

## DIGITAL TRANSMISSION SYSTEMS

### T1C DIGITAL LINE

#### REPEATER DESCRIPTION

CONTENTS	PAGE
1. GENERAL . . . . .	1
2. LINE REPEATERS . . . . .	2
3. OFFICE REPEATERS . . . . .	2
4. T1C SIMPLEX LINE POWERING . . . . .	4
5. REFERENCES AND ASSOCIATED DRAWINGS . . . . .	4

#### 1. GENERAL

**1.01** This section describes the repeaters employed in the T1C digital line. The T1C line repeaters regenerate the 3.152-Mb/s, 50-percent duty cycle, bipolar coded signals which are received from the preceding line section. The regenerated 3.152-Mb/s signal is then transmitted to the next location via the following line section. The office repeaters regenerate the incoming signals and provide passive through-connecting circuitry for outgoing signals.

**1.02** This section is reissued to provide coverage for low powered (60 mA) repeater codes 248A, 248B, 248C, 249A, 249B, 249C, 250A, 250B, and 250C. This reissue also provides coverage for standard power replacement repeater codes 218AA, 218AB, 218AC, 219AA, 219AB, 219AC, 220AA, and 220AB. The standard power replacement repeaters replace existing 120 mA repeater codes.

**1.03** Two categories of repeaters are used in the T1C line: line repeaters (Table A) and office repeaters (Table B). Within each category there are two types of repeaters: 120 mA line current and 60 mA line current. As indicated in Table A, there are twenty 120-mA line repeater codes

and six 60-mA line repeater codes. The 120-mA line repeaters with double-letter suffixes replace manufacture discontinued line repeaters with single-letter suffixes as indicated in Table A. The standard power replacement repeaters incorporate low power technology, with standard power voltage drops and regulator current. The line repeater code used in a particular application is selected according to the cable type, power option (through or looped), and apparatus case required. As indicated in Table B, there are five 120-mA office repeater codes. Office repeater codes with double-letter suffixes replace office repeater codes with single-letter suffixes as indicated in Table B. Repeater code 250C can be used with 120 mA or 60 mA line current. As indicated in Table B, there are three types of office repeaters. The office repeaters with A or AA suffixes provide regulated line current. The office repeaters with B or AB suffixes provide current looping for the line. The office repeaters with C suffixes provide the bridging function. Figure 1 shows a typical T1C repeater. Jacks for line restoration patching are not provided on T1C office repeaters. Patching of the T1C line is performed at the DSX-1C cross-connect bay or the office repeater bay (ORB) jack panel.

**1.04** Selection of office repeater power options and line repeater through or looped power options is made prior to installation. Other than selecting the options, no field adjustments are required. All T1C repeaters incorporate automatic line build-out (ALBO) to compensate for changes in line loss. The T1C repeaters are designed to operate over a temperature range of 0°F to +140°F (office repeaters) and -40°F to +180°F (line repeaters). The use of the repeaters as part of the T1C line is described in Section 365-250-100, T1C Digital Line General Description. Engineering information required to design a T1C line using the repeaters is provided in Section 855-351-110,

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T1C Digital Line Transmission and Outside Plant Design Procedures.

**2. LINE REPEATERS**

**2.01** All T1C line repeaters (Table A) consist of two complete regenerators which provide pulse regeneration for one direction of transmission for two systems (unidirectional operation). The two regenerators are referred to as side 1 and side 2 for convenience of identification. Both sides of these repeaters are powered from the same power supply. Through and looping line powering arrangements are built into or selectable at the repeater as specified in Table A. The 219- and 249-type repeaters contain secondary surge protection, which is the only difference between them and the 218- and 248-type repeaters. A block diagram of these repeaters is shown in Fig. 2 to illustrate the applicable features.

**2.02** Distorted and attenuated pulses from the previous line section are received at the input of the line regenerator. These pulses are coupled into an equalizing amplifier through the input transformer and ALBO network. The ALBO network is used to automatically compensate for variations in cable loss.

**2.03** The equalizing amplifier comprises two shaped feedback amplifiers (AMP 1, AMP 2, and EQL 1 through EQL 3) and is designed to properly equalize pulses transmitted over cables having the maximum loss of 54 dB at 1.576 MHz. The ALBO network has negligible effect at this cable length. When the cable loss is less than 54 dB, the peak detector circuit detects the increased signal and feeds a control signal to the variolossor diodes which in turn control the ALBO network. The ALBO network inserts the proper amount of shaped loss at the input to AMP 1 to build out the cable loss to 54 dB for proper pulse equalization.

**2.04** The balanced output of AMP 2 is applied to the clock extraction circuit and also to the logic circuit. The signals applied to the clock extraction circuit are rectified and then applied to a crystal filter circuit. This resonant circuit extracts a 3.152-MHz frequency component from the applied signal. The extracted signal is first amplified and then used to control the time at which the output signals of AMP 2 are sampled. The extracted signal also controls the width of the regenerated pulse. The function of the logic circuit is to

perform sampling and threshold operations and to regenerate the appropriate pulse. This regenerated pulse is then applied to the line drivers which are used to drive the next section of cable.

