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APPENDIX 1A
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COMMON SYSTEMS
T1 DIGITAL LINE
221-TYPE OFFICE REPEATER

CHANGES

A. Changed and Added Functions

A.1 An improved output circuit was added.

A.2 The low line current was lowered from 70 mA to 60 mA.

D. Description of Changes

D.1 As this is a preproduction change, no record of changes is being kept at this time.

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DEPT 4223-CJM-JBS

COMMON SYSTEMS
T1 DIGITAL LINE
221-TYPE OFFICE REPEATER

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SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 The 221-type office repeater is a plug-in unit that is designed for central office use with the T1 digital line in situations where T1 span termination in a J98725A, B, or C office repeater bay (T1C/-T1 office repeater bay). There are three 221-type repeater codes; the 221A has a line current regulator and pulse regenerator, the 221B has only a pulse regenerator and is intended for power looping, and the 221C is a bridging repeater to be used for in-service patching and for driving the maintenance line.

1.02 The 221-type office repeaters are used to provide span line termination for T1 lines where termination in the T1C/TC compatible J98725( ) office repeater bays is desired. The functions of line current simplexing, line current regulation, and pulse regeneration are provided by the various 221-type codes. Pulse transmission is at the DS1 rate, 1.544 Mb/s.

1.03 The pulse regenerator sections of 221-type repeaters are equipped with automatic line buildout (ALBO). Equalization of the signal received from the line is done automatically by the ALBO network function.

1.04 In the transmit direction, the 221-type repeaters provide an artificial line network to build out short end sections, provide fault current surge protection, and provide the office interface with a well controlled impedance.

1.05 The 221A repeater provides a dual current, multivoltage regulator function. A number of options are required for establishing appropriate powering combinations for the repeatered line.

1.06 The 221B power looping repeater has no regulator circuitry. It is intended to supply the proper interconnection circuitry for completion of the looped power option. There are a number of options required for establishing the proper powering desired for the regenerator portion of power looping repeaters.

1.07 The 221C bridging repeater requires no powering options since it is always powered from the local office battery. It is intended for use in in-service patching and for maintenance line chaining.

1.08 The 221-type repeater does not require field adjustment except for setting the required powering options where necessary.

2. GENERAL DESCRIPTION OF OPERATION

2.01 There are two basic groupings of office repeaters; span termination repeaters and bridging repeaters. Span termination repeaters are provided to fully terminate a T1 line, provide signal regeneration in the receive path, couple the transmit signal to the outside plant through appropriate artificial line and provide for either line current regulation or power looping. Bridging repeaters are for use in patching and as a source of test signal during maintenance tests. The input to a bridging repeater is derived through a high impedance tap on a regenerated T1 pulse stream before it has encountered significant transmission loss.

2.02 A block diagram of a span termination repeater is shown in CD Fig. 1. The three basic functions of these repeaters are shown.

2.03 The receive portion of the repeater is an active pulse regenerator similar to the regenerator circuit used in T1 line (manhole) repeaters. Signals are coupled to the input of the repeater from the cable vault splice, usually via the main distributing frame (MDF) or high frequency distributing frame. The input signal is first attenuated by an artifical line network which builds out the end section to a minimum loss while providing secondary lightning protection for the repeater circuitry. The artificial line is a balanced bridged-T constant impedance circuit and provides a good termination for the cable plant.

2.04 The regenerative portion of the receive path consists of an amplifier/-equalizer, a clock extraction circuit, and a pulse regenerator/driver circuit. The equalizing amplifier is made up of a fixed gain shaped feedback balanced output operational amplifier and a shaped variable loss network called an ALBO network. A peak detector circuit monitors the peak of the amplified and equalized output and adjusts the loss of the ALBO network to maintain a constant output amplitude.

2.05 The output of the balanced equalized amplifier drives the clock extraction and regenerative portion of the regenerator. The equalizer output, when full wave rectified, is used to drive an inductor capacitor (LC) tank circuit which is tuned to the T1 pulse repetition frequency (1.544 MHz). Although the equalized signal has very little energy at the timing frequency, the full wave rectification process creates an impulse of energy at this timing frequency. The medium quality (Q=100) tank circuit functions as a phase filter and memory to ensure proper regeneration of signals during sparse pulse patterns.

2.06 The regenerative portion of the circuit uses the extracted timing information to sample the output of the equation amplifier and transmit a pulse when a "pulse present" decision is made. The output pulses from this regenerator are higher in amplitude than a standard DS1 level pulse. This higher amplitude allows for the use of lossy equalizers to be used to compensate for signal loss in the path from the regenerator output to the cross-connect point.

2.07 Power for the pulse regenerator is derived from a power supply composed of three zener regulator diodes and three rectifier diodes. This power supply develops the required positive and negative voltage used to operate the active circuits in the regenerator.

