CIRCUIT DESCRIPTION
TRANSMISSION SYSTEMS DEVELOPMENT DEPARTMENT

CD-99707-01
Issue 4B
Dwg. Issue 4B

COMMON SYSTEMS
TRANSMISSION MEASURING
24B LOOP CHECKER GENERATOR

SECTION I - GENERAL DESCRIPTION

1. GENERAL FEATURES

1.01 This set provides a swept frequency signal from 1000 to 3000 cps for the testing of a subscriber's loop to determine its adherence to the design rules. This set is ordinarily used with the 24A Loop Checker.

1.02 The circuit is designed so that the swept frequency signal used for the measurement is frequency weighted. That is, the output power vs. frequency is not constant but has a predetermined shape. This shape eliminates the necessity of knowing what requirements are placed upon the loss vs. frequency characteristic of a subscriber's loop.

1.03 The 24B Loop Checker Generator is ordinarily located at the central office.

1.04 The output of the set is made available by use of a standard code dialed by the operator of the 24A Loop Checker. In order to facilitate this specific test line circuits are necessary. Distributing circuits provide proper termination and connect the output of the 24B Loop Checker Generator to the test line circuits. As many as 10 outputs can be provided. See Fig. 2 and Fig. 101.

1.05 The set is completely automatic and requires only minor periodic testing and maintenance.

SECTION II - DETAILED DESCRIPTION

1. GENERAL

1.01 The 24B Loop Checker Generator may be divided into ten (10 distinct circuits (see Fig. 1): Fixed oscillator, Swept oscillator, Sweep control, Modulator drive, Modulator, Flat output, Frequency checking, Shaping, Output amplifier, and DC regulation. Each of these circuits is described below.

1.02 With the (FREQ CHK) switch (S1) in the (OPR) position, the operation of the circuit is as follows:

(1) The sweep control circuit provides a signal which varies the frequency of the swept oscillator such that it changes from 27 to 25 kc in about 6 seconds. The frequency then sweeps back to 27 kc in about 0.4 seconds, and the cycle repeats.

(2) This swept frequency signal passes through the modulator drive amplifier to the modulator where the signal from the fixed oscillator is mixed with it. The sum and difference of the frequencies of these two signals appear in the signal at the output of the modulator.

(3) The shaping network with (S2) in the (OPR) position selects the difference frequency (1 to 3 kc) and introduces frequency weighting to the signal. The level of the signal at the output of the shaping network depends upon its frequency.

(4) The signal is then amplified by the output amplifier making a weighted swept frequency tone available at the (GEN OUT CAL) jack (J1) and at the distribution circuit.

(5) After the difference frequency has been selected [see (3) above], part of the signal is connected to the flat output circuit to give an unweighted swept frequency tone at the (FLAT OUT CAL) jack (J2).

1.03 With the (FREQ CHK) switch (S1) in the (3000~) position, the circuit is set up to check whether or not the upper frequency of the 1 to 3 swept tone is indeed 3 kc. The circuit operates as follows:

(1) The sweep control circuit provides a signal which stops the frequency of the swept oscillator at its lowest frequency.

(2) The signals from the swept oscillator and the fixed oscillator are beat together in the modulator.

(3) The shaping network selects the difference frequency (which is hypothetically 3 kc).

(4) This signal is then amplified by the flat output circuit.

(5) The output of the flat output circuit is connected to the frequency checking circuit.

Printed in U.S.A.

(6) The frequency checking circuit is connected to the (FLAT OUT CAL) jack (J2) where a high impedance voltmeter is externally connected. If a minimum occurs in the output signal when the variable resistor (R82) is changed to its extremes, then the upper frequency of the output signal is within 50 cycles of 3 kc.

1.04 With the (FREQ CHK) switch (S1) in the (1000~) position, the circuit is set up to check whether or not the lower frequency of the 1 to 3 kc swept tone is indeed 1 kc. The circuit operates in the same manner as that described in 1.03 of this section except that the sweep control circuit stops the frequency of the swept oscillator at its highest frequency. This check assures that the minimum frequency of the output signal is within 150 cycles of 1 kc.

