Of–Text, ASCII Code 02h
     sending with one bit accuracy at change of second

dd.mm.yy the current date:
     dd   day of month   (01..31)
     mm   month   (01..12)
     yy   year of the century (00..99)
     w   the day of the week (1..7, 1 = Monday)

hh:mm:ss the current time:
     hh   hours   (00..23)
     mm   minutes   (00..59)
     ss   seconds   (00..59, or 60 while leap second)

xxxx   time zone indicator:
     'UTC'   Universal Time Coordinated, formerly GMT
     'CET'   European Standard Time, daylight saving disabled
     'CEST' European Summertime, daylight saving enabled

u   clock status characters:
     '#'   clock has not synchronized after reset
     ' '   (space, 20h) clock has synchronized after reset

v   anouncement of discontinuity of time, enabled during last hour
    before discontinuity comes in effect:
     '!'   announcement of start or end of daylight saving time
     ' '   (space, 20h) nothing announced

<CR>   Carriage Return, ASCII Code 0Dh

<LF>   Line Feed, ASCII Code 0Ah

<ETX> End–Of–Text, ASCII Code 03h

11.3.5 Format of the Computime Time String

The Computime time string is a sequence of 24 ASCII characters starting with the T character and ending with the LF (line feed, ASCII Code 0Ah) character. The format is:

T:*yy:mm:dd:ww:hh:mm:ss*<CR><LF>

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

T   Start character
sending with one bit accuracy at change of second

yy:mm:dd	the current date:		
	yy	year of the century	(00..99)
	mm	month	(01..12)
	dd	day of month	(01..31)
	ww	the day of the week	(01..07, 01 = monday)

hh:mm:ss	the current time:		
	hh	hours	(00..23)
	mm	minutes	(00..59)
	ss	seconds	(00..59, or 60 while leap second)

<CR>   Carriage Return, ASCII Code 0Dh

<LF>   Line Feed, ASCII Code 0Ah

11.3.6 Format of the SPA Time String

The ABB SPA Time String is a sequence of 32 ASCII characters starting with the characters ">900WD" and ending with the <CR> (Carriage Return) character. The format is:

> **>900WD:*jj-mm-tt_hh.mm;ss.fff:cc*<CR>**

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

jj-mm-tt	the current date:		
	jj	year of the century	(00..99)
	mm	month	(01..12)
	tt	day of month	(01..31)
	_	Space	(ASCII-code 20h)
hh.mm;ss.fff	the current time:		
	hh	hours	(00..23)
	mm	minutes	(00..59)
	ss	seconds	(00..59, or 60 while leap second)
	fff	milliseconds	(000..999)
cc	Checksum. EXCLUSIVE-OR result of the previous characters, displayed as a HEX byte (2 ASCII characters 0..9 or A..F)		
<CR>	Carriage Return		ASCII Code 0Dh

11.3.7 Format of the RACAL standard Time String

The RACAL standard Time String is a sequence of 16 ASCII characters terminated by a X (58h) character and ending with the CR (Carriage Return, ASCII Code 0Dh) character. The format is:

<X><G><U>*yymmddhhmmss***<CR>**

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<X>	Control character sending with one bit accuracy at change of second	code 58h
<G>	Control character	code 47h
<U>	Control character	code 55h

yymmdd	the current date:		
	yy	year of the century	(00..99)
	mm	month	(01..12)
	dd	day of month	(01..31)

hh:mm:ss	the current time:		
	hh	hours	(00..23)
	mm	minutes	(00..59)
	ss	seconds	(00..59, or 60 while leap second)

<CR>	Carriage Return, ASCII code 0Dh

11.3.8 Format of the ION Time String

The ION time string is a sequence of 16 ASCII characters starting with the SOH (Start of Header) ASCII controll character and ending with the LF (line feed, ASCII Code 0Ah) character. The format is:

<SOH>ddd:hh:mm:ssq<CR><LF>

The letters printed in italics are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<SOH>   Start of Header (ASCII control character)
              sending with one bit accuracy at change of second

ddd   day of year   (001..366)

hh:mm:ss   the current time:
           hh   hours   (00..23)
           mm   minutes   (00..59)
           ss   seconds   (00..59, or 60 while leap second)
           q   Quality
                  indicator   (space) Time Sync (GPS lock)
                                 (?) no Time Sync (GPS fail)

<CR>   Carriage-return (ASCII code 0Dh)

<LF>   Line-Feed (ASCII code 0Ah)

11.4 PCI Express (PCIe)

The main technical inovation of PCI Express is a serial data transmission compared to the parallel interfaces of other computer bus systems like ISA, PCI and PCI-X.

PCI Express defines a serial point-to-point connection, the so-called Link:
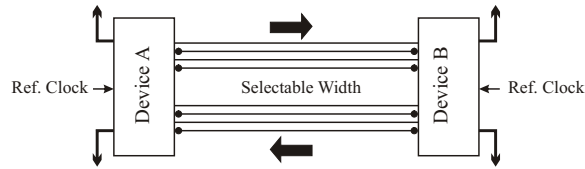
The data transfer within a Link is done via Lanes, representing one wire pair for sending and one wire pair for receiving data:
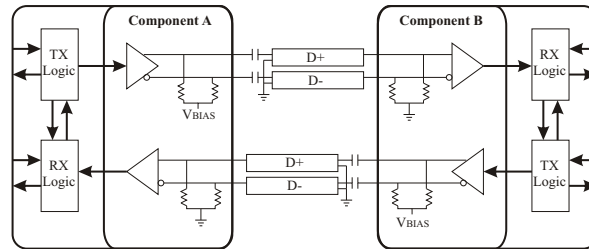
This design leads to a full duplex connection clocked with 2.5 GHz capable of transfering a data volume of 250 MB/s per lane in each direction. Higher bandwith is implemented by using multiple lanes silmutaneously. A PCI Express x16 slot for example uses sixteen lanes providing a data volume of 4 GB/s. For comparison: when using conventional PCI the maximum data transfer rate is 133 MB/s, PCI-X allows 1 GB/s but only in one direction respectively.

11.5 Content of the USB stick

Besides this manual, the provided USB stick includes a setup program for the monitor software MBGMON. This utility can be used to configure Meinberg receivers via their serial ports and to display status information of the module.

If the USB storage device is lost, the installation program can be downloaded free of charge from the Internet at: https://www.meinbergglobal.com/english/sw/

12 Declaration of Conformity

Konformitätserklärung
Doc ID: TCR180PEX-EL-2019-03-22

Hersteller   Meinberg Funkuhren GmbH & Co. KG
Manufacturer   Lange Wand 9, D-31812 Bad Pyrmont

erklärt in alleiniger Verantwortung, dass das Produkt,
declares under its sole responsibility, that the product

Produktbezeichnung   **TCR180PEX-EL**
Product Designation

auf das sich diese Erklärung bezieht, mit den folgenden Normen und Richtlinien übereinstimmt:
to which this declaration relates is in conformity with the following standards and provisions of the directives:

―――

EMV – Richtlinie   DIN EN 61000-6-2:2005
EMC – Directive   DIN EN 61000-6-3:2007 + A1:2011
                          DIN EN 55032:2012
2014/30/EU   DIN EN 55024:2010

―――

Niederspannungsrichtlinie   DIN EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 +
Low-voltage Directive   AC:2011 + A2:2013

2014/35/EU

―――

RoHS – Richtlinie   DIN EN 50581:2012
RoHS – Directive

2011/65/EU + 2015/863/EU
―――

Bad Pyrmont, den 2019-03-22

Stephan Meinberg
Production Manager