**2.05** The line current is simplexed over the cable pairs and applied to the line repeater power supply via the center taps on the input and output transformers. The dc power is extracted at each repeater by means of a series diode regulator which provides dc voltage (nominal +5.5V and -4.0V for 120 mA repeaters and +6.2V and +11.0V for 60 mA repeaters) to both sides of the repeater.

**2.06** T1C line repeaters are intended for use in remote locations such as manholes and utility poles and in offices in express office repeater panels (EORP). The type of repeater case (protected or unprotected) that houses the repeaters is listed in Table A.

**2.07** The repeaters used in unprotected apparatus cases are enclosed in aluminum cans approximately 6-1/2 inches long, 3 inches high, and 3/4 inch wide. The repeaters used in protected apparatus cases are enclosed in similar aluminum cans that are approximately 1-1/2 inches longer.

**3. OFFICE REPEATERS**

**3.01** There are three categories of office repeaters: line current regulating, line current looping, and bridging (Table B). The regulator and looping repeaters contain circuits to process incoming (receive) line and outgoing (transmit) line signals. The basic function of the regulator and looping repeaters is to regenerate the incoming signals and to provide passive through-connecting circuitry for outgoing signals. The bridging repeater is used to bridge an outgoing signal to a maintenance, backbone, or powered unassigned span.

**3.02** With the exception of the current regulator circuit, the regulator and looping repeaters (Fig. 3) are identical. The circuitry associated with the transmitting direction is passive and provides a 12-dB artificial line, secondary lightning protection, and a transformer for simplexing power to the line. The circuitry in the receiving direction is active. It provides pulse equalization, ALBO, timing recovery, and pulse regeneration, as well as secondary lightning protection.

**3.03** All 220-type office repeaters provide 4-volt output pulses and must be used with ED-3C355-30 and ED-3C744-30 equalizers in order to provide proper signal levels at the DSX-1C cross-connect bay or ORB jack field. The 250 type office repeaters provide 6-volt output pulses and require ED-3C655-30 or ED-3C767-30 equalizers.

**3.04** Distorted and attenuated pulses from the preceding repeater are received at the regenerator via the main distributing frame (MDF). These pulses enter the regenerator through a 3-dB pad and secondary lightning protection; then they are coupled to the equalizing amplifier through the input transformer and ALBO network. The ALBO network is used to automatically build the cable section out to the correct loss at 1.576 MHz. The office repeaters can operate satisfactorily over a maximum cable loss range of 4 to 37 dB at 1.576 MHz.

**3.05** The equalizing amplifier in the office repeater is basically a short code pulp line repeater with slight modification of the ALBO circuit. It is also designed to operate with PIC and pulp insulated cables.

**3.06** The clock and logic circuits are identical to those in the line repeaters.

**3.07** The power supply is a zener regulated circuit consisting of two zener diodes and a varistor which develop the required positive and negative voltages used to operate the active circuits in the repeater. In the 220-type regulator and looping repeaters, the power supply develops -4.7 and +6.2 volt power. In the 250-type current regulating and current looping repeaters, the power supply develops +6.2 and +11.0 volt power. The choice of powering the office repeater either from -48 volt office battery or in series with the span line power loop is made on option block S101, Fig. 4.

**3.08** Power for the line repeaters is derived from the line current regulator at one end or at both ends of the span through simplexed power loops, see paragraph 4.01. Depending on the type repeater, the power loop requires a current of approximately 120 mA or 60 mA to develop the operating voltage of the line repeaters. The line current regulator circuit is powered from various combinations of office battery voltages (-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 assignments are made it is then necessary to select the proper options in the line current regulator circuit and also on option block S101, Fig. 4.

**3.09** Four pin jacks (-V, -I, +V, and REG) are provided on the faceplate of the current regulator repeaters. Two pin jacks (-V and -I) are provided on the faceplate of the current looping repeaters. The pin jacks are used to verify that proper power loop voltage and current is present and to verify that the regulator is operating within its regulating range. The -V pin jack is used as a common reference point for measurements as follows:

- -V with -I is used to measure the voltage across a 10-ohm resistor to verify line current. The voltage should be 1.2 volts for 120 mA repeaters and 0.6 volt for 60 mA repeaters.
- -V with +V is used to measure line voltage directly. The line voltage is the sum of the voltage drops across each line repeater and the cable resistance
- -V with REG is used to measure the voltage across the regulator in order to determine the operating point of the regulator.

**3.10** The bridging repeater (Fig. 5) is used to minimize transmission interruption during in-service line patching and restoral. This repeater is to be installed in even-numbered repeater bay shelves, position 13 (slot 26). This repeater is always used in conjunction with a current regulating or current looping repeater; thus, it never interfaces directly with the line. The major functions provided by the bridging repeater are as follows:

- Cross-connection of a signal from a working system to a maintenance or backbone line
- Cross-connection of a signal from one maintenance line to another maintenance line at a through or intermediate office
- Applying a signal from a quasi-random signal source to a maintenance line or other out-of-service working line.