2. SPECIFIC

2.01 Sweep Control Circuit

2.011 The sweep control circuit, with the (FREQ CHK) switch (S1) in the (OPR) position, is a free running multivibrator of a rather unusual variety. The heart of the circuit is the PNPN diode (CR16).

2.012 Suppose that a battery has just been connected to terminal A26 in the sweep control circuit (see Fig. 1). The large capacitor (C40) slowly charges through (R76). The diode (CR16) is in its high impedance state, and, therefore, the voltage across it is the same as that on the capacitor (C40).

2.013 When the voltage on the capacitor (C40) and on the diode (CR16) reaches a critical point called the "breakover voltage" or the "forward breakdown voltage," the diode (CR16) switches to its low impedance state. This causes the capacitor (C40) to begin discharging through the resistor (R73) and the diode (CR16). The discharge path is of relatively low resistance. Hence the discharge time of the capacitor (C40) is much shorter than the charging time.

2.014 A portion of this changing voltage across the capacitor (C40) is connected to the "voltage sensitive capacitor" diode (CR15) through the isolating resistor (R70). The portion of that voltage which appears at the diode (CR15) is determined by the (FREQ ADJ 1) variable resistor (R72). The resistors (R65, R66, R68) limit the variation of the portion of this changing voltage that can be supplied to the diode (CR15). The X, Y option is selected in the factory.

2.015 The average value of the voltage across the "voltage sensitive capacitor" diode (CR15) is adjusted by the (FREQ ADJ 2) variable resistor (R71). Capacitor (C39) is a bypass to ground. The resistor (R67) limits the amount of variation of this average voltage across (CR15).

2.016 The diode (CR15) is connected across the tank circuit of the swept frequency oscillator. This diode (CR15) is the device which, by changing the capacitive tuning of the tank circuit, causes the frequency to change.

2.02 Swept Frequency Oscillator

2.021 The swept frequency oscillator is basically of the Colpitt's variety. The tank circuit determines its frequency of oscillation and consists of the inductor (L6), the capacitors (C16 and C17), and the diode (CR15). The setting of the inductor (L6) is a factory adjustment.

2.022 The resistor (R43) provides coupling between the tank circuit and the emitter of the transistor (Q6).

2.023 The resistor (R40, R42, R44, and R45) provide proper biasing to the transistor (Q6).

2.024 The diodes (CR7 and CR8) along with the resistor (R41) controls the amplitude of oscillation of the oscillator. The capacitor (C15) bypasses the resistor (R42), and the capacitor (C38) blocks the biasing current from passing through the diode (CR15).

2.03 Modulator Drive

2.031 The modulator drive amplifier acts as a buffer between the swept oscillator and the modulator. It also serves to adjust the level of the swept frequency signal to the proper value for food modulator performance.

2.032 The transistor (Q7) is biased by the resistors (R46, R47, and R48). It is directly coupled to the swept oscillator and provides a high input impedance.

2.033 The capacitor (C19) bypasses the resistor (R48), and the capacitor (C20) couples the output from the transistor (Q7) to the next stage.

2.034 The resistors (R49, R50, R51, R52, and R53) provide biasing to transistor (Q8). The capacitor (C21) is a "bootstrap" or feedback path which makes the resistor (R49) appear to be a high value.

2.035 The swept frequency signal is coupled to the modulator by the capacitor (C22) and the transformer (T2). The magnitude of the signal is determined by the setting of the variable resistor (R52). The capacitor (C23) is a bypass to ground.

2.04 Modulator

2.041 The modulator is a simple diode bridge modulator made up of 4 diodes (CR2, CR3, CR4, and CR5).

2.042 The output of the modulator appears between the point B35 and ground.

2.05 Fixed Oscillator

2.051 The fixed oscillator is basically of the Colpitt's variety. The tank circuit determines the frequency of oscillation and consists of the inductor (L1) and the capacitors (C1 and C2). The setting of the inductor (L1) is a factory adjustment.

