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telephone verification system for automatic magnetic observatories

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Abstract. Automatic magnetic observatories at many locations across Canada sample the various components of the geomagnetic field once per minute and record the measurements in digital form on magnetic tape. The magnetic tapes are mailed once a month to Ottawa for processing by computer. This paper describes a system which permits the operation of a remote automatic magnetic observatory to be monitored in Ottawa at any time, by means of commercial telephone circuits.

Résumé. Les observatoires magnétiques automatiques installés en nombre d'endroits au Canada prélèvent une fois par minute les composantes du champ magnétique et enregistrent les mesures sous forme numérique sur bande magnétique. Les bandes magnétiques sont transmises chaque mois à Ottawa aux fins de traitement par ordinateur. L'auteur décrit un système qui permet de télécommander en tout temps d'Ottawa, par circuits téléphoniques commerciaux, un observatoire magnétique automatique éloigné.

Introduction

Eight Canadian stations are now equipped with the Automatic Magnetic Observatory System (abbreviated AMOS) developed by the Division of Geomagnetism, Earth Physics Branch (Andersen, 1969, 1970). The system employs a combination of fluxgates and a proton magnetometer. Once per minute, three voltages proportional to the magnetic north, magnetic east, and vertical geomagnetic components are sampled in quick succession by a digital voltmeter. Then follows a measurement of total intensity by the proton magnetometer. The four readings are recorded on digital magnetic tape; the date, time, and station identification are recorded every tenth minute. The magnetic tapes are mailed to Ottawa once a month for processing by computer.

The AMOS equipment is electronically complex, and although a number of checking procedures are provided, it is difficult for a local operator to ensure that the complete system is functioning properly, and to diagnose faults when they occur. Furthermore, an aim of the AMOS program is to eliminate the need for highly skilled permanent staff at the more remote magnetic observatories.

These problems present a need for some means whereby the proper operation of the AMOS can be verified by personnel and equipment located in Ottawa. For those locations equipped with conventional telephone service the system described here fulfills these requirements.

General description of telephone verification system

Figure 1 shows a block diagram of the system. In use, the operator at the receiving station, Ottawa, makes a phone call to the distant magnetic observatory. At the observatory the equipment automatically answers the phone, and commences to transmit the data currently being produced by the AMOS.

The data is received in Ottawa and printed on a small strip-printer. Upon completion of transmission, the equipment at the observatory disconnects the phone.

At the input to the system the data is in BCD parallel format. For transmission by a single telephone channel the data must be converted into bit-serial format. At the receiving station, Ottawa, conversion back to parallel format is required for use with the printer.

The information being transmitted includes the current geomagnetic data, the time indicated by the observatory clock, the identity of the observatory, and an indication of the performance of the recording equipment. Thus an extensive check on the operation of the AMOS is accomplished by making a phone call to the distant observatory.

Description of the components of the system

The #103A Data-Set. It is mandatory that the connections to the phonelines be made by means of data-sets supplied

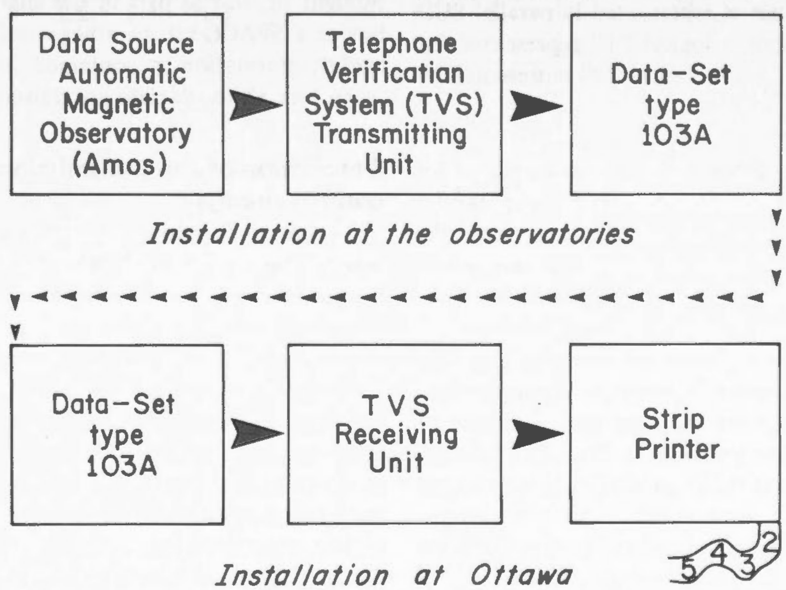

Figure 1. Block diagram of the Telephone Verification System.

