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Author: Henrik Johansen

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RC Circuit Reference Manual

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Preface

The RC Circuit is designed as a terminal network for VDU terminals connected to a cluster controller or Host computer. It is a medium speed communication network with a theoretical bit rate of 250 kbits/sec. It utilizes simple telephone signal cable in a multidrop configuration with up to 33 devices on a 1000 m wide line.

The protocol is block oriented for the RC Circuit I whereas it is character oriented for the RC Circuit II.

In the following the physical, electrical and logical levels are described covering both RC Circuit I and - II. Further the protocol of the RC Circuit II is described. For information on the RC Circuit I protocol please refer to "CIRCUIT Protocol Reference Manual" RCSL no. 31-D598, Klaus Hansen, April 1980.

History

The acronym CIRCUIT is an abbreviation for: Communications Interface for RC Unified Interconnection of Terminals. The development of the first parts of RC Circuit started in 1979 and is in the Reference Manual from 1980 quoted to be "utilizing a fast two wire short distance line". In this early stage only RC Circuit I existed as an interconnect between up to 8 RC850 terminals with one acting as a master and the others as slaves. It was also able to interface to the RC3502. Later the RC890 series was developed giving a possibility to connect up to 32 terminals and the short distance was in some locations interpreted to be 1500 m. The RC3900 was developed leading to the RC39 making a need to extend the existing RC Circuit network with the possibility to make a character oriented communications where the RC Circuit I was block oriented (HDLC). So the RC Circuit II was developed in the late 1983 leading to the revision of the RC Circuit which is used up till today.

Unfortunately the extensions from 8 to 33 devices in a network and from a short distance to 1500 m wide was made without the necessary investigations and precautions. Only recently the fundamental parts of RC Circuit has been reconsidered leading to severe corrections in both the physical and electrical levels as well as improvements in the protocol handlers. The following is based upon the latest investigations of the RC Circuit.

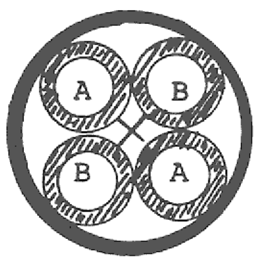
1. Physical Level

1.1 Transmission media

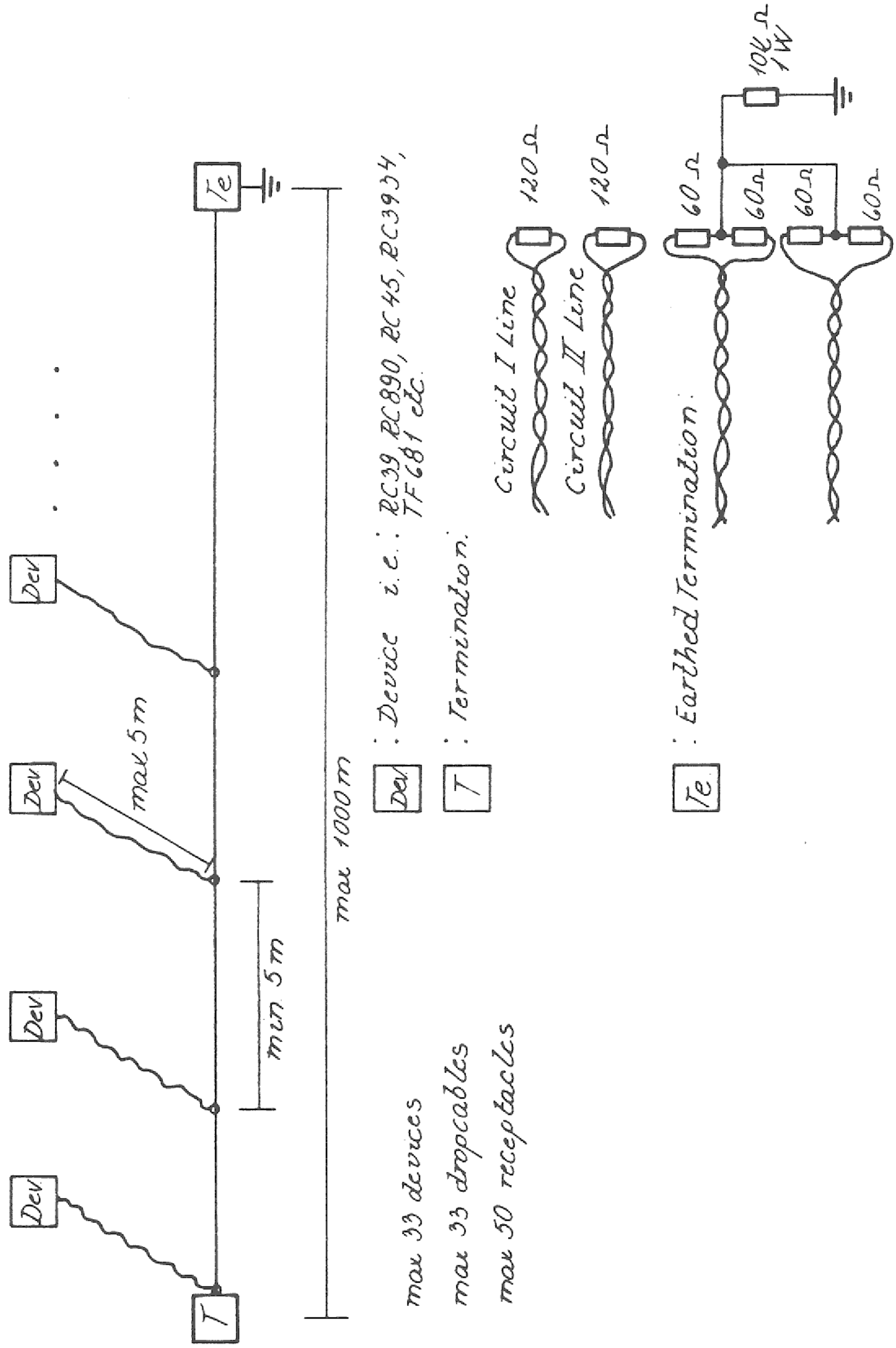
The RC Circuit transmission media is a four wire standard telephone signal cable with the following characteristics

