JOURNAL OF HYDROLOGY (N.Z.) Vol. 11, No. 2, 1972

A 10-CHANNEL ADAPTOR FOR USE WITH A BATTERY-POWERED CHART RECORDER

J. E. Patterson*

ABSTRACT

A 10-channel adaptor for use with a battery-powered chart recorder is described. The adaptor allows up to 10 inputs to be applied sequentially to the input of the recorder. A built-in timer allows scanning cycles to be initiated at hourly or shorter intervals. Scanning cycles may cover either 5 or 10 channels. Other features include holding in any channel, rapid scanning, continuous scanning, and manual operation. Circuit details of the adaptor are given in an appendix.

INTRODUCTION

The Toa EPR2T and EPR2TD Polyrecorders are battery/mains-powered chart recorders utilizing a 15-cm chart. They are designed for widely varying applications. The EPR2T has chart speeds from 20 mm/hour to 180 mm/minute and a full-scale span from 10 millivolts to 200 volts. The EPR2TD differs in that it has a full-scale span from 2 millivolts to 50 volts. Battery operation requires six size-D dry cells for 7 hours of continuous use.

The pen can be zeroed at any position by means of a five-turn potentiometer. Accuracy is quoted as 0.5 percent of full span and drift is less than 10 μV/hour. The balancing speed is greater than 300 mm/second. Input impedance is about 2 megohms.

The range of uses of these recorders has been expanded by means of a 10-channel adaptor (Fig. 1) which allows several parameters to be sampled in sequence and recorded on the chart as a stepped trace. Typical operation involves sampling 5 to 10 channels at hourly intervals, i.e. every hour the adaptor and the chart recorder turn on, 5 or 10 channels are recorded, then the system shuts down until the end of the next hour. This results in power savings, as battery life may be extended from the previously mentioned 7 hours to 2 weeks or more.

* Water and Soil Division, Ministry of Works, Christchurch.

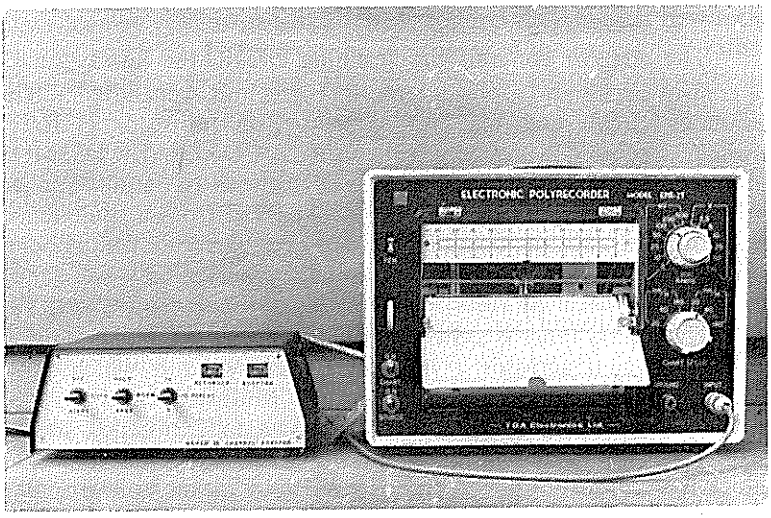

FIG. 1 — The adaptor and a Toa ERP2T Polyrecorder.

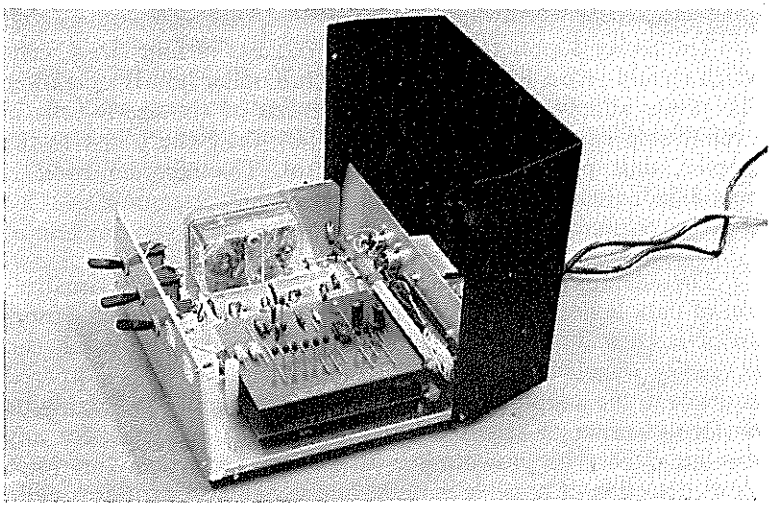

FIG. 2 — The adaptor, showing the circuit, batteries and an Ergas timer.

