



DISCLAIMER

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These VIs are freely downloadable from our WEB site at www.picowatt.fi.

NOTE: Oscilloscope photos for the following text were taken at time, when the computer used DOS operating system, and therefore the delays are short. The minimum predictable delay that Windows offers is 1ms.

2. PICOBUS PROTOCOL

2.1. GENERAL

Picobus is a protocol for simultaneous reading and writing of binary strings to and from shift registers of arbitrary length. It uses four signal lines, one for transmitted bits, one for received bits, one for clock signal, which is common for the transmitted and received data. Picobus includes also a service-request-type signal line, which the instrument can use to indicate that it should be contacted by the controlling computer.

The signals have the following names and abbreviations:

- Clock (CL) is output from the computer
- Data from Computer (DC) is output from the computer
- Data from Instrument (DI) is input to the computer
- Alarm (AL) is input to the computer.

Picobus was initially designed to facilitate interfacing of one or more analog instruments with a PC computer using its RS-232 serial port. Because analog instruments have no intelligence, Picobus was designed to be synchronous, instead of being asynchronous like the RS232.

At least three wires are usually needed for sending data synchronously: clock, data and a strobe, which indicates that sending is complete. While a full Com: communications port has several signal inputs suitable for synchronous operation, it has only two handshake outputs DTR and RTS. It means that there is no line available for strobe. Picobus protocol solves this by using a special strobe condition, where clock is held at zero while the data toggles between 1 and 0. Only a couple of cycles are needed for reliable detection of the strobe condition. A strobe signal is generated and data in shift registers is stored to memories or latches. This is the first of the three important features of Picobus.

At the time when Picobus was designed, around 1990, the serial ports of a PC were at premium. The Picobus was designed to include an address, so that more than one instrument, similar or dissimilar, could use one and the same Picobus cable. This was made by preceding the actual data string by an 8-bit address string. The instrument compares the received address string with its own preset address and, if they are equal, opens gates for coming and leaving data. Due to technical reasons, the maximum number of instruments is limited to 15. This feature has found very little use between instruments, whereas inside some of our instruments like the PLM-5 different modules have had their own Picobus addresses. Because of this addressing facility, Picobus has the letters "bus" in its name.



The Alarm (AL) signal line is used e.g. to indicate that an A/D conversion is complete and the result can be read. According to the original idea, the AL outputs of all instruments are wire-OR'ed and the PC should make a rapid poll in order to find out the reason for alarm. The existence of the AL signal line is the third important feature of Picobus.

These four signal lines are also made available by a USB-232 converter having full hardware handshaking capability.

2.2. PICOBUS SIGNALS AND PICOBUS CABLE

The Picobus cable must have at least five wires surrounded by a shielding jacket. It is wired as below:

Computer end DE9S ¹⁾		AVS-47B end DB25P	
Pin	RS232 signal	Pin	Picobus signal
Not connected		1	SHIELD ²⁾
7	RTS	4	CP Clock pulse
8	CTS	5	DI Data from Instrument
6	DSR	6	AL Alarm Status Line
5	GND	7	GND Signal Ground
4	DTR	20	DC Data from Computer

1) The Picobus cable supplied with the AVS-47B has 25-pin connectors in both ends in order to be compatible with the AVS47-IB GPIB converter box. A 25-to-9 pin adapter (Farnell part number 152861) is supplied for connection to a PC's serial port or to a USB-232 converter (National Instruments part No. 778472-01).

2) The cable shield is connected to pin 1 using a piece of wire. The shield must not touch the metal parts of the connector, or optical isolation is lost. The shield is connected to the metal parts of the connector at the computer end (and so connected to computer chassis) but it has been left floating at the bridge end in order to prevent ground loops. If you need to connect the shield to bridge ground, move the short grounding wire from connector J201 to J202 (circuit board E). In any case, the shield must be grounded somewhere.

