

POWER SYSTEMS
SIGNALING CIRCUIT
DIAL TONE GENERATOR
FOR PBX
"TOUCH-TONE" CALLING

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| | | <u>2. GENERAL METHOD OF OPERATION</u> |
| | | 2.01 The 350 cps frequency generator is shown in FS1. The various bias voltages required in the frequency generator are provided by the shunt voltage regulator shown in FS1. Therefore, the frequency generator is a complete entity, in that it produces a 350 cps sinewave output from a -48 VDC input. |
| | | 2.02 The 440 cps frequency generator is shown in FS2. The various bias voltages required in the frequency generator are provided by the shunt voltage regulator shown in FS2. Therefore, the frequency generator is a complete entity, in that it produces a 440 cps sinewave output from a -48 VDC input. |

2.03 The outputs of the two frequency generators, one operating at 350 cps and the other at 440 cps, are added in the summing circuit, shown in FS3, to produce the desired dial tone. Figs. FS1, FS2 and FS3 constitute a single dial tone generator and is coded as a "404A or 404C Tone Generator" for Crossbar PBXS and a "404B or 404D Tone Generator" for Step-by-Step PBXS. When duplicate dial tone generators (only 404B or 404D) are furnished, both generators operate continuously but only the regular generator (GEN 1) feeds the load.

2.04 Duplicate tone monitors are shown in FS4. There is one voltage monitor for each dial tone generator (only when two dial tone generators are furnished). The monitor will operate a relay if the output voltage should go high or low.

2.05 The automatic transfer circuit for the dial tone generators is also shown in FS4. This circuit transfers the load to the spare generator (GEN 2) in case the regular generator fails. It provides an audio and a visual alarm if either or both of the regular and spare generators fail. The automatic transfer circuit (FS4) and the tone monitors (FS4) constitute a single "10A or 10B Tone Monitor".

2.06 Two separate 48V battery supply fuses TTA & TTB are required to provide power to the 350 CPS frequency generator and the 440 CPS frequency generator respectively. When duplicate dial tone generators are furnished five fuses are required two TTA fuses, two TTB fuses and one F3 fuse to provide power to the tone monitors and the transfer circuit. Each 48V battery lead has its own ground lead paired with it.

SECTION II - DETAILED DESCRIPTION

1. 350 CPS FREQUENCY GENERATOR - FS1

1.01 The -13V and -26V voltages are derived from the zener diode shunt voltage regulator, consisting of zener diodes (CR1) and (CR2), series resistor (R1), and capacitors (C2) and (C3). The zener diodes are 13 volts \pm 5 percent, so the -13 volts will be in the range 12.3 to 13.7 volts and the -26 volts will be in the range 24.7 to 27.3 volts.

1.02 The adjustable bias voltage which supplies the bias to the oscillator transistors (Q1) and (Q2) is adjusted to provide approximately the voltage value shown in FS1, with respect to the -13 volt output, depending on the option furnished. This is accomplished by adjusting the (BIAS ADJ 1) potentiometer.

1.03 Transistors (Q1) and (Q2) are connected in the Darlington compound connection for the purpose of obtaining an equivalent transistor having a current gain α very

close to unity (minimum combined $\alpha = 0.9996$ for minimum individual $\alpha = 0.98$). The equivalent transistor thereby derived is used as the first stage Hartley oscillator transistor. The oscillator has a second stage consisting of transistors (Q3) and (Q4) connected as a Class B amplifier. Part of the output of this amplifier is used to provide positive feedback through resistor (R3) to sustain oscillations. Resistors (R4) and (R5) provide temperature stabilization to compensate for the effects of I_{cbo} .

Inductor L1 and capacitor C4 are connected in parallel and represent the oscillator tank circuit which is designed to oscillate at 350 cps. The amplitude limiting and thus the magnitude of output voltage is controlled by the adjustable bias voltage applied to the collectors of transistors (Q1) and (Q2). The output of the frequency generator is a 350 cps sinewave with a total harmonic distortion content at least 45 db down from the fundamental.

2. 440 CPS FREQUENCY GENERATOR - FS2

2.01 The description of the 440 cps frequency generator is identical to that given for the 350 cps frequency except for the frequency of oscillation 440 cps which is obtained by using a lower inductance value in the tank circuit inductor, the resistance value of several resistors, and the component designation numbers.

