50-KILOBIT WIDEBAND LOOP
1 THROUGH 50 KHZ
WLR-5 REPEATER
MAINTENANCE

CONTENTS PAGE

1.02 This section is reissued to update Table B, correct Fig. 5 and references throughout the section, and to incorporate Addendum dated December 1967. The key numbers of this section have been changed from 500 to 300 to indicate more precise BSP content.

1.03 Routine adjustments should be scheduled on the basis of the desired loop quality, length and cable make-up of the loop, and in the case of the nonregulated loop, the range of cable temperature variation. Satisfactory transmission will result if the net loss of the equalized loop remains within ±1 dB at 25 kHz. The change in cable attenuation at 25 kHz, with a 100°F change in cable temperature for certain cables, is given in Table A.

1. GENERAL

1.01 This section presents procedures for maintaining the 50-kilobit wideband loop. Maintenance procedures to be used during emergency failures and routine adjustments are described. Emergency failures include loss of power and consequent loss of signal, a decrease in signal level due to other causes, or an increase of noise level, and are normally sudden and catastrophic. Pilot regulated loops do not require routine adjustments because they are self-compensating for temperature changes. These loops should only require maintenance when the loop fails (in which case an alarm will be activated) or as a result of a customer complaint. Paragraphs 1.03 through 1.06 apply only to nonregulated loops. Routine adjustments include readjustment of dc power and reequalization of the loop on a scheduled basis. Routine adjustment may also be necessary because of a wide change in the temperature environment of the loop.

TABLE A

VARIATION IN CABLE LOSS WITH TEMPERATURE

GAUGE	CHANGE OF CABLE ATTENUATION AT 25 KHZ ($\Delta T_c = 100°F$)
19 CNB	0.68 dB per mile
22 CSA	1.02 dB per mile
24 DSM	1.46 dB per mile
26 BST	1.88 dB per mile

1.04 ▶The cable temperature varies about three times more on aerial cables than with underground cables. Therefore, pilot regulation is more desirable on aerial cables.

1.05 The layout engineer should recognize that the cable temperature will vary significantly from the 55°F at the probable time of lineup. The anticipated cable loss at the time of lineup should be calculated by the layout engineer and this information furnished to the installation forces.◀

1.06 DC power should be checked and readjusted, if necessary, before the loop is reequalized. Temperature variations also cause a change in the dc resistance of the line and other components. Therefore, simplex current should always be checked before ac measurements and adjustments are begun. In addition, the bias currents of the preamplifier and amplifier should be checked on a nonregulated loop; and the group regulator, preamplifier amplifier, and group control should be checked on a pilot regulated loop.

1.07 ▶For routine maintenance and troubleshooting, refer to Part 4 of this section. Specific adjustment procedures for dc power and signal levels are presented in Section 314-643-500.◀

1.08 To avoid the possibility of sending objectionable signals into another system while maintenance is being performed, the output of the wideband loop at the wideband service bay (WSB) should be terminated where it feeds into the toll plant. A 386B terminating plug (a 135-ohm termination) is to be used for this purpose. The plug is to be removed when service is to be restored.

1.09 On pilot regulated loops, the ACO switch on the ALM unit should be set to its ACO position (up) before troubleshooting or working on the system. This procedure will avoid tripping audible or visual alarms. When responding to a pilot alarm, the loop must first be terminated at the WSB with a 386B terminating plug; then, the ACO switch can be operated. Until the ACO switch is operated, the system is locked out of service.

1.10 ▶Pilot regulated loops should not be powered unless end-to-end transmission continuity exists. This precaution is necessary to prevent operation of repeaters with no pilot to regulate the gain. Otherwise, operation will be at maximum gain, causing noise and crosstalk to be amplified excessively. Interference to other wideband systems, carrier systems, and program channels may result.◀

2. MAINTENANCE LIMITS

A. AC Signals and Noise

2.01 ▶At the completion of the lineup procedure for each direction of transmission (Section 314-643-500), the gain at 25-kHz, frequency response, and noise are to be measured, adjusted to requirements, and recorded on a transmission measurements form. These initial lineup measurements become the transmit and receive reference values for the facility. The need for readjustment or repair is based on the use of these reference values plus a tolerance to account for some change caused by change in cable temperature. The expanded limits are called the maintenance limits and are the same for both regulated and nonregulated loops. The maintenance limits are shown in Table B. The loop will function satisfactorily as long as the maintenance limits are not exceeded. No repairs or adjustments should be necessary as long as this condition exists.◀

2.02 Noise limits are expressed in absolute terms and are as strictly limited for maintenance purposes as during the initial lineup. This is because noise greater than originally specified cannot be tolerated at any time because of its degradation of data signals. The limits may be relaxed by the transmission engineer for special cases such as a loop with a data set at each end.

