VOLTCRAFT 3650CR Digital Multimeter

1. General presentation

A multimeter or a multitester is an electronic measuring instrument that combines several functions in one unit. VOLTCRAFT 3650CR digital multimeter can measure the following quantities: direct and alternating voltage, direct and alternating current, resistance, capacitance, frequency, DC forward transfer current ratio of a transistor, h_{FE}, and logic levels. Moreover, it can be used for diode testing and as a continuity indicator. When continuity is tested, the instrument emits an acoustic signal ("beep") if the measured resistance is smaller than 30 Ω.

The measurement results are displayed both in digital form – with $3^{1/2}$ figures, the maximum displayed value being 1999 – and in analogic form, as bargraph.
The instrument also has some additional functions:

- Auto-testing of the display at power on;
- The possibility to store measured data (DATA-HOLD function);
- The possibility to determine minima and maxima of a quantity (MIN and MAX functions)
- The possibility to compare one or more values of a quantity with a previously measured value which is taken as a reference. In this case the instrument displays the difference between the current value and the reference value (REL function);
- Low battery indicator;
- It can send measured data to a computer by a built in RS-232C standard interface.

2. Functional architecture

The main component of the multimeter is a dual-slope analog to digital converter that can measure only direct voltages in the range of 0-200 mV. For the other measurement functions, the quantities to be measured are first converted to voltage, by appropriate converters (see figure 1). The conversion result and the information about the measuring range are sent to a microcontroller which drives the display and provides the serial communication with a PC through a special cable.

The multimeter takes two to three measurements per second.

Table 1

Function	Range	Maximum permissible error	Resolution	Miscellaneous
Direct voltage (DCV)	200 mV	+/-(0,3% of reading +1digit)	100 µV	Input resistance 10 MΩ
	2 V	--"--	1 mV	--"--
	20 V	--"--	10 mV	--"--
	200 V	--"--	100 mV	--"--
	1000 V	--"--	1 V	--"--
Alternating voltage (ACV)	200 mV	+/-(0,8% of reading +3digits)	200 mV	--"--
	2 V	--"--	100 µV	--"--
	20 V	--"--	1 mV	--"--
	200 V	--"--	10 mV	--"--
	750 V	+/-(1,2% of reading +3digits)	100 mV	--"--
Direct current (DCA)	2 mA	+/-(0,5% of reading +1digit)	1 µA	Maximum voltage drop 300 mV
	200 mA	+/-(1,8% of reading +1digit)	100 µA	max. 300 mV
	20 A	+/-(2% of reading +5 digits)	10 mA	max. 900 mV
Alternative current (ACA)	2 mV	+/-(1% of reading +3digits)	1 µA	max. 300 mV
	200 mA	+/-(1,8% of reading +5 digits)	100 µA	max. 300 mV
	20 A	+/-(3% of reading +7 digits)	10 mA	
Resistance (OHM)	200 Ω	+/-(0,5% of reading +3digits)	0,1 Ω	Maximum voltage drop 800 mV

	2 kΩ	+/-(0,5% of reading +3digits)	1 Ω	max. 280 mV
	20 kΩ	--“--	10 Ω	max. 160 mV
	200 kΩ	--“--	100 Ω	max. 160 mV
	2 MΩ	+/-(1% of reading +2 digits)	1 kΩ	max. 160 mV
	20 MΩ	--“--	10 kΩ	max. 160 mV
Capacitance (Cx)	2000 pF	+/-(2% of reading +3digits)	1 pF	
	200 nF	--“--	100 pF	
	20 µF	+/-(3% of reading +5 digits)	10 nF	
Frequency (kHz)	20 kHz	+/-(2% of reading +3 digits)	10 Hz	
	200 kHz	--“--	100 Hz	

Note: 1 digit represents one unit of the least significant digit (one LSB), e.g. for the measuring range 20 kΩ, the maximum displayed value is 19.99 kΩ and a digit is 0.01 kΩ.