3. SUMMING CIRCUIT - FS3

3.01 The sinewave outputs from the two frequency generators described above are fed into a summing circuit (FS3) to produce the desired "TOUCH-TONE" dial tone signal. The resulting dial tone signal waveform resembles an amplitude modulated signal but in fact contains no modulation products because it is produced by the phenomena of beating two frequencies with each other. The amplitude of the dial tone signal varies as the difference frequency and both frequencies are present within the envelope, however, there are no product or sum frequency components. The summing circuit consists of a three winding transformer (T1), two blocking capacitors (C10A) and (C10B), a distortion reducing capacitor (C9) and a resistor (R6). The output of the 350 cps frequency generator is fed into terminal (1) of primary winding (1-2) of transformer (T1), and the output of the 440 cps, is fed into terminal (6) of primary winding (5-6). Terminals (2) and (5) are ac coupled by two, 2000 μ f electrolytic, blocking capacitors. Therefore, under normal operating conditions, the output of one frequency generator passes through a primary winding, two capacitors, a second primary winding and then into the other frequency generator in order to return to ground and in turn to its own ac ground (-13VDC). Resistor (R6) has no effect on the output voltage produced under normal operating

conditions because of its relatively high impedance to ground compared to the ground return impedance presented by the other frequency generator. Capacitor (C9) also has no effect on the output voltage under normal operating conditions, because its impedance is relatively high compared to the primary windings of (T1) and capacitors (C10A) and (C10B). Capacitor (C9) reduces the harmonic distortion produced by the transformer (T1) by tuning out the transformer excitation currents. However, in the event of a circuit failure in one of the generators or transformer primary windings, the impedance of the ground return for the other generator would be affected and possibly become infinite, thereby tending to cause a partial or complete dial tone failure. Resistor (R6) serves to avoid a complete dial tone failure. This is accomplished by providing a reliable ground return through resistor (R6) for the surviving frequency generator. The worst case occurs when the circuit failure opens the ground return. The summing circuit then changes its mode of operation and the output of the surviving frequency generator passes through only one primary winding, one blocking capacitor and resistor (R6) in order to return to ground. The output of the surviving frequency generator also passes through (C9), the other primary winding, the other blocking capacitor and (R6) to ground. This signal path contributes about 12 percent of the output voltage. Under these conditions the dial tone consists of one frequency (either 350 cps or 440 cps) and the transformer turns ratio changes from about 3.2:1, to 1.6:1. The output voltage provided under trouble conditions is determined by the value of resistor (R6) and the change in the transformer turns ratio. Resistor (R6) and the transformer primary winding associated with the surviving frequency generator represent a voltage divider. Therefore, under trouble conditions a wide range of (single frequency) output voltage level may be obtained by design. This involves choosing the proper resistance value for resistor (R6). The dial tone signal output is single-sided and unbalanced with the tone superimposed on ground and appears across terminals (7) and (8) of (T1).

3.02 The tone generator is self-protecting in that an accidental short circuit applied across terminals (7) and (8) of transformer (T1) will not result in any damage.

4. TONE MONITOR - FS4

4.01 The tone monitor circuit is provided only when duplicate dial tone generators are furnished in large step-by-step PBXs, and this combination of tone generators and monitor circuit coded as a 405A or 405B tone generator. Under this provision one tone voltage monitor is provided for each of the generators. Both monitors are identical, therefore, the operation of only

one of the monitors will be given. The test signal (TT4) is fed in through the (HLV LEV 1) potentiometer to a voltage doubler rectifier made up of diodes (CR5) and (CR6) and capacitors (C11) and (C12). The resulting DC signal, with the polarity shown, is fed to the base of transistor (Q9), which is the signal half of a differential amplifier. The base to emitter junction of (Q9) is forward biased so that collector current flows through resistor (R19) to -25 volts. The base of transistor (Q10) is clamped, with respect to ground, at about 1.6 volts by zener diode (CR7), and the voltage divider across it, made up of resistor (R16) and the (HLV REF) potentiometer. Thus transistor (Q10) is also forward biased, so collector current flows through resistor (R20) to -25 volts. A bridge arrangement is formed by transistors (Q9) and (Q10) and resistors (R19) and (R20). The (HLVM1) relay winding is connected across the bridge. When the dial tone signal is at its nominal level, the relay winding has approximately 2 volts across it, with polarity plus to minus from (TP13) to (TP14). This initial unbalance is necessary in order to obtain alarm limits that are symmetrical with the nominal dial tone level. The circuit unbalance is obtained by adjusting the base drive to transistor (Q9) by means of the (HLV LEV 1) potentiometer.

4.02 The -25 volts is derived from -48V by a zener diode shunt voltage regulator. The regulator consists of resistor (R22), zener diode (CR8) and varistors (RV1), (RV2) and (RV3). The varistors are strapped out as required in order to provide a closer tolerance on the -25 volts than is provided by the ± 5 percent -24 volt zener diode.

