THE RF CHRONOTHERMOSTAT

The system is a wireless Chronotermostat composed by 2 units:

1. The Chronothermostat, 3VDC battery, supplied with RF TX unit.
2. The RX unit, Power line supplied, with RF RX module and Relay.

PAR. 1 CHRONOTHERMOSTAT UNIT.

The Microprocessor must be re-programmed and, instead of driving the relay, it must have 2 ports (2 Output Ports) configurated to some specific operation:

A) The First port must power up the Tx module (TX ENABLE).
B) The Second port has to sent out the code to the TXD input of TX.

The Tx unit is a **BT18S3T-M2** (868.35 MHz). Every Chronothermostat is factory programmed with an univocal code of identification. The message transmitted is *Manchester* codified and it is composed of *PREAMBLE / ADDRESS / one or more bit of command / CHECKSUM.*

The message must be transmitted at a fast data BIT/RATE (I.e. 2500 BAUD) to decrease time of transmission reducing power consumption.

The message is immediately transmitted (combined with proper “SLEEP” time of Micro) at any sort of variation of Chronothermostat status, with emission of 4 subsequential messages.

Every 2/3 minutes the Chronothermostat transmit a *REFRESH* status through emission of 2 messages.

The timing between the 4 and the following 2 messages is *RANDOM derfined* in order to avoid message collisions in case different Tx are employed inside the system.

The length of each message is about 40 ms *(* 15ms *PREAMBLE* / 20 ms *ADDRESS* / *COMMANDS* / *CHECKSUM).*

PAR. 2 CHRONOTHERMOSTAT RECEIVER UNIT.

Included is a sample diagram of an Rx Chronothermostat unit application employing a Micro PIC16F676 Microcontroller.

It may be employed a different Microcontroller.

The Rx employed is a **BR58S5-M2** which is provided of excellent sensitivity, good selectivity and RSSI output.

It si also included an example how to realize an ecomical system of power supply without transformer stage.

The Microcontroller must be provided of *EEPROM* memory, in which should be registered (by means the *AUTO-LEARNING* routine), the *ADDRESSES* of the Chronothermostats configured in the system; additionally it must be provided of *A/D CONVERTER* to measure and memorize received signal intensity.

The RX's functions are described in attached " Preliminary operative description".

PAR. 3 MECHANICAL LAYOUT OF TX.

The P.C.B: should be obviously designed providing the ground plane to be on the right side (as it is right now), positioning the Tx **BT18S3** in the low area nearby the 0.1F ELNA capacitor and also providing due free area from strip line and ground plane at the left side where it would be placed the Antenna.

The Tx module must be the **BT18S3-T** (SMT version) or the **P** version (with 2.45 strip step).

The Antenna is realized through an enamelled wire, with the initial section helical wrapped due to 869 MHz proper resonance and impedance.