2.08 Power for the repeaters on the line is derived from the offices at each end of a span through simplexed power loops. Each power loop requires a current of 140 mA for standard T1 lines or 60 mA for low power T1 lines.

2.09 The line current regulator, FS 2, supplies a constant current of 140 ±4 mA or 60 ±3 mA to the power loop over the allowable operating range. The regulator load is composed of the cable resistance and effective resistance of each repeater in the loop.

2.10 The line current regulator circuit is designed to be powered from various combinations of office battery voltage (-48 volts and battery return, +130 volts and battery return, +130 volts and -48 volts, and +130 volts and -130 volts). Once the office battery voltages are chosen, the correct options must be made in the line current regulator according to Circuit Note 101.

2.11 The choice of power loop voltage is dependent upon the cable length and gauge and the number of repeaters in the power loop. The proper power loop voltage is obtained by selecting options on the fuse and alarm circuit at the top of the repeater bay.

2.12 In the transmit direction, an artificial line network builds out the end section to a minimum loss and provides a good impedance to the office cross-connect.

2.13 The input and output impedances of the repeater are 100 ohms, and the impedanc of the line simulator circuit is 100 ohms.

SECTION II - DETAILED DESCRIPTION

1. BIPOLAR PULSE REGENERATOR (RECEIVING PATH)

1.01 FS 1 details the circuitry of the repeater. At the input to the regenerating side is a 100-ohm artificial line. The artificial line is shown in Fig. A and is a constant resistance loss equalizer. The network provides a good termination for short end sections and makes it possible to operate on sections shorter than 6 dB of cable loss.

1.02 One 170-type hybrid integrated circuit (HIC) is required per repeater. The HIC is mounted on a printed wiring board, along with the discrete components.

1.03 The secondary lightning protection is composed of varistor RV101 shunted across the input transformer T101. Resistors R101 and R117 of the artificial line are also used to limit the current in the event of a lightning surge. If a lightning hit actually breaks down either or both of the carbon protector blocks on the MDF, capacitor C102 temporarily holds the pair at ground potential after the lightning surge has diminished to prevent the arc at the protector blocks from sustaining on the power supply voltage.

2. PREAMPLIFIER

2.01 The preamplifier portion of the repeater is composed of diode CR1 and preamplifier SIC1 and associated components shown on FS 1.

2.02 Preamplifier SIC1 receives dc power from the power supply on terminals 2 and 15, 5 and 11, and 6. A reference voltage is generated within SIC1 and is brought out on terminal 4. This voltage is one diode drop below ground potential (approximately -0.7 volt) and is used as a reference for the preamplifier outputs and clock amplifier SIC3 input.

2.03 Preamplifier SIC1 is a linear differential amplifier with balanced inputs and balanced outputs. The outputs are direct coupled to associated circuits; therefore, good balance and high dc stability is required. The proper dc bias of the outputs is maintained by two dc feedback loops. It is desired that the dc level of the outputs be one diode drop below ground; hence, the dc feedback loops are referenced to the internal -0.7 volt source on terminal 4. The dc potential, E01, at terminal 7 is stabilized by an internal comparator circuit. Capacitor C104 provides filtering for the comparator circuit. The dc potential E02 at terminal 9 is stabilized by the feedback network composed of resistors R9 and R7. To provide for good dc balance at the outputs, the resistance seen by input terminals 17 and 19 is made equivalent.

2.04 The regenerator receives distorted and attenuated pulses from the previous rerepeater or terminal (see CD Fig. 2a). The pulses are coupled to the preamplifier circuit through transformer T101. The transformer converts the 100-ohm line impedance to 400 ohms, as well as providing a dc path for the simplexed dc power. Resistor R1 provides the proper termination for the transformer. The repeater preamplifier SIC1 and associated circuitry provides the necessary gain and equalization to produce signals at the preamplifier outputs that will enable accurate decisions to be made by the logic and clock circuits (see CD Fig. 2b and 2c).

2.05 The transmission characteristic from input transformer T101 to preamplifier SIC1 outputs is such that the loss of the cable plus pad is properly compensated for. The gain-frequency characteristic of SIC1 is controlled by the feedback network connected between leads 9 and 19. The low frequency gain of the preamplifier is controlled by resistors R9 and R7, and the high frequency shaping is set by capacitors C1 and C3, R2, and inductor L101, in combination with R8 and R7. This particular gain characteristic is optimized for a nominal maximum cable loss plus pad loss of 35 dB.

2.06 For losses less than 35 dB and greater than 7.5 dB, the optimum transmission characteristic is maintained by the ALBO network. In general, the ALBO network inserts an amount of loss that, when added to the cable plus pad loss, is equal to 35 dB. Thus, the preamplifier always sees an effective 35-dB cable loss.