Dimensions	2x2xØ0,6 mm
Resistance	65 ohms/km
Capacitance	90 pF/m
Characteristic Impedance	120 ohms
Twists per m.	~~2,5~~ 25

The above listed characteristics is taken from the RC recommended NEK 3002 which is a quadruple twisted type cable. Special attention must be paid to the characteristic impedance Z which is normally not listed in the data from the manufacturer for theese telephone type cables. A mismatch in the impedance in a circuit line segment may lead to incontrolable reflections on the line. Distinguishing pairs in a twisted pair cable should make no problem whereas it must be remembered that when using the quadruple twisted type cable, wires diagonally to each other is regarded as a pair.



Distinguishing pairs in a quadruple twisted cable.



RC Circuit Line Segment Config

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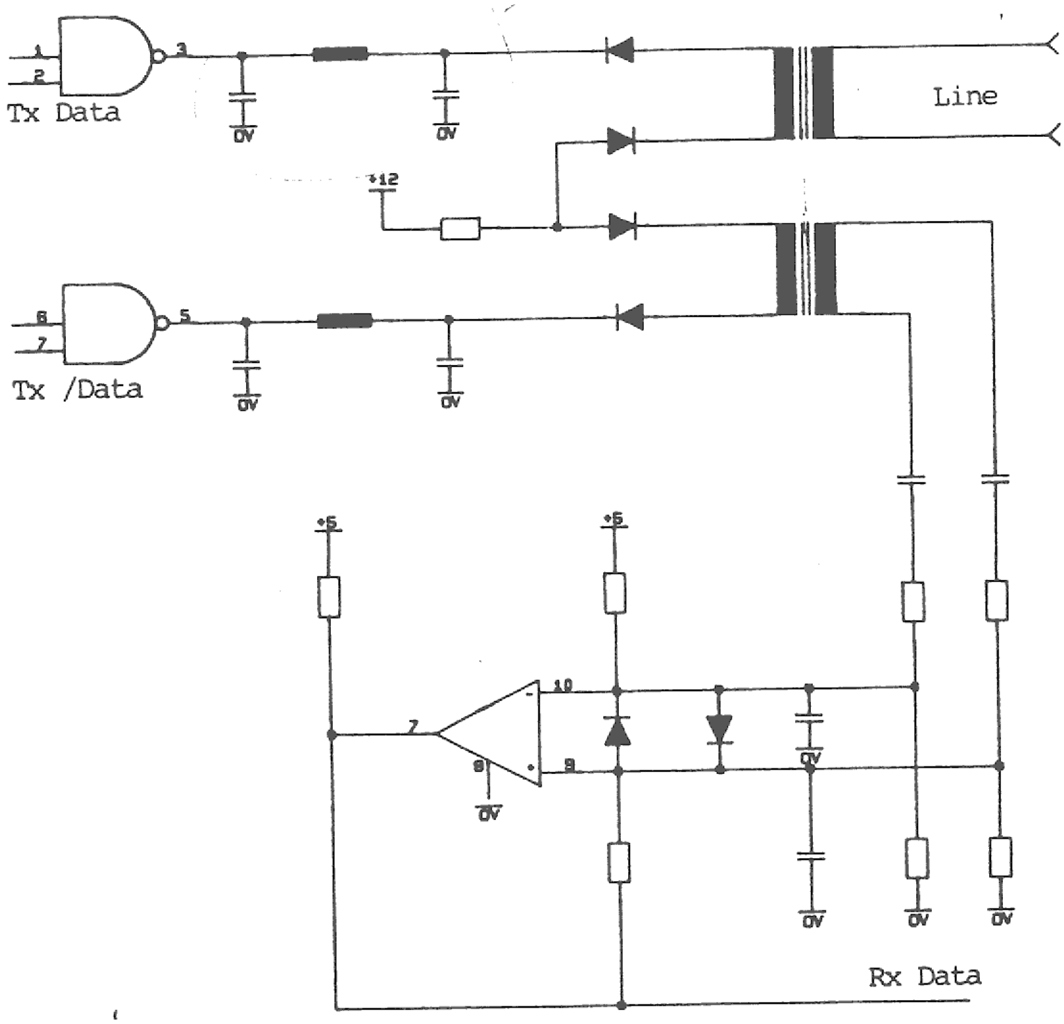
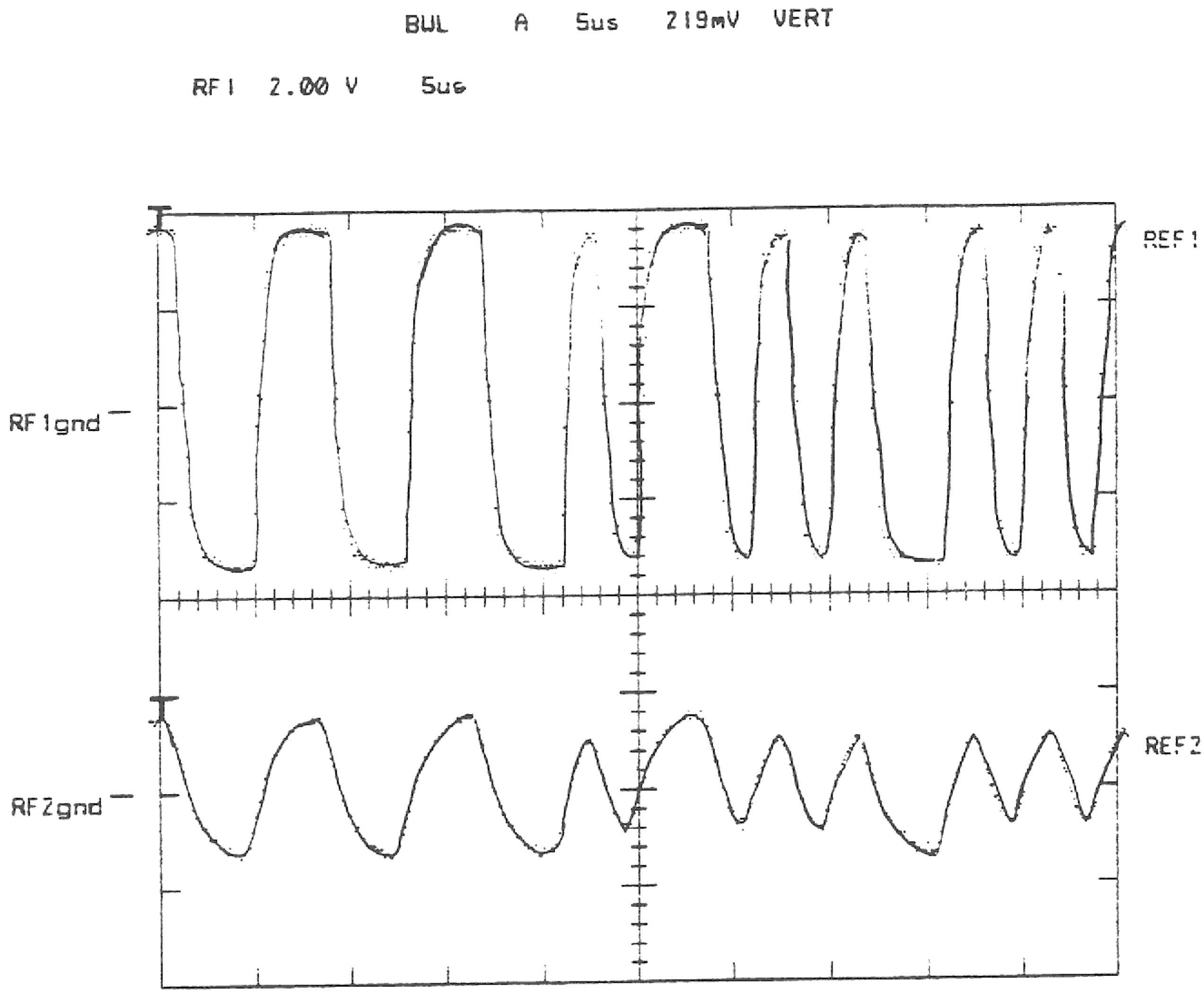
2. Electrical level

