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# 665 FWA E & M SF SIGNALING UNIT

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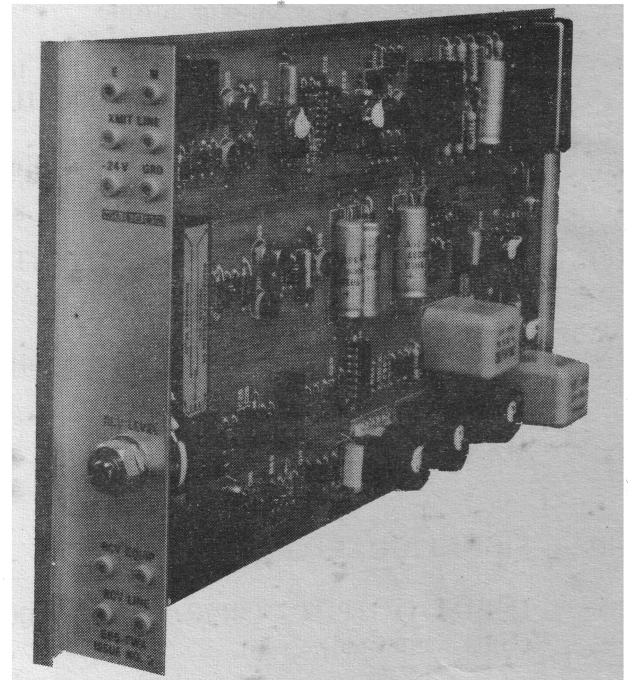


Figure 1. 665 FWA E & M SF Signaling Unit

## 1. GENERAL

1.01 This Section provides circuit description installation and basic testing information for the Wescom 665-FWA, E&M, SF Signaling Unit.

1.02 The 665-FWA (Figure 1) is a plug-in printed circuit module that provides two-way supervision and dialing or multi-frequency pulsing over any 4-wire voice-grade facility, when used with intertoll E & M trunk circuits.

1.03 The 665-FWA is available in four separate signaling frequencies. The part numbers for these units are listed in Table 1.

Table 1. 665-FWA Signaling Frequencies

CATALOG NUMBER	PART NUMBER	SIGNALING FREQUENCY
665-FWA	B91-066500	2600 Hz
665A-FWA	B91-066501	2400 Hz
665B-FWA	B91-066502	1600 Hz
665C-FWA	B91-066503	2280 Hz

1.04 The 665 FWA provides the following features:

- (a) Integrated circuitry and other state-of-the-art components are used wherever possible to reduce space requirements, power consumption, and maintenance, while increasing reliability.
- (b) Plug-in modular construction for rapid service of the equipment with minimum down-time.
- (c) Mounting capabilities which allow the 665 FWA E&M, SF Signaling Module to mount in the same shelf with any of the 650 equipment.

1.05 The 665 FWA is constructed as a plug-in module designed to mount in one position of the Wescom Type 681 or 682 Mounting Assembly. The mounting assembly contains a 56-pin wire wrap connector which allows the module to make electrical connection to the system.

**2. SPECIFICATIONS**

2.01 The specifications describing the electrical and physical characteristics of the 665-FWA are as follows:

- (a) VOICE PATH: Four-wire drop or line, -16 dBm transmit, +7 dBm receive.
- (b) TRANSMIT TONE LEVELS: High level, -24±2dBm; Low level, -36±2dBm.
- (c) FREQUENCY RESPONSE: 250 Hz to 10k Hz ±1 dB relative to 1000 Hz (excluding slot filter).
- (d) RECEIVE SENSITIVITY: -22 dBm (minimum).
- (e) RECEIVE AMPLIFIER ADJUSTMENT: -10 dB to +2 dB.
- (f) 2600-HZ REJECTION: 55 dB (typical), 45 dB (minimum).
- (g) MAXIMUM LINE NOISE: 52 dBmCO.
- (h) SIGNAL/GUARD RATIO: 6 dB.
- (i) INPUT/OUTPUT IMPEDANCE: 600 ohms (nominal).