**3.11** The bridging repeater (Fig. 5) circuitry is functionally the same as the regenerator

portion of the power regulating and power looping repeaters. However, the equalization and ALBO portions of the circuit are modified to accommodate the 20-dB loss of bridging resistors and to optimize operation for short ABAM cable runs (0-650 ft). The threshold, decision, and pulse regenerator circuits are the same as the regulating and looping repeater circuits.

**3.12** Power for the bridging repeater is always provided by the -48 volt office battery through a 422-ohm series current-limiting resistor that is provided in the shop-wired repeater bay. The input battery power is connected to the repeater on the lead designated -RPT. Current flowing through the varistor and zener diodes establishes the power supply voltage.

**3.13** The office repeater, which is about 10-1/2 inches long, 6 inches high, and 1-1/2 inches wide, plugs into a slot provided in the T1C office repeater bay shelf. A quick-release spring catch on the lower front of these repeaters is used to hold the repeater in place but permits easy removal. In addition to the pin jacks described previously (paragraph 3.09), there are two fuses mounted on the faceplate of the regulator repeater. The bridging repeater is not equipped with pin jack test points or fuses.

**4. T1C SIMPLEX LINE POWERING**

**4.01** Figure 6 shows an example of the simplex powering arrangement used to power a T1C digital line using a regulator office repeater. For purposes of discussion, assume the regulator office repeater is powered separately from the line.

**4.02** Shelf 1 is the first shelf of the power loop requiring power option block S101 to have B, E, H, and N options; whereas shelf 3 is the second shelf which requires that power options A, F, H, and N be selected, Fig. 4. Referring to Fig. 6, note that the -48, -130, and +130 volt office battery voltage and battery return (BR) are connected to the line regulator office repeater. Once the cable length and number of line repeaters to be powered are determined, the proper combination of office battery voltages can be determined; ie, -48, +130, +178, or +260 volts. After the required line voltages have been determined, switch positions for S201, S202, and S203 must be selected on the regulator circuit according to Table C.

**4.03** The office repeater is powered separately from the line through a series-dropping resistor by setting the H and N option screws down on power option block S101, Fig. 4. The B and E options set up the proper power loop polarities for the first shelf of the power loop.

**4.04** Shelf 3, the second shelf of the power loop, also defined as the power mate for shelf 1, is then conditioned to complete the loop. The choice of local or series powering for the office repeaters and the choice of office battery voltage options (S201, S202, and S203) must be the same in both power mate repeaters. As in the case for shelf 1, assume that the office repeaters located in shelf 3 are also powered separately from the line through a series-dropping resistor and by selecting options H and N on the power option block. The series dropping resistors are located external to the office repeaters in the office repeater bay. In order to complete the power loop with the correct battery polarities, the A and F options are selected in the shelf 3 repeater. Direction arrows in Fig. 6 depict the power loop path from the central office to the line and back.

**4.05** Once the power loop is established, line voltage, regulator voltage, and line current are measured using the test jacks provided on the repeaters to ensure proper power loop operation, see 3.08. It is important, when measuring the line voltage drop, that test jack -V be used in conjunction with test jack +V from the first shelf of the power loop to the second shelf of the same power loop.

**5. REFERENCES AND ASSOCIATED DRAWINGS**

**5.01** Detailed circuit information and schematics are contained in the following:

DRAWING	TITLE
CD- & SD-3C205-01	T1C Digital Line—218 and 219 Single-Letter Type Repeaters
CD- & SD-3C253-01	Office Repeaters 220A, 220B, and 220C Type for T1C Digital Line
CD- & SD-3C252-01	T1C Office Repeater Bay Application Schematic

DRAWING	TITLE	DRAWING	TITLE
CD- & SD-3C371-01	T1C/T1 DSX Dedicated Office Repeater Bay Application Schematic	CD- & SD-3C407-01	Office Repeaters, 220AA and 220AB Type for T1C Digital Line
CD- & SD-3C377-01	T1C Digital Line—248 and 249-Type Repeaters	CD- & SD-3C408-01	T1C Digital Line 218 and 219 Double Letter Type Repeaters
CD- & SD-3C378-01	Office Repeaters, 250 Type for T1C Digital Line		

