

VME-BASED REMOTE INSTRUMENT CONTROL WITHOUT GROUND LOOPS

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Abstract

New electronics has been developed for the remote control of the pick-up electrodes at the CERN Proton Synchrotron (PS). Communication between VME-based control computers and remote equipment is via full duplex point-to-point digital data links. Data are sent and received in serial format over simple twisted pairs at a rate of 1 Mbit/s, for distances of up to 300 m. Coupling transformers are used to avoid ground loops.

The link hardware consists of a general-purpose VME-module, the 'TRX' (transceiver), containing four FIFO-buffered communication channels, and a dedicated control card for each remote station. Remote transceiver electronics is simple enough not to require micro-controllers or processors. Currently, some sixty pick-up stations of various types, all over the PS Complex (accelerators and associated beam transfer lines) are equipped with the new system.

Even though the TRX was designed primarily for communication with pick-up electronics, it could also be used for other purposes, for example to form a local area network.

1. INTRODUCTION

The CERN 26 GeV Proton Synchrotron accelerates several types of particles, with beam intensities varying widely on a cycle-to-cycle basis. The PS and its beam transfer lines are equipped with a number of electrostatic pick-ups (PUs) [1], to measure the trajectory of the particle beams. The PU electronics consists of variable gain amplifiers, switched attenuators, and some relays to apply test and calibration signals. A VME-based micro-computer is in charge of transmitting the settings for each individual PU, prior to each 1.2 s accelerating cycle of the PS. These settings, different for every PU, are the result of a calibration procedure.

2. CONSTRAINTS

The controlling microcomputer is located at the centre of the accelerator and the PU electronics chassis are near to the ring. Every chassis contains three variable gain amplifiers, one each for the sum, the horizontal and the vertical signal. A cable of some 150 m length, carrying power supply and control signals, connects each chassis to the central processor. Separate sets of three

coaxial cables take the amplified analogue signals to the acquisition system, also at the PS centre.

Due to the sensitive analogue signal processing, a direct galvanic connection from chassis to computer is unacceptable. Past experience has shown that opto-couplers quickly deteriorate under radiation. Transformer coupling is an attractive solution. Modulation removes the DC components from the serial data stream, to avoid saturating the transformers. The adoption of a serial transmission protocol seems a natural choice to reduce the amount of hardware required.

Data are sent over two twisted pairs of wire, one pair for each direction. The signal levels correspond to the RS422/RS485 standard. Transformer coupling, combined with differential transmission, provides excellent immunity to interference (Fig. 1).

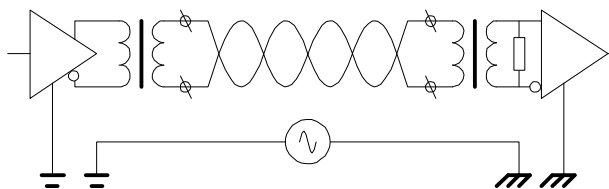


Fig. 1: Differential transmission and transformer coupling rejects common-mode interference.

3. THE DATA TRANSCEIVER (TRX)

A survey of commercial serial data transmission devices showed a void between the simple and very high speed communication links, like AMD's TAXIchip [2], the slow and fairly complex UARTs, and the very complex networking chips commonly used in computer systems. The TAXIchip is too fast to be of use over any significant length of twisted pair cable. UARTs require a microcomputer or controller at both ends of the link. And networking chips are more complicated still than UARTs.

Therefore, we designed the TRX data transceiver [3]. The TRX employs a serial protocol at an effective rate slightly below 1 Mbit/s, sending and receiving 16-bit words over more than 300 m of cheap twisted pair cable. The core of the design takes the form of a set of equations to be burnt into a PLD. A dedicated circuit, the MAD85 from Data Delay Devices [4], takes care of demodulation and clock recovery (Fig. 2).