▶TABLE B◀

MAINTENANCE LIMITS
GROUP BANDWIDTH DATA CIRCUIT – 2-POINT
PRIVATE LINE

MEASUREMENT		EACH SUBSCRIBER LOOP
Relative Envelope Delay†	SLOPE SAG PEAK	0.5 μs 3.5 μs 6.5 μs
Gain Deviation	SLOPE SAG PEAK	0.5 dB 0.5 dB 2.0 dB
Noise Standard Measurement (6F with 50 kbs WTG)	Gaussian	54 dBrn or less
	Impulse*	110 counts/ 30 min
Expedient Measurement (6G with 10-50 kHz WTG)	Gaussian	56 dBrn or less
	Impulse*	130 counts/ 30 min
Single Frequency Interference		−30 dBm or less
Digital Error Rate		3 Errors/5 min
Gain at 25 kHz		0 ± 1.0 dB

*Threshold set at 85 dBrn at 0 SLP.

†The estimated objectives for relative envelope delay have been rounded off because the measuring accuracy of the 26A wideband gain delay set is ±2 microseconds.

B. DC Power

2.03 Simplex current should be readjusted if it does not produce the following readings.

POWER FURNISHED	VOLTS DC	MA
Remote — Pilot regulated	10.5-11.5	105-115
Remote — Non-regulated	6.5-8.5	65-85
Sealing Current only	2.5-3.5	25-35

Caution: The simplex current should always be checked when the loop signal level goes out of limits. The checks should be performed before signal level adjustments are attempted.

The following voltages should also be checked before beginning any signal adjustments.

Power Selector	−19 to −25 vdc
Amplifier Bias	11.0 to 14.0 vdc
Preamplifier Bias	7.0 to 14.0 vdc
Group Regulator Bias	9.0 to 12.0 vdc
Group Control Bias	11.0 to 15.0 vdc
Group Control (Control Voltage)	0.0 to 16.5 vdc (See note.)
Group Pilot Oscillator	0.0 to 1.0 ma

Note: With no pilot frequency or on a very hot day, the control voltage will be 0 vdc; with a nominal pilot or on an average day, the control voltage will be approximately 6 to 10 vdc; and on a very cold day, it will be 16.0 vdc.

▶These dc power checks should be performed first, therefore, no time will be wasted in trying to adjust the signal level when the fault is really in the dc power distribution or in the faulty bias of one of the plug-in units.◀

3. APPARATUS

3.01 The following apparatus may be used during maintenance of the 50-kHz wideband loop. The specific items and quantities required will depend on the particular maintenance situation.

- Volt-ohm-milliammeter KS-14510 or equivalent 20,000 ohms-per-volt meter.
- Hewlett-Packard 3550A test set or equivalent ▶(see Section 314-643-500)◀ for transmitting ac test signals and for measuring received test signals or low-frequency noise.

Note: A Hewlett-Packard ▶E60-204C◀ or E18-204B rack-mounted test set may be installed in the WSB; and when it is available, it should be used for all measurements at the WSB.

- A 6G wideband noise measuring set J94006G (SD-99738-01) equipped with 10- to 50-kHz plug-in weighting networks (for measuring Gaussian (rms) and impulse noise).
- An ED-73285 test connector (for making signal connections at the repeater).
- A 2W42A cord; W2DL cord, 5-1/2 feet long, equipped with 310-type plug on one end and two spade lugs on the other end (for connecting the 3550A test set to jacks of the ED-73285 test connector, WSB or DAS).
- A 2P4C cord; P2B cord, 6 feet long, equipped with 310-type plugs on both ends (for connecting 6G wideband noise measuring set to ED-73285 test connector, WSB or DAS, or to make looping connections).
- A 386B terminating plug; 310-type plug, equipped with 135-ohm resistor (for terminating loop at various points to make noise measurements or to avoid transmission of signals into other systems during tests and adjustments).
- 1-μf capacitor; WE 542D or equivalent, mounted on General Radio 274-MB plug (to band limit the 3550A test set for low-frequency noise measurements).
- Other miscellaneous equipment such as circuit layout cards, transmission measurements form, schematic diagram SD-73051-01, ▶Section 314-643-500,◀ common hand tools, and substitute plug-in units.

4. ROUTINE MAINTENANCE AND TROUBLESHOOTING PROCEDURES

4.01 Figures 1 and 2 outline routine maintenance and troubleshooting procedures. It should be expected, when performing routine maintenance, that the loop will sometimes meet all its transmission and noise requirements. This can be seen on Fig. 1 as a steady progression as each routine loop measurement produces a test power or noise count that is within acceptable maintenance limits. On the other hand, if the maintenance procedure has been started because of a trouble report, one or more of the measurements should produce an out-of-limits result and will cause a digression into what may be considered the troubleshooting area of the flowchart.