and installed by the Telephone Company. Details of the operation of these data-sets can be found in the manufacturer's literature. They are summarized here for completeness. The data-sets permit simultaneous bi-lateral transmission of digital data in bit-serial format, with a logical "1" represented by a dc voltage of −5 to −25 volts and a logical "0" represented by a dc voltage of +5 to +25 volts. The maximum rate of transmission is 300 bits per second. A dc voltage between +5 and +25 volts is required to indicate that the data source is powered and ready to transmit data. For unattended stations an "automatic answer" feature is built into the data-set whereby the set will automatically answer an incoming call and connect the data source to itself for data transmission. Some means must be provided for automatic disconnection when a call is completed.

AMOS characteristics. The Automatic Magnetic Observatory System (AMOS) data characteristics have been described elsewhere (Andersen 1969, 1970). Again they are summarized here for completeness. Once each minute, on the minute, a burst of 24 digits issues from the AMOS. A few seconds later an additional burst of 8 digits is produced. Once each ten minutes this second burst is expanded to 24 digits. The rate of data output, within a burst, is about 170 digits per second. Each digit is represented in parallel BCD form with a logical "1" represented by −12 vdc and a logical "0" represented by 0 vdc.

Printer. Since only a small amount of data is needed to verify the proper operation of the AMOS, and since the data is of no further use once this proper operation has been ascertained, it is not necessary to have a very elaborate or long-lived printer. Accordingly, a very simple, low-cost printer is employed here. Its maximum printing rate is about 25 characters per second. The input requirements are BCD parallel data with signal voltages compatible with TTL Logic. Additional details may be found in the manufacturer's literature.

Transmission unit. This unit, shown in Figure 2, performs the interfacing required between the AMOS and the #103A data-set. The input from the AMOS consists of data, along with a character-strobe signal. The very first strobe pulse initiates a 1200 ms delay which puts the unit into the LOAD mode of operation. In this mode a burst of data characters is converted into TTL compatible signals and the data stored in a shift-register of 24-character capacity. At the conclusion of the 1200 ms delay the unit reverts to the TRANSMIT mode. In this mode, data is transferred, one character at a time, from the storage register to another shift register which performs the parallel to bit-serial conversion. The output of this register is amplified and fed to the #103A data-set.

Each data character is preceded in the serial bit-stream by a "1" bit which indicates the beginning of a new character, and by the Recorder Malfunction (REC MAL) bit which indicates the performance of the recording equipment. Each data character is followed by a "0" bit which indicates the end of a transmitted character. A complete transmitted character may be graphically represented as shown in Figure 3.

Thus each transmitted character consists of eight bits with the last one always a "0" bit. This last bit may also be thought of, not as part of the character, but as a SPACE bit. In other words, the useful information is contained in only seven bits, although eight are transmitted.

Description of the transmission unit control circuits

To understand the operation of the control circuits, suppose that the AMOS has just completed a measurement and is presenting the first digit to the tape recorder and at the same time also to the Telephone Verification System (TVS). The first recorder STEP signal initiates a 1200 ms delay in the TVS which results in the following action; the input gates to the storage register are enabled, the input to the control register is made a logical "1", the action of the serializing circuitry is halted. In this LOAD mode, the storage and control registers are under the control of the incoming data. Both registers are shifted in synchronism with the recorder STEP signal. These conditions prevail for the duration of the 1200 ms delay. During this time the AMOS may present up to 24 characters at virtually any speed, for loading into the storage register.

At the conclusion of the delay, the following action results: the data input gates are disabled, the control register input goes to a logical "0", the serializing circuitry is activated. In this TRANSMIT mode of operation, the storage and control registers are under the control of the serializer circuitry. A multivibrator operating with a cycle time of 5 milliseconds provides the serializer shift signal and also drives a divide-by-eight counter. The output of the divide-by-eight counter provides the shift signal to the storage and control registers. Thus eight serializer shifts occur for each storage register shift. A data character is transferred from the storage register into the serializer register only if the control register contains a logical "1". If the control register does not contain a "1", both control and storage registers are shifted but no characters are serialized and consequently there is no output to the data-set. This feature prevents the redundant zeros in an empty storage register from being transmitted as valid data, since the input to the control register is a logical "1" only during the LOAD mode, and hence contains a logical "1" only when the storage register also contains valid data.