**TABLE A**  
**T1C LINE REPEATERS**

REPEATER CODE	LINE CURRENT (mA)	POWER OPTION	CABLE TYPE (NOTE 1)	MAXIMUM LOSS RANGE (dB) (NOTE 2)	APPARATUS CASE	REPLACEMENT REPEATER FOR
218A	120	Through	Pulp (short code)	5.7 to 38.7	479A Unprotected	—
218B		Through	Pulp (long code)	20.0 to 54.0		—
218C		Looped	Pulp (short code)	5.7 to 38.7		—
218D		Looped	Pulp (long code)	20.0 to 54.0		—
218E		Through	DEPIC & PIC	5.7 to 54.0		—
218F		Looped	DEPIC & PIC	5.7 to 54.0		—
218G		(Note 3)	MAT	10.0 to 54.0		—
218AA		(Note 3)	Pulp	9.0 to 54.0		218A,218B,218C,218D 218E,218F 218G
218AB		(Note 3)	DEPIC & PIC	9.0 to 54.0		
218AC		(Note 3)	MAT	9.0 to 54.0		
219A	120	Through	Pulp (short code)	5.7 to 38.7	479B Protected	—
219B		Through	Pulp (long code)	20.0 to 54.0		—
219C		Looped	Pulp (short code)	5.7 to 38.7		—
219D		Looped	Pulp (long code)	20.0 to 54.0		—
219E		Through	DEPIC & PIC	5.7 to 54.0		—
219F		Looped	DEPIC & PIC	5.7 to 54.0		—
219G		(Note 3)	MAT	10.0 to 54.0		—
219AA		(Note 3)	Pulp	9.0 to 54.0		219A,219B,219C,219D 219E,219F 219G
219AB		(Note 3)	DEPIC & PIC	9.0 to 54.0		
219AC		(Note 3)	MAT	9.0 to 54.0		
248A	60	(Note 3)	Pulp	9.0 to 54.0	479A Unprotected	—
248B	60	(Note 3)	DEPIC & PIC	9.0 to 54.0		—
248C	60	(Note 3)	MAT	9.0 to 54.0		—
249A	60	(Note 3)	Pulp	9.0 to 54.0	479B Protected	—
249B	60	(Note 3)	DEPIC & PIC	9.0 to 54.0		—
249C	60	(Note 3)	MAT	9.0 to 54.0		—

*Note 1:* Refer to Section 855-351-110 for maximum and minimum cable lengths.

*Note 2:* The loss range indicates the range of cable loss over which the line repeaters will operate. This loss is the cable loss as measured at 1.576 MHz. For pulp cable, in 120 mA mode, two repeater codes with the same power options are required to cover the entire loss range of 5.7 to 54.0 dB. For DEPIC and PIC cable, in 120 mA mode, only one repeater code is required for each power option.

*Note 3:* Option screws on 218G, 218AA, 218AB, 218AC, 219G, 219AA, 219AB, 248A, 248B, 248C, 249A, 249B, and 249C repeaters are used to select through or looped power configuration.

**TABLE B**  
**T1C OFFICE REPEATERS**

REPEATER CODE	TYPE	NOMINAL LOOP CURRENT (mA)	APPLICABLE SD-/CD-	CABLE LOSS RANGE (db) (NOTE 1)	REPLACEMENT REPEATER FOR
220A	Current regulating	120	3C253-01	4.0 to 37.0	—
220B	Current looping	120	3C253-01	4.0 to 37.0	—
220C	Bridging	—	3C253-01	—	—
220AA	Current regulating	120	3C407-01	4.0 to 37.0	220A
220AB	Current looping	120	3C407-01	4.0 to 37.0	220B
250A	Current regulating	60	3C378-01	4.0 to 37.0	—
250B	Current looping	60	3C378-01	4.0 to 37.0	—
250C	Bridging	—	3C378-01	—	220C (Note 2)

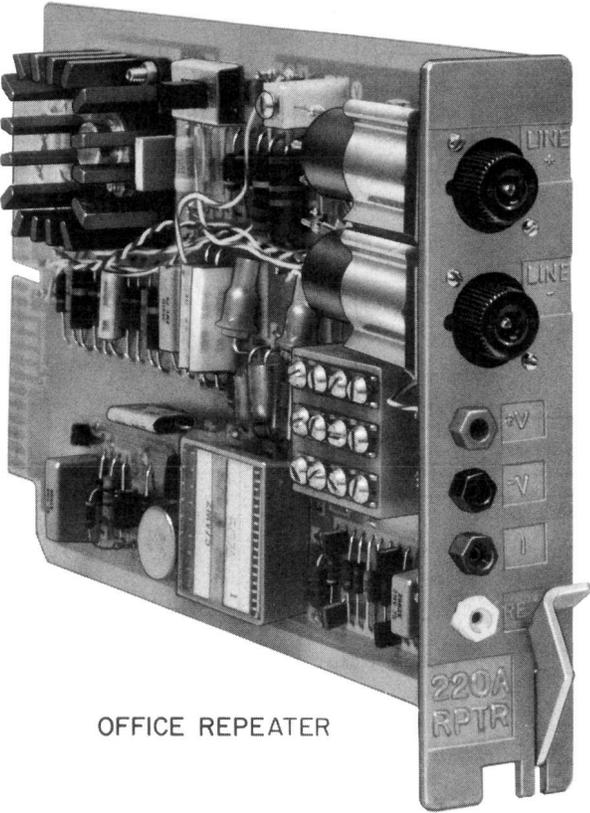
*Note 1:* The cable loss range indicates the range of cable loss over which office repeaters will operate. The cable loss is measured at 1.576 MHz. This range covers cable lengths from 500 to 4000 feet.

*Note 2:* When the 250C repeater is used to replace the 220C repeater, the associated equalizer must be changed also.