4.02 Troubleshooting may consist of a simple readjustment of the end repeater controls, a complete equalization of one or both directions of transmission, or a search for a faulty component or part by signal tracing or voltage measurements. Each measurement, adjustment, or repair procedure may produce the correct result. ***If the result is correct,*** the solid lines in Fig. 1 lead to the next procedure to be performed to further prove the usability of the loop, or lead to a report that the loop is in good condition. ***If the result is incorrect,*** the dashed lines lead to further measurements, adjustments, or repair procedures to clear the trouble.

4.03 When no signal is received over the loop, it is recommended that the dc power system be checked first. Complete signal failure is often caused by power failure and may possibly be cured by a simple fuse replacement. To check the dc power system, perform the procedures of Fig. 2. After the power system has been checked and possibly adjusted or repaired, one of two paths should then be resumed on Fig. 1 depending on whether a power fault was found and corrected or whether no power fault existed. If the power was corrected, the reference measurements should be checked to make certain no other fault exists in the loop. If the power checked out correctly, the cause of signal failure must yet be found. This is done by signal tracing down the loop. Signal tracing should be done when the 25-kHz signal is far out of limits. Troubleshooting procedures will be initiated by a trouble report, customer complaint, or by an activated fuse or pilot alarm. If a pilot alarm is activated, a white light will be lighted on the fuse and alarm panel and an audible minor alarm will sound. The system is now locked out of service and the following procedure should be performed.

STEP	PROCEDURE
	Procedure When System is Locked Out
1	Terminate the WSB with a 386B terminating plug (135-ohm termination).
2	◗Switch the ACO switch to the ACO (up) position at station and WSB.◖
	Note: Audible alarm should stop.
3	Wait approximately 2 minutes and switch the ACO switch to the normal (down) position.
4	If the light on the alarm plug-in goes out, the failure was temporary and has been cleared. Remove the 386B termination and restore the loop to service.
5	If the light remains on, the trouble still exists, switch the ACO switch back to the ACO (up) position and proceed with the troubleshooting procedures of 2.03 and Part 4.

4.04 ◗***Signal Tracing:*** The loop should have been placed into the condition shown in Fig. 3 by looping at the DAS. (If an 806D DAS, place DAS in remote test 1 called RT-1 to check the level of the 1, 3, 5.5, 10, 18, 25, 32, and 50 kHz signals sent around the loop.) A full discussion of making looped measurements is given in Section 314-643-500, Part 9.◖

4.05 If a 3550A test set and a craftsperson are available at the DAS, the direction of transmission at fault can be isolated by removing the loop at the data set and making test set connections at the DAS as shown in Fig. 4. Test signals can now be fed into both ends of the line simultaneously; but, unless a fault affecting both directions of transmission exists, only one VTVM will show a received signal. The test set connections to the good direction of transmission may be removed. Then, successive meter measurements down the faulty direction of transmission will reveal the point of failure. Use the ED-73285 test connector to provide measurement access points at the repeaters.

4.06 If it is not feasible to send and receive at both ends of the loop simultaneously, trouble isolation may be accomplished by forming intermediate loops at repeaters located in central offices. An ED-73285 test connector is required at each central office to form the loops. Since the measurements are initiated at the WSB, eliminate the active elements of the terminal repeater as a source of trouble. Continue to feed the 25-kHz test signal to the loop (with the line looped at the DAS) and measured with the VTVM at the LINE jack of the ED-73285 test connector connected to the TST IN jack of the regulator of the direction 1 repeater. Set REJ FLT switch to GRP. The normal input power at this point should be between +6 and -24 dBm (+6 dBm minus the cable loss). See note.

> ***Note:*** The nominal test tone power in the WSB or DAS is 0.0 dBm with +6.0 dBm actually transmitted to the line. This power is progressively reduced as the signal is transmitted down the line. The ED-73285 test connector introduces a loss of 0.8 dB when using the LINE 1 and LINE 2 jacks.

If the test tone power is very low or nonexistent, the trouble is out on the loop away from the WSB. If the signal is normal, the trouble is in the terminal repeater. If the test tone is not present at the input of the direction 1 repeater, check the signal output of the direction 2 side of the terminal repeater. The ED-73285 test connector is removed and the shorting plug reinserted in the regulator of the direction 1 repeater. Plug P1 of the ED-73285 test connector is connected to the TST OUT jacks in the amplifier of the direction 2 repeater, the REJ FLT switch is set to GROUP, and the signal is measured with a VTVM at the EQPT 1 jack of the ED-73285 test connector. The

normal test tone power here should be +6 dBm. If the test tone power is very low or nonexistent, the trouble is in the direction 2 portion of the terminal repeater. Turn off the 3550A oscillator. Switch the REJ FLT switch to NO and measure the pilot frequency. The normal pilot frequency power here is -4 dBm. If the pilot frequency power is very low or nonexistent, replace the group pilot oscillator and recheck the loop. If the terminal repeater is eliminated as a possible source of trouble, remove the ED-73285 test connector and reconnect the VTVM to the WSB jack. Successive intermediate loops should be made at points along the loop, as shown in Fig. 5 and described in the following procedure.

