Kraus Messtechnik GmbH

Gewerbering 9, D-83624 Otterfing, ☎ +49-8024-48737, Fax. +49-8024-5532 – Germany
Home Page http://www.kmt-gmbh.com E-mail: kmtgmbh@aol.com

PCM4/8/16
User manual

4/8/16 channel telemetry system

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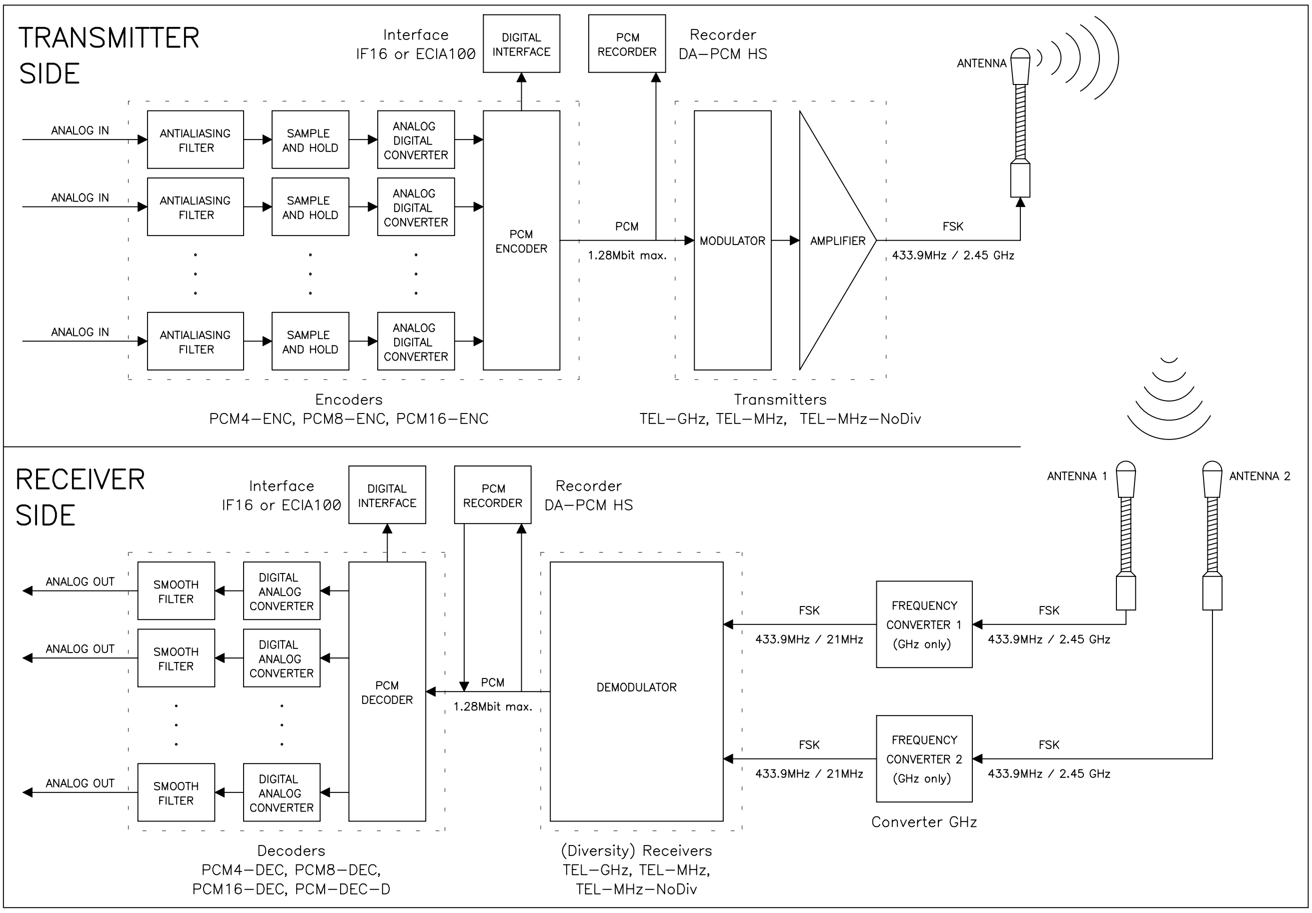
1 Introduction

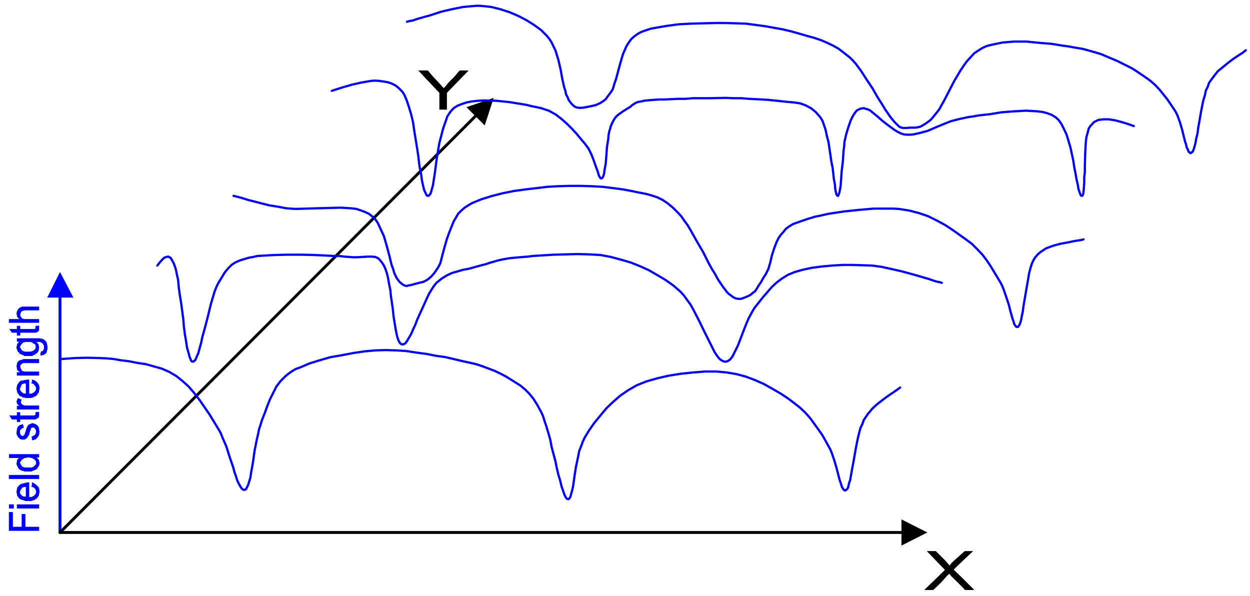
1.1 System description

- **Highlights**
  The PCM4/8/16 is a powerful telemetry system, designed for wireless transmissions of 4, 8 or 16 analog and one digital signal. The small system size, robust design and modular concept allow a wide range of applications for collecting data from mobile objects and inaccessible areas under harsh environment, like shocks, vibrations, dust, etc. A variable transmitter power makes flexible transmission ranges possible.
  With the implemented diversity function, the best transmission safety also under worst-case environment conditions is guaranteed. The wide range phase-locked loop circuit (PLL) eliminates a phase jitter of the received signal of up to 15%. A field strength bar graph indicator and an error LED allow an optimization of the antenna positions.
  Due to the digital conversion and modulation a theoretical unrestricted transmission dynamic range will performed. In practice a 72dB limit is set by the 12 bit A/D conversion of the encoder.
  The simultaneous sample and hold circuit enables accurate time correlations between all channels during evaluation and analysis. Implemented 8-pole Butterworth low pass filters avoid aliasing effects by automatically adaptation of the cut-off frequency to the current sample rate. Different channel modes optimize the relation between the bandwidth and the number of active channels
  A great number of periphery devices, like PCM data recorder, digital interfaces as well as comfortable acquisition and analysis software complete the system performance.

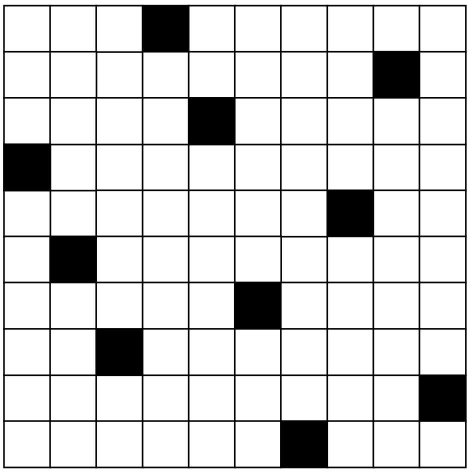


- **Measuring chain**
  The input signal voltages of ±5V (standard) or ±10V (optional) are routed via a 8-pole antialiasing filter to a sample and hold circuit for simultaneous acquisition of all channels. The analog values will converted into 12 digital bits, encoded in a PCM format and transferred to the HF transmitter. Here takes place a frequency shift keying modulation (FSK) with carrier frequencies of 433,9MHz or 2,45GHz. This electromagnetical wave will emitted via the antenna in the environment. Depending on the distance to the receiver, the transmitter power is variable from 10mW to 5W.
  The receiver unit demodulates the received HF signals into a digital PCM current, which is decoded, converted to an analog signal and output via a smooth filter as a voltage in the ±5V range. In the GHz range additional down-converters decrease the carrier frequency from 2.45GHz to 21MHz for reducing signal attenuations in the connector cables. The function principle of the diversity receiver will described with a simple example in next section.
  All digital signal values can recorded simultaneously by a digital PCM recorder. Reproduction takes place via the PCM input at the demodulator, which outputs the associated analog signals.
  Two interfaces are available for digital data acquisition on desktop computers (IF16 ISA board) or notebooks (ECIA100 PCMCIA card). The powerful software packages µLab and µGraph enables real time data storage on hard disk, online data visualization and a great number of tools for evaluation and analysis.

