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Remreed Switching Networks for No. 1 and No. 1A ESS:

Remreed Line Scanner

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A new line scanner design was undertaken as part of the No. 1 ESS remreed network development. The new design reduces frame and unit wiring, improves maintenance, lowers manufacturing cost, and occupies less space. The new scanner has been designed to be completely compatible with all existing No. 1 ESS system programs to permit its use in growth applications as well as in new machines.

I. INTRODUCTION

The No. 1 ESS line scanner is used to detect originations on subscriber lines. The original design, used in ferreed line link networks, is described in Ref. 1. The new scanner design takes advantage of the remreed network packaging and interconnection technologies to achieve a significant reduction in frame and unit wiring, manufacturing costs, and floor space by integrating the line supervisory element with the connectorized network fabric. Additional cost and space savings, reduced wiring, and improved reliability are achieved through the use of an integrated-circuit controller. The new scanner is referred to as the remreed line scanner because of its physical packaging with the remreed network fabric.

1.1 Scanner function

Most of the No. 1 ESS scanning logic is built into the scan programs. A scan request is generated in the central control in small offices or in the signal processor in large offices and transmitted to the scanner control over the peripheral unit-address bus. Each scanner in an office monitors the state of 1024 scan points, organized in 64 rows of 16 scan points in a particular row specified by the order. The scanner interrogates the 16 points specified by the order received over the peripheral unit-address bus and responds with a 17-bit message on the scanner-answer bus. The first 16 bits in this message give the states of the scan points in the selected row with the convention of 0 indicating off-hook and 1 indicating on-hook. The seventeenth bit, called all-seems-well (ASW), provides the principal scanner-maintenance function. An ASW of 1 indicates successful scanner-control operation.

1.2 The 2A ferrod

The scan element in the new scanner design is the 2A ferrod, basically a repackaged version of the 1B ferrod (used in the existing scanner) to permit its mounting within the remreed-network first-stage switch package.[2] The 2A ferrod, like its predecessor the 1B, consists of a ferrite rod (or stick) around which is wound a pair of control windings. The control windings are wired in series with the subscriber's loop in such a way that sufficient loop current magnetically saturates the ferrite rod.

The ferrod state is determined by a single-turn interrogate winding and a single-turn readout winding threaded through a pair of holes in the center of the ferrite rod. The ferrod functionally acts as a transformer whose magnetic coupling between the interrogate and readout windings is controlled by current in the control windings.

Interrogation is accomplished with a bipolar current pulse through the interrogate winding. If the subscriber line is on-hook, only loop leakage current, less than 5.5 mA, should flow through the control windings. This permits energy from the interrogate pulse to couple through the unsaturated ferrite rod to the readout winding where an output is detected as a logical 1 by the detector circuit. The bipolar current pulse consists of a reset portion and an interrogate portion of opposite polarities. This assures full magnetic switching of the ferrite material during interrogation.

When the subscriber goes off-hook, loop current in excess of 10 mA flows through the control windings, magnetically saturating the ferrite rod. The interrogate pulse energy is no longer coupled to the readout winding, and a logical 0 is detected.

1.3 Subscriber-loop wiring

The line ferrod is wired to the subscriber's loop through a pair of remreed cutoff contacts. These contacts are closed whenever the line is in the idle state, enabling the line scanner to detect a service request. Once the service request has been detected (line off-hook) and reported to the system, the cutoff contacts are opened and supervision is transferred through the network to a trunk scanner.

There are two methods of wiring subscriber loops to their line ferrods. The normal method, called loop start, is used on most ESS

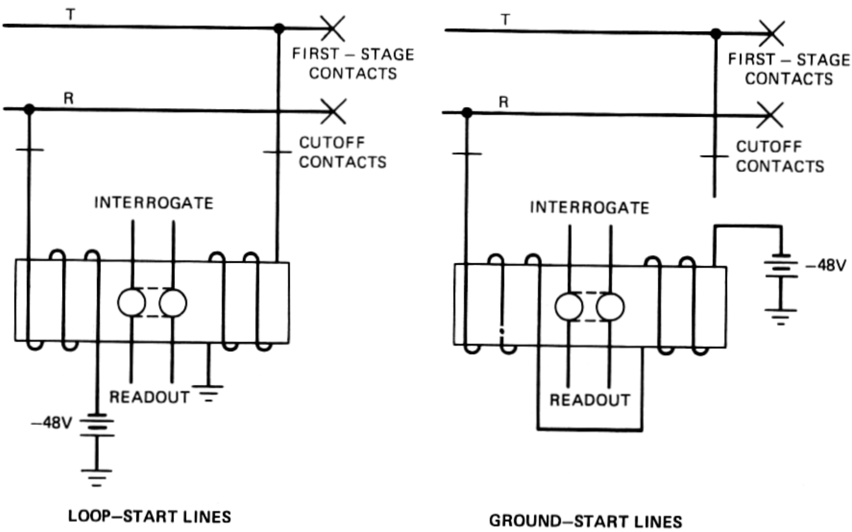

Fig. 1—Ferrod wiring options.