The RS232 names of the corresponding signals are: CP=RTS=Ready To Send, DC=DTR=Data Terminal Ready, DI=CTS=Clear To Send and AL=DSR=Data Set Ready. The RS232 names are here only for help, if you want to monitor the Picobus operation with an RS232 tester.

The CP and DC lines are outputs from the PC and they are found in the **Modem Control Register** of the corresponding COM port. The DI and AL lines are inputs to the PC and they exist in the **Modem Status Register**.

The four Picobus lines are **optically isolated** from the bridge. In default configuration, the shielding jacket of the standard Picobus cable is not connected to the bridge in order to avoid ground currents. If possible, connect the jacket to the conducting wall of the shielded cryostat

room at the entering point. Do it mechanically, not by soldering.

2.3. TRANSACTIONS

Communications via Picobus are based on “**transactions**”. One transaction consists of sending all setup information from the PC to the bridge and of reading the full setup of the bridge plus the result of the most recent A/D conversion from the bridge to the computer. Because these two things happen at the same time, the response from the bridge indicates the old state, that was effective *just before* the transaction. Information is sent via the Picobus signal lines as high and low voltage levels, corresponding to bit values of ones and zeros. As the number of bits is rather high, 48 in case of the AVS-47B, the bit stream is more conveniently understood as a string of 48 characters (“0” or “1”) than as a 48-bit binary number.

A transaction consists of four parts:

- 1) Send the **Picobus Address (PBA)** from the PC to the AVS-47B. The address string consists of 8 bits. PBA can range from 1 to 15. AVS-47B factory default is 1, and all resistance bridges have been originally set for this PBA (if there is only one bridge connected to the computer, the address should not be changed). The address is determined by a DIP switch on the “AVS47E” circuit board.
- 2) **Strobe the address.** Strobing tells to the AVS-47B that the computer has sent all the 8 address bits. If the received PBA is the same as the DIP switch address of the bridge, input and output ports of the AVS-47B primary interface are opened for receiving and transmitting the actual data. If the PBA is not recognized, the ports remain closed. No Picobus traffic whatsoever can then reach the bridge, and all bits that one may try to read out from it will be zeros.
- 3) **Send the data and read the response.** The configuration data is sent as a 48 bit long string, called “**TXSTR**” (transmitted string), and the received data is an 48 bit long string called “**RXSTR**” (received string or response string).
 - TXSTR contains, in addition to the complete setup data, also the digital REFERENCE setting for the ΔR difference amplifier.
 - RXSTR contains, in addition to the old complete setup data, the result of the latest A/D conversion in BCD format.
- 4) **Strobe the data.** Strobe condition tells to the AVS-47B that all 48 data bits have been transmitted to the



instrument and all 48 data bits have been received from the instrument. Strobe closes the input and output ports of the bridge, and they remain closed until the next time when a valid PBA is recognized. The strobe condition generates a strobe signal, which is used to enter and save the setup data in latches.

- The new configuration comes into effect as soon as data has been strobed.
- The just received data (RXSTR) reflects the instrument state before the transaction.

2.4. PICOBUS WAVEFORMS

The five oscilloscope screenshots show, how the various signals on the Picobus look like.

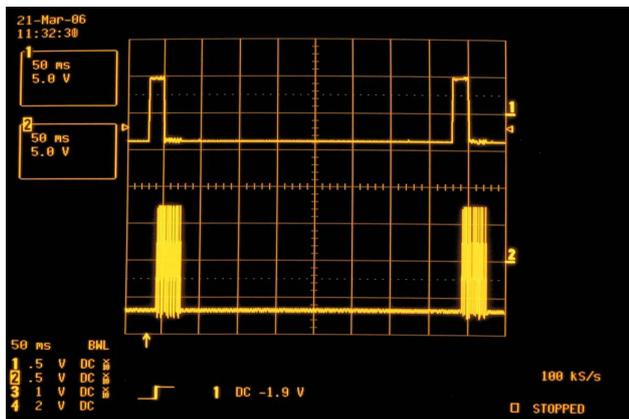


Fig. 1: When an A/D-conversion completes, the AVS-47B asserts the AL signal (trace 1). After about 10ms, transactions with the bridge starts (trace 2). The time interval between two successive transactions in synchronized mode is 0.4 seconds, which is the A/D conversion rate.