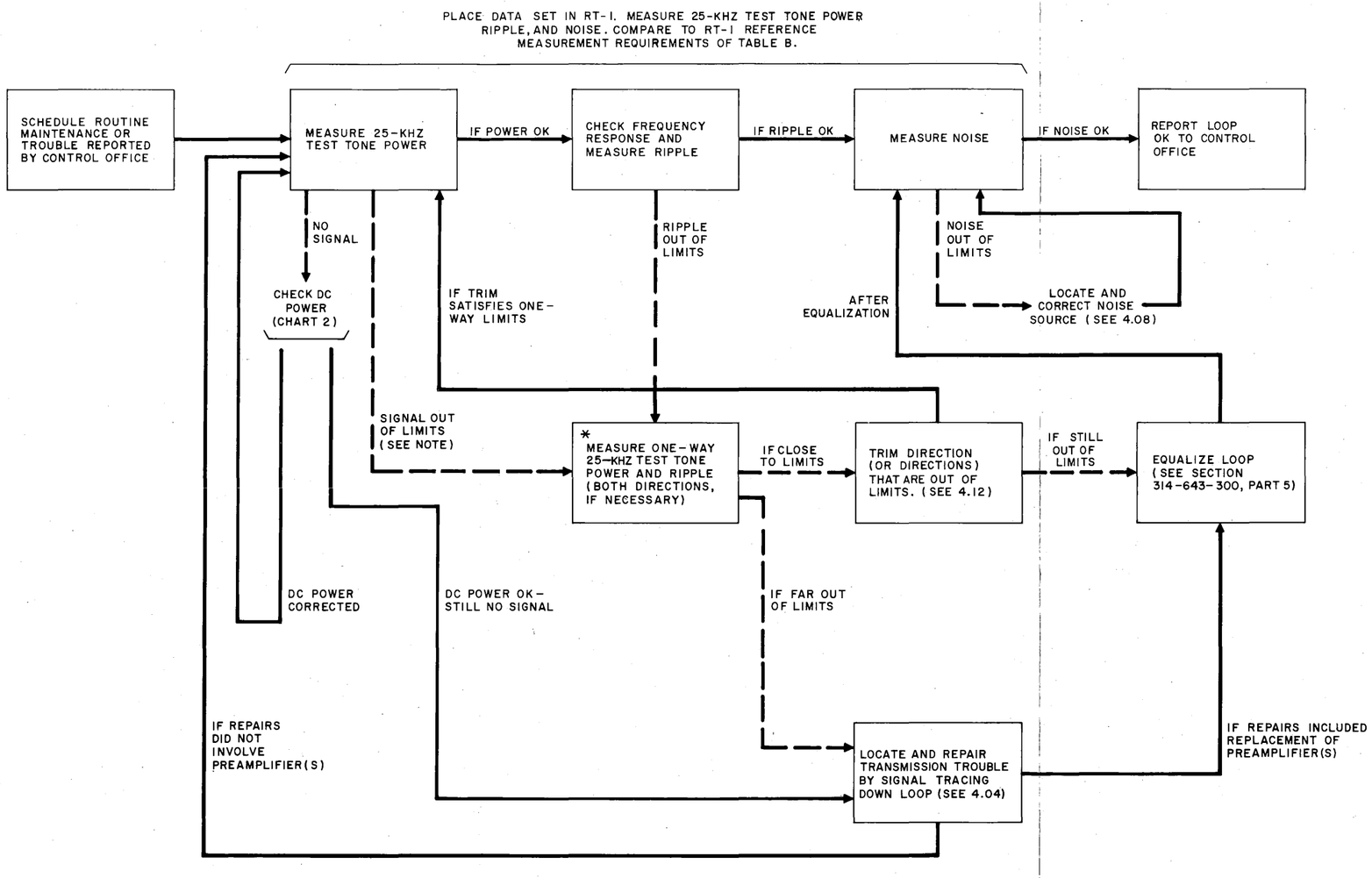
STEP	PROCEDURE
	To Loop at the Outputs of an Intermediate Repeater (See Fig. 5)
1	Check that the loop has been removed at the DAS.
2	Remove the P1 from the TST OUT jacks in the amplifiers of the DIR 1 and DIR 2 repeaters. Connect plug P1 of the ED-73285 test connector to the TST OUT jack in the amplifier of the DIR 1 repeater. Connect plug P2 of the ED-73285 test connector to the TST OUT jack in the amplifier of the DIR 2 repeater. Set the REJ FLT switch on the ED-73285 test connector to NO.
3	Patch the EQPT 1 jack to the LINE 2 jack of the ED-73285 test connector using a 2P4C cord.
4	Patch the EQPT 2 jack to the LINE 1 jack of the ED-73285 test connector using a 2P4C cord. ***Note:*** This procedure will check the DIR 2 line, DIR 2 repeater, and DIR 1 line.
5	Remove test connections from the TST OUT jacks of the repeater and reinsert plug P1 in the TST OUT jacks of the DIR 1 and DIR 2 amplifiers.