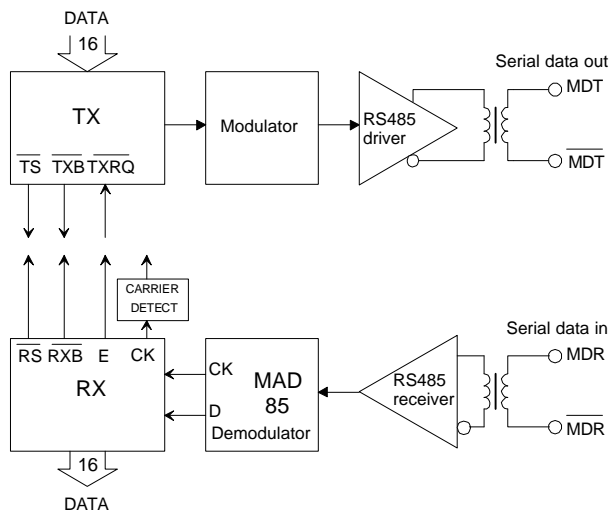


Fig. 2: Transceiver (TRX) block diagram.

The TRX uses an isochronous serial protocol [5]. Data are sent in frames, consisting of one or more consecutive words. A word consists of a start bit, 16 data bits, even parity and a stop bit. No assumptions have been made about the semantics of the data exchanged.

Interfacing to the TRX is extremely simple. Received words are made available on a 16-bit parallel bus (Fig. 3). A receive-strobe signals the presence of valid data. The timing is very relaxed and data can be latched or clocked at the trailing edge of the strobe. Transmission is started by activating a transmit request line. A transmit-strobe then invites devices to apply data to the parallel bus for transmission. Data are accepted at the trailing edge of the strobe. Two status lines indicate when the receiver or the transmitter are busy. The receiver also provides a carrier-detect and an error flag.

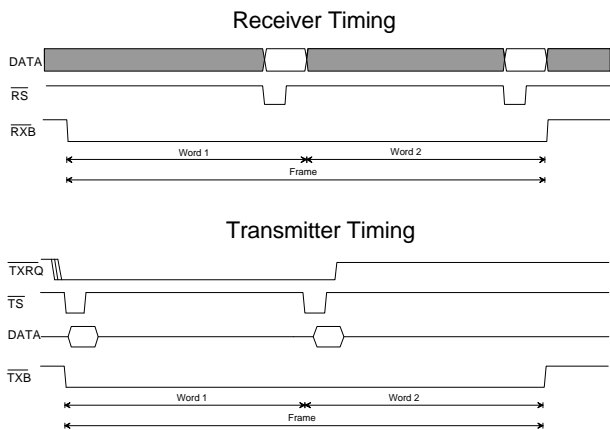


Fig. 3: VMETRX interface.

4. THE VMETRX MODULE

A VMEbus [6] compatible module has been designed (Figs. 4 & 5), which fits 4 bi-directional TRX channels on a single card. It is able to simultaneously transmit and receive data at full speed. To relieve the host processor

from having to keep up with the data rate of the TRX proper, receivers and transmitters are buffered by 256-word FIFOs. The VMETRX can be programmed to generate interrupts upon reception or transmission of a frame of data. The interrupt level and vector are set by writing into the appropriate internal registers and are common to all 4 channels on the board. Each channel can be accessed through two registers in the VME short-I/O addressing space. The serial line connections are brought out on the P2 connectors at the rear of the VME crate.

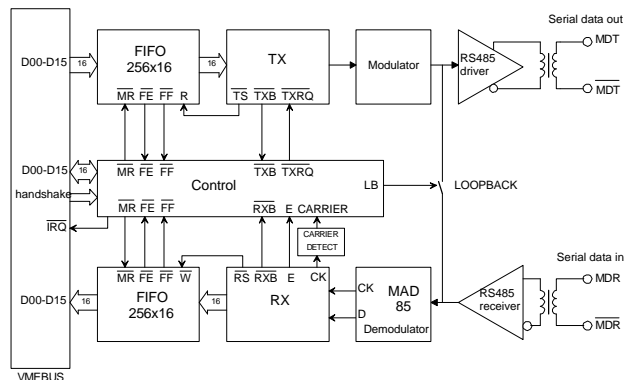


Fig. 4: VMETRX structure (one channel).