lines. In this arrangement, the line ferrod supplies battery to the ring and connects the tip to ground (see Fig. 1). Loop-start lines make use of the balanced ferrod windings to prevent the scanner from responding to longitudinal currents that may be induced in the outside plant.

Some coin and PBX lines require ground-start wiring of their line ferrods. In this arrangement, both ferrod windings are connected in series with the ring conductor, the tip conductor being left open in the idle state. On originating calls, the PBX line equipment grounds its ring conductor, saturating its line ferrod. On terminating calls, the line is switched by ESS to a loop-supervised trunk circuit, which furnishes a ground on the tip conductor, signaling seizure to the PBX.

All line ferrods are wired loop-start initially. The ground-start wiring option is provided on half the lines and is applied where needed during installation.

1.4 Scanner organization

The functional arrangement of the scanner controller and ferrods is shown in Fig. 2. The 2A ferrods are the elements of a 1024-point array. The matrix is arranged in 64 rows of 16 ferrods. The interrogate windings of the 16 ferrods in each row are wired in series to a pulse transformer from which the bipolar reset-interrogate pulse sequence is delivered when that row is selected. The readout windings of the 64 ferrods in each matrix column are wired to a readout circuit.

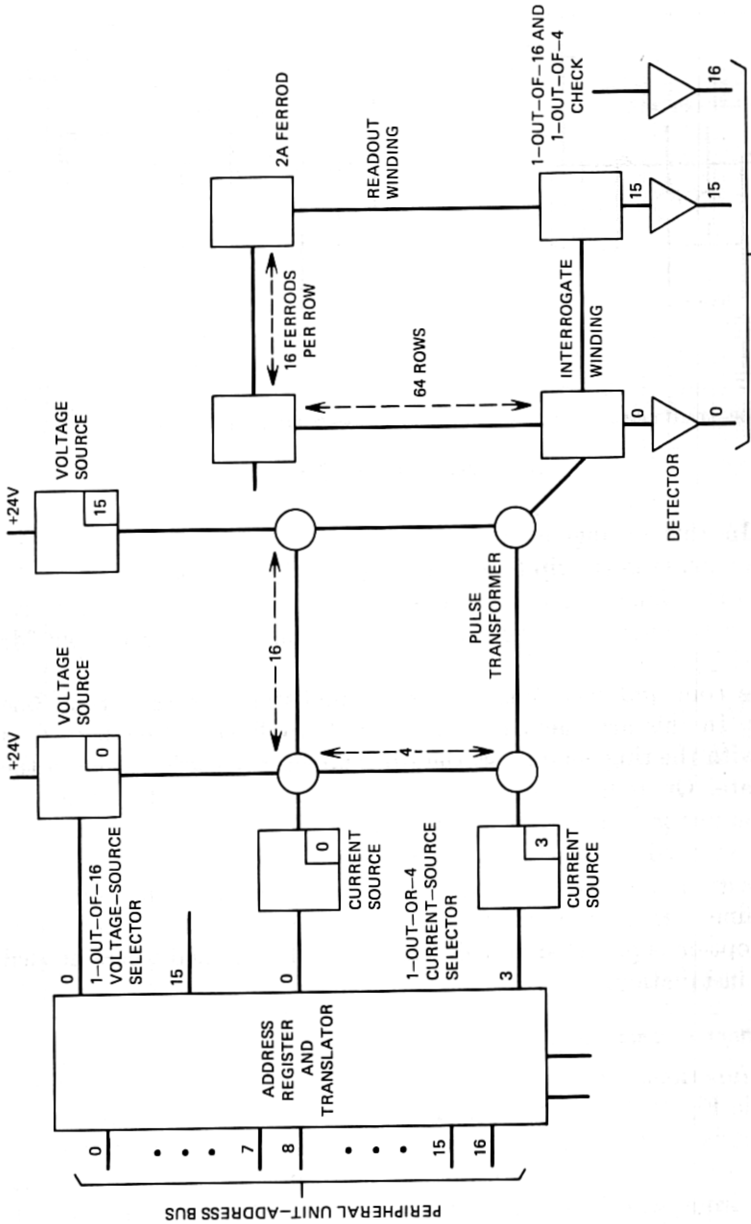

Fig. 2—Scanner block diagram.