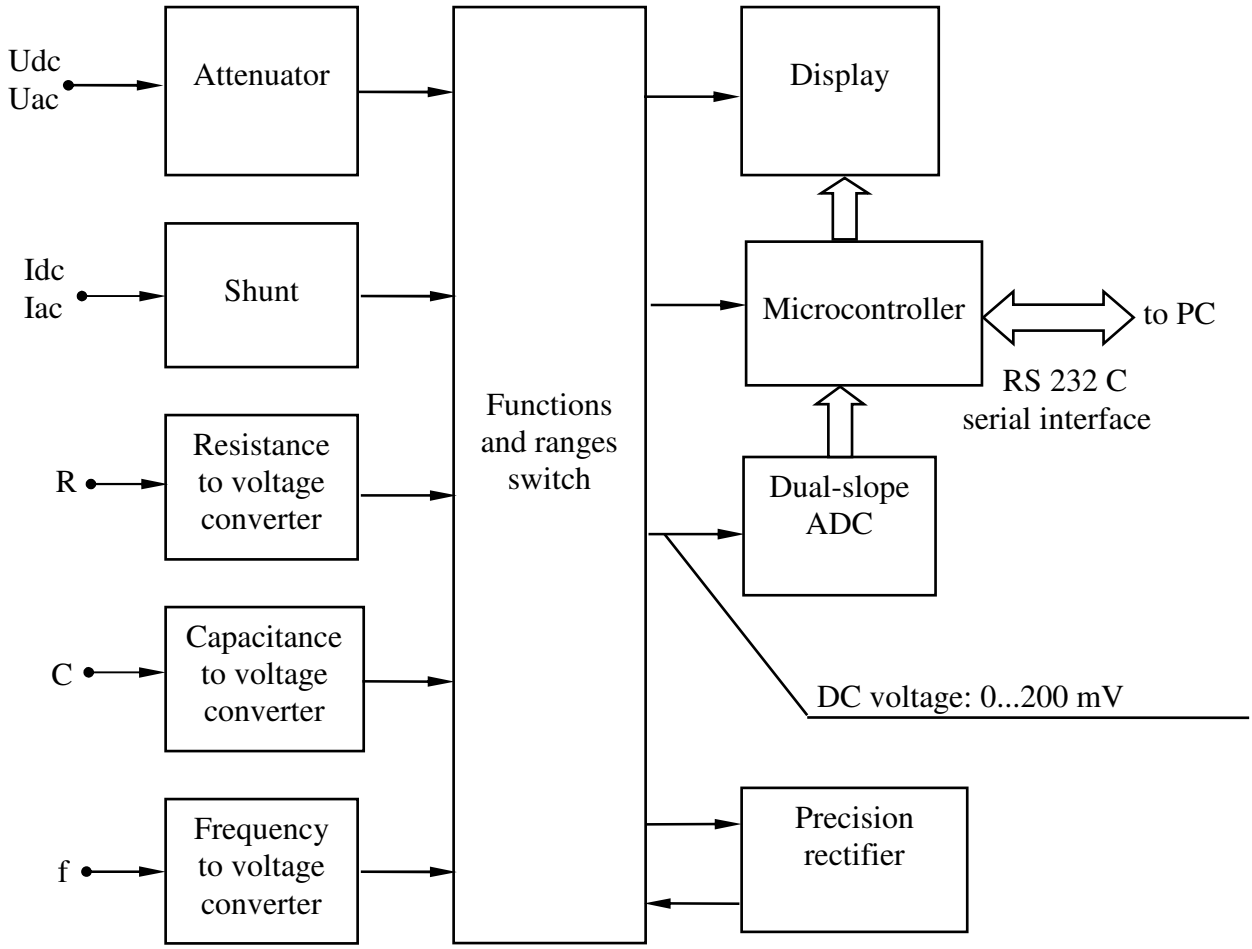

Fig.1. Block diagram of the multimeter

3. Mode of operation

In order to measure some electrical quantity, one must first select the desired function and measuring range and the measurand is applied to the proper terminals:

- between A and COM terminals, when measuring currents smaller than 200mA;
- between 20 A and COM terminals, when measuring currents greater than 200mA;
- at Cx terminals when measuring capacitors (if the capacitor is polarized, polarity must be respected)
- between V/Ω and COM, when measuring all other quantities (DC or AC voltage, resistance, frequency, logic levels)

In order not to damage the multimeter, the values indicated in table nr. 2 should not be exceeded.

It is also necessary to obey the following rules:

1) Switching the range and/or function should be done after having disconnected the measurand from the multimeter's terminals.