2.07 The series portion of the ALBO network is comprised of resistors R3, R4, and R5; capacitor C2; and inductor L102. The shunt portion of the network contains R6, C4 and C101, and diode CR1. The small signal ac impedance of CR1 at terminal 3 varies as a function of dc current supplied at terminal 11. The dc current is supplied from terminal 13 on preamplifier SIC1 through the low-pass filter comprised of R10 and C110.

2.08 Preamplifier SIC1 contains a peak detector circuit that attempts to maintain the preamplifier output signals at constant amplitude. At losses less than 35 dB, the preamplifier output signals try to increase. The peak detector circuit senses this and feeds a larger dc current to diode CR1 which causes the ac impedance of the diode to decrease. This, in turn, lowers the impedance of the shunt arm which increases the loss of the input network returning the signal peak to normal.

2.09 Filtering for the peak detector circuit is provided by capacitors C103 and C106 and resistor R11. C105 filters the -0.7 volt reference supply.

2.10 The preamplifier for the 221C repeater is somewhat different from the other six codes. The input signal is a normal bipolar signal which has been flatly attenuated approximately 20 dB and transmitted over 0 to 1000 feet of cable. The ALBO component configuration used is similar to that employed in the 99A HIC; component values reflect the differences in the signal shape and amplitude variations. The signal, coupled through transformer T601, passes through the series portion of the ALBO comprised of resistors R3, R4, R5, and R208; capacitor C2; and inductor L602. The shunt portion, consisting of R6, C4 and C601, and diode CR1, changes impedance as the input level changes and maintains the optimum gain and shape characteristics of the overall preamplifier. Fixed gain shaping is provided for the amplifier by R7, R2, R80, L601, C1 and C3. The remainder of the regenerator circuit operates as described for the six line repeater codes.

2.11 To summarize, the two preamplifier outputs are biased at -0.7 volts dc. The signal peak is maintained at approximately +0.7 volt dc by the peak detector circuit. This places the average value of the positive half of the preamplifier output signal at 0 volts dc which is the threshold level of the logic circuit inputs. The peak detector and ALBO circuit maintain the preamplifier output signals at constant amplitude and properly shaped for optimum performance over a wide variation in cable losses.

3. CLOCK EXTRACTION CIRCUIT

3.01 The clock extraction circuit consists of clock amplifier SIC3, a high quality resonant circuit, and other associated components. The function of the circuit is to extract timing information from the preamplifier output signals and generate a 1.544-MHz clock signal to properly time the logic SIC2.

3.02 Clock amplifier SIC3 receives dc power from the power supply on terminals 2, 8, and 11. The -0.7 volt reference voltage from preamplifier SIC2 is applied on terminal 1.

3.03 The two preamplifier SIC1 outputs supply opposite phase signals to clock amplifier SIC3 inputs on terminals 14 and 15 (see CD Fig. 2b and 2c). The signals are full wave rectified and clipped in the clock amplifier. The clipping threshold is established by the -0.7 volt reference supply. The rectified and clipped signal is applied to the high quality LC tank circuit composed of capacitor C107 (C607) and transformer T103 (T603). C107 (C607) is permanently adjusted to resonate with the primary winding of transformer T104 (T603) at 1.544 MHz. The LC tank extracts a 1.544-MHz component from the rectified signal. The extracted clock signal is coupled into the secondary of T104 (T603) and connected to the input of SIC3 on terminal 16. The nature of the extracted clock signal is such that it can vary in amplitude as a function of pulse density at the input. SIC3 contains a linear differential amplifier with nonlinear feedback. The nonlinear feedback maintains the output of the amplifier at a constant amplitude as the input to the amplifier varies over a 20-dB range.

3.04 The output of clock amplifier SIC3 appears on terminal 4 (see CD Fig. 2d). The output is biased at 0 volts dc relative to ground, and the amplified clock signal swings symmetrically about this point. This signal is applied to a slicing circuit in the logic SIC2 at terminal 19. The threshold of the slicing circuit is at 0 volts, thus, the clock signal is sliced at the zero crossings. The correct timing information for the logic circuit is contained at the zero crossings.

3.05 For proper pulse regeneration, it is necessary that the zero crossings of the clock signal in the negative direction be properly aligned in time with the center of the pulse out of the preamplifier. The resistor capacitance (RC) network, consisting of resistor R12 and capacitor C5, provides the proper delay to ensure this. C6 is used to limit the bandwidth of the clock amplifier to ensure gain stability.

3.06 A control voltage is applied to clock amplifier SIC3 on terminal 10 from preamplifier SIC1. This voltage is normally equal to 0 volts, but in the absence of a signal at the preamplifier input, the voltage goes negative. When the voltage is the clock amplifier is properly biased to produce 0 volts dc at the clock amplifier output. However, when there is no signal input and the control voltage is negative, the clock amplifier output is biased positive. This ensures that the logic circuit is biased off and will not produce pulses in the no signal condition.