The information on the RC Circuit is transmited on the physical line as square pulses of two frequencies, 125 kHz and 250 kHz. On the RC Circuit II transmission a special start pulse with a frequency of 82,5 kHz is also used.



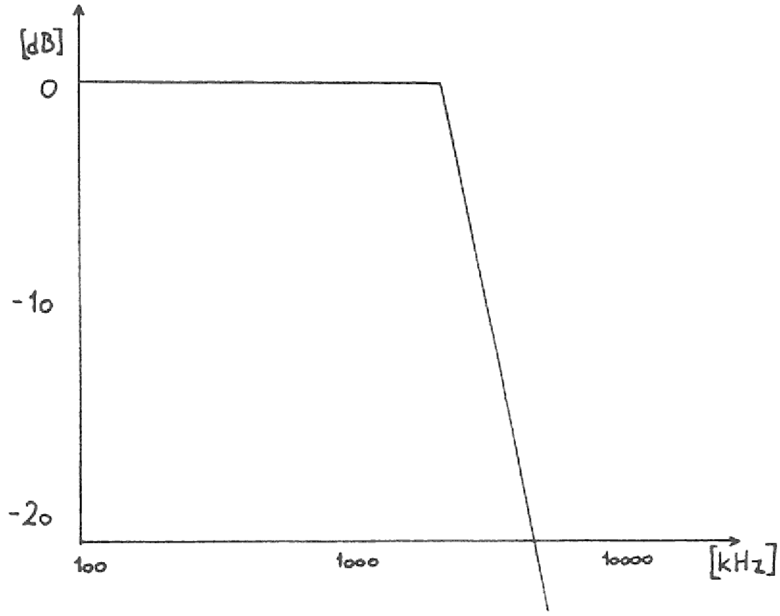
The Transceiver is fully galvanic isolated from the transmission media through a 4 winding transformer. One winding is connected to the line, another to the receiver and the last two connected in a "push-pull" configuration to the transmitter. Attempts has been made to make the highest possible input impedance when receiving. (Ref. page 8). The common mode rejection CMR is better than 40dB over the complete frequency range.