- **Diversity**
  A very important point regarding the transmission quality is the diversity receiver. It consists of 2 independent receivers with own antennas and in case of a GHz telemetry also own down-converters. The two modulated input signals will added phase-locked and therefore the resulting signal has in always an improved quality against any of the input signals. This is also the main difference between diversity systems and simple antenna couplers, where the existing phase difference can lead to an addition of the signals, but also to an extinguishing. An using of a diversity system is recommended in case of dynamical changings of the electromagnetical environment conditions, like mobile systems with moving transmitter or receiver antennas and indoor applications with many reflections on walls, bottoms, ceilings, moving objects, persons, etc. In practice the transmission quality of a diversity system against a non-diversity system is improved by a factor of 10. This will now explained on a simple example.



The diagram on the previous page shows the measured field strength distribution in a XY-plane inside a testing stand cabin for cars. Here exists extremely complex conditions, because of the small dimensions and the metal covered walls. Following the graph in X-direction for a fixed Y-value, we see wide sections with high field strengths and small section with low field strengths due to interferences. For different Y-values the graphs are similar with a relation between good and low field strengths of approximately 10 to 1. With the premise, that we have an equivalent distribution in Y-direction for fixed X-values, we can derive a discrete XY-plane, marked with good field strength areas (white) and wrong areas (black). From ten squares in every row and column are nine good and one wrong. Next scheme shows such a possible distribution for a fixed time.



To get a feeling for practical field strength conditions, we must suppose now, that every moving object, e.g. a opening door, a person or the incoming car, will indefinable change the distributions of the black squares in the 10x10 area, but not the number (1 per row and 1 per column). Suppose, that the receiving antenna position is in one square, we have a probability for a black square area of 10/100 = 1/10. Using a diversity system with 2 independent antennas, this value is reduced to 10/100 * 9/99 = 1/10 * 1/11. So, in this example, the diversity function will increase the insensibility against transmission errors by a factor of 11. Additional, in the case of two antennas in black squares, the two low field strengths will added and therefore increased, so that further transmission errors can be avoided.

1.2 How to arrange the telemetry system

- Generally it give many applications for telemetry systems, each with its own requirements and special environment. So it doesn’t exist one universal system for all, but it is necessary to combine various components. To find the most suitable system for your application, use the following check list.

1. What is the maximum number of analog channels?
2. What is the necessary maximum channel bandwidth?
3. What are the requested transmission quality and environment conditions?
4. What is the maximum transmission range?
5. What is the type of data acquisition on receiver side?

The next sections give a detailed description of every check point with all important hints for the user. At the end of this chapter you have specified a complete telemetry system consisting of one pair of encoder/decoder, one pair of transmitter/receiver and the accessory equipment as well as the necessary options.

- **Number of analog channels**
  Depending on the number of channels you can choose between the 3 types of modulator/demodulator pairs PCM4, PCM8 and PCM16 with 4, 8 or 16 analog channels. If a digital acquisition is desired, the analog decoder on receiver side will replaced by a digital one with an additional computer interface IF16 (desktop) or ECIA100 (notebook), data acquisition software µLab (necessary) and data analysis software µGraph (recommended).
  For a number of channels less than 4 the PCM4 telemetry is normally to expensive. In this case we recommend to check the suitability of our RTSE600 system, which is designed for short transmission ranges of 1 up to 4 channels.
  Has the application more than 16 channels it is possible to combine 2 or more systems, e.g. for 24 channels a PCM8 and a PCM16 system. Note, that such a multi-telemetry system leads to some general restrictions. At first the type of data acquisition on receiver side is important. For analog outputs there are no effects, but for a digital acquisition, if a simultaneous sampling of all channels is desired. That means in our example with 24 channels, that the first 16 channels will sampled at a time 1 and the other 8 at a time 2. Because you need for every demodulator an own digital interface with independent free running FIFO memories on the acquisition cards, there is no way to correlate the first 16 channels with the other ones in time. For simple test measurements it's possible to use one channel of every system for transmitting the same signal to detect the fixed time delay between the to systems. But any type of correlations between one channel of system 1 and a second channel of system 2 during data analysis will not supported in software. A further restriction of multi-telemetry systems exists, if you will work with a more cost efficient TEL-MHz transmitter/receiver pair. In the authorized ISM band (Industry, Science and Medicine) from 433,15 to 434,65MHz it's only possible to transmit a maximum total bit rate of 320kbit/s. So the upper limit for a multi-telemetry system are 32 channels, build with two PCM16 systems and a transmission rate of 160kbit per system. For more information regarding the bit rates see also section "Channel bandwidth".
  Additional to the analog channels every PCM4/8/16 system enables the transmission of one digital channel (TTL signal). The sample rate is equal to the total bit rate divided by 16 and the resulting jitter (maximum high/low level transition time difference between original and received signal) is the reciprocal value of the sample rate.

System bit rate	160kbit/s	320kbit/s	640kbit/s	1280kbit/s
Digital sample rate	10kS/s	20kS/s	40kS/s	80kS/s
Jitter	100µs	50µs	25µs	12.5µs

- **Channel bandwidth**
  Because of the digital data transmission of the PCM telemetry system every analog value must sampled, hold and converted in a digital one. The total sample rate (number of samples per second for all channels) can derived by dividing the bit rate by 16. These 16 bits are one data word composed of 12bits for the analog data value, 1 bit for the digital channel, 1 synchronization bit and 1 system bit.
  Depending on the channel mode the total sample rate will distributed evenly to the active number of channels. According to Shannon's theorem this sample rate must be at least two times higher than the highest analog signal frequency to avoid aliasing effects. Because the highest signal frequency is a unknown value, it's necessary to filter the input signal. In the PCM modulator this is realized by implemented 8-pole low pass filters with Butterworth characteristic. The 3dB cut-off frequency of these filters is equivalent with the channel bandwidth and can derived by dividing the channel sample rate by 3,125.
  For monitoring and controlling systems with fast reaction activities it's also important to know the time delay between the modulator input and the demodulator output. In the field of measurement this has no influence for e.g. cross-correlations, because the time delay is constant for all channels.

Following table shows the relationship between bit rate, sample rate, analog signal bandwidth and time delay for the different channel modes.

System bit rate		160kbit/s	320kbit/s	640kbit/s	1280kbit/s
Total sample rate		10kS/s	20kS/s	40kS/s	80kS/s
2-channel mode	Channel sample rate	5kS/s	10kS/s	20kS/s	40kS/s
	Channel bandwidth	1,6kHz	3,2kHz	6,4kHz	12,8kHz
	Channel time delay	1,4ms	0,7ms	0,35ms	0,175ms
4-channel mode	Channel sample rate	2,5kS/s	5kS/s	10kS/s	20kS/s
	Channel bandwidth	0,8kHz	1,6kHz	3,2kHz	6,4kHz
	Channel time delay	2,8ms	1,4ms	0,7ms	0,35ms
8-channel mode	Channel sample rate	1,25kS/s	2,5kS/s	5kS/s	10kS/s
	Channel bandwidth	0,4kHz	0,8kHz	1,6kHz	3,2kHz
	Channel time delay	5,6ms	2,8ms	1,4ms	0,7ms
16-channel mode	Channel sample rate	625S/s	1,25kS/s	2,5kS/s	5kS/s
	Channel bandwidth	0,2kHz	0,4kHz	0,8kHz	1,6kHz
	Channel time delay	11,2ms	5,6ms	2,8ms	1,4ms
Transmitter/receiver pair		MHz/GHz	MHz/GHz	GHz	GHz

This time are 2 frequency bands for data transmission available, one in the MHz range and one in the GHz range. For bit rates greater than 320kbit only the TEL-GHz transmitter/receiver pair is possible, but for 160 and 320kbit the decision depends on various factors. These will described in the next section.

- **Transmission quality and environment conditions**

  The most important point for the well-function of a telemetry system is the suitable adaptation to the environment conditions. This section summarized all information and relationships for the user. Note, that the MHz system can delivered with or without a diversity receiver, but in the GHz system it's included by default.

  Inside of buildings in most cases the standard transmission power of 10mW for TEL-MHz and 20mW for TEL-GHz is sufficient. For short distances, e.g. from door to door, the MHz telemetry fulfil almost all applications. Because of many reflections on walls, floors and ceilings and the resulting interferences, a diversity system is recommended. For longer distances, e.g. from the 1st to the 9th floor in great buildings, a GHz system offer an improved performance. Here the shorter wave length enables an advanced ability to get through mediums like iron, steel, concrete, etc. Examples for such applications are transmissions from the inside of great dams, stoves and vacuum systems.

  On open air conditions we have to separate between fixed and mobile applications. Will the position of the transmitter and receiver not moved during the data transmission, the electromagnetical environment is relative stable. So, if the user has found the best transmission performance by checking different placements of the antennas, he has a constant transmission quality. For such point-to-point telemetry systems a diversity in the MHz range is not necessary.

  In mobile applications, where the transmitter and/or the receiver are not fixed, the electromagnetical conditions are changing permanently. Here a diversity system will reduces the transmission errors considerable.

  In GHz range the properties of the electromagnetic waves approaches to these of light, so that the insensitivity against electromagnetic influences from the environment is greater than in MHz range. A second conclusion is that in GHz range for long transmission ranges a line-of-sight connection between the transmitter and receiver antennas is necessary, because the reflected energy, e.g. from mountains, is lower. Vice versa the higher reflected power in the MHz range leads to the result, that the transmitter antenna has to placed on the highest possible point to minimize reflections from the ground.