4.03 If the TT4 voltage should become high, the voltage across capacitor (C12) will become higher, increasing the base drive to transistor (Q9) and thus increasing its collector current and decreasing its collector to emitter voltage. The increase of (Q9) collector current will increase the voltage drop across resistor (R18). This voltage is plus to minus from ground to the emitter of (Q10). The forward bias for transistor (Q10) will decrease, due to the increased voltage drop across (R18), and therefore decrease its collector current and increase its collector to emitter voltage. If the collector to emitter voltage of (Q9) decreases and that of (Q10) increases, there will be an increase in the voltage unbalance across the relay (HLVM1). When the unbalance becomes great enough, the relay will operate.

4.04 In a similar manner if the TT4 voltage should become low, transistor (Q9) will start to turn off (increase its collector to emitter voltage). With the resulting reduction in its collector current, the voltage drop across (R18) will become

smaller. The result is that the forward bias to (Q10) will increase. The increase of base current to (Q10) will increase its collector current and decrease its collector to emitter voltage. Since the voltage across (Q9) is increasing and that across (Q10) is decreasing, the resulting unbalance of voltage across the relay (HLVM1) will cause it to operate.

4.05 When the voltage monitor relay (HLVM1) operates, a holding ground through the 2 break contact on the relay is removed so that relay (GT) can operate. Make contact 1 closes a ground to the (HLVM1) lamp which then lights. When the voltage monitor relay (HLVM2) operates, a holding ground through the 2 break contact on the relay is removed so that relay (TF) can operate. Make contact 1 closes a ground to the (HLVM2) lamp which then lights.

4.06 Under normal operating conditions, with (GEN 1) supplying the load, relay (GT) is released. It is shunted down to ground through its own break contact 5, the (AUTO) position contact of the (GEN TRFR) switch (S1) and the number 2 break contact of relay (HLVM1). If (HLVM1) relay in (MON 1) should operate due to a trouble in the (GEN 1) regular generator, the holding ground will be removed. Relay (GT) will then operate through resistor (GT) and the (RT1) thermistor. The thermistor will delay the operate of the (GT) relay about 2 seconds and then it is shorted out by the 4 make contact on relay (GT) when (GT) operates. When the (GT) relay operates, the lead transfers to (GEN 2), the (GT) lamp lights and the parallel holding ground for the (TF) relay, provided by the (GT) 6 break contact is removed. Also the (GT) relay locks up in the operated position due to its own 5 break contact. The (TF) relay will operate through resistor (TF) and thermistor (RT2). The thermistor will delay the operate of the (TF) relay by about 2 seconds and then it will be shorted out by the 4 make contact on (TF) when (TF) operates. When the (TF) relay operates, it provides a ground, through its 3 make contact over the (CAP) lead to the (MISC ALM CKT) to provide a minor visual alarm. It also provides a ground through its 2 make contact over the (F) lead to the alarm circuit to provide a minor alarm. After the trouble has been cleared the circuit can be restored by momentarily operating the (RST) switch (S2), which shunts down the (GT) relay and places it back under the control of the (MON 1) relay. The load may be manually transferred to (GEN 2) by momentarily operating the (TRFR) switch (S1) and restored by momentarily operating the (RST) switch (S2).

4.07 Relay (TF) is normally shunted down to ground by the number 2 break contact on the (HLVM2) relay in series with the number 6 break contact on the (GT) relay. If (GEN 1) is operating normally and (GEN 2)

should fail, operating the (HLVM2) relay, relay (TF) will operate and provide the minor alarms described in paragraph 4.6.

5. ROUTINE VOLTAGE CHECKS

5.01 These generators are factory adjusted and normally should not require field adjustment. The following voltage measurements will verify the factory adjustment. The test equipment required to perform the tests described below are as follows: One KS-14510, 11 volt-ohm-milliammeter 3V AC scale or equivalent. Remove all supply and discharge fuses. Install input fuse TTA feeding the 350 cps frequency generator. Verify that 1.30 to 1.55 volts "Z" option and 1.60 to 1.85 volts "Y" option, exists between pin jacks TP11 and TP4. Remove the TTA fuse feeding the 350 cps frequency generator and insert the TTB fuse feeding the 440 cps frequency generator. Verify that 0.95 to 1.20 volts "Z" option and 1.60 to 1.85 volts "Y" option exists between pin jacks TP11 and TP4. Install the TTA fuse feeding the 350 cps frequency generator. Verify that 1.50 to 1.75 volts "Z" option and 2.05 to 2.30 volts "Y" option exists between pin jacks TP11 and TP4.

Note: If duplicate generators are furnished, the above tests should be performed on each unit.