2.052 The resistor (R2) provides coupling between the tank circuit and the emitter of the transistor (Q1).

2.053 The resistors (R1, R3, and R4) and the diode (CR1) provide proper bias to the transistor (Q1).

2.054 The diode (CR1) limits the amplitude of oscillations of the oscillator.

2.055 The (FLAT GAIN) variable resistor (R4) determines the amplitude of the the signal at the output of the modulator depends upon the magnitude of the fixed oscillator signal. Therefore, the (FLAT GAIN) variable resistor (R4) determines the level of the signal at the (FLAT OUT CAL) jack (J2).

2.056 The capacitor (C3) couples the fixed oscillator signal at the (FLAT GAIN) variable resistor (R4) to the transistor (Q2) which acts as a buffer amplifier and provides the proper impedance to the modulator.

2.057 The resistors (R5, R6, and R7) provide biasing to the transistor (Q2). The resistor (R8) determines the output impedance of this stage, and the capacitor (C4) couples the fixed oscillator signal to the modulator.

2.06 Shaping Network

2.061 The shaping network is a bridged-tee filter preceded by a low pass L-section filter.

2.062 The low pass filter selects the difference frequency between the swept and fixed oscillators at the output of the modulator. It is made up of the inductors (L2 and L3) and the capacitor (C5). The inductors (L2 and L3) are set as a factory adjustment.

2.063 The bridged-tee network is made up of inductors (L4 and L5), capacitors (C6 and C7), and resistors (R9, R10, R11, and R12). The components were chosen by computation to give the desired frequency weighting to the 1 to 3 kc swept signal.

2.064 The capacitor (C8) couples the weighted swept signal to the output amplifier.

2.065 With the switch (S2) in the (LEV CHK) position, the resistors (R32 and R33) introduce a fixed loss and replace the bridged-tee network for test purposes.

2.07 Output Amplifier

2.071 The output amplifier provides proper termination to the shaping network; it provides gain for the shaped, frequency swept signal and it provides a very low output impedance at the last stage.

2.072 The resistors (R13, R14, R15, R16, and R17) provide biasing to the first transistor (Q3). The input impedance to the amplifier is determined by the resistors (R13 and R14). The gain of the first stage is determined by the resistors (R15 and R16). The capacitor (C9) bypasses the resistor (R17). The capacitor (C10) couples the output of transistor (Q3) to transistor (Q4).

2.073 The resistors (R18, R19, R20, R21, R22, and R23) provide biasing to the second transistor (Q4). The gain of this stage depends upon the setting of the (OUT GAIN) variable resistor (R22). The capacitor (C11) is a bypass to ground.

2.074 The transistor (Q5) is directly coupled to the transistor (Q4). The bias current in this stage is determined by resistor (R24). Since this is a common emitter stage, the output impedance is quite low.

2.075 The capacitor (C12) couples the output of the amplifier to the output transformer (T1).

2.076 The resistors (R25, R26, R27, and R28) following the output transformer (T1) are connected according to circuit Note 104.

2.077 The resistors (R29 and R30) are used to build out the impedance to the proper value. The resistor (R31) is a dummy load which is removed when the (GEN OUT CAL) output jack (J1) is in use.

2.078 Also connected across the output are the distributing circuits as explained in paragraph 1.04 of Section I and illustrated in Fig. 101.

2.08 Flat Output Amplifier

2.081 The flat output amplifier is coupled to the output of the low pass filter section of the shaping network (see 2.061 of this section) through capacitor (C24).

2.082 The resistors (R54, R55, R56, and R57) provide biasing to the transistor (Q9). The capacitor (C25) is a bypass for (R56).

2.083 The diode (CR6) is used to prevent excessive currents in the emitter of the transistor (Q9) when the output is shorted.