To summarize the free field conditions in simple examples, the best transmission is guaranteed from mountain to mountain, followed from a transmission from mountain to valley with a line-of-sight connection (no trees between transmitter and receiver antennas) and the worst case from valley to mountain. In flat regions the mountain can replaced by a high transmitter mast.
The maximum transmission range in free field depends from the last 3 conditions, the transmission power and the antenna design. This questions will answered in next section.
Regarding the bit rate, it's clear, that the required analog channel bandwidth is the determined value. Generally we recommend not to work with bit rates higher than necessary, because every decreasing of the data rate will increase the transmission stability.
For telemetry applications in industrial and commercial areas, please check before order the availability of the specified frequency band on site and the authorization by government for your country! In case of reservations it's possible to modify the transmitter/receiver pair for alternative carrier frequencies.

Transmitter/receiver pair	TEL-MHz	TEL-GHz
Frequency range	433,15MHz – 434,65MHz	2,400 – 2,483GHz
Wave length	70cm	12,5cm
Supported bit rates	160 / 320kbit	160 / 320 / 640 / 1280kbit
Advantages	• Cost efficient • High insensitivity against interferences (diversity not always necessary) • Low attenuation on rain and fog conditions	• High modulation bandwidth (high bit rates and channel bandwidths, parallel function with other services possible) • High insensitivity against shielded rooms, stoves, metal vessels, etc. • Smaller transmitter antennas
Disadvantages	• Many other services in band (higher liability due to alarm systems, door opener, etc. in the neighborhood) • For long transmission ranges are higher transmitter antenna positions necessary, because of energy loss by ground reflections	• More expensive • On receiver side only diversity available, because of more interferences due to shorter wave length

- **Transmission range**

As mentioned in last section the height of the transmitter antenna against ground, the transmission power and the antenna design are the primary aspects for the possible maximum transmission range. Generally the real range must determined in practice on actual conditions, but as a rough formula the next table shows approximated values for a standard transmitter antenna 10m above ground.

Transmission power	TEL-MHz	TEL-GHz
10mW	300m	
20mW		500m
1W	1000m	1000m
5W	2000m	2000m

For ranges higher than 2km we recommended to contact our company to discuss the increasing of transmitter power and the using of direction antennas or for example tracking antennas for transmissions from an air craft to ground.
Please read also the security notes in next chapter, especially for high power systems with 1W and more.

- **Type of data acquisition**
  The last point for specifying your telemetry system is the question of analog or digital data acquisition on receiver side. This depends on the type of application and the acceptable budget.
  For complex systems, where the telemetry is only one part of many components with the only task to transmit analog data from place A to place B, the decision is normally analog, because the user has is own digital acquisition system with his standard evaluation software.
  In stand-alone systems with the task to measure data on place A, transmit these to place B and store the data on a hard disk of a notebook or desktop, we recommended a digital telemetry interface on receiver side. Some users work in this case with analog telemetry outputs and a PC-integrated data acquisition card, but this reduces the signal quality, because the digital transmitted data will converted to analog and after them back to digital.
  Regarding the budget, a digital system is with an increasing number of channels more cost efficient against an analog one. So, for 16 channels, a digital decoder PCM-DEC-D, with computer interface IF16 or ECIA100, data acquisition software μLab and data analysis software μGraph is cheaper than an analog decoder PCM16-DEC. For detailed information see chapters “Components” and “Periphery”.

1.3 Security and application notes

- In high power systems with 1 Watt and higher it’s very important, that the whole power will emitted via the antenna. Therefore, don’t power-up the transmitter without connected antenna or attenuator, because the irradiated electromagnetical wave will reflected on the antenna connector and the power of the return wave can destroy the final output stage of the transmitter.
  Such telemetry systems are designed for long transmission ranges, so that the minimum distance between transmitter and receiver antennas is 100m for a 5W system working with full power output. Otherwise the receiver is overloaded and loss the synchronization or the diversity doesn’t work. In this case connect a 10 or 20dB attenuator between transmitter output and antenna to reduce the emitted power.
  Another negative influence of HF power have to be considered for sensitive measurement devices. When high frequencies are injected in the measuring signal path, a differentiated rectification normally occurs in semiconductors, which results in an offset shift at the output, especially by using large gains (e.g. 1000 for strain gage amplifiers). This offset shift can be as much as 10% of the measuring range. So, the minimum distance of the transmitter antenna from other electronically components should be at least 5m for a 5W system.
  A further important point is the hot discussed topic of electromagnetical influences (EMI) to organic cells, like the human brain. Although a scientific proof is missing, it’s recommended to handle high HF power devices with a given respect. The problem is, that people can’t recognize electromagnetical waves, they are not to see, not to hear and not to feel. A simple experiment will help to get a sentiment for the emitted energy. Power-up a 5W transmitter in the near of a computer monitor and you will see the result on the screen. Therefore, avoid staying over long times in the near of high power transmitter antennas (minimum distance should be 5m for a 5W system).
- If you use antennas with magnetic sockets, avoid any contact with transmitters or receivers, because the ferrite cores of the internal band filters will premagnetized and change there center frequency. For transportation put every time an iron plate on the magnetic socket area to absorb the magnetic field strength.

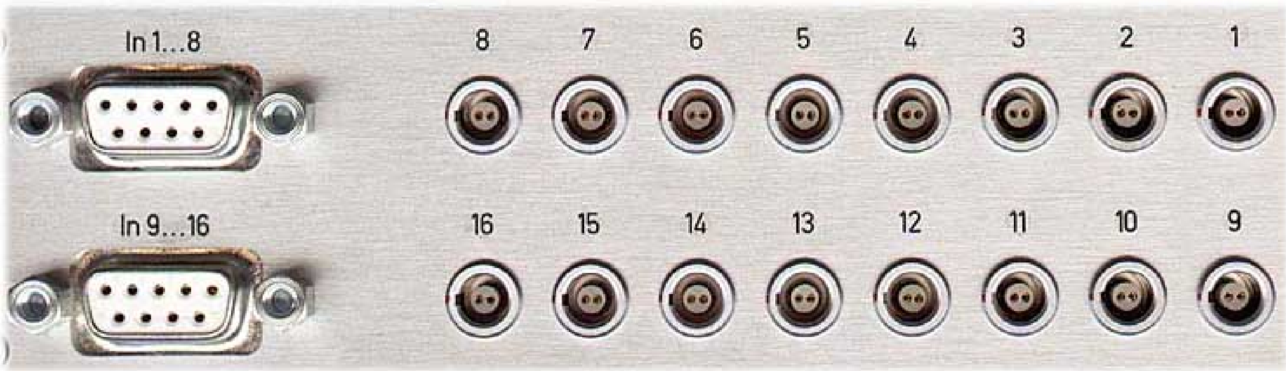
2 Installation

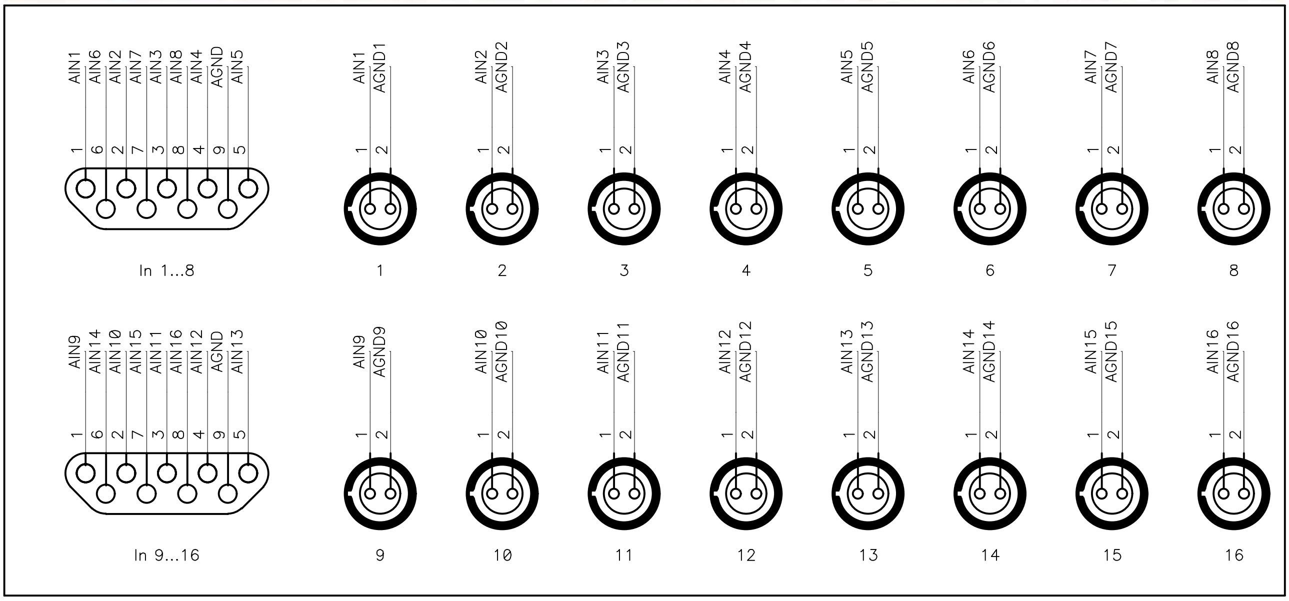
- Connect at first the antennas on the transmitter and receiver side. In case of a GHz telemetry connect the two receiver antennas with the outer connectors of the converter using the short HF cables (1m). After them establish the connection from the two middle converter connectors to the diversity receiver using the long HF cables (10m). If you test high power systems with 1Watt or more in laboratory with short transmission ranges, implement a 10 or 20dB attenuator between transmitter and antenna, because otherwise the receiver will overloaded and the diversity function doesn't work.
- Plug the 7-pole Tuchel in the female connectors labeled with "Pwr." or "Power" of the encoder and decoder and the Banana connectors into a DC voltage supply (plus is red, **minus** is **black**). The DC voltage input range is from 10 to 30V or otherwise specified beside the power connector or on the type sign of the device (older versions). Check, that you have enough power and the voltage is not to high, because in this case the internal overvoltage protection circuit will destroy the fuse. If nothing happens with PCM16 modulators or demodulators the power switch is off and you must turn the "Pwr./Ch. Mux." switch at least one position in clockwise direction using the delivered screw driver. In standard applications, the transmitter will powered from the encoder and the receiver from the decoder. Only when working with 5W power, the transmitter will separate powered. The same is valid for the receiver in systems with digital decoders. Here the DC input ranges of the transmitter and receiver are limited from 12 to 15V. The down-converter in GHz systems will powered always from the diversity receiver.
- Connect the transmitter with the encoder and the receiver with the decoder via the 9-pole SubD connector cables or in case of digital decoders via the 2-pole Lemosa to BNC cable. Check, that you have enough field strength on the "RF Level" bar graph on the receiver. At least 4 LEDs should be light up, if not, than change the positions of the antennas until the maximum field strength is reached. Test the diversity function by manually moving the transmitter or receiver antennas. The "Ant. 1" and "Ant. 2" LEDs have to go on and off alternately, otherwise the receiver is overloaded and you have to reduce the transmitter power by an additional attenuator. If the "Error" LED on the demodulator is permanently off, the telemetry transmission is successfully established.
- A first step to check the transmission is to change the channel mode on the modulator. The current mode must displayed automatically also on the demodulator. Then an analog signal, e.g. a 1Hz sine wave, can input on the encoder and measured on the output of the decoder.
- When using a digital interface connect the interface cable on the analog decoder. Switch off the computer and plug the ECIA100 PCMCIA card in your notebook (KMT logo on the top side) or the IF16 ISA board in your desktop. Plug the software security key (dongle) on the LPT1 printer port and power-up the PC. The Win95/98/NT operating system will detect the new hardware and request the belonging driver. After successfully installing from floppy disk or CD on notebook, you hear a short beep and you see the card icon on the right side in the taskbar. Now install the software packages µLab and µGraph and start the µLab application. For every customer an example configuration for µLab is delivered on a separate floppy disk. Copy the files ".mhc" and "*.mlb" in a new folder, e.g. "Examples" in the "MicroEdition" directory and open the "*.mlb" file in µLab. Save the configuration as "Test.mlb" using the *SaveAs* command in the *File* menu to avoid an overwriting of the presentation settings. Click the start button on the symbol panel for activating the measurement. A graphical display with all physical channels will appear. If you get an error message, make a double click on "Hardware" in the "Extras" folder of the project tree, reload the configuration file ".mhc", click on "Job", choose the "Clock source", select the belonging "Device name" depending on the current channel mode and start again. Use this example as base for more complex configurations and for an easy entrance in µLab.
- Now connect the 37-pole SubD decoder output with the interface card input to see the real input test signal. For further operations see the µLab and µGraph tutorials.