4. LOGIC

4.01 Logic circuit SIC2 contains threshold and decision making circuits that determine the presence or absence of a pulse and contains pulse regenerators that reconstruct the pulses.

4.02 Logic circuit SIC2 receives dc power from the power supply on terminals 7, 8, 3, 13, and 18.

4.03 The two preamplifier SIC1 outputs supply opposite phase signals to logic circuit SIC1 inputs on terminals 2 and 14 (see CD Fig. 2b and 2c). The threshold level of the logic inputs is at 0 volts. The signals applied to the logic inputs are biased such that one-half the positive pulse amplitude (the optimum decision level) occurs at 0 volts. Thus, the logic circuit responds to signal levels that exceed the 0-volt threshold. Each successive pulse creates a response at alternate logic inputs because of the alternating polarity of the bipolar signal.

4.04 The clock signal is applied to the logic circuit SIC2 on terminal 19. The simultaneous occurrence of the clock signal passing through zero in the negative direction and a pulse at either logic input greater than 0 volts will initiate a pulse at the logic output terminals 4 or 12 (see CD Fig. 2e and 2f). The pulse width is determined at the next zero crossing in the positive direction (see CD Fig. 2d). Capacitor C7 provides a delay in a logic gate to optimize the timing circuit performance.

4.05 The two logic outputs are coupled to the driver transistors Q101 (Q601) and Q102 (Q602) via resistors R13 and R14. The two transistors drive opposite halves of the output transformer T103 (T603) primary winding. Diode CR105 (CR607), when used, establishes a higher decision threshold in the output circuit and provides tight pulse width control. R113 (R602) and R114 (R603) supply additional current to the output transistors.

4.06 An extra secondary winding on transformer T102 (T602) is used for fault locating tests. Resistor R112 (R601) and inductor L103 (L603) provide isolation from other repeaters connected to the fault locating filter.

5. TRANSMITTING PATH

5.01 A signal from the 1.544-Mb source in a terminal office or from another repeater in an intermediate office follows the transmitting path in line terminating repeaters. Transformer T102 is a repeat coil which powers the line through the center tap and keeps power out of the transmission path where the jacks are located.

5.02 The secondary lightning protection is composed of two varistors RV106 and RV107. The output circuit has twice as many varistors shunted across it as the input circuit, so the higher level output signal will not be clipped. The varistors protect the transformer from a high voltage if lightning hits the line. Resistors R102 and R120 of the artificial line limit the current in the event of a lightning surge. The artificial line loss in the transmit path is lower than the receive path. The reduced loss in the transmit path allows up to 3 dB of cabling loss between the DSX1 and the office repeater in the transmit direction.

5.03 If a lightning hit actually breaks down either or both of the carbon protector blocks on the MDF, capacitor C1 temporarily holds the pair at ground potential after the lightning surge has diminished to prevent the arc at the protector blocks from sustaining on the power supply voltage.

5.04 The 100-ohm artificial line network, shown in Fig. A, simulates cable loss. The network is a constant impedance loss equalizer which is composed of components L106, L107, R102, R107, R108, R109, R118, R119, R120, and C113. The network provides a good termination for the office repeater driving a short end section.

6. BRIDGING REPEATERS

6.01 Bridging repeaters are designed to bridge across working lines without affecting its operation and regenerate that signal.

6.02 Monitor resistors are located at the DSX1 or cross-connect field, and attenuated signal is transmitted to the repeater bay over office cable. Input transformer T601 provides a 100-ohm termination for the office cable. The ALBO range of 0 to 1000 feet of 22-gauge cable is well beyond the DSX1 limit of 655 feet from the office repeater bay.

6.03 The 221C bridging repeaters has no fault-locating output since it will never be tested in this manner.

7. POWER SUPPLY

7.01 The power supply develops the required operating voltage for the pulse regenerator circuitry. Current flowing from terminal 6 of option block S101 (see FS 1) flows through zener diodes CR105 and CR101 and diode CR106, producing the positive power supply voltage used to operate the output stage. This voltage is about +10.2 volts and is required for the output stage so that the 6-volt peak (+6 dB hot) output pulses can be developed. CR102 provides a dc voltage drop that reduces the positive 6.2 volts (measured at the junction of CR101 and CR105 relative to the circuit ground) to +5.5 volts which is used to power the remainder of the repeater circuits. CR104 is also a zener diode used to establish the negative power supply voltages. Negative 4.7 volts is established in reference to circuit ground. CR103 reduces the negative power supply voltage to -4.0 volts required by the repeater circuits. CR106, CR102, and CR103 prevent reverse voltages from being applied to the repeater circuits during surge conditions. Capacitors CR109 and C108 provide filtering of the dc voltage. C114 provides high frequency filtering of the repeater to frame ground. C115 filters the output current.