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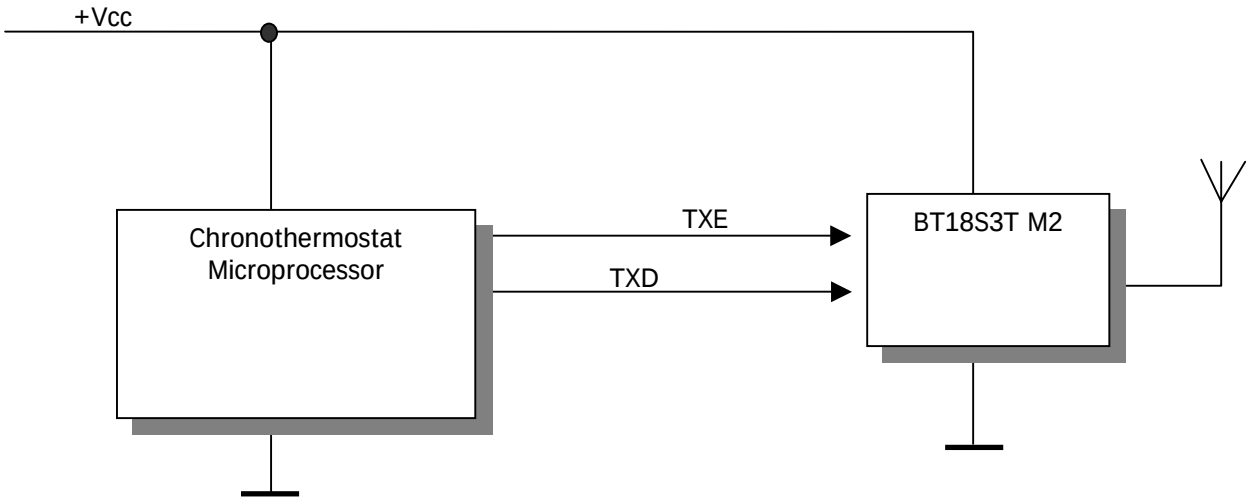
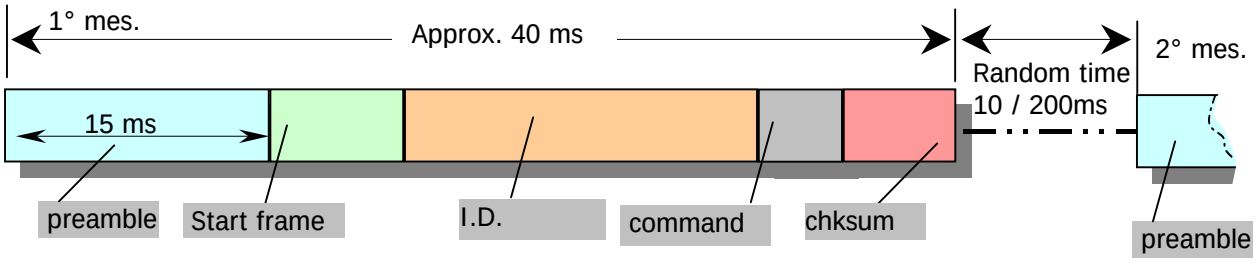
PAR. 4 BLOCK DIAGRAM OF TX.



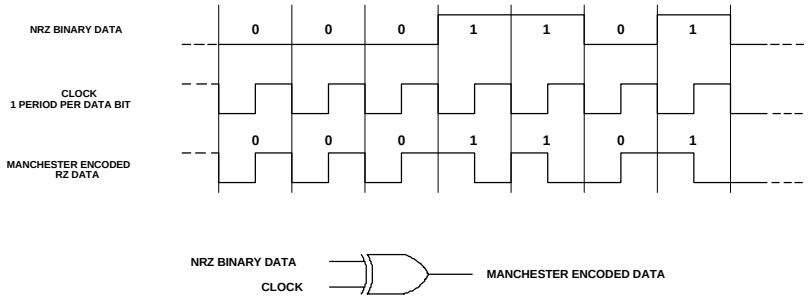
PAR. 5 MANCHESTER ENCODED MESSAGE.



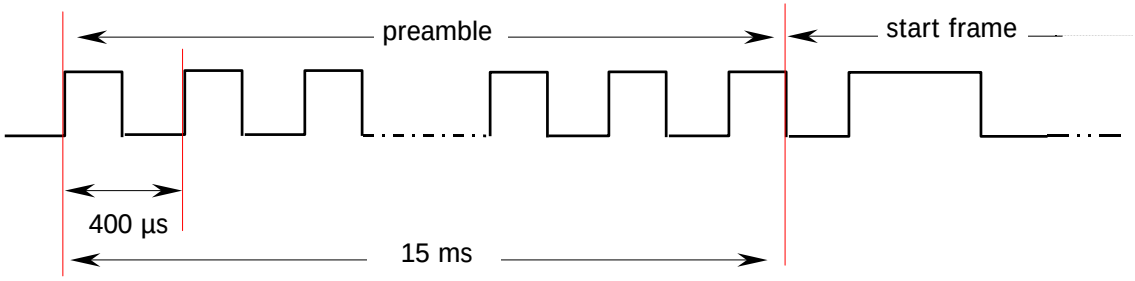
PAR. 6 MANCHESTER MESSAGE ENCODING.