The receiver is a positive feedback voltage comparator. The feedback provides a hysteresis of $\pm$350 mV for noise immunity purpose.

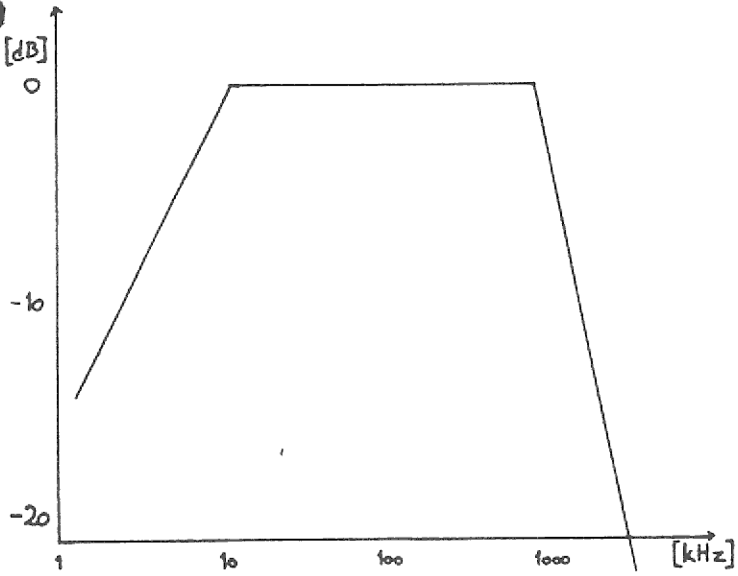


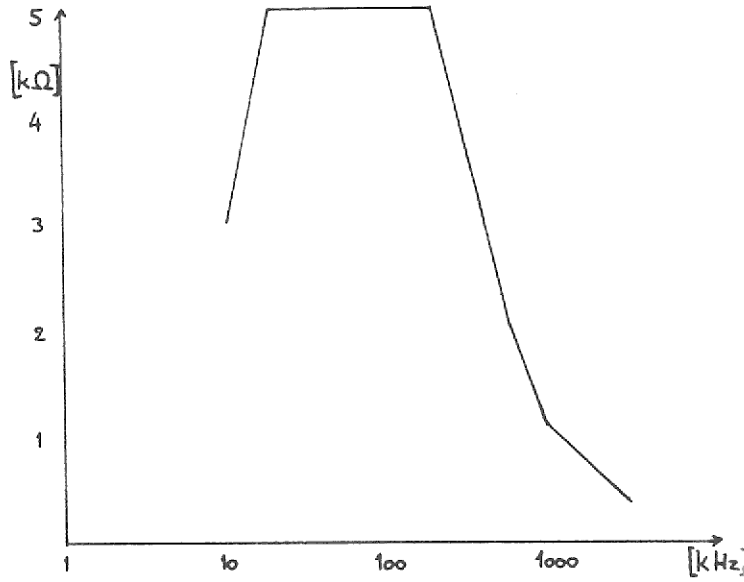
Above: Signal close to transmitter
Below: Signal remote from transmitter

The output voltage swing is $\pm$4V. The input hysteresis is $\pm$ 350mV. A greater difference between output swing and input hysteresis would cause secondary reflections to be detected by receivers which means erroneous behaviour. Primary reflections is taken care off by lockout at the receiver logic.



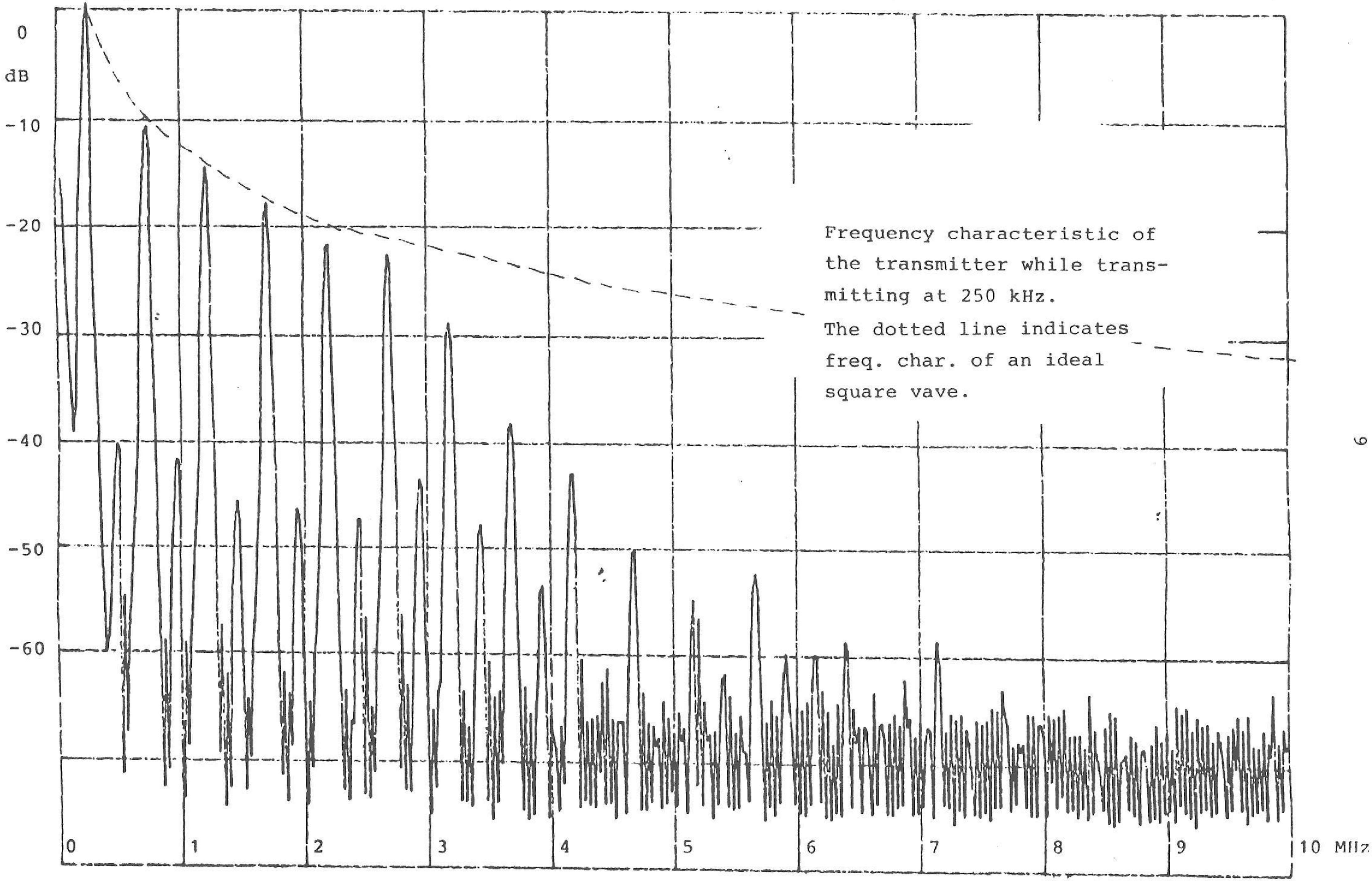
Output butterworth filter characteristic.