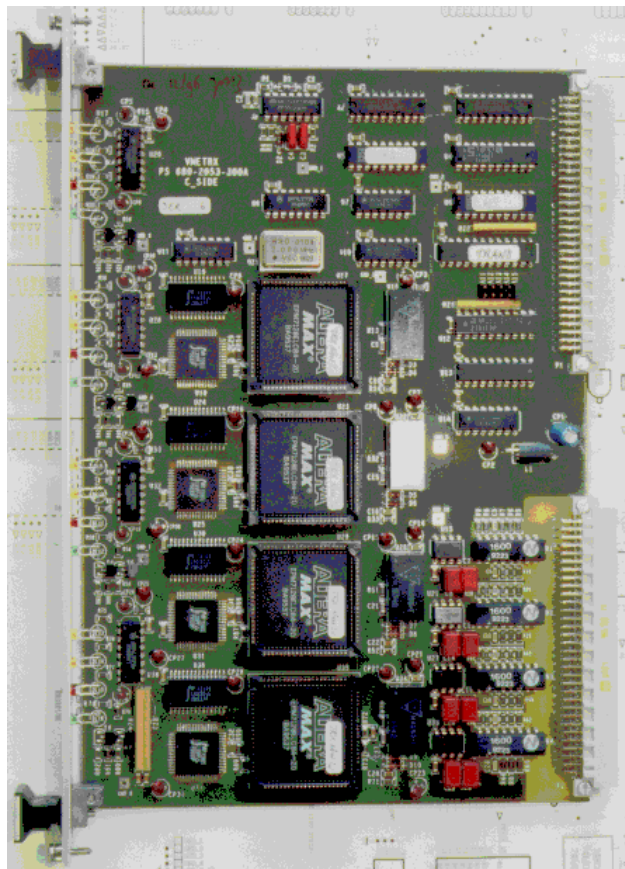


Fig. 5: VMETRX module.

At present, the VMETRX is used to communicate with some 60 PUs around the PS complex. Some C-language routines were written to interface the VMETRX to higher level software.

5. THE PICK-UP CHASSIS

A variant of the TRX is used in the control circuit of the PU preamplifier chassis (Fig. 6), in the PS ring. This version is somewhat stripped down. It doesn't use FIFOs because the surrounding hardware is fast enough to keep up. It also doesn't need to be able to simultaneously transmit and receive data. It interprets a field in each word of a command frame as an address and distributes the data over a number of internal registers accordingly. The registers correspond to DACs and relay drivers, which set the amplifier gain, attenuators and test relays. There are no restrictions on the order or number of words in a command frame.

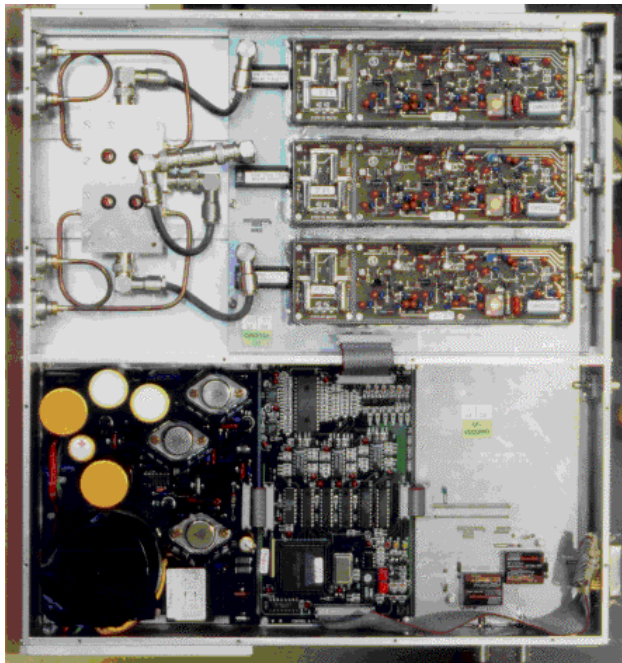


Fig. 6: PU preamplifier chassis.

6. CONTROL AND DIAGNOSTICS

The chassis control card contains a state machine which collects diagnostic data from the PU hardware and transmits a message to the controller. Every command frame will trigger this state machine. A diagnostic frame is a sequence of 16-bit words, similar in structure to a

command frame. A field in each word determines its meaning. Information returned includes the values of power supply and gain control voltages, the states of attenuator and test relays, and the chassis temperature.

The TRX, the decoding logic and the state machine fit in a single Altera EPM7064 PLD.

7. CONCLUSION

The TRX hardware design carefully avoids any application specific details. It simply sends frames of 16-bit words from one point to another. It can easily serve as a medium to build data communication networks. The hardware basically implements distinct bi-directional point-to-point links. A layer of software, committing a few words in each frame to routing information, could make a collection of point-to-point links appear as a network of any desired topology. Ring, tree and star structures can readily be built.

8. ACKNOWLEDGEMENTS

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