MESSAGE ENCODING

Code modification , Manchester style , means combining a clock with the data to give two bits of output data for any single input bit.
Recommended clock frequency is 4,8 KHz to 19,2 KHz (maximum clock frequency is 38,4 KHz).



PAR. 7 EXAMPLE OF « PREAMBLE » (MANCHESTER CLOCK = 2,5 KHz).



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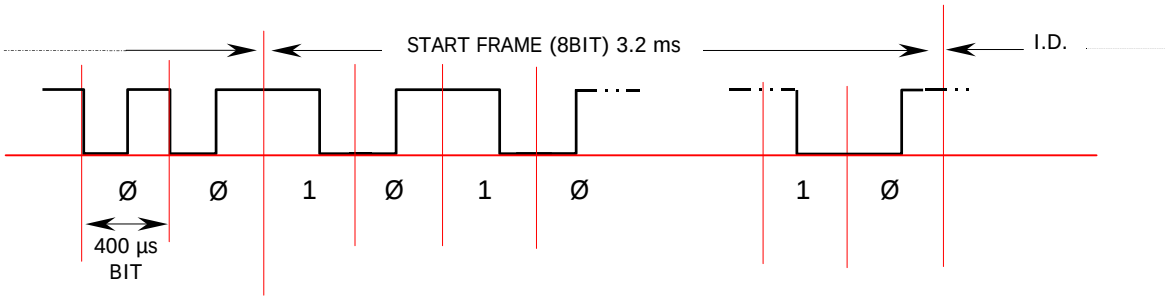
PAR. 7 EXAMPLE OF « START FRAME ».



Note 1: The «Preamble» has mainly the function to stabilize the RF Tx-Rx Link. The «Preamble» must be long enough taking in consideration also the problems of low signal, TX/RX Frequency mismatch, anomalies of radio propagations, interfering signals, etc.

Note 2: the Transition from the «PREAMBLE» to the «START FRAME » must be detected as a valid start of the message data (in the example this is the change from 2,5 KHz to 1,25 KHz SQUARE WAVE).
Than the last BITS of the «START FRAME» (2,4 or 6 BITS, depending on the required accuracy) can be detected to define the start time for the data sampling clock (see par. Cfr. 10).

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PAR. 9 RECEIVER.

Preliminary operative description

A. Receiver unit : at power on the 3 colours led (LD1) is red.
B. By pushing the P1 button (for a time higher than 0.25 sec., but less the 10 sec.) the 3 following phases of routine are activated:
    1. AUTO (LD2 Yellow led on).
    2. MANUAL ON (LD3 Red led on).
    3. MANUAL OFF (LD3 Red led off).

Note: the operation will be activated when button is released.