**RECEIVE PULSE CORRECTION**

(j)

% - BREAK		
PPS	INPUT	OUTPUT
8	35	46
8	58	55
8	65	61
10	40	58
10	58	59
10	70	63
12	45	57
12	58	58
12	75	59

**TRANSMIT PULSE CORRECTION**

(k)

% - BREAK		
PPS	INPUT	OUTPUT
8	35	47
8	58	47
8	80	63
10	40	57
10	58	58
10	80	59

% BREAK		
PPS	INPUT	OUTPUT
12	45	57
12	58	58
12	75	59

**NOTE:** Due to component variation and aging, pulsing output figures may vary by ±3% break.

- (l) E-LEAD DELAY, 33 ms, nominal; M-LEAD DELAY, 10 ms nominal.
- (m) HIGH LEVEL HOLD TIME: 400 ms ± 100 ms
- (n) DIALING SPEED: 8 to 12 pps.
- (o) DIAL AND SUPERVISORY RANGE: 1000 ohms maximum (M-lead).
- (p) INPUT VOLTAGE: -21 to -55 Vdc, filtered (voltages between -21 and -24 may cause a slight degradation of specifications)
- (q) CURRENT REQUIREMENT: 55mA ± 5mA at -48Vdc input; 32mA ± 5mA at -24Vdc input.
- (r) OPERATING TEMPERATURE: 0° to 120°F.
- (s) HUMIDITY: to 90%.
- (t) DIMENSIONS: Height, 6.6 inches; Width, 1.4 inches; Length, 13.4 inches.
- (u) WEIGHT: Approximately 3.0 lbs.

**3. CIRCUIT DESCRIPTION**

3.01 The 665-FWA is used to provide two-way supervision and dialing or multifrequency pulsing over any four wire, voice-grade facility when used with intertoll E&M trunk circuits. The 665 additionally provides full duplex signaling with complete independence of transmit and receive signals.

Refer to the attached 665-FWA Signaling Unit schematic diagram during the following discussion.

**transmit circuit - local terminal on-hook**

3.02 The tone switch network consists of four parts: (1) M-lead delay circuit (Q11 and Q12), (2) pulse corrector circuit (IC2-1 and IC2-2), (3) tone on-off gate (CR4 and CR5), and (4) high level tone gate (C5, CR1 and CR3). The entire tone network is balanced to ground consistent with four-wire line and hybrid term set requirements.

3.03 With the M-lead at ground potential (on-hook) the current flowing through resistor R36 charges capacitor C15. After 20 ms, capacitor C15 becomes sufficiently charged to turn on transistor Q12, which turns off transistor Q11. Transistor Q11, turning off resets the 20 ms time constant by discharging the potential on capacitor C15. With transistor Q12 conducting, there is a negative potential at the input of integrated circuit IC2-1. This negative input causes integrated circuit IC2-1 to have a ground output. A ground output from IC2-1, causes a negative 20V output at integrated circuit IC2-2. This negative output causes transistor Q6, to turn on and transistor Q7 to turn off. With transistor Q6 on, the positive potential present at its collector forward biases the tone gate diodes CR4 and CR5, connecting the 2600-Hz signaling tone generator to the transmit line. Capacitor C5 is charged to -24 volts by the previous off-hook condition, causing the high level control diodes CR1 and CR3 to be forward biased. This causes the high level tone to be transmitted for the first 400-ms of the on-hook condition. During this period resistor R8 discharges capacitor C5, causing the high level tone diodes CR1 and CR3 to become reverse biased, allowing the transmitted tone to drop to a -36 dBm level.

3.04 The M-lead goes to an on-hook condition, operating the "CO" relay which presents a 600-ohm termination toward the transmit line and a short towards the transmit drop. This prevents any noise on the transmit drop from interfering with the signaling tone until the far terminal receives a sufficiently long tone burst to disable its guard amplifier. With the M-lead on-hook, transistor Q9 turns-on and energizes the CO relay. If there is no incoming SF tone, the CO relay remains energized for 500 ms and then releases. This is accomplished by transistor Q10 which is held on by the negative charge stored in capacitor C17 during the previous off-hook operation. If there is incoming SF tone present, transistor Q8 turns on, holding transistor Q10 on until the incoming SF tone ceases. This causes the CO relay to energize and remain energized until either the near or far terminal goes off-hook.

#### local terminal off-hook

3.05 With negative 48 Vdc present on the M-lead (off-hook), transistor Q12 turns off after 20 ms. Transistor Q11 turns on resetting the 20 ms delaying circuit. With transistor Q12

off, ground potential is present at the input of integrated circuit IC2-1 causing a -20 volt output. The -20 volt output causes a ground output at IC2-2. This ground turns on transistor Q7 and turns off transistor Q6. With transistor Q7 on and Q6 off, a -24 volt potential is present on the common collectors. The negative 24 volts reverse biases the tone gate diodes CR4 and CR5, stopping the transmission of signaling tone over the transmit line. At the same time capacitor C5 charges to a -24 volts through diode CR2, conditioning the high level tone for transmission during the first 400 ms of the next on-hook operation.