3 Components

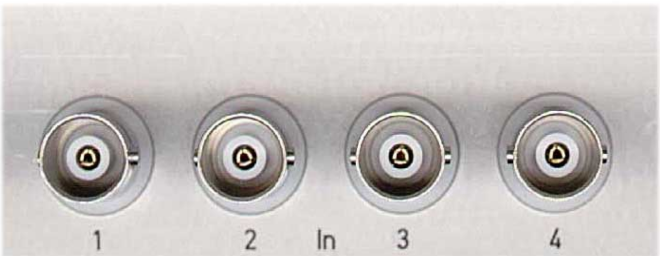
3.1 Encoder

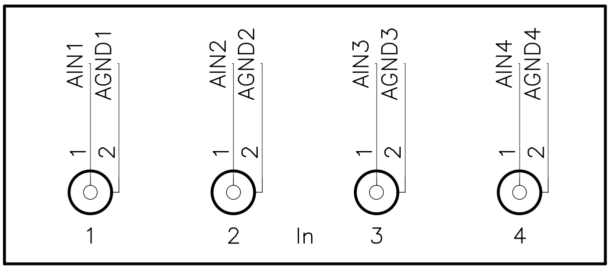
- Depending on the number of analog channels, 3 types of encoders are available, a 4-channel version PCM4-ENC, a 8-channel version PCM8-ENC and a 16-channel version PCM16-ENC. On the receiver side every encoder must combined with the belonging analog decoder (PCM4-DEC, PCM8-DEC, PCM16-DEC) for analog data transmission or with the digital decoder PCM-DEC-D for digital data acquisition.





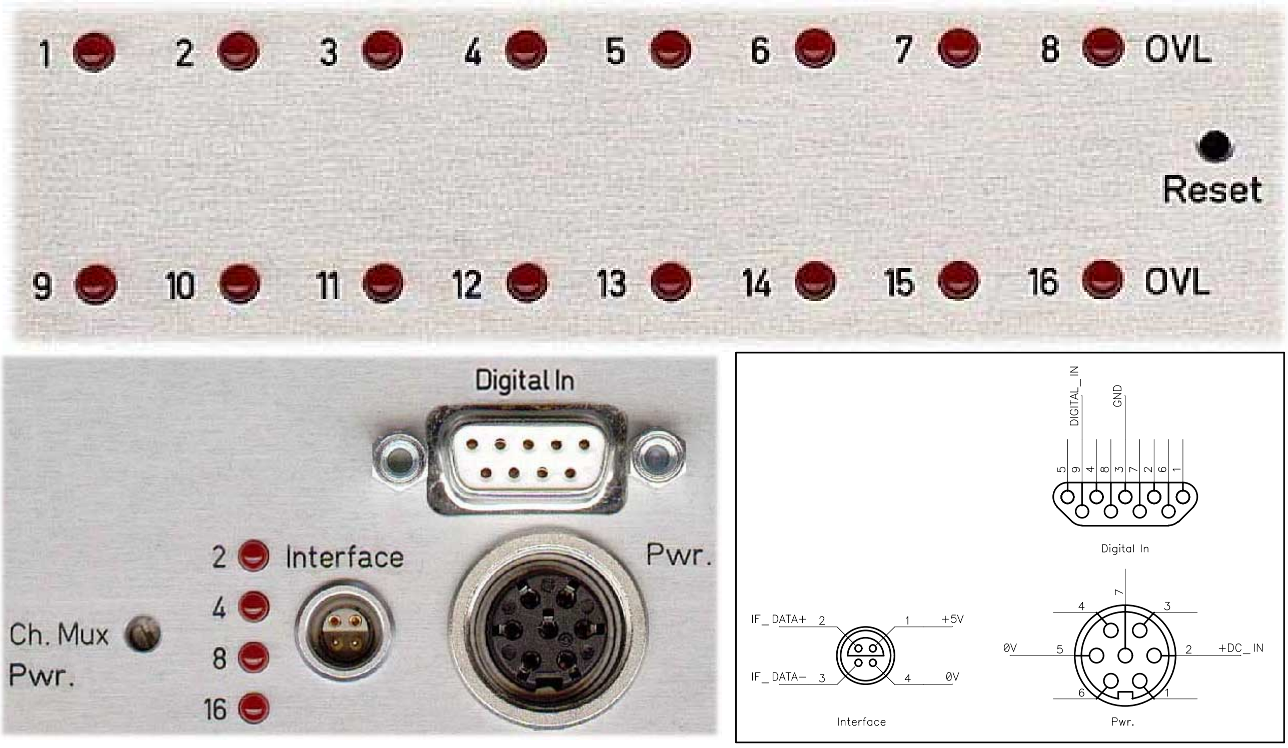
- The 16- and the 8-channel versions are absolutely equivalent with the only exception of the missing channels 9 to 16. The 4-channel versions has another mechanical construction with the main difference, that instead of 2-pole Lemosa single analog inputs and 9-pole SubD multiple inputs only 4 analog BNC inputs are implemented.





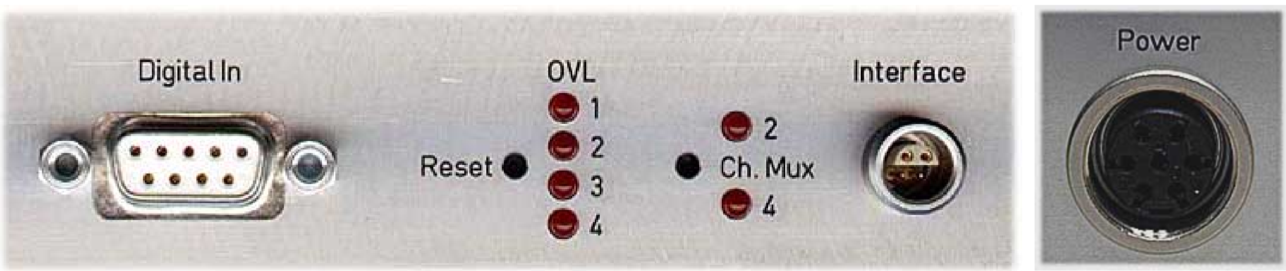
- The PCM4-ENC does not have a special power switch. It's powered on, as soon as the power supply is connected. Make sure that you work with the correct supply voltage with at least 10W output power. New systems are designed for DC input voltages from 10 to 30V, but the first series have a shared range from 9–18V and from 18 to 32V. In last case the valid input range is labeled beside the power connector or on the type sign.

- All PCM8/16-ENC works by default with an input range from 10 to 30V DC. If the voltage is to low, the encoder don't work properly, is it to high, the internal fuse will destroyed immediately. The pin assignment for the power connector you find in the following drawings, and for the DC cable the red banana plug is plus and the other one **minus** (**black** or in older versions blue).