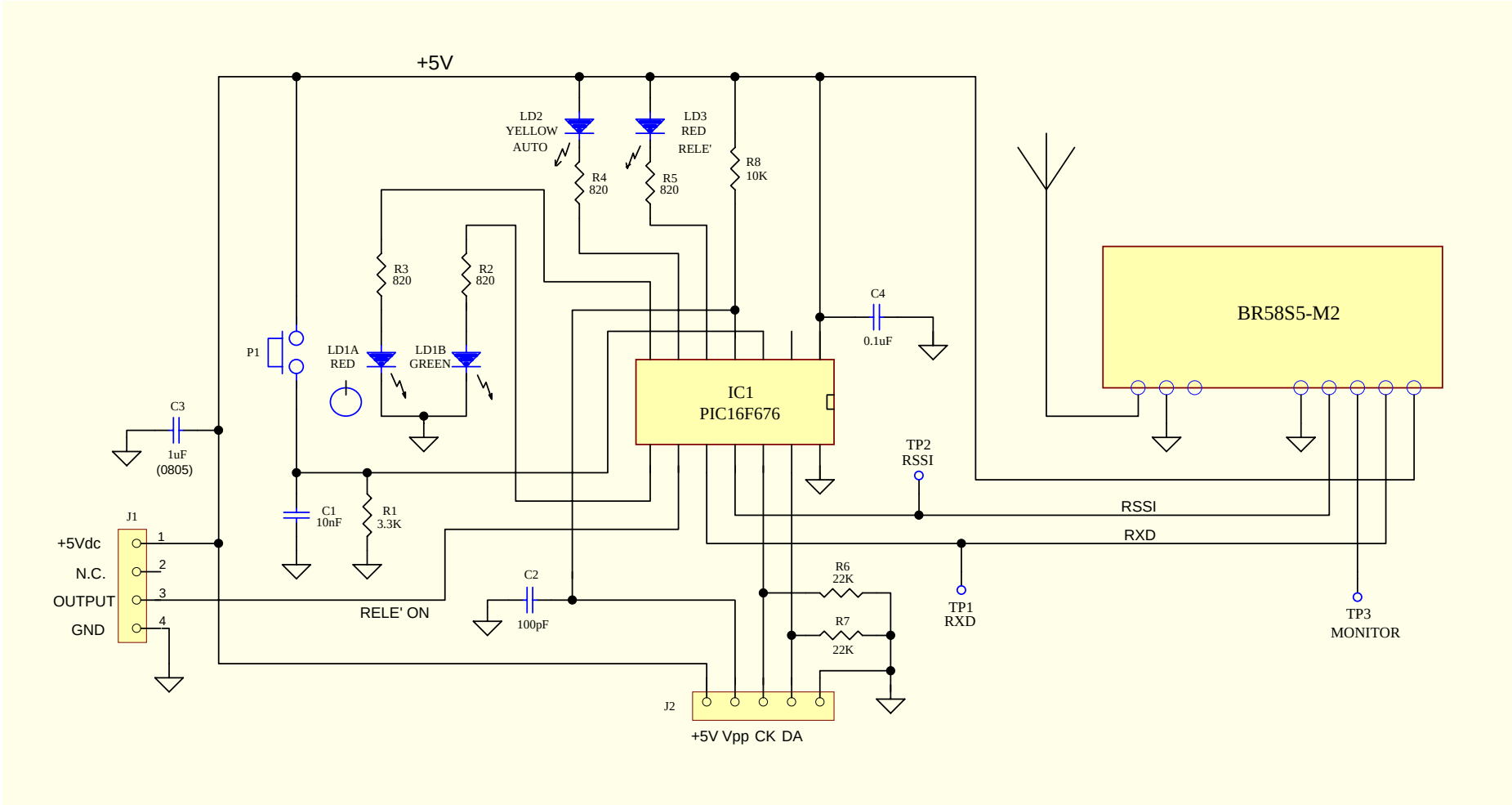
C. By pressing the button, (starting with AUTO Yellow led on), more than 10 sec., the system switch into AUTO-LEARNING routine and Yellow led starts blinking. This routine last for about 1 minute, than return to the initial status.

   To initialize the SELF-LEARNING procedure it is necessary that the Chronothermostat (Tx) will go into active mode and will send out code within 60 sec.

   To avoid possible memorization of other codes from interfering systems, the Rx sensitivity, during SELF-LEARNING routine, is reduced therefore it is necessary that Tx is activated inside an area of max 2 meters. The SELF-LEARNING routine validation is enanched by 1 sec blinking of POWER-ON led.

   Note-1: The sensitivity reduction is performed measuring the “RSSI” output of the Rx and allowing the self-learning only for an “RSSI” level of more than 1 Volt.

D. When Rx unit receive a correct message, POWER-ON led start blinking and, if in AUTO routine, it is activated or disarmed the RED led (OUTPUT RELAY).
E. After a correct message the POWER-ON led will remain active and it will indicate proper signal intensity received:
    1. GREEN = GOOD Signal
    2. YELLOW = MEDIUM Signal
    3. RED = LOW Signal.
F. In case no signal is received, after about 4 minutes the POWER-ON led will become red, indicating a system failure.