3.06 With the local terminal off-hook, transistor Q9 turns off in approximately 110 ms allowing the CO relay to de-energize to complete a through circuit.

#### local terminal dialing

3.07 Dial pulses transmitted appear as ground from battery pulses on the M-lead. A ground on the M-lead turns on transistor Q12 after charging capacitor C15 through resistor R36. This delay is approximately 20 ms to allow for pre-cut of the CO relay on the transmit line before tone is applied. As soon as transistor Q12 saturates, transistor Q11 turns off, causing capacitor C15 to reach ground potential. This automatically resets the time constant of capacitor C15 and resistor R36, a symmetrical delay therefore exists in the turning on and off of transistor Q12.

3.08 Integrated circuit IC2 consists of two differential amplifiers which are used as a dial pulse corrector ensuring a break of 58 ms and a make of 42 ms. A break pulse appears as -24 volts at the collector of transistor Q12, forcing a ground output on pin 12 of IC2-1. This positive voltage is coupled across capacitor C13 charging capacitor C14. The positive potential on capacitor C14 is fed back to the non-inverting input of the first differential amplifier, ensuring a 58 ms minimum break. The time constant of the break pulse is fixed by the factory adjusted resistor R27. The ground output of IC2-1 forces a -20 volt output from IC2-2, turning on transistor Q6. With Q6 conducting the tone gate diodes CR4 and CR5 are forward biased, connecting the 2600-Hz signaling tone to the transmit line. A make pulse appears as a ground at the collector of transistor Q12. This changes IC2-1 output to -20 volts. The -20 volt change at the output of IC2-1

is coupled to capacitor C13; however, diode CR11 prevents the change from causing IC2-1 to have any effect on the make portion of the dial pulse. The -20 volts at the input of IC2-2 results in a ground output. This positive change in voltage at the output of IC2-2 couples back to the positive input of IC2-2 ensuring a minimum make pulse of 42 ms. Simultaneously the ground output from IC2-2 turns on transistor Q7, reverse biasing the tone gate diodes CR4 and CR5, preventing signaling tone from being transmitted. The -24 volts at the collector of transistor Q7 recharges capacitor C5 ensuring that the next break pulse is transmitted at a -24 dBm level.

3.09 During dialing, the CO relay operates and remains operated until the end of a dial pulse train. The first break pulse appears as a ground on the M-lead, charging capacitor C16, and turning on transistor Q9. Transistor Q9 activates the CO relay. During the make portion of the dial pulse, the negative M-lead charges capacitor C17, turning on transistor Q10. The combination of C16 and R39 provides a 110 ms time constant and the combination of C17 and R42 provides a 500 ms time constant. These time constants prevent the CO relay from de-energizing during the break portion of the dial pulse train.

#### receive circuit - far terminal on-hook

3.10 Audio energy is received on pins 5 and 7 and is coupled across differential hybrid transformer T1. One-half of T1's output is connected to a tuned filter network to determine whether this energy is speech or signaling tone. If there is signaling tone present in the tuned circuitry, an output is applied to the tone amplifier from the secondary winding of T2. The tone amplifier IC3-1 is an integrated circuit differential amplifier tuned to the signaling tone frequency. The output of this amplifier is rectified to a positive potential by diode CR18 maintaining a positive voltage across capacitor C21. This voltage is compared to the output voltage of the guard amplifier to determine whether there is sufficient signaling tone present to allow the comparator (IC4-1) to go to its on state.

3.11 All non-signaling energy is routed to the input of the guard amplifier, IC3-2. The

guard amplifier is also an integrated circuit differential amplifier. Its output is rectified by diode CR20 and is used to change the threshold of the comparator. If there is a 6 dB or better signal to guard ratio present, the comparator produces a ground output. This output turns field effect transistor (FET) Q13 off, raising the gain of the tone amplifier 3dB. It also turns FET Q14 off and Q15 on, connecting the output of the tone filter to the input of the voice amplifier IC4-2. This ensures a 45 dB attenuation of signaling tone energy in reference to speech energy at the receive drop. At the same time, the ground output of the comparator charges capacitor C28 through resistor R58 allowing FET Q16 to turn on in approximately 225 ms. With Q16 turned on, the guard circuit is disabled so any further voice or noise on the four-wire facility can not disable the comparator's ground output. The ground potential present at the output of IC4-1 charges capacitor C30 through constant current diodes CR26 and CR27. After 33 ms, capacitor C30 is charged sufficiently enough to allow integrated circuit IC1-1 to change to a negative output causing integrated circuit IC1-2 to have a ground output which turns on transistor Q17, opening the E-lead.