4.07 The 3550A test set (in conjunction with the ED-73285 test connector) must be used for signal tracing at repeaters which are not located in a central office. By measuring and looping at each remote repeater with the test connector, line segments and components can be quickly checked.

Caution: If a preamplifier is replaced, the repeater must be reequalized by use of the test connector while the craftsperson is still at the remote location.

4.08 ***Noise Troubleshooting:*** Noise troubleshooting may be instituted after receipt of a trouble report or as a consequence of performing routine maintenance measurements. In either case, the noise may already be classified as low-frequency noise, rms (flat) noise, or impulse noise. The VTVM of the 3550A test set, or equivalent, should be used to locate the source of low-frequency noise. Rms noise or impulse noise is detected by using a 6G wideband noise measuring set, equipped with a 10- to 50-kHz weighting network.

4.09 Troubleshooting for noise should begin by placing the loop into the condition shown in Fig. 3 by looping at the DAS and terminating the transmitting side of the WSB with a 135-ohm termination (386B terminating plug). This procedure will verify the presence of noise and determine its type and severity. Remove the loop at the DAS and make 1-way measurements, as shown in Fig. 4, to determine whether the noise exists in both directions of transmission or only in one direction of transmission. When these tests have been performed, check the receiving side of the



* WHEN THE 25 KHZ TEST TONE IS OUT OF LIMITS, IT IS ADVISABLE TO MEASURE THE 1, 3, 5.5, 10, 18, 32, AND 50 KHZ GAIN-FREQUENCIES WHEN MEASURING THE 25 KHZ TEST TONE.

NOTE:

OUT-OF-LIMITS SIGNAL OR PILOT ALARM MAY BE CAUSED BY LOW DC POWER. THIS WILL BE REVEALED DURING SIGNAL TRACING PROCEDURE. SEE CHART 2 FOR SIMPLEX CURRENT AND BIAS REQUIREMENTS.