+5V
LD2
YELLOW
AUTO
LD3
RED
RELE'
R4
820
R5
820
R8
10K
R3
820
R2
820
C4
0.1uF
BR58S5-M2
P1
LD1A
RED
LD1B
GREEN
IC1
PIC16F676
C3
1uF
(0805)
TP2
RSSI
RSSI
RXD
J1
+5Vdc
N.C.
OUTPUT
GND
1
2
3
4
C1
10nF
R1
3.3K
C2
100pF
RELE' ON
R6
22K
R7
22K
TP1
RXD
TP3
MONITOR
J2
+5V Vpp CK DA

PAR. 10 RECEIVED SIGNAL DATA DECODING.

The radio link performance (practically speaking, the Tx/Rx distance) depends on the TX Power and RX Sensitivity, but also it depends on the antennas efficiency and (very important) on the ability of the RX decoding system to recovery data from weak and garbled signals.

1. The first step, in every radio link, is to transmit data encoded with a good DC balance (at “BIT” level): « MANCHESTER » encoding is a good choice.

2. At RX side the RXD data (on the border of the useful range) doesn’t have any sharp an stable rise and fall fronts, but rather they are received with some form of “JITTER” and probably with a time distortion. Also with very symmetrical « MANCHESTER» encoded data, it is possible to have rise and fall time of the pulses modified by multipath propagation anomalies.

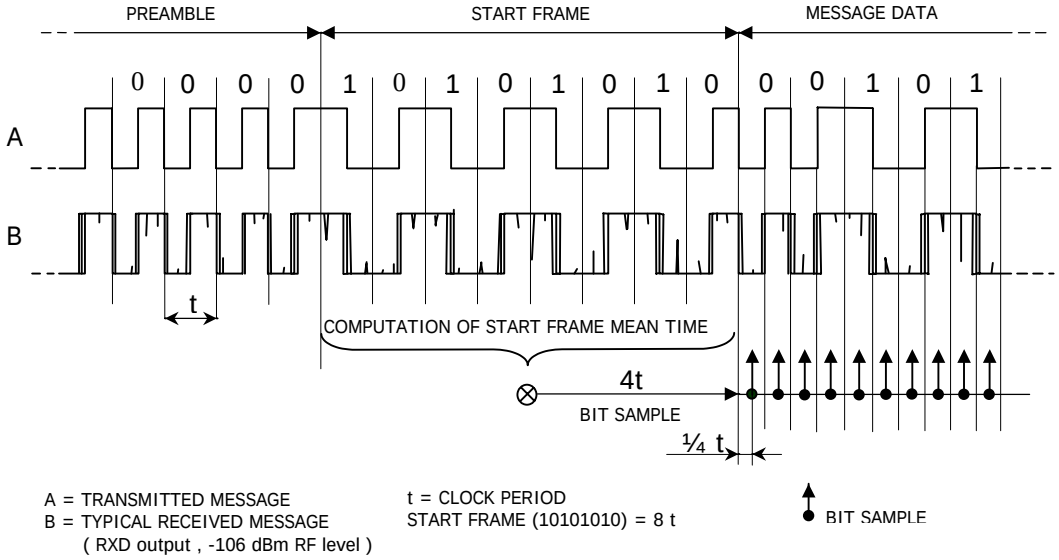
3. Experience and practical tests have demonstrated that normally interferences or pulse noise (spikes) are not the main problem (in Low Speed Short Data Messages).

To extract (Decode) useful data, from garbled received output, a good system is to employ (as described previously) the « START FRAME » to define a « START TIME » to synchronize a clock and than sampling received data in the center of the BITS.

4. Important: noise and propagation anomalies can change the duty-cycle of the transmitted pulses, but not the frequency (the frequency of Manchester clock in this example).