The ferrod matrix itself is the only part of the scanner that is not duplicated. Each row contains the scan elements for the 16 lines that share the same first-stage switch. The line concentrators (12A or 13A grids*) are arranged so that their removal affects only the two or four rows of lines equipped in the concentrator.

The interrogate and readout circuits are completely duplicated. Under normal conditions, one scanner controller is active and the other is standby. Four enable circuits from the central pulse distributors are provided to select the peripheral unit-address bus and scanner controller. The enable pulse is used to open an address window, during which address information is received over the peripheral bus. The received address is stored and translated by the controller.

Each controller is also equipped with 16 readout circuits that receive information from the ferrod matrix readout windings. The readout information is then gated from the active controller to both scanner-answer buses.

II. PHYSICAL DESIGN

Many manufacturing economies achieved in the new scanner design are the result of new approaches to mounting and interconnecting the scanner components.

2.1 The remreed line-switch package

In the ferreed line-switch frames, the first stage of switching and line-cutoff switches are mounted in the same equipment unit and connected by unit wiring. The ferrod elements are mounted in a separate unit and connected to the various lines by frame cable. The remreed line-switch frames are organized so that the first stage of switching, cutoff contacts, and line ferrods for 16 lines are equipped within the switch package, replacing the unit and frame wiring with printed-circuit interconnection technology. To accomplish this, the 2A ferrod was packaged as an individual unit and is mounted and soldered in the switch-package circuit board.

Half the line ferrods are wired in the loop-start configuration on the switch printed-circuit board. The remaining half may be externally strapped in either the loop-start or ground-start configurations.

2.2 Connectorization

Since the 2A ferrods are mounted in the line-switch package, they are a physically integral part of the switching fabric. The 32-line 12A concentrator used for high-traffic applications and the 64-line 13A concentrator used for regular-traffic applications are fully connectorized

* References 3 and 4 describe the line concentrators.

replaceable modules. Bypass resistors are provided in the connectors to maintain the integrity of all readout loops while a concentrator is being replaced. The remaining scanner circuits are equipped on completely duplicated plug-in circuit packs.

2.3 Frame physical design

Two remreed frame designs use the new scanner. The 2:1 remreed line-switch frame contains two 2:1 concentration-ratio line-switching circuits and a line-scanner circuit. This frame provides the line scanner, cutoff contacts, and first two stages of switching for 1024 lines. It is used in high-traffic applications (exceeding about 4 ccs/line) where an overall 2:1 or 3:1 concentration ratio is needed.

The 4:1 remreed line-switch frame contains two 4:1 concentration-ratio line-switching circuits and two line-scanner circuits equipping 2048 regular traffic lines with their scanner, cutoff contacts, and first two stages of switching. This frame is used where an overall 4:1 or 6:1 concentration ratio is called for (usually below 4 ccs/line). In either case, a single bus unit, mounted at the top of the frame, provides the interface between the peripheral unit-address busses, scanner-answer buses, central pulse distributors, and the scanner and network controllers on the frame.

III. SCANNER-CONTROL CIRCUITS

As illustrated in Fig. 2, the scanner-control functions are divided into four sections: address register and translator, interrogate circuits, readout circuits, and maintenance functions.

3.1 Address register and translator

Scanner address information is sent from the processor to a scanner controller over a peripheral unit-address bus. The scanner controller and bus choice is made by selecting one of four enable pulses from the central pulse distributor. The arrival of an enable pulse at a scanner opens an address window gating information from the selected bus into the selected control register. A normal scan order contains 16 bits consisting of two 1-out-of-8 codes. These data are translated into a 1-out-of-4 and a 1-out-of-16 selection used to drive the analog portion of the scanner. The register and translator circuits associated with one controller are located on a single circuit pack consisting of 1A (137-type) silicon-integrated circuits interconnected with thin-film technology on a ceramic substrate.