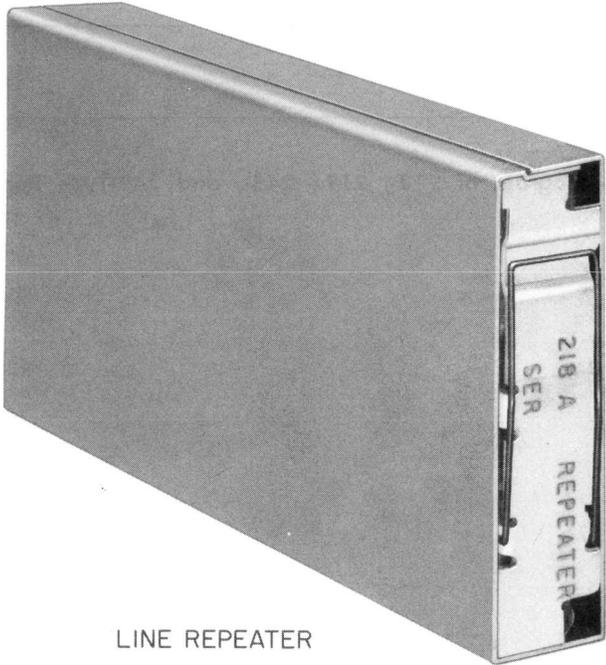
**TABLE C**  
**LINE CURRENT REGULATOR POWERING OPTIONS**

OFFICE BATTERY	OPTIONS REQUIRED			
	SWITCH		SELECTOR BLOCK S203	S203 SCREW POSITION
	S201	S202		
—48 VOLTS & BATTERY RETURN*	W	Z	V	DOWN
+130 VOLTS & BATTERY RETURN*	X	Y OR Z	OPEN	UP
+130 & —130 VOLTS (260 VOLTS)	W	Y	OPEN	UP
+130 & —48 VOLTS (178 VOLTS)	W	Z	OPEN	UP

\* When —48 volt office battery and battery return is used, it is necessary to replace the LINE + fuse with a dummy fuse. Conversely, when +130 volt battery and battery return is used, replace LINE — fuse with a dummy fuse.