2.084 The resistors (R56 and R57) supply dc current to the (FLAT OUT CAL) jack (J2).

2.085 The capacitor (C26) is a bypass for the -22 volt power supply.

2.09 DC Regulation

2.091 The dc regulator is made up of the three resistors (R60, R61, and R69), the capacitor (C28), and the six diodes (CR9, CR10, CR11, CR12, CR13, and CR14).

2.092 The action of the two diodes (CR9 and CR10) is the same. There are two only to split the load on them. Each of them breaks down at about 22 volts and the resistors (R60 and R61) limit the current through them.

2.093 The capacitor (C28) is used to bypass the office battery.

2.094 The resistor (R69) limits the current through the four series diodes (CR11, CR12, CR13, and CR14).

2.095 The four regulator diodes (CR11, CR12, CR13, and CR14) provide a temperature stable voltage for biasing the diode (CR15).

2.10 Frequency Checking [(3000~) Position of (FREQ CHK) (S1)].

2.101 All of the above discussion has assumed that the (FREQ CHK) switch (S1) was in the (OPR) position. In this position, the flat output amplifier is connected to the (FLAT OUT CAL) jack (J2). All other circuitry in the frequency checking assembly is disconnected.

2.102 When the (FREQ CHK) switch (S1) is turned to the (3000~) position the sweep control circuit, the frequency check circuit, and the flat output circuit are all affected. This was described in paragraph 1.03 of this section.

2.103 In the sweep circuit the (3 KC CHK ADJ) variable resistor (R75) is connected to the regulated 22 volts and replaces the resistor (R76). The resistor (R75) is adjusted so as to put a voltage just below the "breakover voltage" on the diode (CR16) (see 2.013). This sets the frequency of the variable oscillator to its lowest value.

2.104 The output of the flat amplifier is connected to the input of the frequency checking circuit.

2.105 With the (FREQ CHK) switch (S1) in this position, the frequency checking circuit is made up of a voltage divider consisting of the resistors (R81, R82, R83, and R84) and a twin-tee network made up of resistors (R77, R78, and R79) and capacitors (C41, C42, and C43).

2.106 The twin-tee network is designed to produce a minimum in its output for a given frequency of the input signal. However, the frequency at which this minimum occurs can be changed by the setting of the variable resistor (R82).

2.107 The (FREQ CHK) variable resistor (R82) and the resistors (R81, R83, and R84) connected to it are chosen such that the minimum output of the twin-tee network lies between 3050 and 2950 cps depending upon the setting of variable resistor (R82).

2.108 The output of the twin-tee network is connected to the (FLAT OUT CAL) jack (J2).

2.109 Now, if the signal at the input to the frequency checking circuit is between 2950 and 3050 then a minimum will occur in the signal at the (FLAT OUT CAL) jack (J2) at some position of the variable resistor (R82).

2.11 Frequency Checking [(1000~) Position of (S1)].

2.111 In this position of the (FREQ CHK) switch (S1). The (1 KC CHK ADJ) variable resistor (R74) in the sweep control circuit is connected to the regulated 22 volts and replaces the resistor (R76). The resistor (R74) is factory adjusted so as to put that current through the PNPN diode (CR16) which just holds it in its "on" or low impedance state (see 2.013). This sets the frequency of the variable oscillator to its highest value.

2.112 The output of the flat amplifier is again connected to the input of the frequency checking circuit.

2.113 The voltage divider portion of the frequency checking circuit consists of resistors (R80, R82, R83, and R85). Note that (R80 and R85) have replaced (R81 and R84) from paragraph 2.105.

2.114 The variable resistor (R82) and the resistors (R80, R83, and R85) are chosen such that the minimum output of the twin-tee network now lies between 940 and 1150 cps.

2.115 The output of the twin-tee network is connected to the (FLAT OUT CAL) jack (J2).

2.116 Now, if the signal at the input to the frequency checking circuit is between 930 and 1150 cps then a minimum will occur in the signal at the (FLAT OUT CAL) jack (J2) at some position of variable resistor (R82).

3. OPERATION

3.1 Warm-up

No warm-up time is required.