3.2 Interrogate circuit

The interrogate circuit (functionally illustrated in Fig. 2) consists of 16 voltage sources, 4 pairs of current sources, and a 16-by-4 array of 64 three-winding transformers, each corresponding to a ferrod row. The 1-out-of-16 selection from the translator activates one of the voltage sources, while the 1-out-of-4 selects one of the pairs of current sources. The details of the voltage source, current source, and pulse transformer are shown in Fig. 3. One current source in the pair generates the first or reset portion of the current pulse which is driven through a single transformer winding and delivered to one of the 64 ferrod rows, resetting the magnetic state of the ferrite rod. The second current source in the selected pair then generates a similar current pulse through the second winding of the same transformer. The sense of this winding is opposite that of the first, and the result is an opposite-polarity, interrogate current pulse delivered to the ferrod row. Any of the 16 ferrods in the selected row that is not saturated (by loop current corresponding to an off-hook line) is thus switched, producing an output signal across its readout loop.

3.3 Readout circuit

The readout circuit has the function of detecting an output from an interrogated, unsaturated ferrod and delivering a logical 1 over the scanner-answer bus to the processor. The circuit consists of two analog detector-amplifiers and a digital integrated-circuit logic chain that strobes the detector outputs, stores the resulting 1 or 0, and then gates the result onto both scanner-answer buses. The readout circuit of a controller is illustrated in Fig. 4. As previously mentioned, the readout circuits are duplicated. The strobing technique prevents noise present during the switching of interrogate and readout currents from being falsely interpreted as logical 1s.

3.4 Maintenance functions

The principal scanner fault-detection mechanism is the all-seems-well (ASW) detector. This feature, used on every scanner order, verifies that one, and only one, scanner row has been selected, reset-pulsed, and interrogate-pulsed. Failing to reset or interrogate a row, or resetting or interrogating multiple rows, inhibits the generation of the ASW signal. The ASW signal is normally delivered, along with the 16 information bits (corresponding to the state of the 16 interrogated ferrods), to the processor over the scanner-answer bus.

A seventeenth bit is also provided in the address field (in addition to the 16 address bits) to permit the system to check all readout circuits. This maintenance bit is sent during diagnostic testing to activate special circuitry that generates a current pulse in each readout loop. The 16 readout circuits should detect current flow and report logical 1s back on the scanner-answer bus. An open readout loop or a