OFFICE REPEATER



LINE REPEATER

Fig. 1—Typical TIC Repeaters

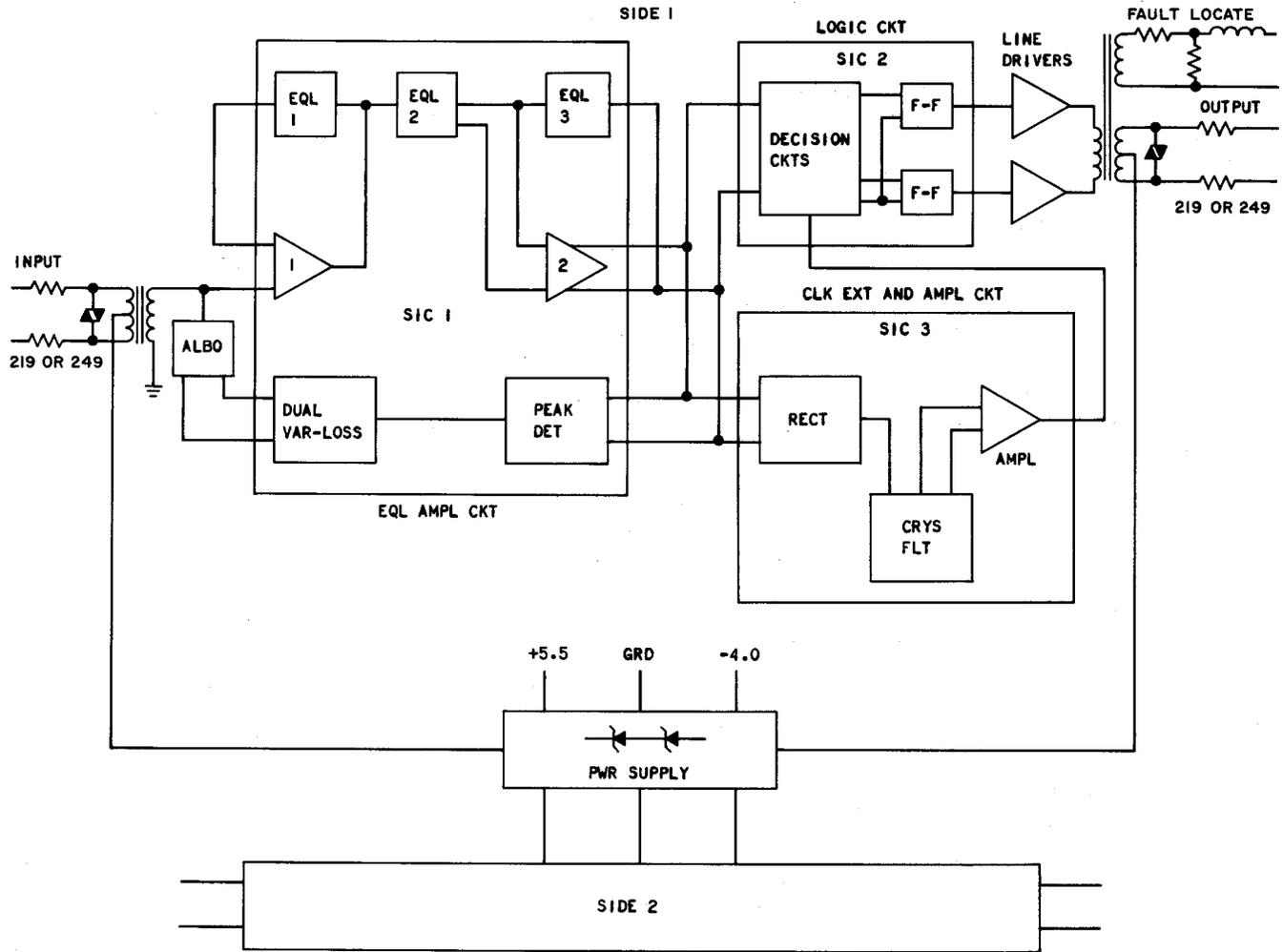
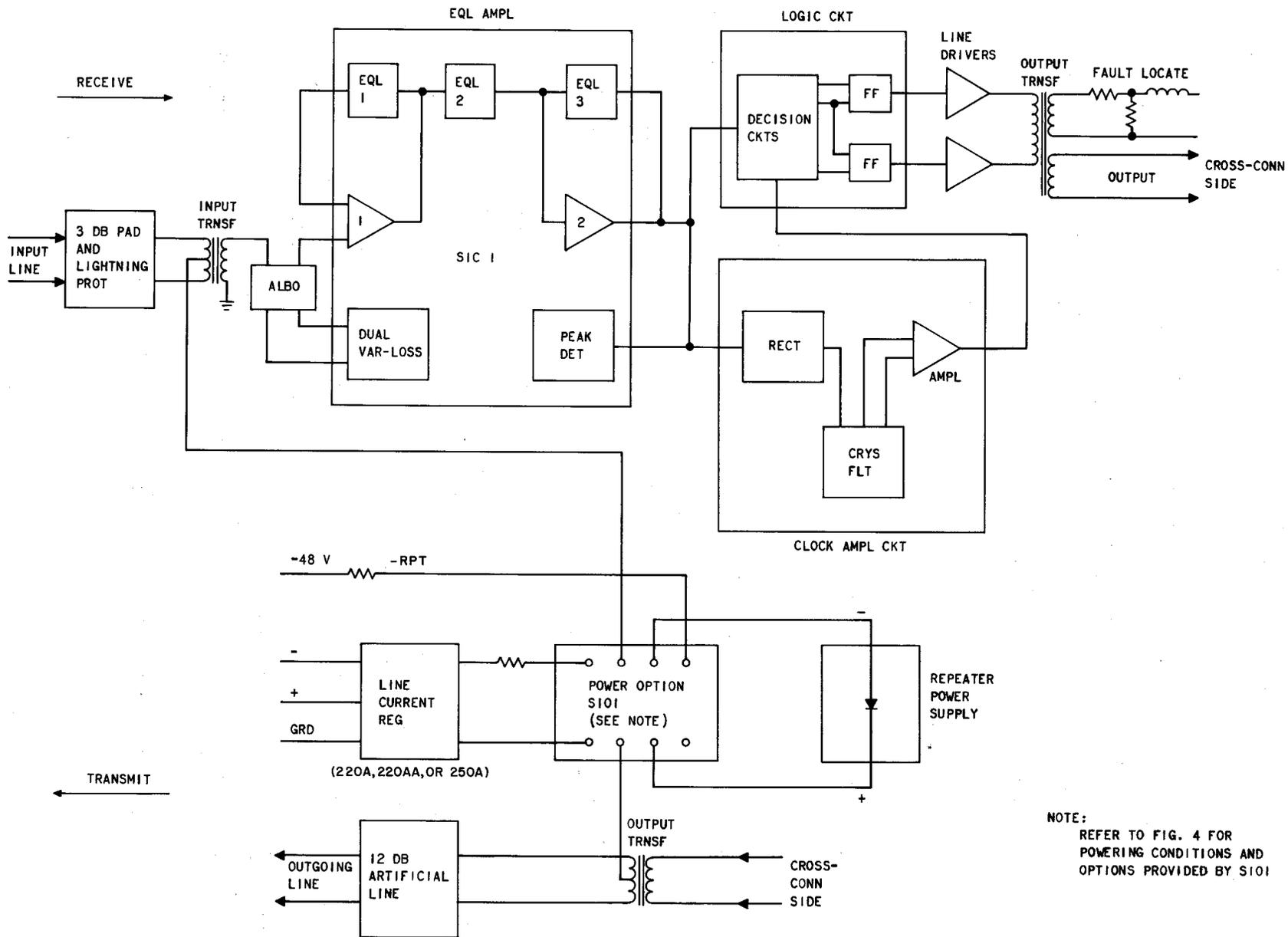
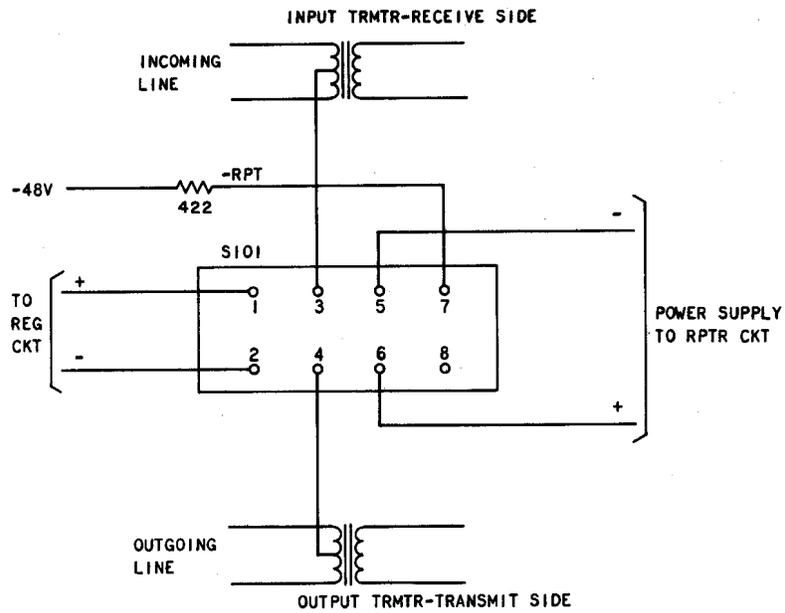