As each character of valid data is presented to the serializer, it is loaded into the serializer along with the START, REC MAL, and STOP bits. Then the serializer is shifted eight times.

The output is a character of eight bits in serial form.

Description of the disconnect circuit

With the data-sets equipped with automatic answer capability, it is necessary to present the data-set with a

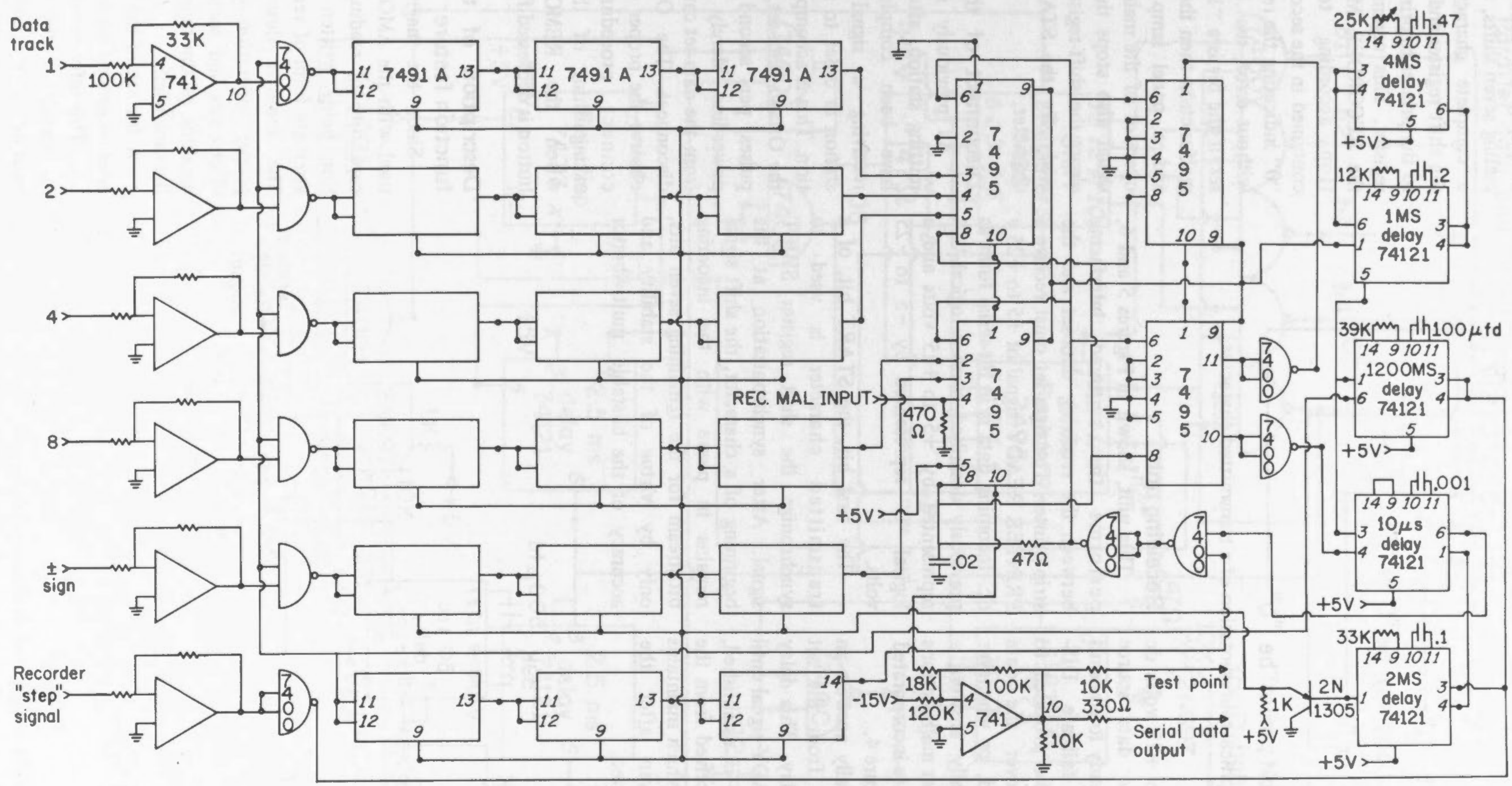

Figure 2. Circuit diagram of the transmission unit.