PCM8/16-ENC connectors, indicators and pin assignment

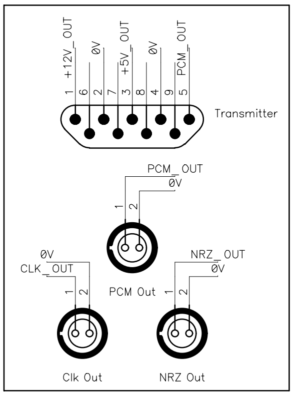
- The "Ch. Mux/Pwr." switch of the PCM8/16-ENC on the left side has the function to power on/off the device and to select the desired channel mode (2/4/8/16). Use only the delivered screw driver for the switch behind the hole. The anti-clockwise stop is the power off position, followed from the 2-channel mode, 4-channel mode, etc. If you power down the device by cut the power supply, the last used channel mode will activated after reconnection and displayed on the belonging LED. The same is valid for the PCM4-ENC with the difference, that you have to use the delivered 2mm hexagon key to press the key for changing the channel mode. Depending on this mode, only the signals from the first 2, 4, 8 or 16 channels will transmitted. A reducing of the number of channels will increase the bandwidth per channel (for detailed information see chapter 1.2 section „Channel bandwidth").

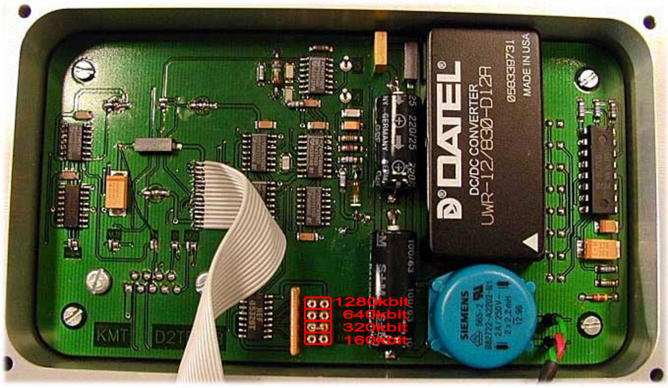


PCM4-ENC connectors and indicators (pin assignment is compatible to PCM8/16-ENC)

- The analog input range for all encoders is ±5V by default or optionally ±10V. If the input signal goes out of this specified range, the red overload LED of this channel lights up. These LEDs are placed on the rear side of the 8/16-channel system and on the front side of the 4-channel system. The LED remains on, if the signal is returned into the valid range and will only goes off, when you press the overload „Reset" key (use 2mm hexagon key). In case, that the LED of a channel doesn't goes off, the input signal is in the overload range permanently or temporary with a high frequency, so that the LED immediately light up again after clearing.

- The „Interface“ output is the connector to the computer using the digital interface IF16 (desktop) or ECIA100 (notebook). Normally, digital data acquisition takes place with a digital decoder on receiver side, but it works also for analog encoders. Here it can used for test purposes or as a stand-alone data acquisition system. The bipolar serial output signal will converted in a 16-bit parallel IF16 compatible format inside the 37-pole SubD connector cover on the other end of the interface cable. Note, that for a digital acquisition with analog encoders and decoders the bit rate for the interface cable is set to a fixed value (160 / 320 / 640 / 1280kbit).
- Any type of encoder enables the transmission of 1 additional digital channel with TTL levels using the „Digital In“ connector. This signal will reproduced on the „Digital Out“ connector on the belonging analog decoder. For the digital decoder this feature is not available. Sample rates and the resulting jitter related to the bit rate are described in chapter 1.2 section „Number of analog channels“.

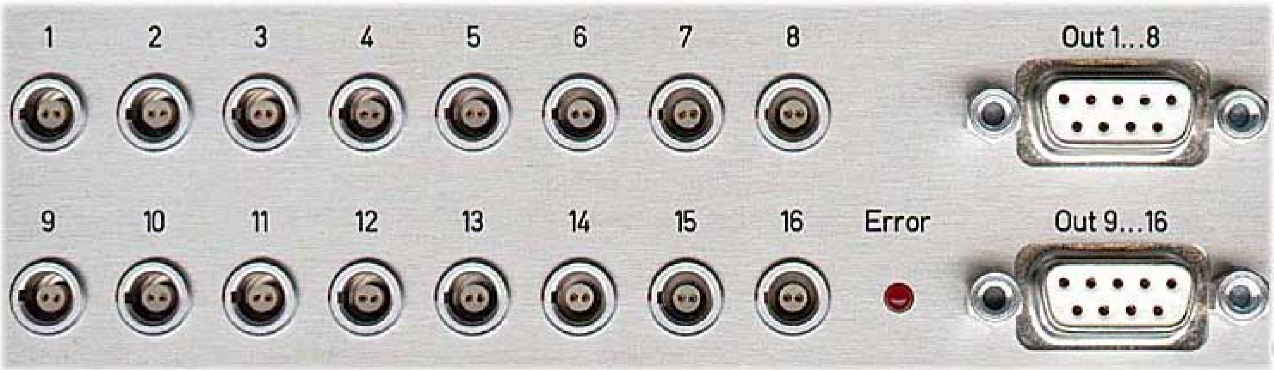


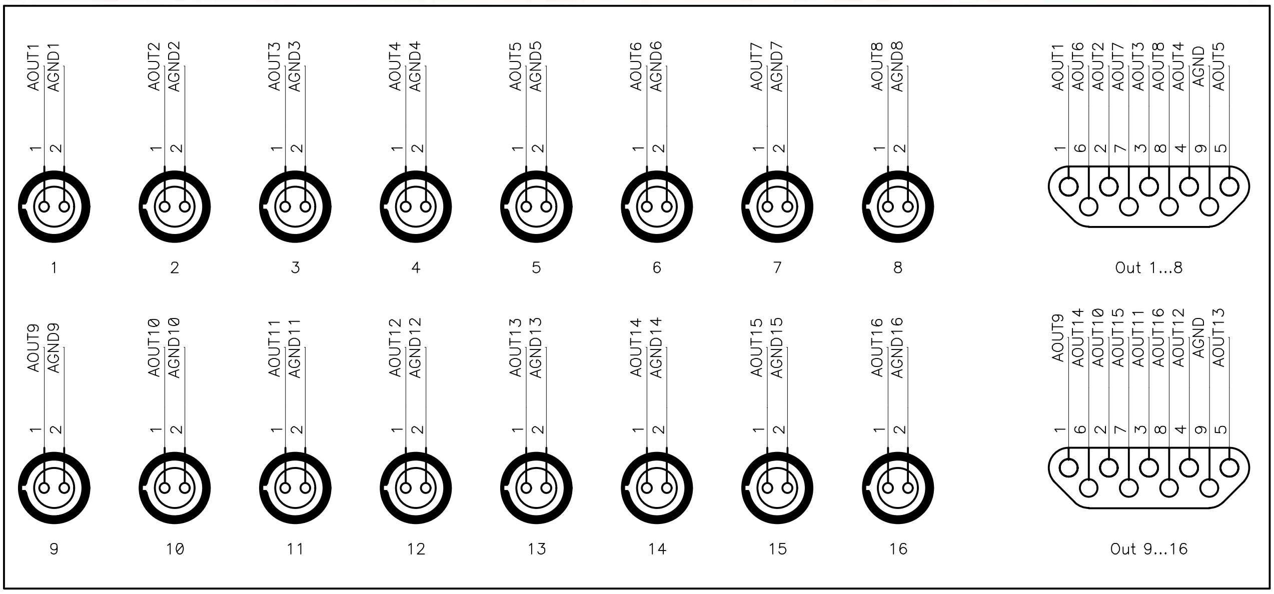


- The connectors on the top are equal for all types of encoders. The transmitter will connected via a cable with 9-pole SubD connectors and is powered from the encoder. Additional exists a 2-pole Lemosa output for data transmissions via cable and for test purposes. In case of malfunction of the telemetry system, the first step for locating the reason is to disconnect the transmitter + receiver from the encoder + decoder and to realize a cable connection from the „PCM Out“ of the encoder to the „PCM In“ of the decoder. Using a BNC cable, the length could be up to 100m. If the cable transmission works („Error“ LED of decoder goes off and signal transmission is without problems) the encoder/decoder pair is OK, if not, the reason are in most cases different bit rates in the encoder and decoder. Normally, this bit rate is specified before order and set to the possible maximum of the telemetry. But in special cases, e.g. for increasing the transmission quality or for data reduction, it could be, that it’s necessary to change it. This is possible by opening the top of the encoder and decoder using a 2mm hexagon key and set both jumpers to the desired bit rate as marked in the interior picture above. In analog systems with additional digital interface, the bit rate of the interface cable is fixed and therefore the data acquisition to the PC will not work if you change the bit rate. In extraordinary cases contact our company to give a plan of soldering modifications in the interface cable, if a changing of the bit rate is unavoidable. The clock output „Clk Out“ together with the „PCM Out“ are useful for parallel data storage with a high speed PCM data recorder. See chapter „PCM Recorder“ for more details. The second data output „NRZ Out“ is only specified for test purposes.

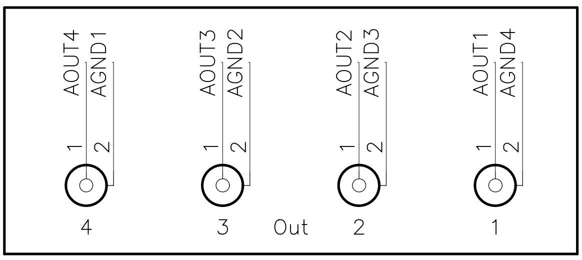
3.2 Decoder

- Four types of decoders are available, a 4-channel version PCM4-DEC, a 8-channel version PCM8-DEC and a 16-channel version PCM16-DEC for analog data acquisition as well as the digital version PCM-DEC-D. On the transmitter side every decoder must combined with the belonging analog encoder (PCM4-ENC, PCM8-ENC, PCM16-ENC). The digital decoder works with all 3 types of encoders.