THE ADAPTOR

The adaptor contains the scanning circuit, the hourly timer, a control circuit and a power supply (Fig. 2 and Appendix 1). The scanning circuit uses ten 2N5485 field-effect transistor (F.E.T.) switches operated in sequence from an RCA CD4017AE COS/MOS decade counter. This is an integrated circuit with 10 outputs applied directly to the F.E.T. switches. Pulses derived from a unijunction oscillator advance the counter one step every 8 seconds, thus operating the F.E.T. switches in sequence and allowing only one signal at a time to reach the recorder.

The hourly timer is a Swiss Ergas movement driving a one-step cam. The cam actuates a microswitch every hour, which turns on the adaptor and the chart recorder. Multistep cams may be employed for shorter time intervals, down to 2 minutes, at the expense of battery life. A clutch allows presetting of the cam. The clock is wound from the recorder batteries by means of a dropping resistor and an inhibit circuit. The inhibit circuit prevents the clock winding when the recorder is operating, as electrical noise from the clock motor may interfere with the recorder during low-level measurements.

The control circuit allows the adaptor and the recorder to be turned off by a pulse from the decade counter. Other features include manual operation, continuous operation (i.e. continuous scanning), selection of 5 to 10 channel scans, holding in any channel, and rapid scanning. Variable dwell-time in each channel may, in some cases, be a worthwhile feature.

The power supply for the adaptor consists of four size-C cells which should give a life of at least a month under hourly operation. The power supply for the recorder consists of six size-D cells in a removable battery box. Three wires link the battery box to the adaptor, thus providing recorder control. The recorder itself is unmodified.

APPLICATIONS

The adaptor has important applications where good visualization of data is needed and where trends among a group of sensors are of interest. For example, soil temperatures against depth can be readily visualized by connecting thermocouples in an ordered sequence to the adaptor. One or two channels should preferably be left free in order to separate groups of data or to check for any base-line drift. The presentation of raw information in this form allows detection of possible patterns and variations in patterns more readily than scanning a mass of figures typical of the output of many

data-logging systems. The patterns obtained may suggest new techniques which can be tried during the course of the experiment rather than after data processing. The recorder and adaptor may offer an economical 'first look' at experiments before more expensive and better data-logging systems are invested in.

An adaptor of the type described has been used for temperature measurements using thermocouples. Temperature differences corresponding to a few tens of microvolts have been resolved.

The adaptor has also been used for recording all-wave net, shortwave incoming, and shortwave outgoing solar radiation at half-hourly intervals. This spot sampling may not, however, give a true representation of solar radiation, especially under variable cloud conditions. As a check, the shortwave incoming radiation is integrated by a special low-power long-term integrator, using analogue and digital circuitry. The output of the integrator is sampled at the same time as the spot readings are taken. Agreement between the integrated shortwave incoming radiation and an integral computed from the sampled values would give a guide to suitability of the data for further analysis. The whole system is battery operated and portable, thus allowing energy balance studies to be done economically at more remote sites.

An early form of the adaptor has been used for sampling five gypsum-block resistances for the measurement of soil moisture using a 1-kHz constant-amplitude signal. Four reference resistances are also read during each scanning cycle as a check. The recording system was deliberately made non-linear in this case, to accommodate the wide range of resistances encountered. A template will be used for taking values off the chart.

Other uses of the unit could include short-term surveys of water quality using standard sensors and meters with a recorder-compatible output.

In summary, the recorder and adaptor combine to form a useful recording system suitable for short-term multipoint experiments and surveys.

ACKNOWLEDGMENTS

The co-operation of Messrs G. J. Blake and G. Martin for testing and using prototype adaptors is acknowledged. Mechanical construction was carried out by Mr S. McGregor at the New Zealand Hydrological Services Depot.

The work described in this paper was carried out in the Water and Soil Division of the Ministry of Works, and permission to publish the paper was given by the Commissioner of Works.