Fig. 2—Block Diagram of 218-, 219-, 248-, and 249-Type Repeaters



NOTE:  
REFER TO FIG. 4 FOR  
POWERING CONDITIONS AND  
OPTIONS PROVIDED BY S101

Fig. 3—Block Diagram of 220A, 220AA, 220B, 220AB, 250A, and 250B Repeaters



POWERING CONDITION			
OFFICE REPEATER POWERED IN SERIES WITH LINE REPEATERS	AT POWERING OR LOOPING OFFICE	TWO CABLE SYSTEM-1ST SHELF OF POWER LOOP-OFFICE REPEATER IN POWER LOOP WITH TRANSMIT LINE REPEATERS	B, D, G (NOTE 1)
		TWO CABLE SYSTEM-2ND SHELF OF POWER LOOP-OFFICE REPEATER IN POWER LOOP WITH RECEIVE LINE REPEATERS	A, G, M
OFFICE REPEATER POWERED SEPARATELY FROM LINE REPEATERS	AT POWERING OR LOOPING OFFICE	TWO CABLE SYSTEM-1ST SHELF OF POWER LOOP	B, E, H, N
		TWO CABLE SYSTEM-2ND SHELF OF POWER LOOP	A, F, H, N

NOTE:  
WHEN SPECIFIED BY ENGINEERING  
OPTION C, E, K IS USED.