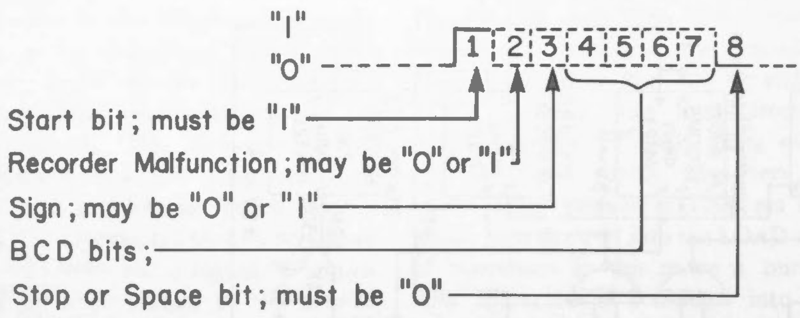

Figure 3. Graphical representation of a transmitted character.

READY signal of +5 to +25 volts dc which indicate that the data source (AMOS) is powered and ready to transmit data. In addition a fail-safe DISCONNECT signal must be provided to cause disconnect whenever the data transmission is completed, or whenever the data set automatically answers a wrong number, or whenever malfunctions occur. These capabilities are incorporated in the circuit shown in Figure 4.

As the set automatically answers an incoming call, a signal from the set initiates a 30-second delay. This delay provides a temporary READY signal until two-way communication is established, whereupon a signal is received from the calling station, Ottawa, which maintains the READY signal even after the 30-second delay is completed.

Receiving unit

This unit, shown in Figures 5 and 6, performs the required interfacing between the receiving data-set and the strip-printer. The data-set must receive a PRINTER READY signal of +5 to +25 v dc. Incoming data is in bit-serial form as previously described, with a logical "1" represented by +5 to +25 volts and a logical "0" represented by -5 to -25 volts.

The first bit, the START bit, of a transmitted character is used to synchronize the shift register SHIFT signal. After synchronization at the beginning of a character, the shift signal remains in phase with the incoming bit-stream for the remaining seven bits, only by virtue of the stability and accuracy of the bi-stable multivibrator providing the shift signal. Upon completing seven shifts, the unit assumes that a complete character is contained in the shift register and a command is issued to the printer to print the contents of the register. This command signal also sets the RECORDER MALFUNCTION flip-flop according to the information contained in the second bit. If this bit is a "0" indicating the recorder is functioning without error, the flip-flop will not be set; if the bit is a "1" indicating recorder malfunction then the flip-flop will be set and a panel lamp warns the Ottawa operator of the malfunction. The PRINT signal also stops the SHIFT signal and clears the shift-register. The unit is now ready for the START bit of the next character.

Disconnect of the remote station

As previously indicated, the transmitting station, after initial connections have been completed, depends upon receiving a signal from the calling station in order to maintain the connection. This is accomplished by inputing to the Ottawa data-set, a square-wave of 60 pulses per second derived from the power-line. Merely removing this signal from the data-set causes the distant set to disconnect. The Ottawa operator can observe the proper operation of this disconnect procedure by noting the extinguishing of the CARRIER lamp when the REMOTE DISCONNECT button is depressed for a few seconds.

Description of the recorder malfunction feature

Since the magnetic tape recorders used with the AMOS do not afford the capability of reading back the information being written on the tape, some alternate form of verification is desirable. The method described here verifies proper operation of all the recorder electronics and some of the mechanical handling of the tape but does not check the tape itself.

A feature of the tape recorders is the internal generation of the parity information. This information is computed from the signals on the data input lines. A separate parity computation is made

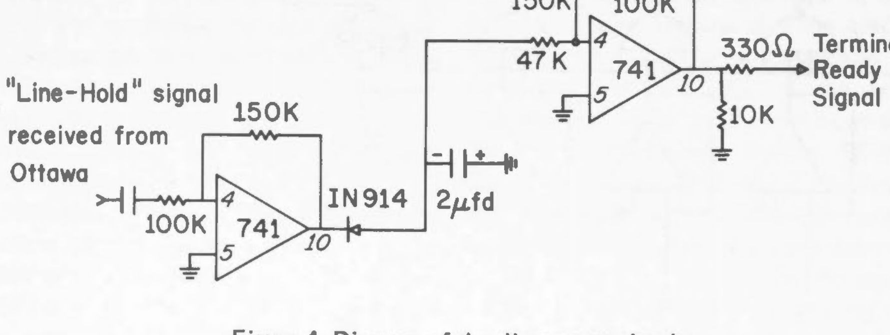

Figure 4. Diagram of the disconnect circuit.