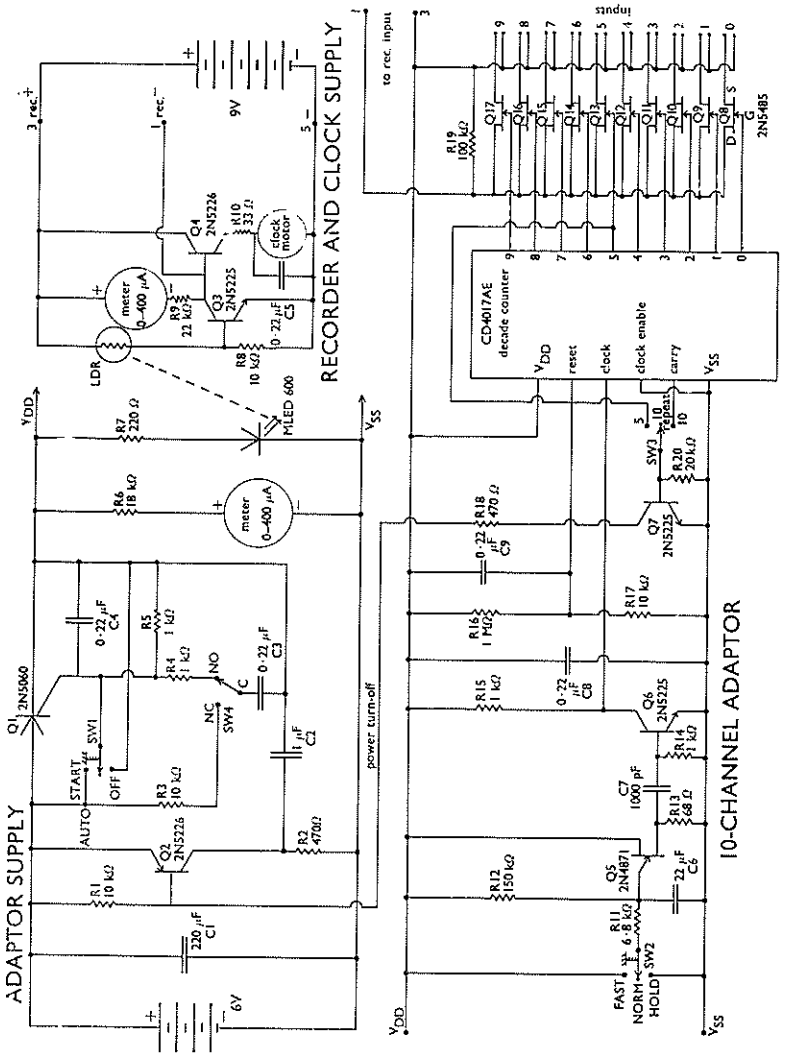

FIG. 3 — The circuit.

APPENDIX I — Circuit details

The circuit is shown in Fig. 3 and functions as follows: A microswitch, SW4, is operated at intervals determined by the cam fitted to the Ergas timer. With SW4 in the normally closed (N.C.) position, C3 charges via R3. When SW4 changes over to the normally open (N.O.) position, the charge on C3 is fed via R4 into the gate of the silicon controlled rectifier, Q1, turning it on. Q1 may also be turned on by setting the switch SW1 to the "START" position. A battery check meter operates via resistor R6. An optical coupler provides the necessary isolation between the adaptor supply and the recorder supply while allowing control of the recorder. This unit comprises an MLED600 light-emitting diode and a light-dependent resistor in a suitable housing. Q3 is thus turned on, causing the recorder to start operating. Drift is so small that for most practical purposes it can be ignored, even immediately after turn-on. While Q3 is on, Q4 prevents the clock motor from winding the Ergas movement; this prevents electrical interference from spoiling the recording. A recorder battery check operates via R9. At the moment of power turn-on, C9 is uncharged. This forces the reset input of the RCA CD4017AE COS/MOS decade counter* into the high state (6 volts). R17 charges C9, thus removing the reset function before the first count arrives. R16 ensures discharge of C9 during times when the power is off.

Q5 and Q6 combine to supply a suitably shaped pulse to the "clock" input of the CD4017AE decade counter. The 2N5485 junction field-effect transistors (F.E.T.) Q8 to Q17† are turned on in sequence, thus allowing successive channels to be switched through to the recorder. Once the cycle starts to repeat, a "turn off" signal is fed via SW3 and Q7 to Q2, which causes the whole system to shut down. This is achieved by forcing Q1 off with the charge held on C2. A partial cycle covering the first five channels is possible with SW3 set in position "5". If SW3 is set in position "10 REPEAT" then no turn-off signal reaches Q7; thus the scanning cycle repeats indefinitely. Switch SW2 is used to hold any channel on indefinitely in the "HOLD" position. In the "FAST" position scanning is speeded up to a rate of two channels per second. In the "NORMAL" position the scanning is one channel per 8 seconds. The scanning rate may be changed by altering R12. R19 may be increased to suit higher source impedances at the expense of performance at very low levels. The errors introduced by the scanner with R19 at 1 megohm are only of the order of a few tens of microvolts. Greater errors may be introduced in unused channels if the inputs are not shorted to V_{DD}. The input may be a.c. or d.c. with a maximum amplitude of ± 400 millivolts with respect to V_{DD}. As the scanning rate is low, no discernable errors are introduced by switching transients feeding through to the output.

Low-cost 2N5485 junction field-effect transistors were chosen for this adaptor as they are made to remarkably close tolerances. Although primarily intended for U.H.F. work, they are ideal in this application.

The circuit is generously laid out on two type-308 Veroboards. A single printed circuit of similar size could easily accommodate all the components.

---

* See: RCA COS /MOS Integrated Circuits Manual, Technical Series CMS270.

† See: Field Effect Transistors in Chopper and Analogue Switching Circuits. Motorola Application Note AN220.