5.02 These monitors are factory adjusted and normally should not require field adjustment. The following voltage measurements will verify the factory adjustment. Insert fuse designated F3. Remove the input fuse TTA feeding the 350 cycle frequency generator of the regular generator. Verify that the HLVM1 and GT lamp lights. To verify that the spare generator is now feeding the load: Connect the volt meter to the tone distributing circuit and verify that the voltage is between 1.50 and 1.75 for the "Z" option and 2.05 and 2.30 for the "Y" option. Install input fuse TTA feeding the 350 cycle frequency generator. Operate the RST switch to restore the circuit to the regular generator. The HLVM1 and GT lamps should extinguish. Verify that the voltage is between 1.50 and 1.75 for the "Z" option and 2.05 and 2.30 for the "Y" option. Operate the TRFR switch to bring in the spare generator. Remove the input fuse TTA feeding the spare 350 cycle frequency generator. Verify that the HLVM2 lamp lights. Operate the RST switch to restore the circuit to the regular generator. The HLVM2 lamp should extinguish.

6. ADJUSTMENTS

6.01 If the generators do not meet the voltage checks of 5.1 then they must be adjusted per the following procedure. Insert a resistor in the vicinity of 35 to 50K between pin jacks TP8 and TP10. Connect a thermocouple voltmeter with a 3-volt scale

(Weston Model 622 or equivalent). between pin jacks TP11 and TP4. Adjust the BIAS ADJ 1 potentiometer to provide 1.41 volt rms for the "Z" option and 1.70 volt rms for the "Y" option. Remove the resistor from pin jacks TP8 and TP10 and insert it between pin jacks TP3 and TP5. Adjust BIAS ADJ 2 potentiometer to provide 1.06 volt rms for the "Z" option and 1.70 volt rms for the "Y" option. Remove the resistor from pin jacks TP3 and TP5. The voltage measured shall be 1.75 ± 0.01 volt rms for the "Z" option and $2.40 + 0, -0.03$ volt rms for the "Y" option.

6.02 If the monitors do not meet the checks of 5.2, then they must be adjusted per the following procedure. Verify that $2.40 + 0, -0.03$ volt rms exists between pin jacks TP11 and TP4, using a thermocouple meter that is described in 6.1. Adjust potentiometer HLV-REF to provide 1.60 volt dc between pin jacks TP12 and TP4. (Use Weston Model 1 3V scale or equivalent.) Turn potentiometer HLV-LEV completely clockwise and connect the voltmeter on 3V scale between pin jacks TP13 and TP14 for Monitor 1 and TP17 and TP18 for Monitor 2, observing that the plus (+) lead of voltmeter is inserted in pin jacks TP13 or TP17. Slowly turn potentiometer counterclockwise until the voltmeter reads 2.0 volts. Reverify the 2.40 to -0.03 volt rms between pin jacks TP11 and TP4. Leaving the thermocouple voltmeter in this position. Slowly turn the BIAS ADJ 1 potentiometer counterclockwise until the HLVMI relay operates and note the output voltage read on the voltmeter. The relay shall operate within the limits of 1.85 to 2.04 volts rms.

Slowly turn the BIAS ADJ 1 potentiometer clockwise until the output voltage is 2.40 to -0.03 volt rms. The relay should be released. Repeat this procedure for Monitor 2.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

Input:

44 - 52.6 volts DC
Max. current drain = 0.35 amps.

Output:

TT1 - 350 cps - 1.41V RMS
440 cps - 1.06V RMS
Combined - $1.75 \pm 12\%$ V RMS
Max. load 28 connections of
Z = 800 $\pm 60^\circ$ each.
TT4 - 350 cps - 1.58V RMS
440 cps - 1.58V RMS
Combined - $2.24 \pm 9\%$ V RMS
Max. load 108 connections of
Z = 33000 $\pm 55^\circ$ each.
TT1 & TT4 - Frequency 350 cps $\pm 1\%$
440 cps $\pm 1\%$

Operating temperature
range 0° to 60° C. Total
harmonic distortion con-
tent 40 db down from the
fundamental tone level.

SECTION IV - REASONS FOR REISSUE

CHANGES

B. Changes in Apparatus

- B.1 In cps 1A and 1B code of transistor Q3 has been changed from 31D to 31C.
- B.2 In cps 1A and 1B code of resistors R4 and R5 has been changed from KS-16312, L3A to KS-16313, L6A.
- B.3 In cps 2A and 2B code of transistor Q7 has been changed from 31D to 31C.
- B.4 In cps 2A and 2B code of resistors R10 and R11 has been changed from KS-16312, L3A to KS-16313, L6A.
- B.5 In cps 3 code of transistors Q9 and Q10 has been changed from 31D to 31C.
- B.6 In cps 4 code of transistors Q11 and Q12 has been changed from 31D to 31C.

F. Changes in CD Sections

- F.1 In Section III Reference Data 1.0 Working Limits expanded.
- F.2 In Section II Detailed Description paragraphs 5 (Routine Voltage Checks) and 6 (Adjustments) added.

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