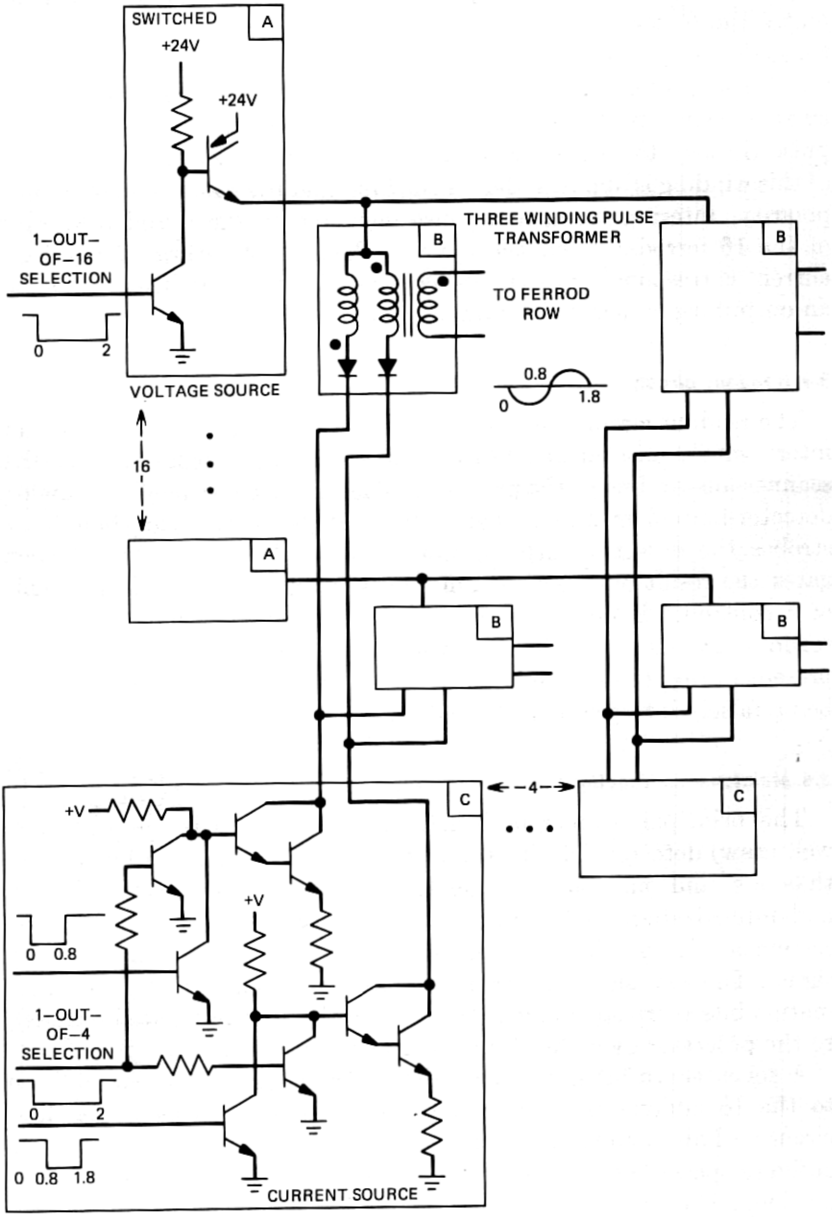

Fig. 3—Interrogate circuit.

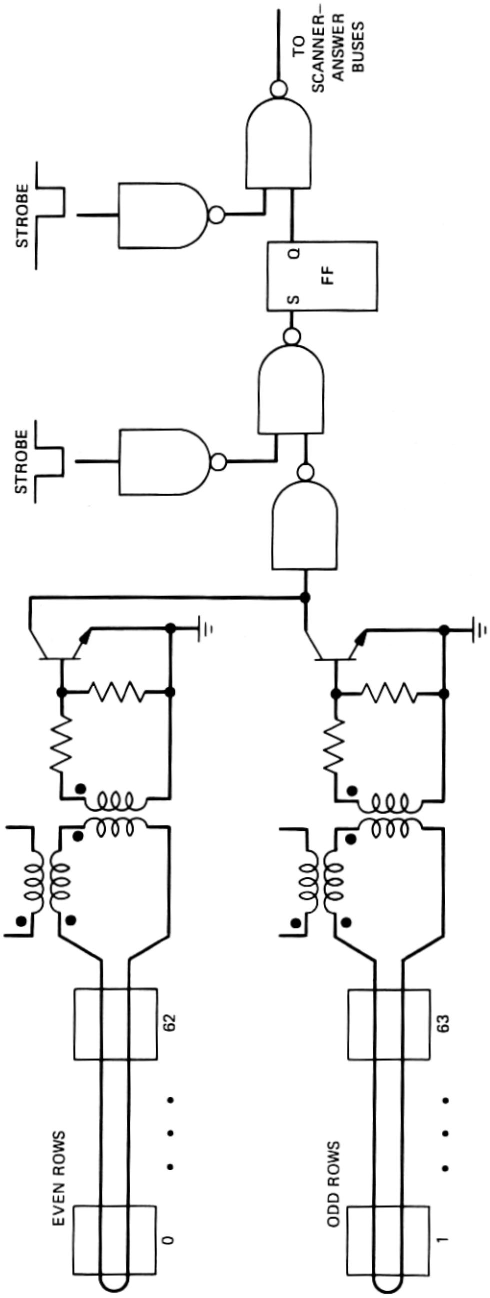

Fig. 4—Readout circuit.

faulty detector results in a logical 0 being returned on the scanner-answer bus.

IV. ADDITIONAL SCANNER FEATURES

In addition to the original design objectives stated at the beginning of this paper, the new scanner provides improved noise margin and higher-speed operation than the existing scanner, both enhancing system performance.

The existing scanner resets the ferrod rods in a scanner row after completion of an interrogation. The interrogate-reset sequence has the disadvantage that essentially all changes of state take place in the interval between a reset and the following interrogation. An off-hook to on-hook transition removes the control winding current that held the ferrod saturated in the off-hook state, but does not switch the ferrite rod. Consequently, the rod is left in an intermediate state. The following interrogate pulse partially switches the rod, producing a low-amplitude output. The detector threshold in the existing scanner is adjusted to be able to detect this low-amplitude output signal.

The new scanner uses a reset-interrogate sequence, always resetting immediately prior to interrogation. As a result, every unsaturated ferrod makes a full transition on interrogation, generating a full-amplitude output signal. This permits the detector threshold to be set at full amplitude in the new scanner, enhancing the noise margin over that in the existing scanner.

The new scanner was also designed for a worst-case response time (the longest time from receipt of address to scanner answer) of 2.3 μs and a recovery time of 4.5 μs to permit its use at the 7-μs scan interval planned for 1A ESS. This improvement in the scan rate over the 11-μs scan interval used in No. 1 ESS will help increase system call capacity.

V. ACKNOWLEDGMENTS

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