Input sensitivity vs. freq.   Input impedance vs. freq.

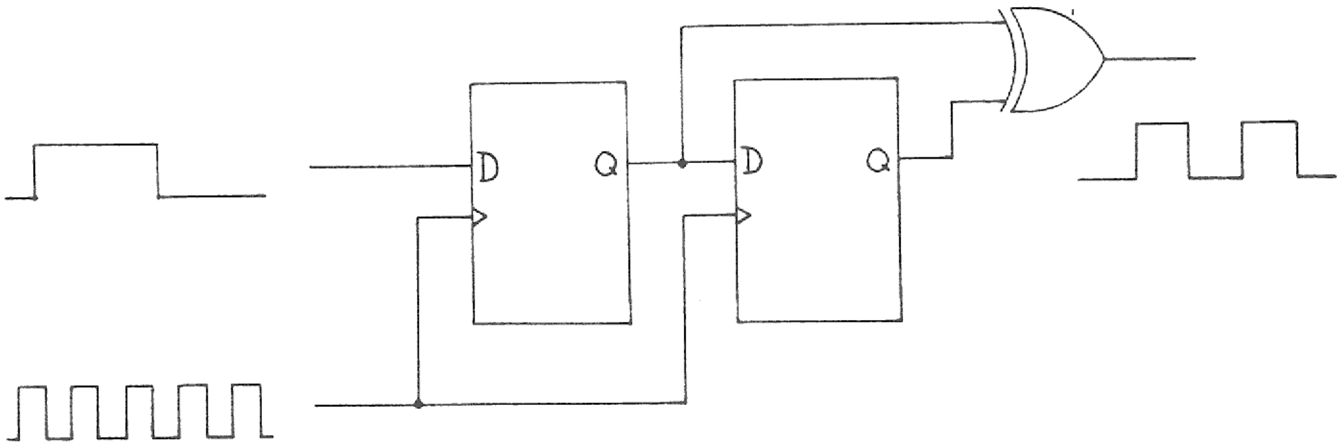
Since an ideal square pulse is made of an infinite number of harmonic frequencies the RC Circuit transmitter has been provided with an output filter which removes frequencies beyond 2 MHz to reduce noise emission. Similarly for noise immunity purpose the receiver is provided with a filter which cut off frequencies above 1MHz and below 10kHz. The change in pulse frequency during transmission, produce low frequency components in the overall frequency spectrum which explains the rather low lower cut off frequency.



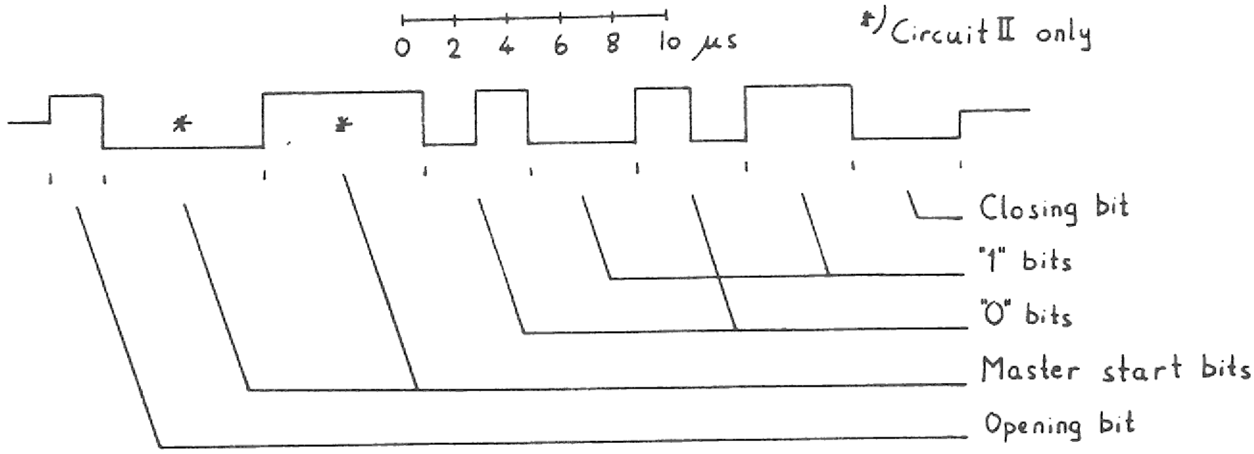
Frequency characteristic of the transmitter while transmitting at 250 kHz.
The dotted line indicates freq. char. of an ideal square vave.