Fig. 1 — Routine Maintenance and Troubleshooting Flowchart

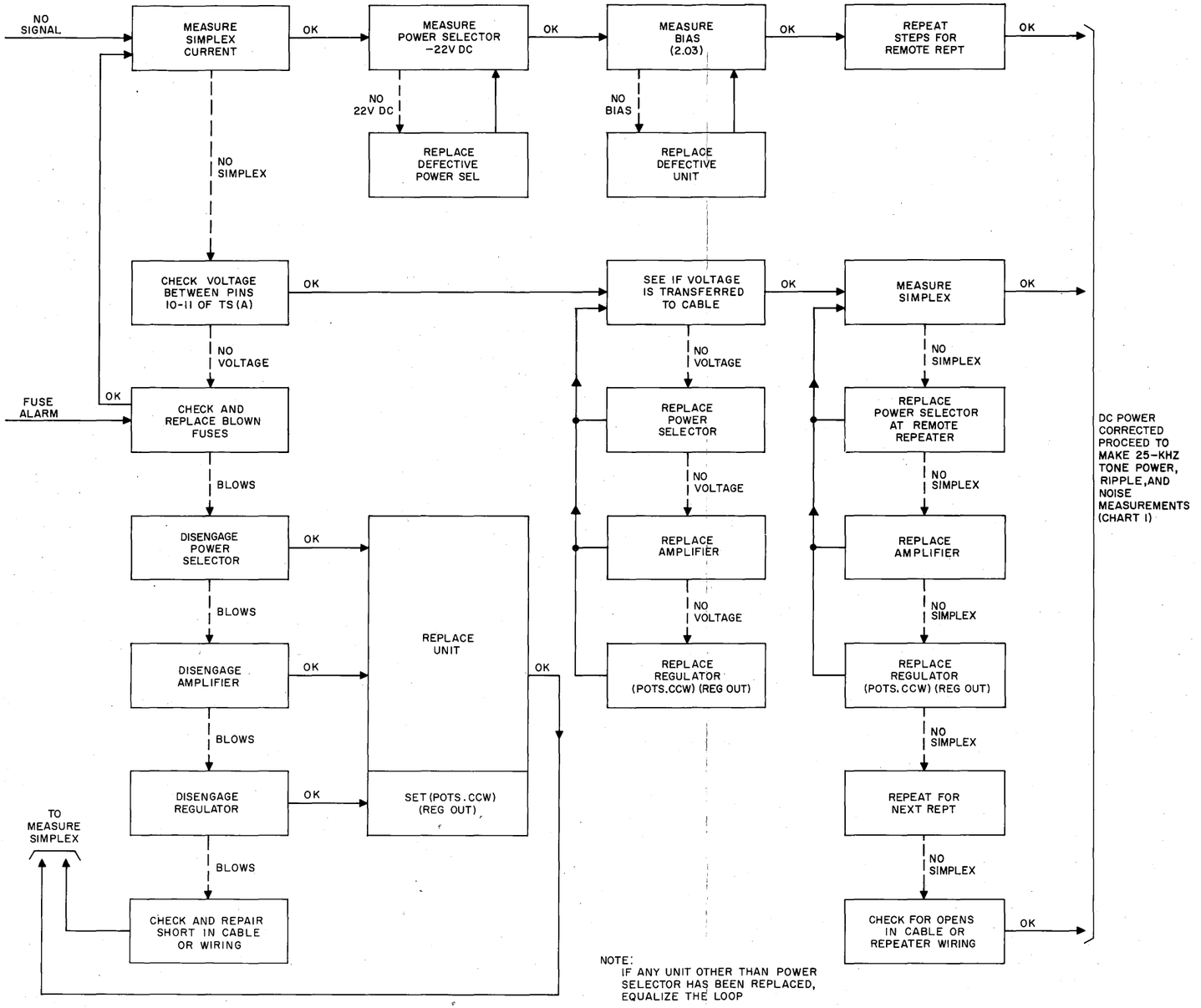


Fig. 2—Troubleshooting DC Power System for Cause of Signal Failure Flowchart

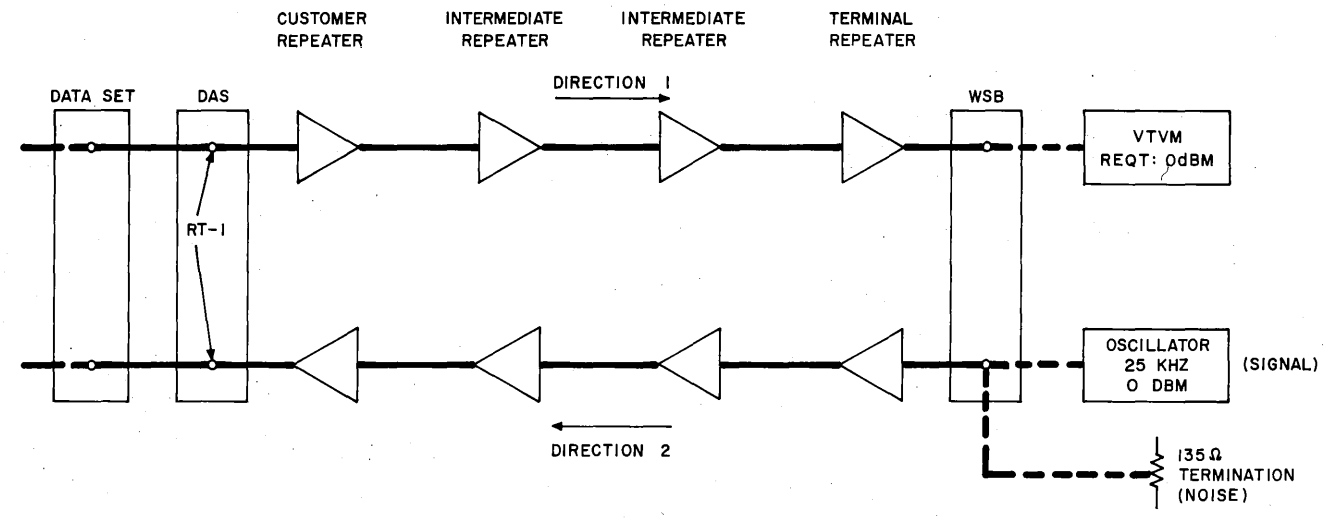


Fig. 3—25-kHz Test Tone Loop Measurement

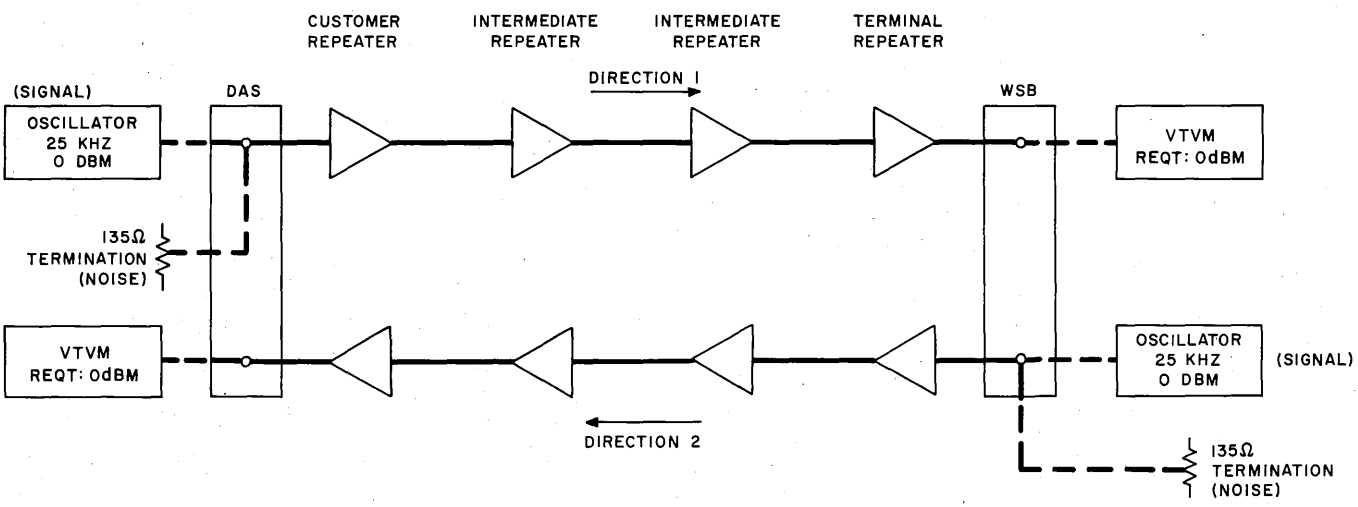


Fig. 4—Isolating Faulty Direction of Transmission

final repeater (terminal in DIR 1, customer in DIR 2) for noise. This test is made by switching the REG switch to OUT on the group regulator, removing plug P1 in the TST IN jack of the GR REG, and measuring the noise at the WSB or DAS. The noise measured at this point will be from the terminal or customer repeater only, since the removal of plug P1 isolates the repeater from the line.

> ***Note:*** The FREQ switch of the 3550A test set must be set to <5KC when the test set is used to measure low-frequency noise.

Possible sources of noise in the terminal or customer repeater are improper grounding and signals coming in on the power leads. The transmitting side of the repeater (DIR 2 at the terminal repeater, DIR 1 at the customer repeater) is checked by removing plug P1 in the TST OUT jack of the amplifier, provided that on pilot regulated loops the REG switch in the group regulator of ***each*** repeater has been switched to OUT in order for the loss of pilot not to affect the transmission properties. This procedure removes the transmitting side of the repeater from the loop, and any noise observed will be generated at some point beyond this repeater.