7.02 The choice of powering the office repeater either from -48 volt office battery or in series with the span line power loop is made at option block S101. The available line powering options are indicated in brackets and covered by Circuit Note 101. The 1, 2, 3, and 7 options shown provide for powering the office repeater in series with the line, and the 4, 5, and 6 options provide for powering the office repeater from the -48 volt office battery. When the 4, 5, or 6 options are used, a series current limiting resistor (not shown on this circuit) is provided as part of the shop-wired bay.

7.03 Resistor R115 provides a voltage crop proportional to the line current. The nominal voltage across this resistor is 1.4 volts corresponding to a line current of 140 mA or 0.60 volt corresponding to a line current of 60 mA.

7.04 The line current regulator (see FS 2) has output leads designated +(plus) and - (minus) that are connected to FS 1 where test points and line connection options are options are available. These functions will be explained later.

8. LINE CURRENT REGULATOR

8.01 The line current regulator is shown on FS 2. The office battery input leads on terminals 33, 37, and 39 are designated --, +, and -48 volts. Battery ground return designated BR connects to the repeater via pins 15 through 19 which are also connected to pin 44. Terminals 29 and 30 are provided for connecting to the power dissipation resistor that is associated with transistor Q201. The power dissipation resistors are mounted in the office repeater bay.

8.02 Fuse alarm leads are provided for both fuses F201 and F202. Resistors R201 and R202 appearing in the alarm leads are provided to limit the maximum current in the alarm leads.

8.03 The line current regulator design is such that it may be used with different combinations of office battery voltages, depending upon the desired operating voltage required (based upon the cable length and number of repeaters to be powered). Option switches S201 and S202, along with option block S203, provide the necessary connections that permit the line current regulator to operate from the various office battery voltages. Circuit Note 101 covers all the required options for the regulator circuit.

8.04 The line current regulator uses a single NPN power transistor. The circuit operates in the following manner: Considering the -48 volt battery and battery return (BR) condition, it is necessary to switch S201 and S202 to the W and Z options. The option block S203 is closed. The Z option allows the -48 volt battery to be applied to switch S202 terminal 6. Connection is made through the switch to the regulator via fuse F202. At the same time, terminals 2 and 3 of S202 are made, which puts resistor R206 in parallel with R205, since S201 terminals 1,2 and 4,5 are made (W option). A temperature-compensated bias voltage circuit consisting of diode CR202 and varistors RV201, RV202, and RV203 and the parallel combination of R205 and R206 is connected between the battery input and ground. This circuit develops a constant bias voltage of nominally 8.2 volts between the base of transistor Q201 and -48 volt battery input. Since Q201 is forward biased in the operating range of the regulator, the emitter of the transistor will be only slightly negative in respect to the base. Thus, most of the 8.2-volt bias will appear across the emitter bias resistors composed of the parallel combination of R203 and R204. The resultant current flow through the parallel resistors is constant. The constant current (60 mA) is shop adjusted by selecting the optional R204 according to Circuit Note 106. The constant current (140 mA) is shop adjusted by closing option block T (S204) and selecting optional resistor R207 according to Circuit Note 106.

8.05 The constant emitter bias current divides between two paths, transistor Q201 and the power dissipation resistor (located at the top of the office repeater bay) connected across the emitter-collector of Q201 via terminals 29 and 30. The division of this current is dependent on the operating point of the regulator (see CD Fig. 3).

8.06 As previously mentioned, the line current is constant because the bias voltage VB is constant. Since the base current IB of the transistor is very small compared to the total transistor or current, the line current IL is approximately equal to the input line current.

8.07 Referring to CD Fig. 3, the line current IL=IQ and is constant over the normal operating range of the regulator. For small values of line resistance (RLINE), the current through the dissipation resistor IDR is large, and very little current flows through the transistor IQ. For large values of line resistance, just the opposite condition exists; IDR is small and IQ is large. The midpoint of the operating range is defined as the point where the current through the dissipation resistor; that is, IQ=IDR=1/2 IL.

8.08 Also included in FS 2 are diodes CR201 and CR203. These diodes protect the regulator from damage due to high voltage lightning surges. Positive voltage surges on the + lead which exceed +130 volts cause CR203 to conduct current toward the office battery connected to the input. Negative surge voltages cause CR201 to conduct. To summarize, the lightning protection diodes limit surges to the range from -130 to +130 volts.

8.09 Test point 4 is used in conjunction with other test points in FS 1 and will be covered later.

8.10 The line current regulator operates in basically the same manner for the +130 and -130 volt inputs. It is necessary to select the correct switch options according to Circuit Note 101.