3. Logical Level

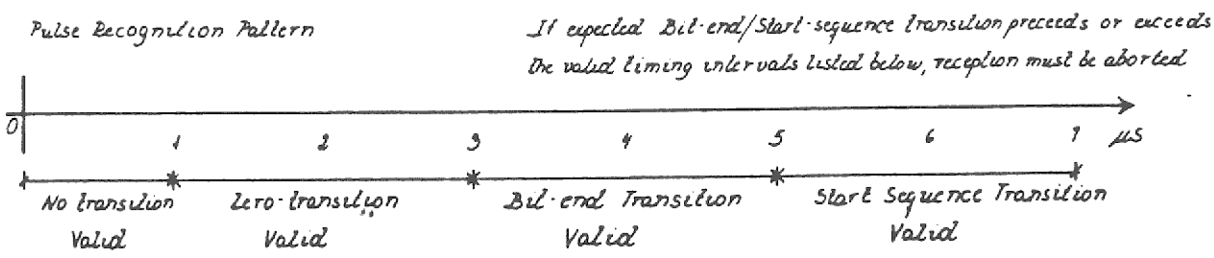
The logical levels is based upon edge detection of the analog pulses on the line.



The bit coding is of Manchester type, called Biphase S coding.



Upon a transition on the line a timer is initiated measuring the time to the next transition to distinguish the bit values.



Since the RC Circuit line is a multidrop line any transmitter who wants to be active on the line must open the transmitter and when finished close it again. This causes a half transition pulse on the line since it goes from inactive ("Three state") to active. (At RC Circuit II the opening of the line is allways made 2 us prior to transmission while closing is made 4 us after last transmitted bit).

4. Circuit II Protocol

The RC Circuit II utilizes a half duplex single master polled protocol for multipoint operation of up to 32 slaves. The master is responsible for proper communication. It issues polls, and the slaves respond. All data flow goes to or from the master.

A poll from the Master can be made in two ways:

- Poll containing data
- Poll not containing data.

The respond from the slave may again be in either of two ways:

- respond containing data
- respond not containing data.

The master Poll allways starts with a Master startsequence (two successive 6 us startbits) followed by 1 byte containing the slave address in bits 0..4 and with bit 5 asserted if a databyte is contained within the poll. Bit 6 and 7 are don't cares saved for future use. A parity and a stopbit follows every byte just as a startbit is preceeding a possible databyte.

The slave respond starts with a slave start sequence (two successive ones) followed by another one bit if no data is responded whereupon transmission is terminated. If data is responded a zero bit follows the startsequence then followed by a data byte, parity- and stopbit and transmission termination.

Due to the character oriented structure of the protocol no data validation is made except for the parity check. Also there is no possibility to request a retransmission upon a faulty poll or response.

