



Circuit of multimeter for blind students (G. P. Roberts). Tr_1 and Tr_2 are silicon p-n-p types, e.g. BC177, BC187. D_5 is a 400mW, 4.3V zener diode, e.g. BZX79/C4V3, and other diodes are small signal silicon types, e.g. BA100, IN914A.

diodes D_6 or D_7 is able to sink the 3mA required to operate the "minisonalert" which produces an audible signal at 3500Hz. However, the network consisting of R_8 , R_9 and R_{10} is arranged so that for values of reference voltage very nearly equal to the input voltage, the outputs of both amplifiers go positive, producing an audible null. The width of the null—a compromise between accuracy and ease of setting of R_7 —is adjusted by means of R_8 . In practice, the high open loop gain of the Motorola 1458 dual op-amp ensures that the "edges" of the null are quite sharply defined, allowing the null width to be made as small as 0.2mV.

Where an attenuator raises the source impedance as seen by the input, the capacitor C_1 allows the instrument to be used to measure d.c. quantities containing moderate amounts of a.c. ripple. Although slowing the response time, this facility is useful when poorly regulated mains supplies are involved. The zener diode D_5 is included to further stabilize the current sources Tr_1 and Tr_2 against changes in battery voltage.

The instruments were built in diecast aluminium boxes measuring $8\frac{1}{2}$ in \times $5\frac{1}{2}$ in \times 2in. A simple in-built attenuator provides push-button selection of three voltage ranges (1V, 10V and 100V) and three current ranges (10mA, 100mA and 1A). A standard linear wirewound potentiometer was used for R_7 and this, in conjunction with a large pointer and

embossed scale of 2.2in radius, was found to be easily read to accuracies of within 2% of full scale. Front panels were made from plastic laminate board. Braille dots were made by pushing ordinary dress-making pins through tight fitting holes drilled in the board, and cutting off their stems flush with the other side. The panel was also engraved for the benefit of sighted teachers.

The materials and metalwork were provided by the School of Mathematics and Physics, Macquarie University, with help particularly from Mr Ingram Paterson.

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