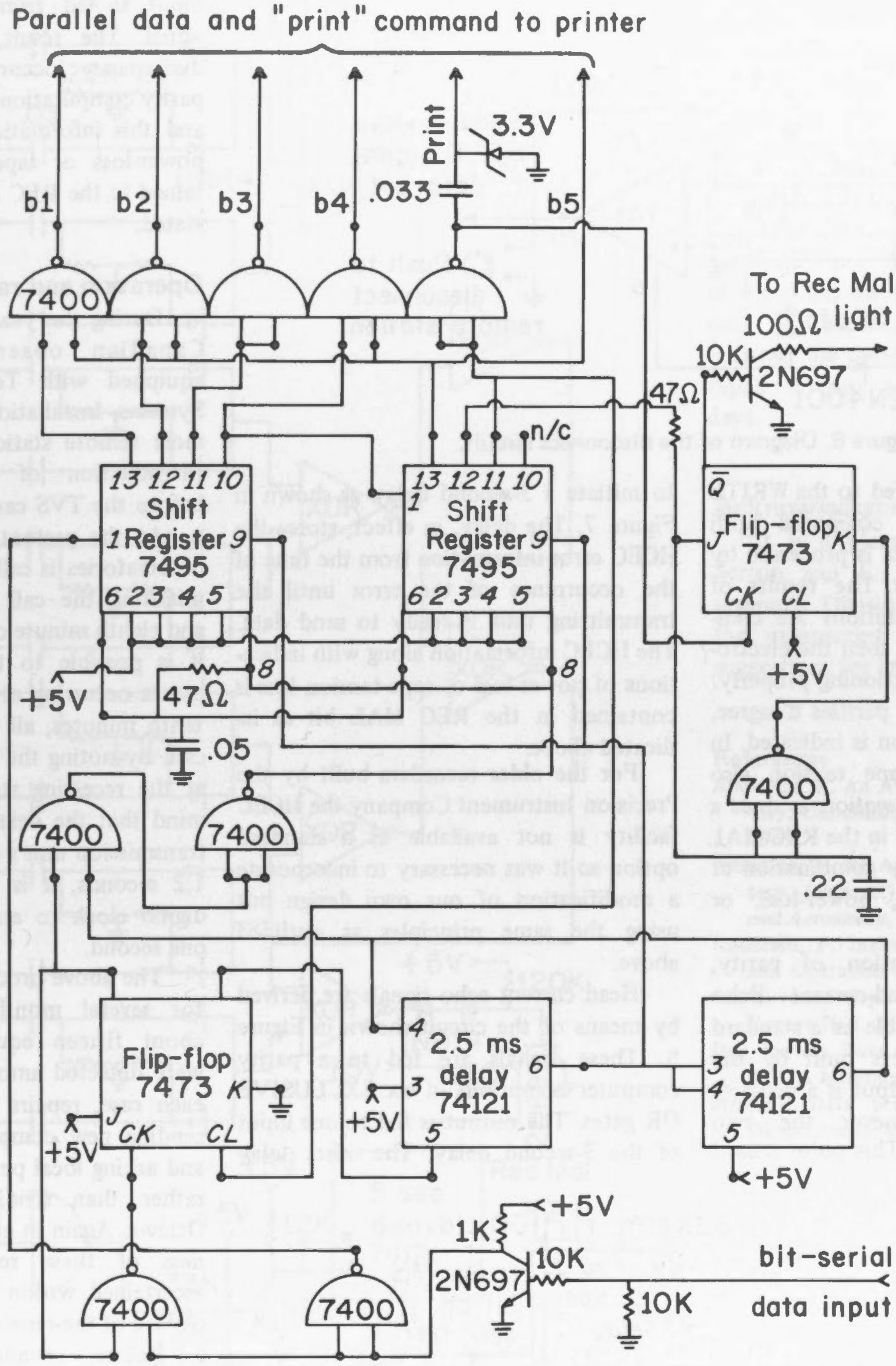

Figure 5. Diagram of the receiving circuit.