#### far terminal off-hook

3.12 With the far terminal off-hook there is no signaling tone present on the four-wire receive line. With the signaling tone removed, the output of the tone amplifier ceases and the comparator's output reverts back to a -20 Vdc. The -20 volts immediately turns off field effect transistor Q16 re-enabling the guard amplifier and turns on field effect transistor Q13, lowering the gain of the tone amplifier. The -20 volts from the comparator also turns off transistor Q15 and turns on transistor Q14 which switches the input of the voice amplifier to the unfiltered side of the differential hybrid T1. The negative output of the integrated circuit IC4-1 charges capacitor C30 and allows integrated circuit IC1-1 to switch to a ground output. This ground output present at the input of integrated circuit IC1-2 forces it to have a -20 volt output. The -20 volts turns off transistor Q17 which allows relay K1 to release, placing a ground on the E-lead.

3.13 The voice amplifier IC4-2 is also an integrated circuit differential amplifier whose input is switched between the direct side of the differential hybrid T1 or the tone filtered side of differential hybrid T1 depending whether

## 7. OPTIONS

7.01 Each 665-FWA Signaling Unit is provided with three strapping options. Strapping posts are provided on the component side of the board to facilitate strapping. Perform the strapping procedures as required, in accordance with Figure 2 and the following paragraphs:

**CAUTION:** When soldering straps do not use a soldering iron larger than 30 watts.

7.02 24 VDC M LEAD—If the M-lead is to operate from a  $-24\text{Vdc}$  supply add straps across options "B" and "C" strapping posts. If the M lead is to be operated from a  $-48\text{Vdc}$  supply (factory strapped) remove any existing straps across the "B" and "C" strapping posts.

7.03 C-LEAD CONTROL—If E & M Signaling with C-lead control is specified, remove the strap across option "D" strapping posts. If C-lead control is not required (factory strapped), add a strap across option "D" strapping posts.

7.04 CO RELAY DISABLE—If the CO relay K1 is not required, disable the CO relay K1 by removing the strap across option "A" strapping posts. If the CO relay is required (factory strapped), add a strap across option "A" strapping posts.

### inserting modules

7.05 After the mounting assembly has been installed and all installer connections and strapping have been completed, the 665-FWA plug-in units, which are packaged separately, may be inserted into the mounting assembly.

**CAUTION:** The mercury wetted relays on the signaling units often collect excess amounts of mercury on the contacts causing malfunctions. Consequently, the unit must be gently tapped on a hard surface, while being held upright to remove the mercury, prior to installation.

7.06 Installing or removing the 665-FWA modules must be done with care. Ascertain that the module is upright and that the edges of the module are in the guide strips. Slide the module into position and exert firm pressure on the front panel of the module the last quarter-inch of travel, so that the 665-FWA and connector make solid connection. If any bending or excessive resistance is encountered, remove the card and examine the card guides and connector for proper alignment, damage or foreign particles.

## 8. LINE-UP

8.01 The alignment procedure for the 665-FWA Signaling Unit consists of a screwdriver adjustment of the RCV LEVEL potentiometer (shown in Figure 1) to obtain the desired receive level.