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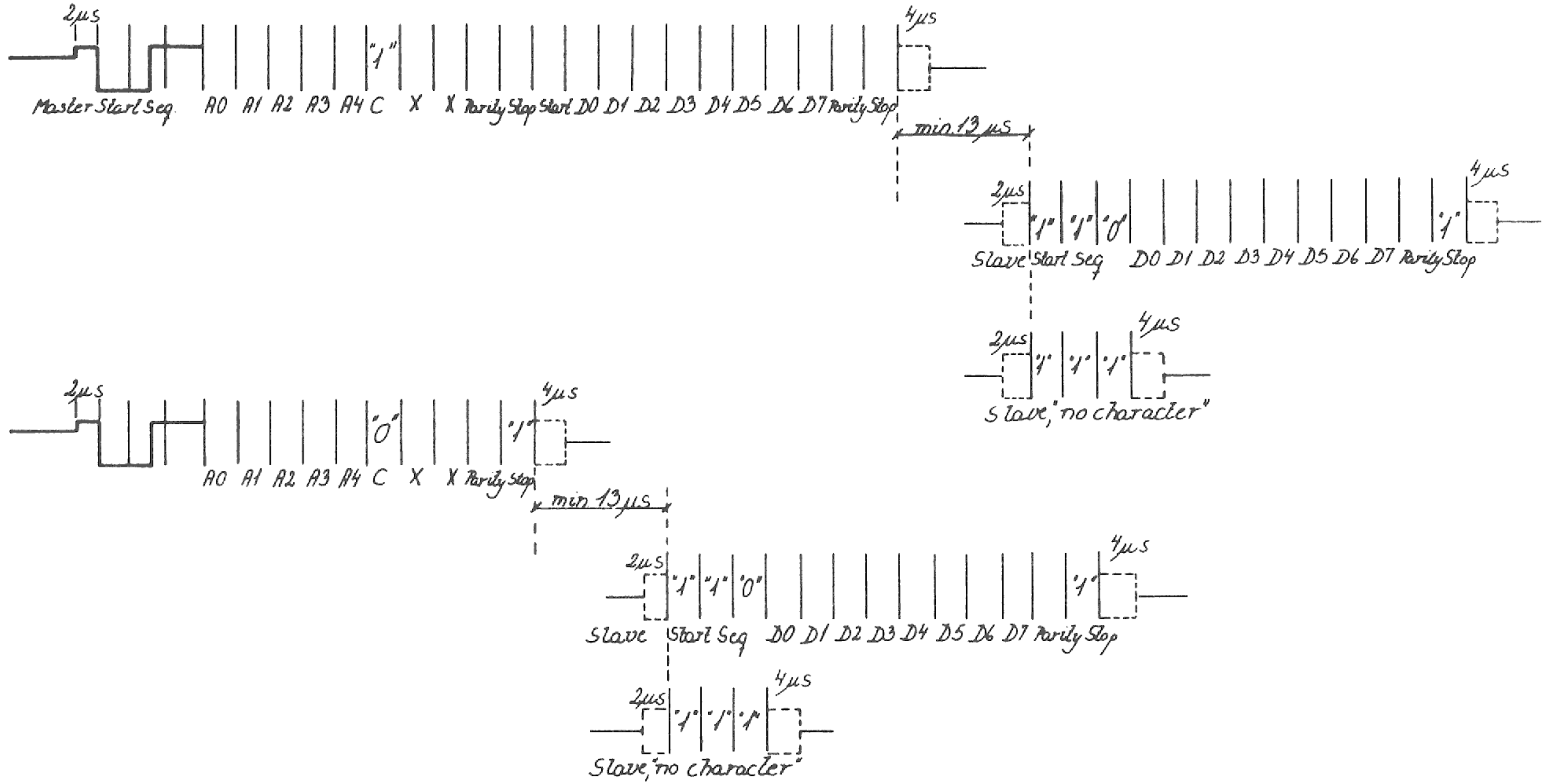
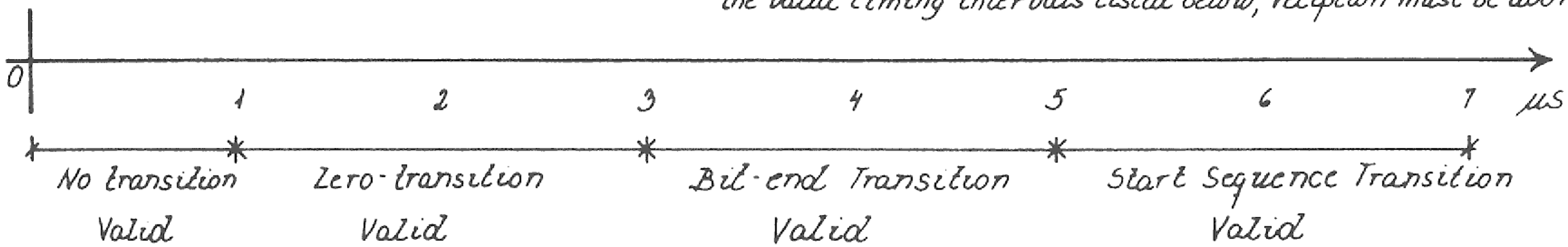


Pulse Recognition Pattern

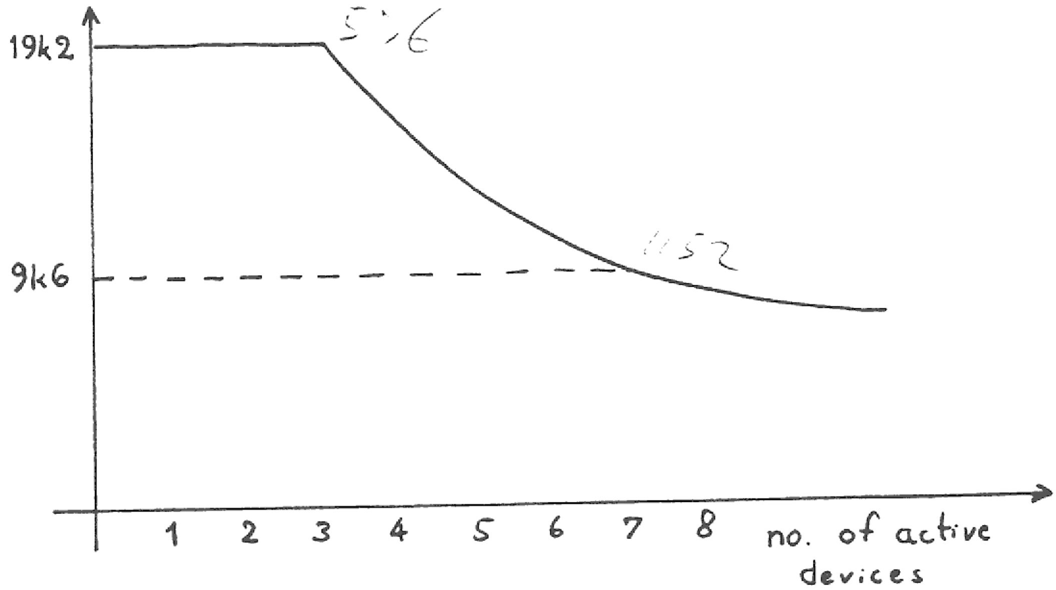
If expected Bit-end/Start-sequence transition preceeds or exceeds the valid timing intervals listed below, reception must be aborted.