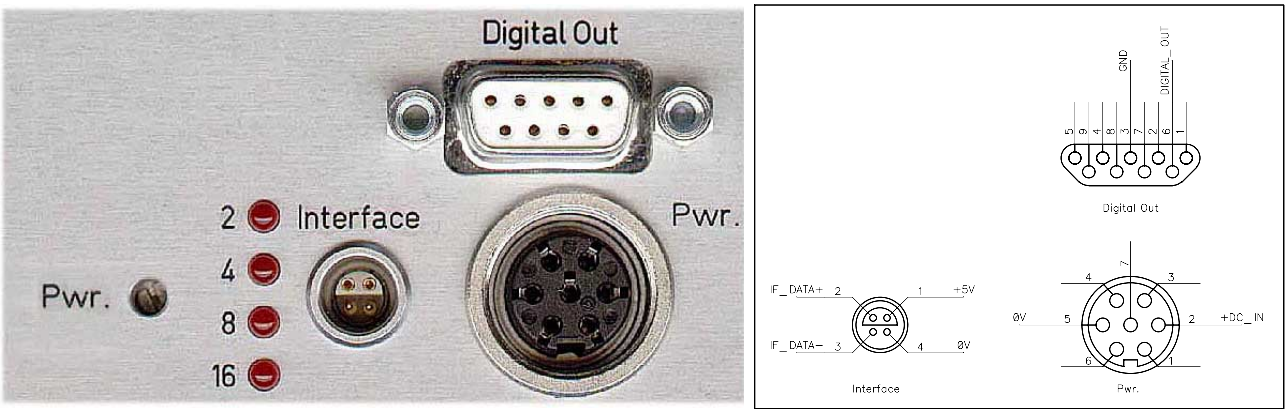


- The 16- and the 8-channel versions are absolutely equivalent with the only exception of the missing channels 9 to 16. The 4-channel versions has another mechanical construction with the main difference, that instead of 2-pole Lemosa single analog outputs and 9-pole SubD multiple outputs only 4 analog BNC outputs are implemented.



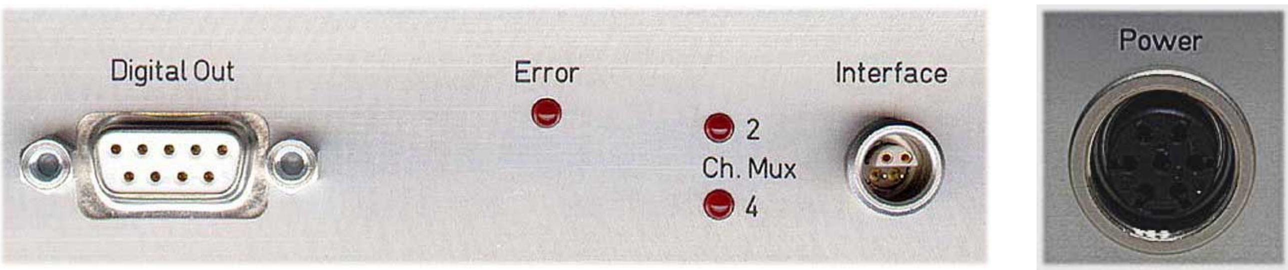
- The PCM4-DEC and PCM-DEC-D don't have a special power switch. They are powered on, as soon as the power supply is connected. Make sure that you work with the correct supply voltage with at least 10W output power. New systems are designed for DC input voltages from 10 to 30V, but the first series have a shared range from 9–18V and from 18 to 32V. In last case the valid input range is labeled beside the power connector or on the type sign.

- All PCM8/16-DEC and the PCM-DEC-D works by default with an input range from 10 to 30V DC. If the voltage is to low, the decoder don’t work properly, is it to high, the internal fuse will destroyed immediately. The pin assignment for the power connector you find in the following drawings and for the DC cable the red banana plug is plus and the other one **minus** (**black** or in older versions blue).



PCM8/16-DEC connectors, indicators and pin assignment

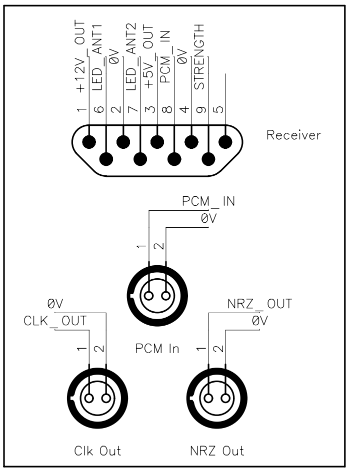
- The “Pwr.” switch of the PCM8/16-DEC on the left side has the function to power on/off the device. Use only the delivered screw driver for the switch behind the hole. The anti-clockwise stop is the power off position. If a telemetry or cable connection is realized, the „Error“ LED goes off and the selected channel mode on the transmitter side will also displayed on receiver side. Here is a selection not necessary and therefore also not possible. Depending on this channel mode, only the signals from the first 2, 4, 8 or 16 analog channels will received. For the analog decoders the current mode is indicated by an LED and for the digital one by a 2-digit display as 2, 4, 8 or 16. An transmission error will visualized additional to the „Sync“ LED with SL (Synchronization Loss).
- The analog output range for all analog decoders is fixed to ±5V.



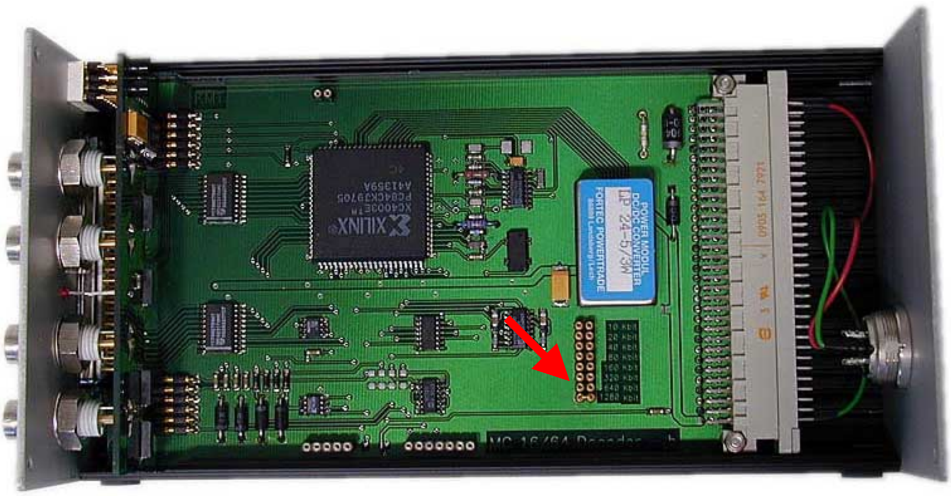
PCM4-DEC connectors and indicators (pin assignment is compatible to PCM8/16-ENC)

- The „Interface“ output is the connector to the computer using the digital interface IF16 (desktop) or ECIA100 (notebook). Normally, digital data acquisition takes place with a digital decoder on receiver side, but it works also with analog decoders. The bipolar serial output signal will converted in a 16-bit parallel IF16 compatible format inside the 37-pole SubD connector cover on the other end of the interface cable. Note, that for a digital acquisition with analog encoders and decoders the bit rate for the interface cable is set to a fixed value (160 / 320 / 640 / 1280kbit). The digital decoder has a direct parallel interface output to the IF16 or ECIA100 card.
- Any type of encoder enables the transmission of 1 additional digital channel with TTL levels using the „Digital In“ connector. This signal will reproduced on the „Digital Out“ connector on the belonging analog decoder. For the digital decoder this feature is not available. Sample rates and the resulting jitter related to the bit rate are described in chapter 1.2 section „Number of analog channels“.

- The connectors and indicators on the top are equal for all types of analog decoders. The receiver will connected via a cable with 9-pole SubD connectors and is powered from the decoder. Additional exists a „PCM In“ 2-pole Lemosa input for data transmissions via cable as described in previous chapter. The clock output „Clk Out“ together with the „NRZ Out“ are useful for parallel data storage with a high speed PCM data recorder. The LEDs on the right side are equivalent to that of the receiver and display the receiving field strength as well as the active antenna to check the correct diversity function. In standard applications these indicators are disabled, because they are visible on the receiver. They are only active for MHz receivers without diversity and in cases, where the receiver is placed near the antenna and the display is invisible.



- The connections of the digital decoder are similar to that of the analog one. Here the receiver has its own power supply and will only connected to the „PCM In“ of the decoder with a BNC cable. „PCM Out“ and „Clk Out“ are implemented for parallel data storage on a digital PCM recorder. The „Clk In“ input has no function in telemetry applications.

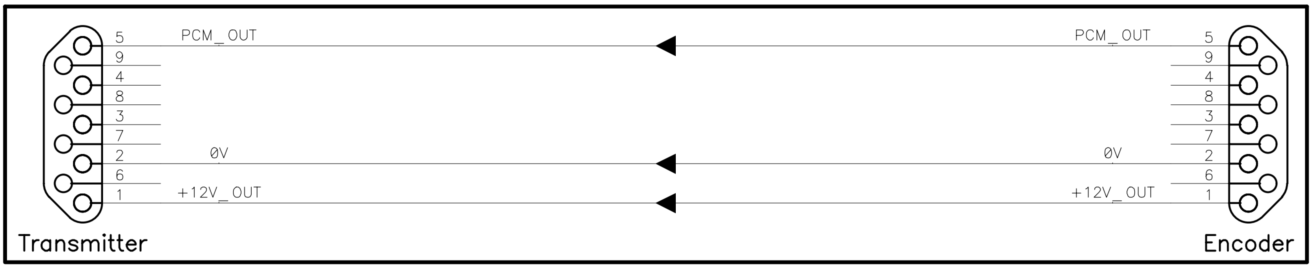


Bit rate jumpers, connectors and indicators of the digital decoder

- The changing of bit rate for all decoders is equivalent to that of the encoders.