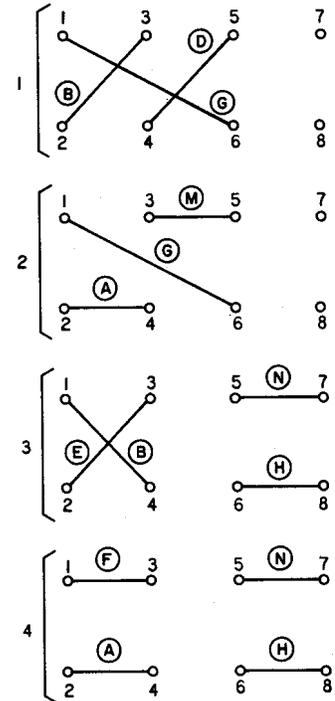


Fig. 4—Powering Conditions and Options Provided by S101

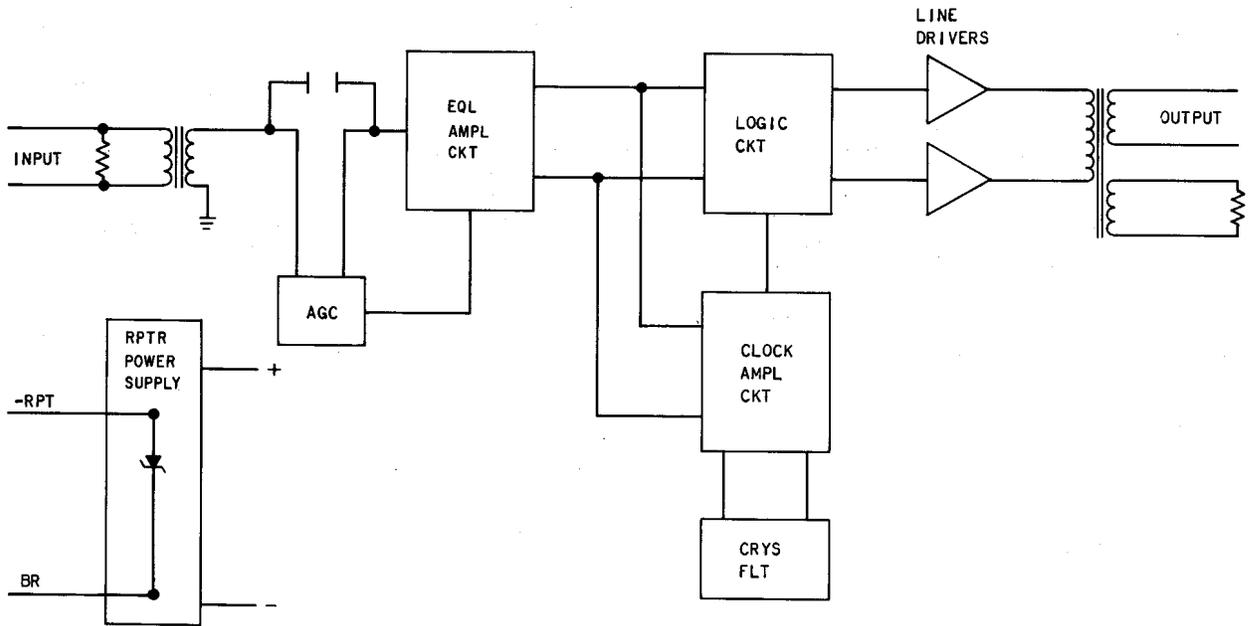


Fig. 5—Block Diagram of 220C and 250C Bridging Repeaters

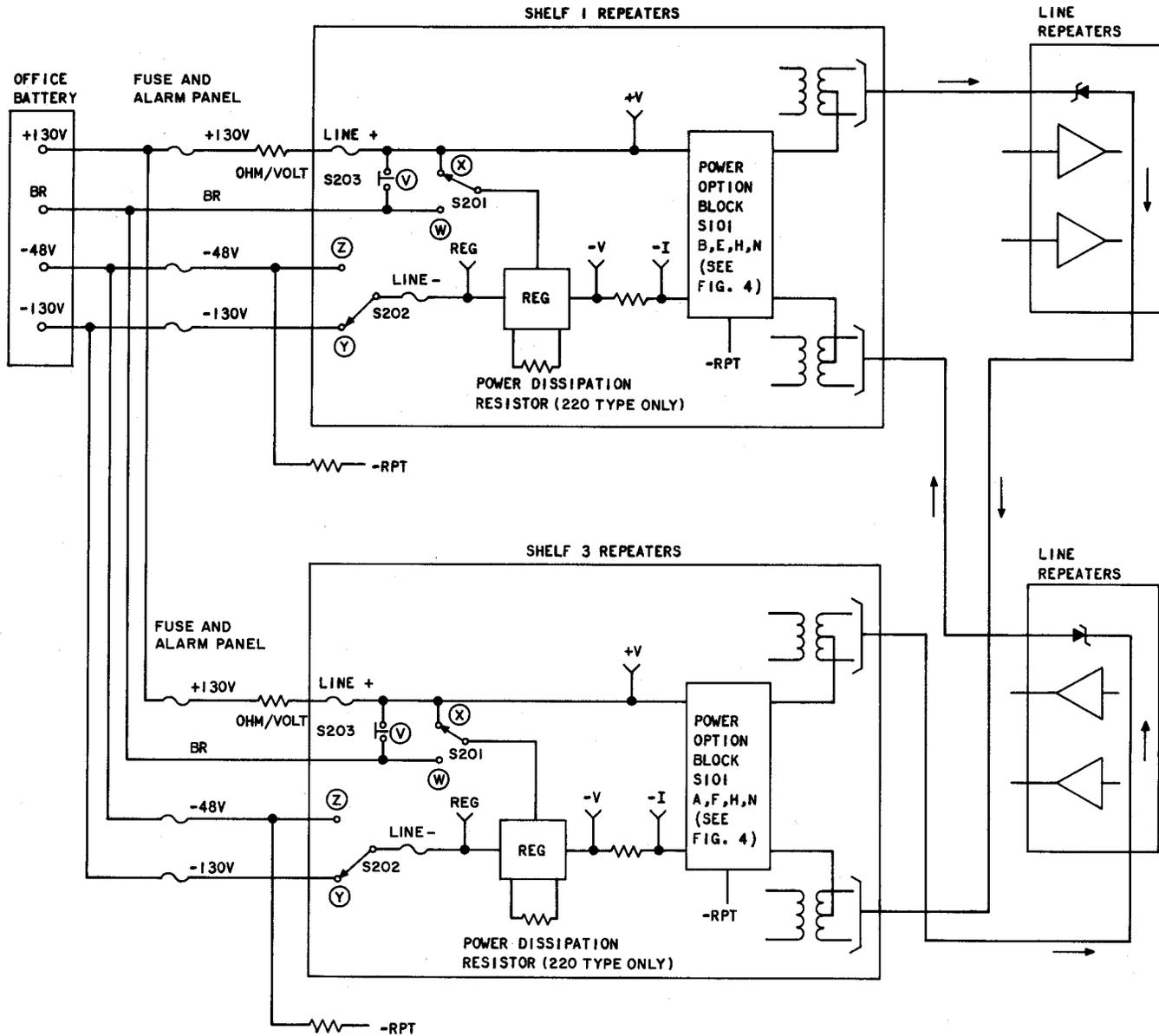


Fig. 6—Simplex Powering Arrangement