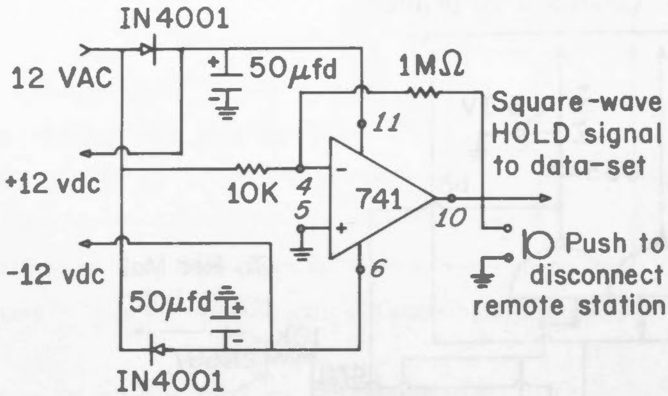

Figure 6. Diagram of the disconnect circuit.

using the signals being fed to the WRITE heads. Thus parity is computed both before and after the data is processed by the recorder electronics. The results of the two parity computations are compared and if they agree then the electronics are very likely functioning properly. Conversely, if the two parities disagree, an electronic malfunction is indicated. In addition, a loss of tape tension also indicates recorder malfunction as does a loss of power. Thus a "1" in the REC MAL bit indicates one or any combination of electronic malfunction, power-loss, or tape-tension loss.

The dual computation of parity, sometimes called Head-current Echo Check (HCEC) is available as a standard option on the recorders built by the Digi-Data Corp. The output is a negative pulse occurring whenever the two computations disagree. This pulse is used to initiate a 3-second delay as shown in Figure 7. The delay, in effect, stores the HCEC error information from the time of the occurrence of the error until the transmitting unit is ready to send data. The HCEC information along with indications of power-loss or tape-tension loss is contained in the REC MAL bit as indicated above.

For the older recorders built by the Precision Instrument Company the HCEC facility is not available as a standard option so it was necessary to incorporate a modification of our own design but using the same principles as outlined above.

Head current echo signals are derived by means of the circuit shown in Figure 8. These signals are fed to a parity computer comprised of six EXCLUSIVE OR gates. The output is fed to one input of the 3-second delay. The other delay input is fed from the recorder STEP signal. The result is that whenever a discrepancy occurs between the two parity computations, the delay is initiated and this information along with that of power-loss or tape-tension loss is contained in the REC MAL bit as previously stated.

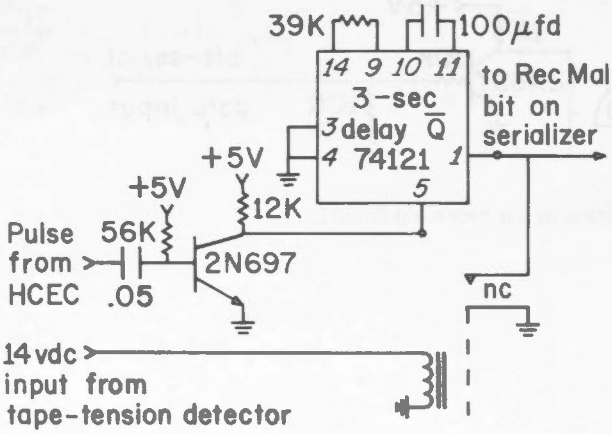

Figure 7. Diagram of the REC MAL indication circuit for Digi-Data Corp. recorders.

Operation and results

During the year 1972, a total of six Canadian observatories have been equipped with Telephone Verification Systems. Installations at a number of the most remote stations must wait for the introduction of telephone-via-satellite before the TVS can operate successfully.

At the present time each of the six observatories is called once each day. By initiating the call between the seventh and eighth minute of a ten-minute record, it is possible to transmit the measurements occurring at the eighth, ninth and tenth minutes, all within a three-minute call. By noting the time of arrival of data at the receiving station, and bearing in mind that the delay of data through the transmission unit's storage buffer is about 1.2 seconds, it is possible to check the digital clock to an accuracy of at least one second.

The above procedures have been used for several months. During this time about fifteen equipment malfunctions were detected among the six stations. In each case, repairs could be effected by sending new components to the station and asking local personnel to install them rather than sending technicians from Ottawa. Again in each case, the effectiveness of these repair procedures was ascertained within a short time of completion of the repair.