2) The resistances should be measured off circuit (no voltage should be applied between V/Ω and COM when measuring resistance).
3) The capacitors should be discharged before measuring the capacity.
4) No voltages should be applied between 20 A and COM.

Function	**Terminals**	**Maximum allowed values**
DCV	V/Ω - COM	1000 Vdc
ACV	V/Ω - COM	750 Vac
Ohm	V/Ω - COM	250 Vdc/ac
DCA, ACA	A - COM	200 mA, 250 Vdc/ac
f [kHz]	V/Ω - COM	250 Vdc/ac
Logic	V/Ω - COM	250 Vdc/ac

3.1 DATA-HOLD, MIN and MAX functions

The multimeter has the possibility to store and display (only) the measured data when the D-H button is pressed. The stored data is displayed for an undefined time (until the command is canceled), even if the measurand has been disconnected.

If D-H button is pressed once again, MAX function is activated ("MAX" symbol is displayed) and the multimeter stores and displays only the maximum value of the measurand.

If D-H is pressed for the third time, MIN function is activated ("MIN" symbol is displayed) and the multimeter stores and displays only the minimum value of the measurand.

3.2 REL function

If the LOGIC/REL button is pressed while measuring a quantity, the "delta" symbol will be displayed and the value of the measurand at that instant is considered as a reference value. The subsequent measurements provide only the difference between the actual value of the measurand and the reference value.

REL mode is canceled when LOGIC/REL is pressed again or when the function or measuring range is changed.

3.3 Logic level indicator

- select the LOGIC TEST function; the multimeter will display an "**rdy"** message;
- connect the COM terminal to the ground of the analyzed circuit;
- connect the V/Ω terminal to the supply voltage, V_+, of the circuit;
- press LOGIC/REL button (the device stores the value of the power supply voltage);
- the V/Ω terminal is connected in the points of interest of the circuit.

The multimeter will display one of the symbols:

a) “Hi” – if the measured voltage is greater than 0.7 V_+
b) “Lo” – if the measured voltage is smaller than 0.3 V_+
c) “---“ – if the measured voltage is between 0.3 V_+ and 0.7 V_+.

3.4 Testing diodes

When the function switch is set to “diode”, the multimeter can test diodes or transistor junctions (at a current of about 1mA). The multimeter displays OL (OverLoad) for a reverse biased or interrupted diode, and the voltage drop in mV for forward biasing.

3.5 Measuring the DC forward transfer current ratio of a transistor, h_{FE}

In order to measure the **DC** forward transfer current ratio of a transistor, the functions switch must be set to “h_{FE}”. The transistor should then be placed in the proper socket of the multimeter. Measurement is taken at a base current of 10 μA and a collector-emitter voltage of 2.8 V.

3.6 Sending data to a PC

Most PCs are provided with a serial RS-232 interface, so it is possible to exchange data between the multimeter and a PC. In serial communication, the bits of a byte and the bytes are successively sent to computer. The multimeter sends to the computer messages of 14 bytes each. The structure of a message is illustrated below:

Byte	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Message 1	D	C	-	1	.	9	5	4		.	V			CR (Carriage Return)
Message 2				1	4	.	3	2		M	o	h	m	CR

The transmission rate is 1200 baud (bits/second). Data is ASCII coded (on 7 bits); 2 bits are used for STOP and no parity bit is used.
The multimeter can store up to five values, which are sent to PC when the PC sends an **M** command. If the PC sends a **D** command, the measured data is sent to PC. If the PC sends a **C** command, the stored values are erased.

4. Practical Work

4.1 Measurements are taken for every function and measuring range. For every measured value, the uncertainty should be calculated, using the formulas in table 1.

4.2 The 2 kΩ range of the multimeter should be calibrated using a decade resistor box. Calibration should be performed in 10 points, evenly spread within the range.

4.3 A batch of 50 resistors of 1.8 kΩ ± 2% has to be measured in order to establish the percent of values out of the tolerance field. Measurements should be taken in both normal operating mode and in REL mode, emphasizing the advantage of the latter.

4.4 Use DATA-HOLD, MAX and MIN functions to notice their effect.

4.5 The resistor batch used at **4.3** is measured using the PC.