3.2 Calibration

3.21 Both level and frequency must be initially adjusted and periodically checked. In order to do this a 900 ohm measuring set is required.

3.22 With (S1) and (S2) set in the (OPR) position the 900 ohm measuring set is connected to the (FLAT OUT CAL) jack (J2) for the initial adjustment.

3.23 The (FLAT GAIN) variable resistor (R4) is adjusted for the proper indication on the 900 ohm measuring set.

3.24 Now the 900 ohm measuring set is connected to the (GEN OUT CAL) jack (J1).

3.25 The calibration and checking procedure is as follows:

(1) Set the (FREQ CHK) switch (S1) to the (3000~) position.

(2) Set the switch (S2) to the (LEV CHK) position.

(3) Adjust the (OUT GAIN) variable resistor (R22) for the proper indication on the 900 ohm measuring set.

(4) Set the (FREQ CHK) switch (S1) to the (1000~) position and release the (LEV CHK) switch (S2).

(5) The 900 ohm measuring set shall indicate a prescribed power.

(6) Set the (FREQ CHK) switch (S1) to the (3000~) position. Slowly turn the potentiometer (R75) until the 900 ohm measuring set indicates a maximum. This maximum shall be prescribed power.

(7) Set the (FREQ CHK) switch (S1) to the (OPR) position. Operate the (LEV CHK) switch and observe the reading of the 900 ohm measuring set. This reading shall remain relatively constant.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 The 24B Loop Checker Generator has been designed to operate between 40° and 110°F and between 45 and 52 volts office battery.

2. FUNCTIONS

2.1 Provides up to ten (10) outputs plus an output jack with a frequency weighted swept tone between 1000 and 3000 cycles per second.

2.2 Provides circuits for checking and adjusting the upper and lower frequencies.

2.3 Provides circuits for checking and adjusting level of the output.

2.4 Provides an unweighted swept tone between 1000 and 3000 cycles per second to an output jack.

2.5 Provides the unweighted tone to terminals for a bridging distribution amplifier.

3. CONNECTING CIRCUITS

3.1 Test Line Ckt. - SD-98100-01

SECTION IV - CHANGES

B. CHANGES IN APPARATUS

B.1 Superseded	Superseded by
1-Res (R57) KS-13490, L1 1100 Ω	1-Res (R57) KS-14603, L1A 464 Ω
1-Res (R55) KS-13490, L1 30,000 Ω	
1-Diode (CR9) 426 M	1-Diode (CR9) IN 1430

B.2 Added (Optional)

1-Res (R65)
KS-13490, L1
0.39 Meg

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 Options "E and F" were added to cover B.1 above. "E" option only was previously shown and not rated "Mfr. Disc."

D.2 Options "A and B" were added to cover B.2 above. "A" option only was previously shown and not rated "Mfr. Disc."

D.3 Note 302 was added.

D.4 The designations of the (J1) and (J2) Jacks were changed to agree with equipment information.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 2137-MJT/RCH-BCB-EE

CIRCUIT DESCRIPTION
TRANSMISSION SYSTEMS DEVELOPMENT DEPARTMENT

CD-99707-01
Issue 4B
App. 1B
Dwg. Issue 5B

463.315

COMMON SYSTEMS
TRANSMISSION MEASURING
24B LOOP CHECKER GENERATOR CKT

CHANGES

B. CHANGES IN APPARATUS

B.1 Superseded	Superseded by
1 - Res (R65) KS-13490 L1 0.39 MEG	1 - Res (R65) KS-13490 L1 0.13 MEG
1 - Res (R68) KS-13490 L1 0.22 MEG	1 - Res (R68) KS-13490 L1 0.13 MEG

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 "G" option was added to cover the value of resistance for (R65) above. "B" option was rated "Mfr. Disc."

D.2 "H and J" options were added to cover the (R68) above. "H" option only was previously shown and not rated "Mfr. Disc."

D.3 "G" option was added to the (CR9) diode to reflect change made in other "B" option.

All other headings, No change.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT. 2194-RCH-BCB-AH