Multi channel contact resistance measurement equipment for telecommunication connectors

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The telecommunication connectors, produced in BTK-Borima Ltd., Bulgaria in accordance with AMP have 20 separate lines in each unit. According to the production quality requirements the resistance of every line should be measured. Unfortunately the time necessary for the measurement of one unit if a standard manual miliOhm meter is used is around 11 minutes while the total production cycle (quality checking excluded) is 8 minutes and 30 seconds. So if a 100% quality check is applied (according to the requirements of AMP) the Quality Checking Department should be larger then the other production departments all together. All that means that a different approach should be used.

In order to resolve this problem a specialized testing equipment was designed that is capable to measure the contact resistance of all the lines simultaneously. It has 20 independent microprocessor controlled miliOhm meters connected in a network with a Personal Computer throe a standard RS232 communication port (COM1 or COM2). The communication between the different miliOhm meters is done via an asynchronous serial interface with standard CMOS levels. Every miliOhm meter has its own address .All the transmitters have tree-state outputs and only if a request is send by the main Personal Computer the measurement result of the corresponding channel is transmitted so it is impossible to have a conflict on the line between two different devices. After that the CMOS levels are converted to RS232 standard levels of the Personal Computer.

The main computer can start all the channels simultaneously and read them after that one by one or if a very high precision is required every channel can be started separately so the noise of the other miliOhm meters could be eliminated. Every device measures the resistance around 10 times per second and the final result sent to the Personal Computer is the average value of all the measurements done between the start and the stop command for the corresponding unit. Because of that the precision of the measurement system depends also on the measurement time (number of results to be integrated). That should be considered in the case the channels are started one by one – one second more measurement time would give immediately 20 seconds delay for the total test of the unit. That's why in the final version of the system a simultaneous start for all the miliOhm meters has been applied.

According to the requirements of the Bulgarian State Standard [2] the miliOhm resistance measurement should be done applying positive and negative current over the unknown resisrance in the following way:

1. Connect R_x.
2. Apply positive current source + I_{ref}.
3. Measure the voltage over R_x.
4. Apply negative current source - I_{ref} (change current direction).
5. Measure the voltage over R_x.
6. Disconnect R_x.
7. Calculate the result as medium of the both measurements.

Another limitations of the Bulgarian State Standard [2] are:

1. Maximum current $I_{ref} = 100$ mA.
2. The voltage between the probes should not exceed 20 mV if there is no resistance connected.

As discribed in [1] the requirements mentioned above could be satisfied with a conventional microcontroller measurement system as shown in fig. 1.

The main problems in such a design are the long time and temperature stability of the current source and the high gain DC instrumentation amplifier. For example if the range for R_x is 100mΩ and I_{ref} is the maximum 100 mA then $V_x = R_x * I_{ref} = 10$ mV and for a standard ADC with 5V dynamic range the amplification should be 500. The offset of such an amplifier could give a serious error too.

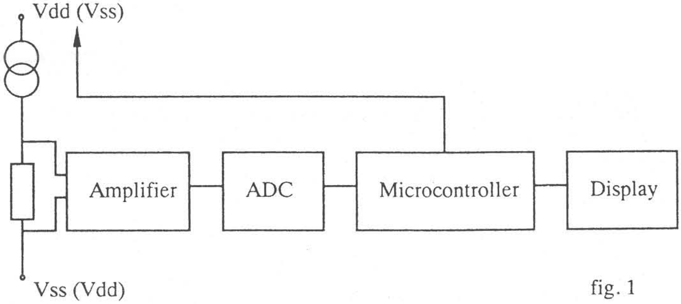

fig. 1

In order to resolve the problems mentioned above and still maintain the low cost of the system the single channel miliOhm meters were designed with a Universal Transducer Interface (UTI) chip that uses the three-signal measurement technique to eliminate the effect of the offset and the unknown gain [3]. According to that technique in addition to the measurement of the unknown signal U_x two reference signals U_{ref1} and U_{ref2} are measured in an identical way and if the transfer of the system consists only of an offset and gain the measurement result can be calculated as:

$$M = (U_x - U_{ref2}) / (U_{ref1} - U_{ref2})$$

As described in [1] the advantages of such a design are:

- measurement with positive and negative polarity thus eliminating the offset and parasitic thermocouples;
- measurement current of 20mA thus reducing self heating effect;
- power down mode when there is no R_x connected in order reduce current consumption and electromagnetic emission of the system;
- no need for amplifier if 0.25% imbalance mode is used;
- a very simple and cheep amplifier if 4% imbalance mode is used;

- reference resistor is used instead of an expansive reference current source;
- R_x and R_{ref} are measured in four-wire setup;

The schematic of a single channel board is shown on fig. 2. It is based in a Microchip's PIC16C73 single chip microcontroller, UTI and a low-cost operational amplifier (LM358).

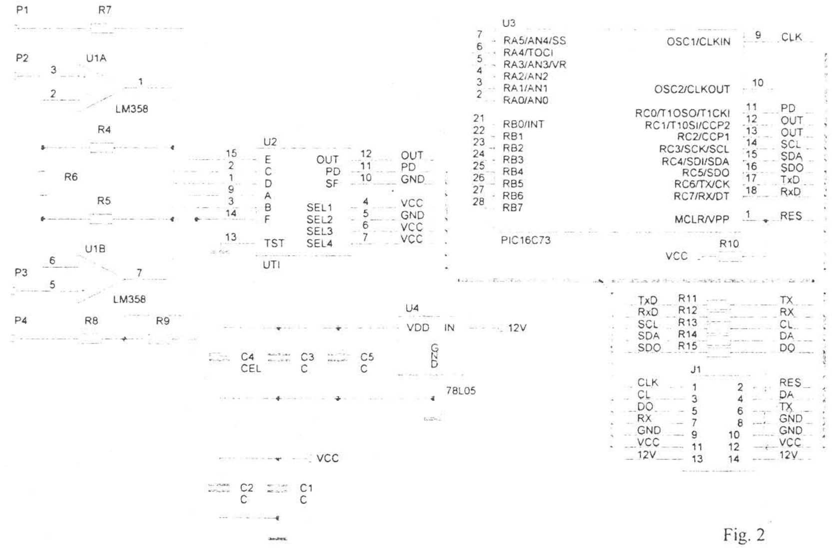

Fig. 2

The analog and digital power supplies, synchronous and asynchronous serial interfaces are connected to the local bus so all interfaces implemented on the chip could be used for internal communication without changing the hardware. In this specific application the asynchronous serial interface with no return to zero format was chosen as a multiprocessor hardware communication. In order to avoid the conflict between all the different transmitters connected on the same line a three-state capability is necessary for the transmitting device. Unfortunately it is impossible to put the build-in asynchronous serial transmitter of PIC16C73 in three-state mode while the receiver of the system is active. That's why the transmitter was implemented in software on a different pin that is going out of three state mode only during the transmission of the data on a request from the main computer. On the other hand all the receivers are always active and are "listening" to the commands send from the main computer. The CMOS levels of the multiprocessor asynchronous bus are converted after that to RS232 levels using a MAX232 chip.

Every single board has its own linear voltage regulator in order to stabilize the analog power supply for the Universal Transducer Interface chip and the amplifier. That is reducing the noise on the power supply lines for the very sensitive measurement part of the system.

Because the measurement precision in 0.25% imbalance mode of the UTI was not enough it was substituted with 4% imbalance mode and a low cost external amplifier as described in [1].

The whole system has a modular construction of 21 single board miliOhm meters connected on a passive bus. Only the analog and digital power supplies, the oscillator and CMOS-RS232 level converters are situated on the backboard. In order to eliminate the noise of 21 unsynchronized crystal oscillators of the microcontrollers one external oscillator was designed that drives all the microcontrollers. The oscillator frequency line is well shielded on the printed circuit board so the emission of that high frequency is negligible. Twenty miliOhm meters are connected to the 20 lines of the module to be checked; the last one is an auxiliary device that can be connected manually to every line in order to control the proper functioning of the others.

The device was installed in the quality-checking department of BTK-Borima Ltd., Bulgaria and is the base of a 100% quality checking of the outgoing production of the factory.

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3. Frank van der Goes, Low-cost smart sensor interfacing, ISBN 90-407-1324-3, Delft University Press, the Netherlands.