9. TEST POINTS AND OPTIONS

9.01 Four voltage test points are provided to measure current and voltages necessary to establish that a power loop is being powered properly and that the regulator is operating within its regulating range. The + test point is used in common with the other three as follows.

(a) + with -I: measures the voltage across a 10-ohm resistor R106. This voltage reads 1.4 volts when the line current is 140 mA (line current = V/10 amperes and 0.60 volt when the line current is 60 mA.

(b) + with -V: measures the line voltage directly. The line voltage is the sum of the voltage drop across each line repeater, the cable resistance and 100-ohm artificial line or flat loss network in the 221-type repeater.

(c) REG (Fig. 2 or 3) with +: measures the voltage across the regulator and is used to determine the operating point of the regulator.

9.02 The line voltage and regulator voltage are variable and will depend on the number of repeaters in the power loop, length and gauge of cable, and cable temperature. The line current, however, is practically constant for all normal conditions and is between 136 and 146 mA or 57 and 63 mA, depending on the option used.

9.03 Power loop options are covered by six different combinations of screw-down options. Combinations 1, 2, and 3 provide for powering the office repeater in series with the line in both 1- and 2-cable systems. Combinations 4, 5, and 6 provide for powering the office repeater and line separately.

9.04 Resistor R121 (R607) is provided to discharge the - lead when the repeater is removed from its receptacle.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 The maximum cross connect distance between repeaters is 180 feet without the DSX1.

1.02 The maximum distance between the office repeater and first manhole repeater is 23 dB at 772 kHz (4500 feet with 22-gauge cable) for line terminating repeaters. The minimum distance between the DSX1 or cross-connect point and the first manhole repeater (ALBO type only) is 2.5 dB, but impulse noise must be considered in the shorter sections.

1.03 The repeaters will operate on various cable gauges where the 772-kHz loss is between 2.5 dB and 23 dB.

1.04 Maximum ambient temperature extremes over which the repeaters will operate are -0 to +140 degrees F.

1.05 The maximum distance between a DSX1 bridging point and a 221-type bridging repeater is 4.7 dB at 772 kHz (1000 feet of 22-gauge ABAM cable).

1.06 The maximum distance between the output of a 221-type repeater and the DSX1 is 3.0 dB at 772 kHz. The actual distance determines which ED-3C585-30 type equalizer is to be used according to the following table.

Length (dB at 772kHz)	ED-3C585-30
0 - 1	G1
1 - 2	G2
2 - 3	G3

2. FUNCTIONAL DESIGNATIONS

2.01 None.

3. FUNCTIONS

RECEIVE PATH (221A, B)

3.01 Provides constant impedance for terminating short end sections.

3.02 Provides means for automatically building out line end sections.

3.03 Provides regeneration of T1 carrier bipolar pulses.

3.04 Provides a ±6-volt bipolar output which, when combined with the proper 983-type equalizer, permits office repeater to DSX1 distances of up to 3.0 dB at 772 kHz.

3.05 Provides secondary lightning protection.

3.06 Provides a means for simplexing power on the line.

TRANSMITTING PATH (221A, B)

3.07 Provides a constant impedance termination for the transmitting source.

3.08 Provides a means for simplexing power on the line.

POWER REGULATOR (221A)

3.09 Provides regulated line current with powering options.

3.10 Provides power fusing and fuse alarm.

LOOPING REPEATER (221B)

3.11 Provides means for looping power in a 2-cable system.

BRIDGING REPEATER (221C)

3.12 Provides regeneration of bipolar T1 carrier pulses when bridged across a working system.

3.13 Provides a means for in-service patching with no interruption of service.

4. CONNECTING CIRCUITS

4.01 T1C Office Repeater Bay - Application Schematic - SD-3C252-01

4.02 T1 Application Drawing for the T1/T1C Office Repeater Bay - SD-3C252-02

4.03 T1 Carrier - Application Schematic - SD-97080-02

5. MANUFACTURING TESTING REQUIREMENTS

5.01 The manufacturing testing requirements for 221-type repeaters are specified in X-18196.

5.02 The manufacturing testing requirements for the ED-3C585-30 equalizers are as follows.

Balanced 100-Ohm Insertion Loss

Equal. Group	Frequency	
	100 kHz	1000 kHz
G1	5.76	5.39
G2	5.21	4.23
G3	4.73	2.98

All requirements in dB, ±0.1 dB.