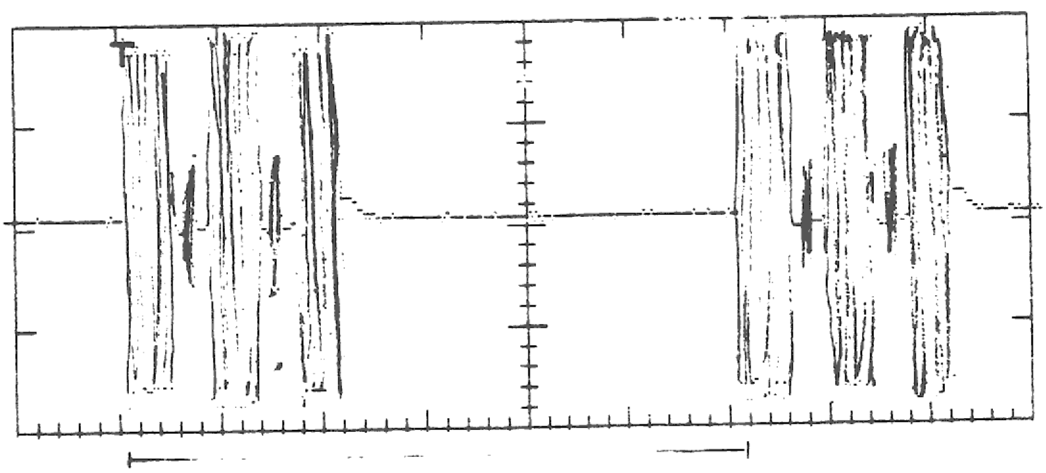


Circuit II Protocol Timing

Since the RC Circuit II protokol is character oriented and the interface from a users point of view is like any other asynchronous terminal, the number of polls to a specific slave device is controlled by a timer. This timer, which is software programable, is currently provided with two settings, 9600 bits per sec. and 19.200 bits per sec. These values refer to the equivalent bit rate of a normal V.24 line configured to 11 bits/byte. The timer acts as initiator of a poll sequence which subsequently polls all active devices in the order they have been logged on to the line. Another timer puts a poll, for one of the not active devices in turn, into the poll queue each 100 ms.

By calculating the amount of time needed for each poll to an active device can be shown that the equivalent bps rate is only valid up to a specific maximum of active devices. If the no. of active terminals exceeds this value, the bps rate is derated by a hyperbolic function.





poll cycle time

1152
576

Appendix

Quality control

It is recommended that a newly installed network is checked using a reflectometer to determine and localize possible faults. If a fault occurs later on, a comparison of the output of a new set of tests with the output of the original reflectometer tests will quickly localize the fault. The alternative is a detailed physical inspection of the cable network.

It is recommended that noise ingress to the network is measured, since a large noise level increases the probability of errors in data transmission.

The person responsible for the building must be made aware that the cable network must be treated with care. Workmen and others who may get in contact with the network must be given instruction in handling the cables.

Tools

To provide TS with better means for trouble shooting attempts are p.t. made on two projects:

- An analog test equipment for verifying a circuit line with or without terminals attached. This equipment is used to verify that signal damping on a line is within the specifications. It is also possible to check crosstalk between circuit I and -II.

- Similar to the Circuit I test programs which test transfer of blocks to and from a specific slave with statistic checks for retransmissions, CRC errors, sequence errors etc., test programs are made for the RC Circuit II which checks for timeout, parity and framing errors with the possibility from one terminal to test the condition of all slaves connected.

Old installations

In older installations (i.e. installations made up till today) the equipment does not meet the electrical requirements listed in chapter 2. The noise immunity is less, the CMR is poorer, the output voltage on RC Circuit I is lower, and the input impedance is less. This together with the allowed maximum segment length of 1500 m at the time of installation means that there may occur trouble in larger installations. Below is listed the possibilities for correcting an old faulty installation with the meaning of the correction:

1. Bring the Master up to date with the latest FCO's. This provides the master with improved noise immunity etc., as well as the RC Circuit II receiver is made able to suppress first order reflections upon a master poll.

2. Implement earthing of one of the terminations of the segment. This may improve the noise rejection of the line as well as protect against build up of high voltages due to the galvanic separation of the line from the devices.

3. Split up one long segment in two or three smaller ones by means of the RC Circuit repeater, TF681. This will give a higher signal to noise ratio since the signal damping is highly dependent on cable distance between transmitter and receiver.

4. Interchange or FCO all device interfaces if possible. The RC855 interface to RC Circuit is neither interchangeable with a new interface nor is there any FCO available. If problems should occur in an installation containing RC855 terminals they may be solved by concentrating these terminals on a smaller segment (i.e. paragraph 3).

Detecting noisy environment

Two measurings of noise ingress are to be made at all receptacles with connected dropcables and over so long a time frame that the worst conceivable noise conditions have influenced the measurings (i.e. that all noise generators in the immediate area e.g. lifts, pumps etc. have been activated):

1st. measuring	By means of a voltage measuring instrument, sensitive from DC to 100MHz (e.g. oscilloscope), measure voltage between conductors in a pair. Noise measurement must at no time exceed: 100 mV peak or 200 mVpp
2nd. measuring	By means of a current measuring instrument, sensitive from 1 KHz to 100 MHz (e.g. a "current probe" connected to the above oscilloscope), measure common mode noise current in the transceiver cable to the terminal. Noise measurement must at no time exceed: 100 mA peak or 200 mApp

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