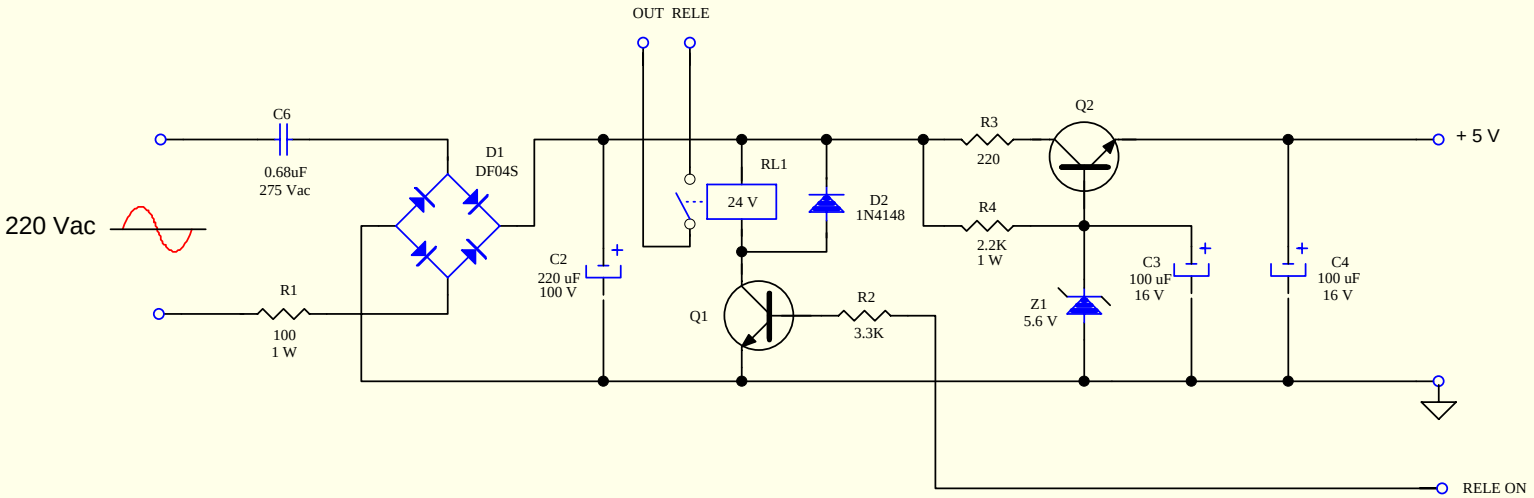
MESSAGE DECODING

On the receiver side, trasmitted (bi-iphase encoded) datas, must be extracted from noise, interference and multipath propagation distortions.
It is very instructive, before any decode attempt, to examine the received datas as appear on the "MON" analog output.
A good system is to employ as a beacon a transceiver module in transmit mode, modulated by a square-wave (clock frequency) and to simulate all the steady and transitory situations of a real message exchange.
Suppose transmitted data are Manchester encoded , as described in the previous example. It will be necessary to send a preamble, a syncronization frame and then the message .
The preamble is only to allow Tx and Rx to stabilize on the frequency and to centre modulation and data slicer.
The syncronisation frame is to be used to define start point for following bits decoding.



In the above example , if " t " is the clock period, the total length of the eight bits start frame (10101010) is " 8 t ".
The start frame must be extracted from a noisy reception detecting the rising and falling edge of the received message.
Once extracted from the received noisy signal , the 8 bits of the start frame can be averaged on the total frame time to permit to define the data message start point. The following message data bits are best decoded sampling two times every bit.

Note:
- *Obviously any tolerance in the Rx and Tx clock frequency must be taken in consideration and related to the total message bit number.*
- *Control and validation of the message together with error correction algorithms, message retry request, etc. is a task to be performed by the " packet" protocol.*



D1 = PONTE DIODI DF04S

D2 = 1N4148

Q1 = TRANS. NPN 0.5A 60-80 Vce (SOT23)

Q2 = TRANS. NPN 1.5A 60-100 Vce 1.5W (BCP52 SOT223)

RL1 = RELE' 24V BOBINA 1100 OHM

Z1 = ZENER 5.6 V 0.5 - 1 W

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