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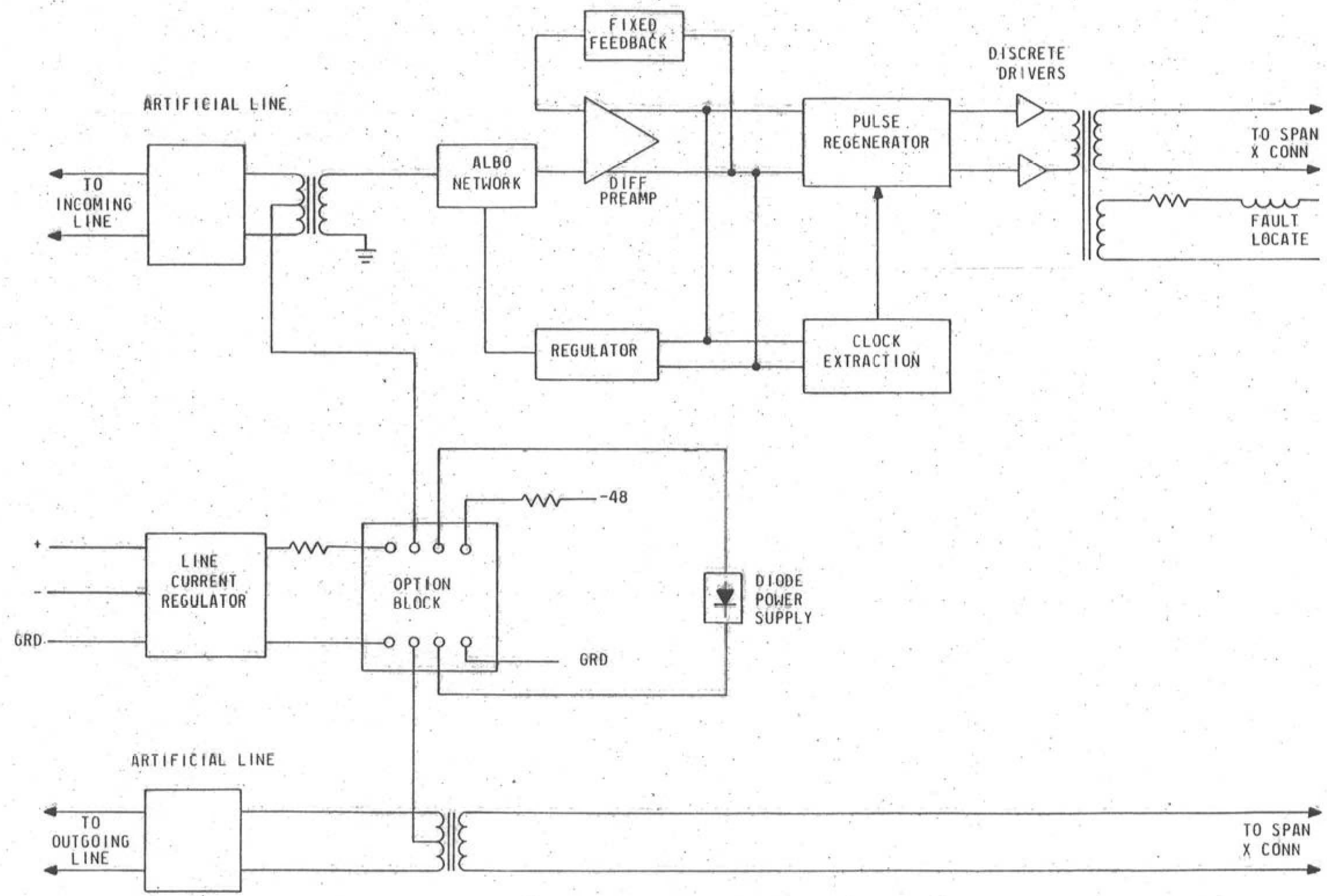
Attachments
CD Fig. 1 through 3



CD Fig. 1 - 221-Type Repeater

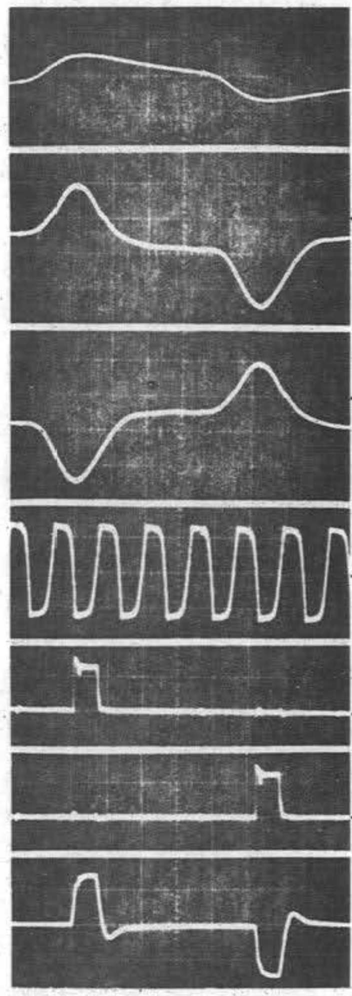


FIG. 2a

DISTORTED AND ATTENUATED PULSES AT PREAMPLIFIER INPUT. (TERMINAL 6 ON TRANSFORMER T101) VERT SCALE 0.5V/DIV.