Before installation of TVS the operation of the AMOS could only be ascertained from the magnetic tapes which were sent to Ottawa once a month. Thus the AMOS could be out of service for several weeks before the malfunction was known and remedial action taken. In addition, a technician could not be certain of his success in repairing the AMOS until a test tape had reached Ottawa and verification performed by computer. The use of the TVS has resulted in early

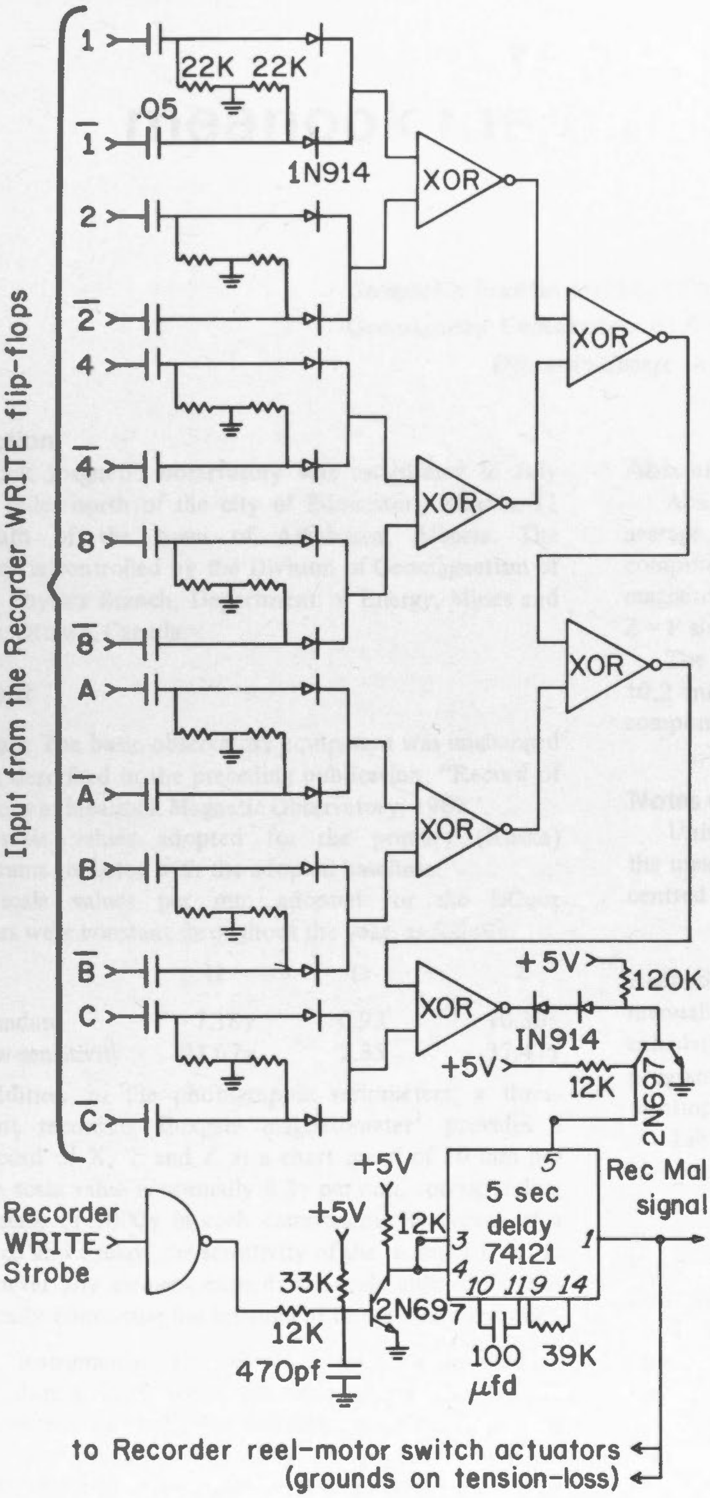

Figure 8. Diagram of the REC MAL indication circuit for Precision Instrument Co. recorders.

discovery of AMOS malfunctions; typically, a fault is known within 24 hours of its occurrence. The ability to effect most repairs by sending new components for installation by local personnel rather than sending technicians from Ottawa, has resulted in much less travel for the two technicians assigned to the AMOS project. Possibly the amount of travel has been reduced by a factor of ten. In addition, the elapsed time between the occurrence of a fault and its repair is now typically one to seven days.

Acknowledgments

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