3.3 Transmitter

- Regarding the carrier frequencies of the transmitters there exist two types, one for the TEL-MHz telemetry and one for TEL-GHz. For both systems different transmission powers are available (10/20mW, 1W, 5W by default, others on request) to adapt the telemetry to the desired transmission range in outdoor applications. Here it's very important to place the transmitter antenna on the highest possible point above ground with a line-of-sight connection to the receiver antennas, especially for GHz telemetry. All further necessary information you find in chapter 1.2.



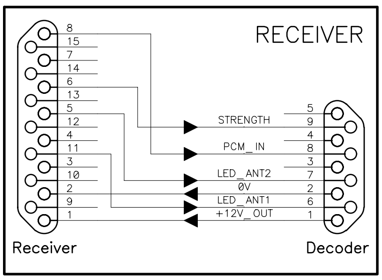
- The transmitters are designed in many different forms and packages. They are powered from the encoder with the exception of systems with 5W transmitter power, where the transmitter has an own DC input from 12 to 15V. The connection to the encoder is realized by a cable with 2m length and two female 9-pole SubD connectors.

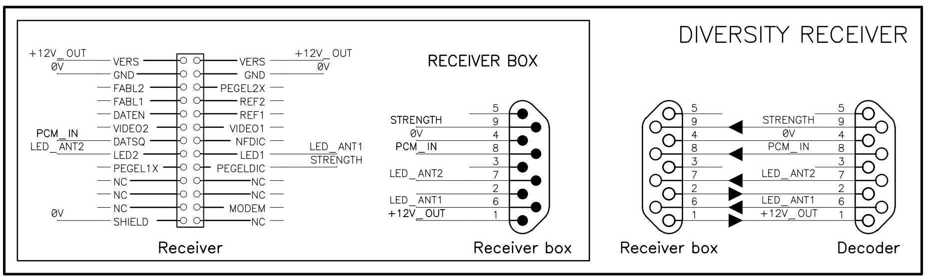
3.4 Receiver

- On the receiver side we distinguish between two general types, a single receiver (TEL-MHz-NoDiv) and the diversity receiver (TEL-MHz, TEL-GHz). The difference between the MHz and the GHz diversity is the additional 2-channel down-converter, which converts the incoming GHz modulated signal to a carrier frequency of 21MHz. The "RF Level" bar graph displays the received field strength and is useful for optimizing the antenna positions.

Connectors and indicators of the GHz converter and the diversity receiver

- The receivers will powered from the decoder with the exception of systems with a digital decoder, where the receiver has an own DC input from 12 to 15V. The connection to the decoder is realized by a cable with 2m length and two female SubD connectors or in case of using a digital decoder via a 2-pole Lemosa to BNC cable from "TTL Out" to "PCM In".





4 Periphery

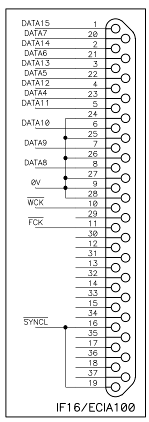
4.1 PCM-Recorder

- The small and rugged DA-PCM HS has been specially designed for data acquisition in PCM telemetry applications. It records the digital PCM bit stream from one system on transmitter or receiver side using the “PCM Out” (for decoder “NRZ Out”) and “Clk Out” connectors. The analog measured data may be reproduced by injecting the replayed bit stream into the “PCM In” connector of the decoder.

- Two variants exist, one for bit rates from 80 to 640kbit/s and a second for 1280kbit. The maximum recording capacity is approximately three hours. An additional voice channel is useful for acoustical comments during measurement. See user manual of DA-PCM HS for further information.

4.2 PC Link

- The serial bipolar bit stream from the “Interface” output of the analog encoder and decoder will converted in the plug cover of the 37-pole SubD connector in a 12 bit parallel format, which is compatible with the “Interface” output of the digital decoder. For this standard output two types of digital interfaces are available for transferring the data into the PC. These are the ECIA100 for PCMCIA slots in notebooks and the IF16 for ISA slots in desktop computers.
- All further data processing is performed by the convenient µEdition software for Win95/98/NT. The program modules µLab and µGraph use the full 32bit qualities of these operating systems for real-time data storage on hard disk, online visualization and calculations as well as evaluation and analysis (see also next two chapters).



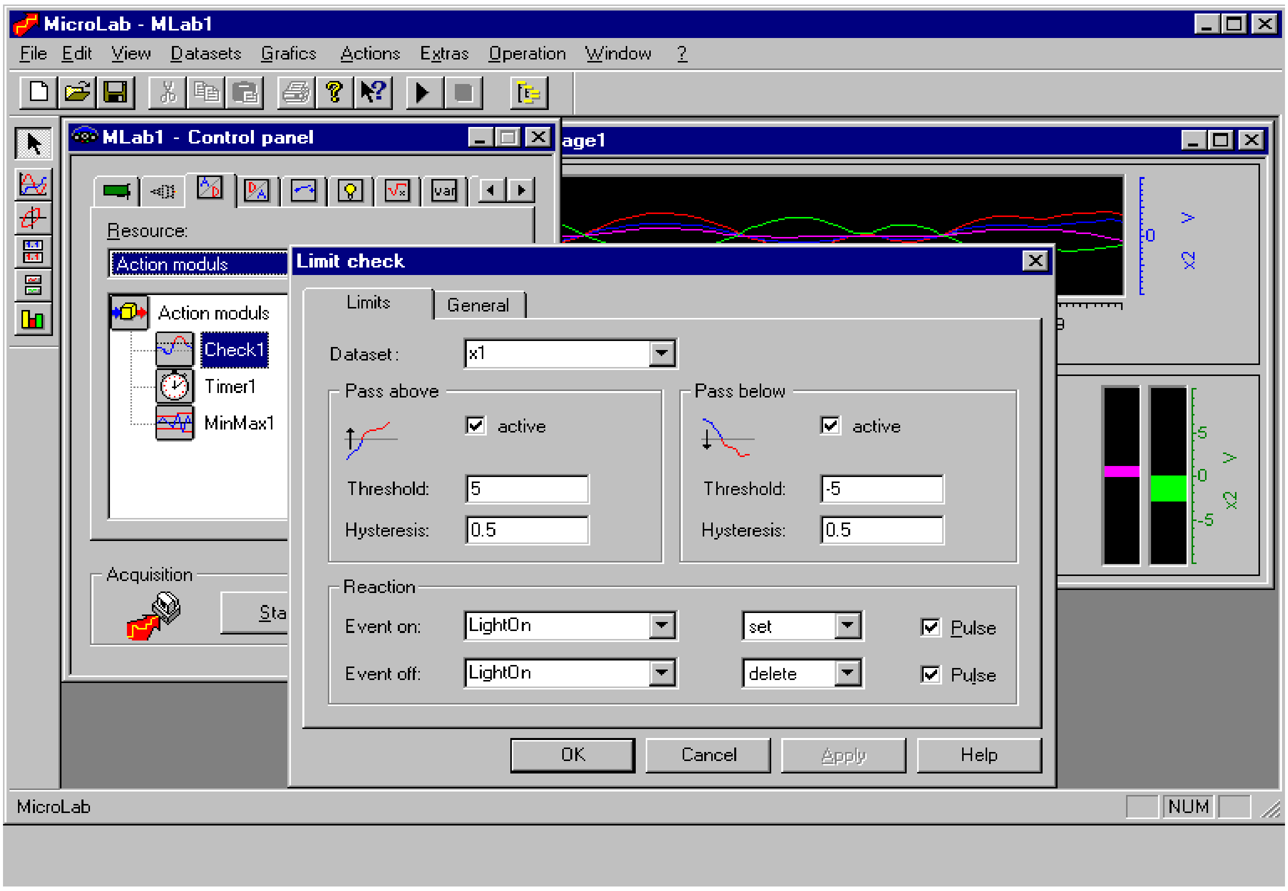
Digital interface IF16 for ISA slots in desktop computers, cable for analog decoders and pin assignment

- Don't forget, that the digital interface cables for analog encoders and decoders are set to a specified fixed bitrate of 160, 320, 640 or 1280kbit/s.