FIG. 2b

AMPLIFIED AND EQUALIZED PULSES AT PREAMPLIFIER SIC1 OUTPUT ON TERMINAL 7 (TP1). VERT SCALE 1.0V/DIV.

FIG. 2c

AMPLIFIED AND EQUALIZED PULSES AT PREAMPLIFIER SIC1 OUTPUT ON TERMINAL 9. VERT SCALE 1.0V/DIV.

FIG. 2d

OUTPUT OF CLOCK AMPLIFIER SIC3 AT TERMINAL 4 (TP2). VERT SCALE 0.5V/DIV.

FIG. 2e

REGENERATED PULSE OUT OF LOGIC SIC2 AT TERMINAL 4. VERT SCALE 0.5V/DIV.

FIG. 2f

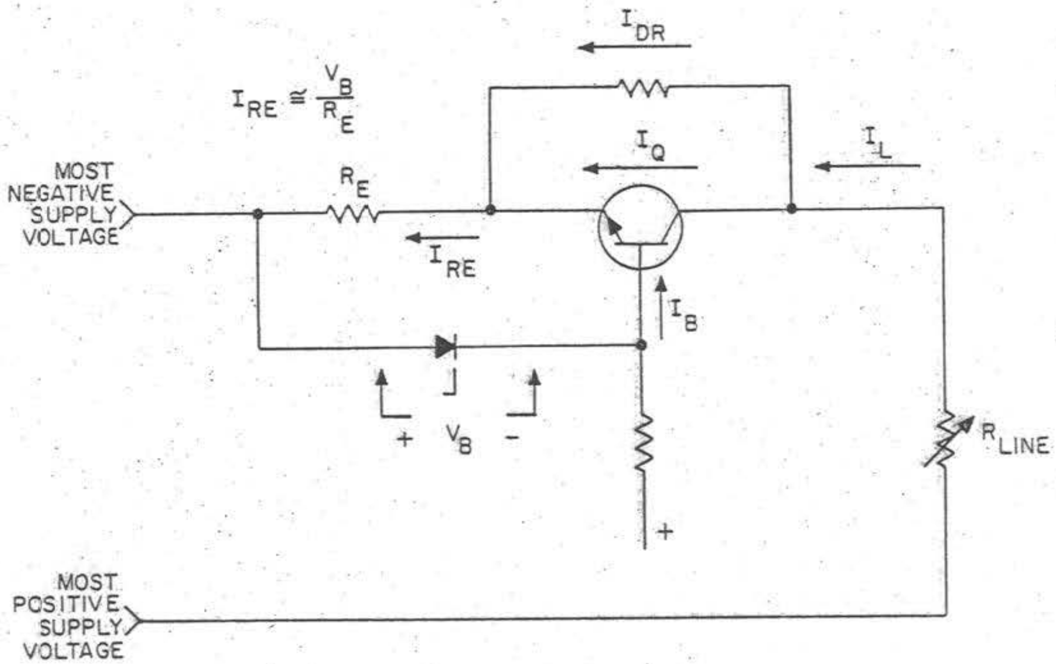
REGENERATED PULSE OUT OF LOGIC SIC2 CIRCUIT AT TERMINAL 12. VERT SCALE 0.5V/DIV.

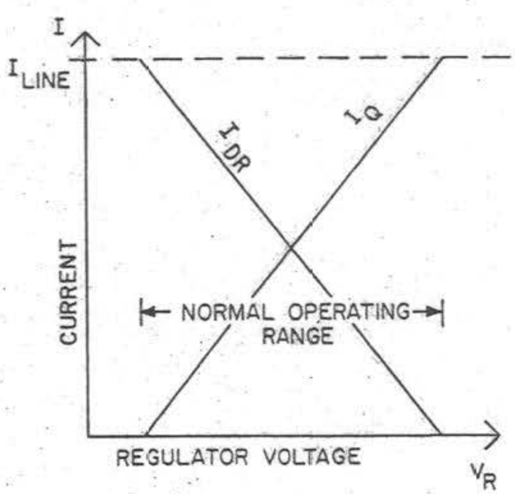
FIG. 2g

REGENERATED BIPOLAR PULSE AT REPEATER OUTPUT. (TERMINALS 6 AND 10 ON TRANSFORMER T103) VERT SCALE 2.0V/DIV.

HORIZ. SCALE - 0.5 usec/div

CD Fig. 2 - Waveshapes in 206-, 208-, and 221-Type Repeater for 1 our of 8 Pulse Patterns





CD Fig. 3 - Regulator Circuit