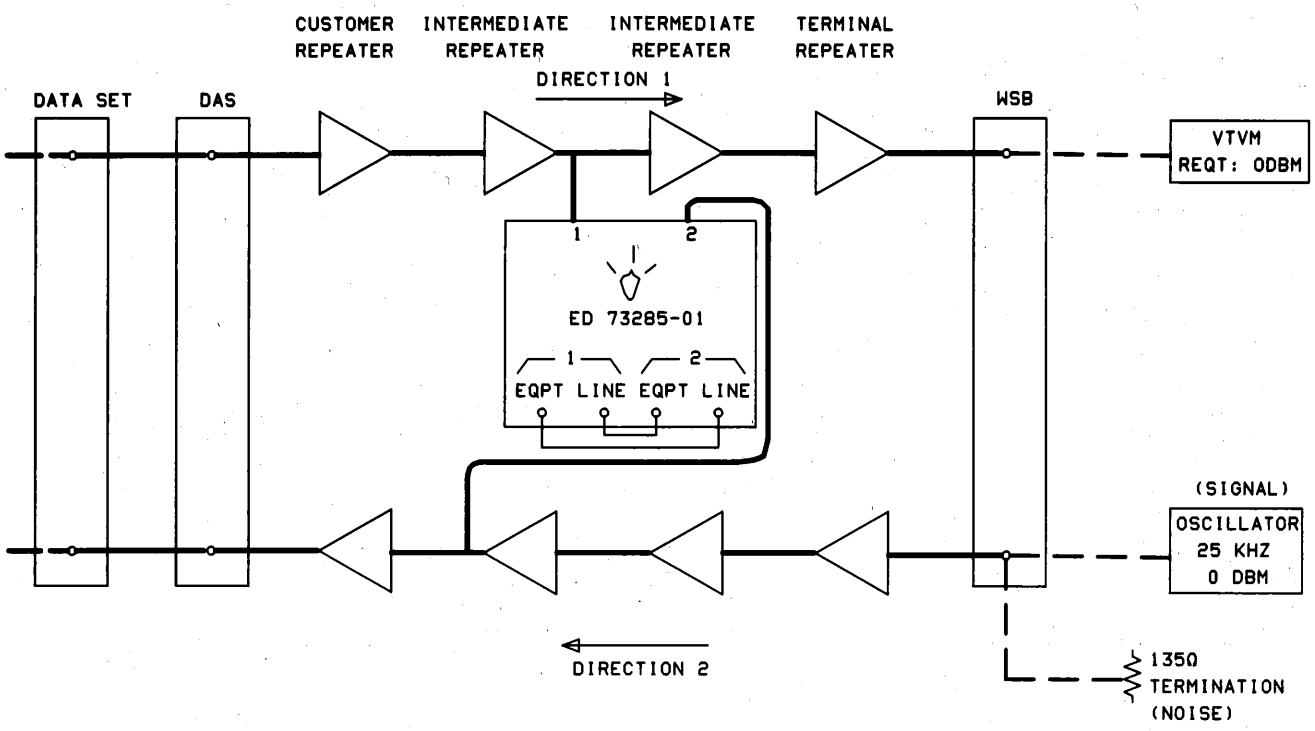


Fig. 5—Isolating Transmission Trouble by Intermediate Loops

Once the terminal repeater is free of noise, successive repeaters and line sections are checked by following the looping procedure described under the section on signal tracing (4.06).

4.10 After the noise source is localized, component substitution or further noise tracing by use of the noise measuring set or the VTVM, as required, will pinpoint the trouble. Common causes of noise are poor grounds, an increase of the external noise, or a noisy part in any active portion of the repeater.

4.11 ***Trim:*** In making 1-way transmission tests, 3550A test sets are connected at the WSB and at the DAS as shown in Fig. 4. (An E60-204B test set may be used at the WSB.) If the 25-kHz test tone power and ripple measurements for a direction of transmission are nearly within the maintenance limits, it is expedient to readjust the terminal repeaters at the regulator and preamplifier to try to bring the measurements within limits. In this case slightly more correction than ordinarily required may be inserted in the end repeaters at specific frequencies. The equalizing procedure of Section 314-643-500 should be followed as if the intermediate repeaters did not exist. If trimming the end repeaters does not correct the ripple deviation, the complete equalizing procedure will have to be performed.

5. REPEATER GAIN MEASUREMENTS

5.01 Repeater gain measurements may be made to verify that the repeater is functioning properly. However, prior tests should have already verified this condition. Since the equalization of the repeater is lost by these measurements, they are not recommended except as a last resort.

Note: The repeater must be reequalized after making this measurement.

STEP	PROCEDURE
1	Connect plug P1 of the ED-73285 test connector to the TST OUT jack in the amplifier of the repeater under test. Connect plug P2 of the ED-73285 test connector to the TST IN jack in the regulator of the repeater under test. Set the REJ FLT switch on the ED-73285 test connector to NO.
2	Set the equalization controls in the preamplifier fully counterclockwise.
3	Set the GAIN controls in the regulator fully ***clockwise*** for maximum gain.
4	If the repeater is a pilot-regulated repeater, set the REG switch in the group regulator to OUT.
5	At the oscillator of the 3550A test set, set the AMPLITUDE control fully counterclockwise.
6	Using a 2W42A cord, patch from the INPUT jack of the 3550A test set to the EQPT 1 jack of the ED-73285 test connector.
7	Set the oscillator of the 3550A test set to 1 kHz.
8	Set the FREQ switch of the 3550A test set to <5KC and the MEAS-CAL switch to MEAS.
9	Using a 2W42A cord, patch from the OUTPUT jack of the 3550A test set to the EQPT 2 jack of the ED-73285 test connector.
10	Slowly increase the amplitude control on the oscillator of the 3550A test set to obtain a reading of 0 dBm on the VTVM.
11	Switch the 3550A test set to CAL and measure the output of the oscillator. This reading should be in the region of -23 dBm. By converting the sign the gain of the repeater is read directly. ***Example:*** 0 dBm - (-23 dBm) = +23 dBm gain
12	Change the oscillator frequency setting to 25 kHz.
13	Reset the 3550A test set to MEAS.
14	Set FREQ switch to >5KC.

STEP	PROCEDURE
15	▶Readjust the amplitude control of the oscillator to obtain 0 dBm at the output of the repeater.
16	Repeat Step 11. ***Note:*** VTVM reading should agree with the 1-kHz reading ±0.5 dB.
17	Repeat Steps 12 through 16 for 50 kHz.
18	Remove the P2 plug of the ED-73285 test set from the TST IN jack of the regulator and reinsert shorting plug P1.
19	Reequalize the repeater per procedure outlined in Section 314-643-500.◀