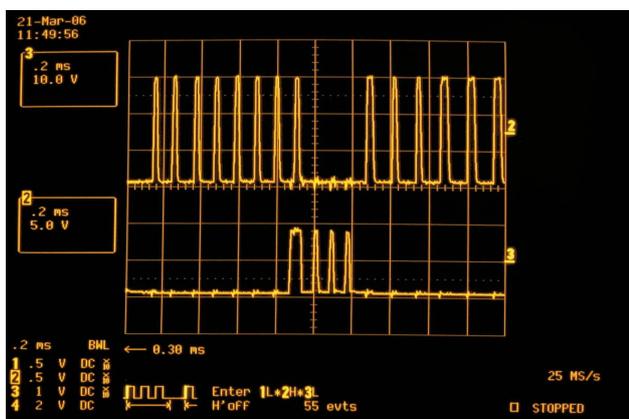


Fig. 2: A transaction starts by sending the address. Trace 1 shows the eight clock (CP) pulses. The 8th pulse from left is for the least significant bit LSB of the address. The default AVS-47B address is 1, so data (trace 2=DC) goes from 0 to 1 before the clock pulse. A strobe condition is implemented by keeping CP down and toggling DC for 3 cycles.

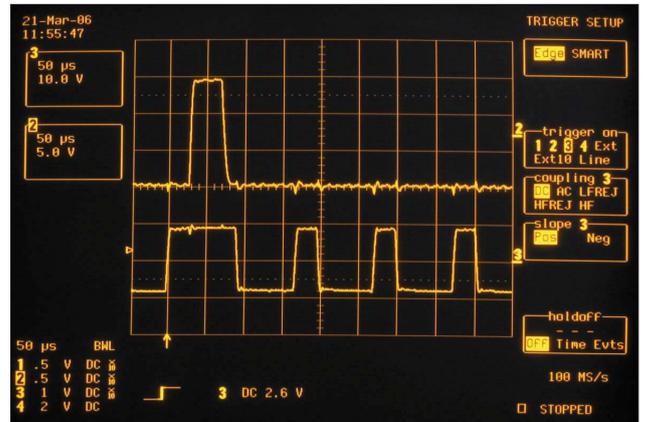


Fig. 3: Magnified view of the 8th clock pulse for Picobus address and the data bit for PBA=1. Note the delays from the rising edge of the data to the rising (clocking) edge of the CP signal. The CP is high for 1ms (Windows) before going down. Then the “strobe condition” follows, where clock is held down while data toggles. Generally there are always 1ms delays between changes in clock and data.

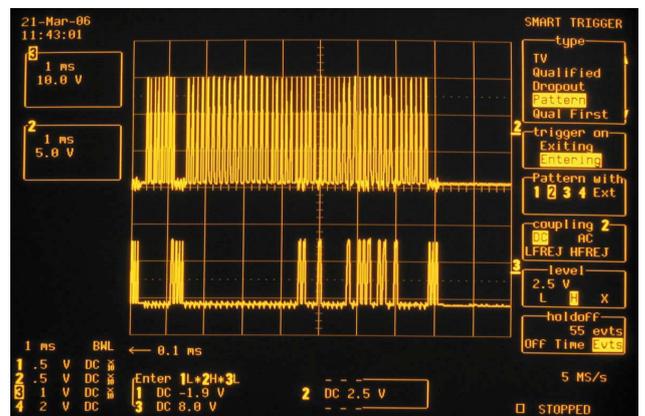


Fig. 4: One complete transaction consist of 8 CP pulses for clocking the Picobus Address (PBA) and of 48 clock pulses for clocking in the configuration data. Trace 2 shows the clock pulses and trace 3 is the data from computer (DC). It shows 4 pulses after address (one for address=1 and three for strobing). The transaction ends with three strobing DC pulses after the data string.