Digital interface ECIA100 for PCMCIA slots in notebook computers with cable (pin assignment equal to IF16)

4.3 Data Acquisition with µLab

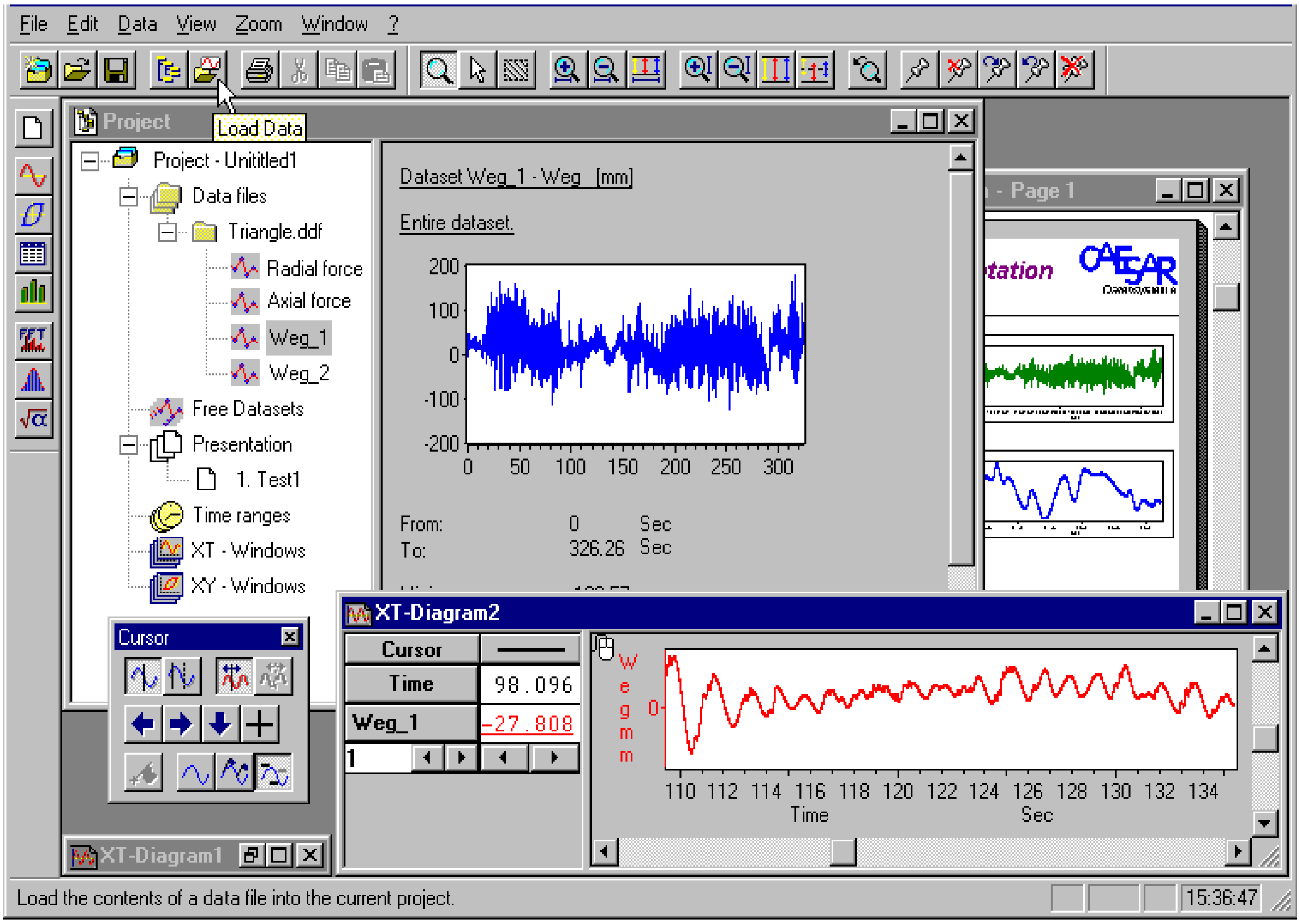
- µLab enables the analog measured data to be acquired, processed online, saved and displayed again. Even the basic µLab version contains a wide range of trigger functions and action modules for limit surveillance, time control, data reduction and various smoothing algorithms. Each channel can be calibrated either linearly or non-linearly.



- By means of the online graphics, an unlimited number of graphical objects can be displayed simultaneously, e.g. xt-diagram (incl. scroll and scope mode), xy-diagram, bar graph, numerical display or text switch. The properties, e.g. axis scaling, color, text fonts, can be defined separately for each individual object. The functionality of the basic version can be extended, if desired, with the help of additional modules, e.g. for online computation, DIN and Rainflow classification, frequency analysis and signal generation. For detailed description see the µLab tutorial.

4.4 Data Analysis with µGraph

- µGraph is a flexible, graphical analysis program for all kinds of measured data. It combines the following functions: quick-look, interactive processing, data management, presentation graphics, statistics, formula generator and, optionally, frequency and bin analysis in a user interface, which is particularly intuitive and easy to use. The analysis is carried out simply by dragging the marked data sets and dropping to the corresponding button in a toolbar , e.g. for printing or FFT calculations.



- A special highlight is the incredibly fast quick-look function, which enables the largest data sets to be displayed in a fraction of a second - simply click on the data set name and even several megabytes of measured data appear at once on the screen without any noticeable delay together with the most important statistical parameters. The quick-look has even more to offer. With the help of the mouse, any particular data set can be marked and either printed or displayed in the interactive cursor mode. Here a wide range of functions are available, e.g. line, crosshair and difference cursor, zooming, scrolling, marking and labeling. While scrolling through long sequences of data, bookmarks can be set, so that points of particular interest can easily be found again. Each data set can be displayed in a xt-diagram, xy-diagram, bar diagram or table with manual or automatic scaling. The flexible presentation graphics in µGraph enables records and reports to be freely defined. Together with standard functions for drawing and labeling, the OLE interface makes it possible to include objects from other Windows programs (e.g. Excel or Word). A report that has been designed once can be stored as a template and used again when required simply by clicking a button. For detailed description see the µGraph reference manual.

5 Specifications

Encoder	Type			PCM4-ENC		PCM8-ENC	PCM16-ENC
	Analog inputs	Number		4		8	16
		Channel mode		2, 4		2, 4, 8	2, 4, 8, 16
		Input range		±5V (±10V)			
		Input impedance		100kΩ			
		Antialiasing filter		8^{th}-pole Butterworth low pass			
		Simultaneous sample & hold		X			
	Digital input	Number		1			
		Input signal		TTL			
	Power supply	Input voltage		10-30V DC (9-18V or 18-32V)		10-30V DC	
		Consumption		<4W		<8W	<10W
				without Transmitter			
	Digital interface	IF16 ISA board		X			
		ECIA100 PCMCIA card		X			
		Bitrate		160, 320, 640, 1280 kbit/s fixed			
	Dimensions			150x90x70mm		150x90x85mm	150x90x85mm
	Weight			≈800g		≈1000g	≈1100g
Decoder	Type			PCM4-DEC	PCM8-DEC	PCM16-DEC	PCM-DEC-D
	Analog Outputs	Number		4	8	16	-
		Channel mode		2, 4	2, 4, 8	2, 4, 8, 16	-
		Output range		±5V			-
		Output impedance		2Ω, 10mA			-
		Smoothing filter		8^{th}-pole Butterworth low pass			-
	Digital output	Number		1			-
		Output signal		TTL			-
	Power supply	Input voltage		10-30V DC (9-18V or 18-32V)	10-30V DC		
		Consumption		<4W	<8W	<10W	<1W
				without Receiver			
	Digital interface	IF16 ISA board		X			
		ECIA100 PCMCIA card		X			
		Bitrate		160, 320, 640 or 1280 kbit/s			
				fixed			with jumper
	Dimensions			150x90x70mm	150x90x85mm	150x90x85mm	210x65x110mm
	Weight			≈800g	≈1000g	≈1100g	≈900g
Transmitter/ receiver	Type			TEL-MHz		TEL-GHz	
	Supported bitrate			160 / 320kbit		160 / 320 / 640 / 1280kbit	
	Wave length			70cm		12,5cm	
	Frequency range			433,15MHz – 434,65MHz		2,400 – 2,483GHz	
	Transmission range	10mW transmitter power		≈300m		-	
		20mW transmitter power		-		≈500m	
		1W transmitter power		≈1000m			
		5W transmitter power		≈2000m			
	Converter			-		X	
	Single receiver			X		-	
	Diversity			X			
Data conversion	Resolution			12bit			
	Dynamic range			72dB			
	Signal to noise ratio (SNR)			≈70dB			
	System accuracy			0,2% at 0Hz			
Sample rates	Analog channels	System bit rate		160kbit/s	320kbit/s	640kbit/s	1280kbit/s
		Total sample rate		10kS/s	20kS/s	40kS/s	80kS/s
		Channel sample rate	2-channel mode	5kS/s	10kS/s	20kS/s	40kS/s
			4-channel mode	2,5kS/s	5kS/s	10kS/s	20kS/s
			8-channel mode	1,25kS/s	2,5kS/s	5kS/s	10kS/s
			16-channel mode	625S/s	1,25kS/s	2,5kS/s	5kS/s
		Channel band-width	2-channel mode	1,6kHz	3,2kHz	6,4kHz	12,8kHz
			4-channel mode	800Hz	1,6kHz	3,2kHz	6,4kHz
			8-channel mode	400Hz	800Hz	1,6kHz	3,2kHz
			16-channel mode	200Hz	400Hz	800Hz	1,6kHz
		Channel time delay	2-channel mode	1,4ms	0,7ms	0,35ms	0,175ms
			4-channel mode	2,8ms	1,4ms	0,7ms	0,35ms
			8-channel mode	5,6ms	2,8ms	1,4ms	0,7ms
			16-channel mode	11,2ms	5,6ms	2,8ms	1,4ms
		Required transmitter/ receiver pair		TEL-MHz, TEL-GHz	TEL-MHz, TEL-GHz	TEL-GHz	TEL-GHz
	Digital channel	Digital sample rate		10kS/s	20kS/s	40kS/s	80kS/s
		Jitter		100µs	50µs	25µs	12.5µs

PCM recorder	**Type**		**DA-PCM HS**
	Bit rate		80 – 640kbit or 1280kbit
	Digital inputs		TTL, 100kΩ
	Digital outputs		TTL, 10Ω, 10mA
	Remaining jitter		< 1%
	Voice channel		8bit, 400 – 3000Hz
	Power supply	**Input voltage**	10-30V DC (older Versions 9-18V or 18-32V)
		Consumption	<8W
	Recording time		max. 3h
	Error correction		double encoded Reed-Solomon
	Bit error		$< 10^{-10}$
	Dimensions		160x90x75mm
	Weight		≈1000g
Environment conditions	**Types**		**All components**
	Operating temperature range		-5 °C to +45 °C
	Storage temperature range		-20 °C to +60 °C
	Humidity		20 - 80% non condensed
	Vibration		5g Mil Standard 810C, Curve C
	Shock		10g in all directions

- Technical specifications are subject to change without notice !