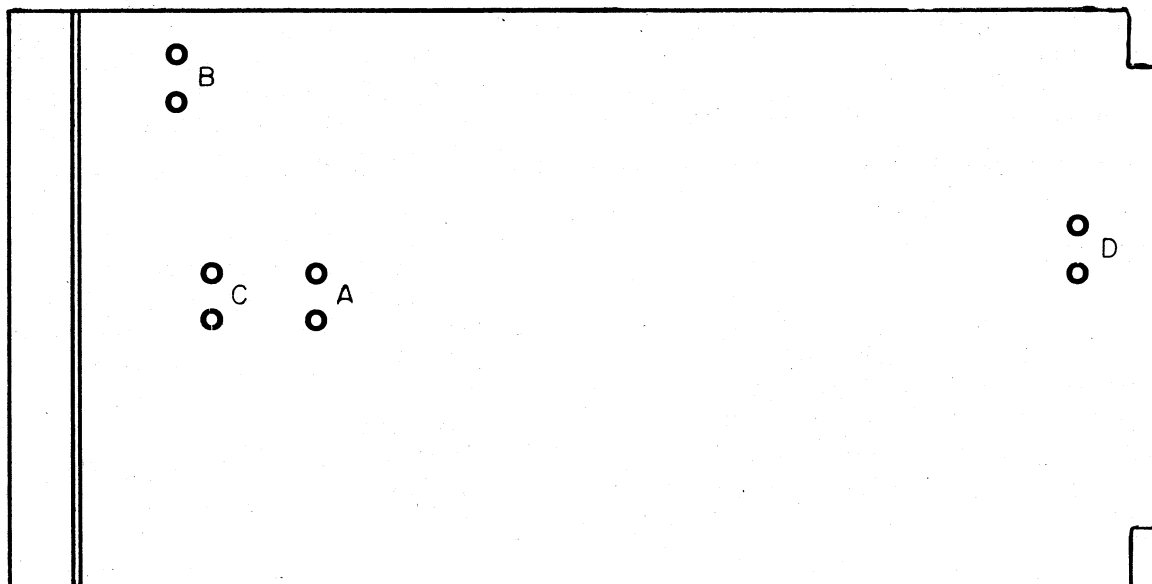


Figure 2. Strapping Locations

NOTE: Overall facility levels must be checked prior to initial line-up procedures.

**test equipment**

8.02 Test equipment (or functional equivalent) required at both the local and distant terminals to properly align the 665-FWA is as follows:

- (a) Transmission Test Set (TMS): Northeast Electronics TTS4C or W.E.Co. 23A (or equivalent).
- (b) Variable Frequency Oscillator (VFO): Hewlett Packard 200 CD (or equivalent).

NOTE: If the Northeast Electronics TTS4C is used, the VFO is not required.

- (c) Multimeter: Simpson 260 (or equivalent).
- (d) Associated Test Cords: Two, two-conductor test cords equipped with a Type 310 plug at one end and Type 59 cord tips at the other.

**procedure**

8.03 Perform the following steps in aligning the 665-FWA Signaling Unit.

**ALIGNMENT PROCEDURE**

STEP	ACTION	VERIFICATION
1	At both terminals (local and distant) place the signaling equipment in the off-hook (busy) condition.	
2	Request the distant terminal to transmit a 1000 Hz test tone, at the required level and impedance specified on the CLR card, on the channel under test.	
3	Arrange the TMS for bridging measurement and connect the test set to the RCV LINE test points located on the front panel of the 665 FWA module.	The TMS should indicate $+7.0 \pm 0.25$ dBm. If this condition is not met, a facility alignment check should be made.
4	With the TMS still arranged for bridging measurement, connect the test set to the RCV EQUIP test points located on the front panel of the 665 FWA module.	The TMS should indicate $+7.0 \pm 0.25$ dBm. If this condition is not met, adjust the RCV LEVEL control unit on the front panel of the 665 FWA until the TMS indicates the required level.

**9. TESTING**

9.01 If trouble is encountered with the operation of the 665-FWA Signaling Unit check the obvious. Verify that power is applied to the equipment, and that all installer connections and strapping have been properly made. In addition, check that the modules are making a solid

connection with their respective card connectors. If the trouble persists, perform the tests described in paragraph 9.02 for the transmit section and paragraph 9.03 for the receive section.

**transmit**

9.02 Test the transmit section of the 665-FWA as follows:

## TRANSMIT TEST PROCEDURE

STEP	ACTION	VERIFICATION
1	Obtain a release on the circuit before performing any tests.	
2	Verify that the distant terminal is in the idle-circuit condition. Connect the TMS (set for bridging measurement) to the RCV LINE test points on the 665 FWA front panel.	The TMS should indicate $-13 \pm 2$ dBm.
3	Connect the TMS (still set for bridging measurement) to the XMIT LINE test points on the 665 FWA front panel.	The TMS should indicate $-36 \pm 2$ dBm.
4	If the 665 FWA is connected to a trunk circuit, key the trunk circuit M-lead "off-hook" and "on-hook" several times while observing the TMS.	When the trunk circuit is keyed to the "off-hook" condition, the TMS should drop off-scale. Each time the trunk circuit is keyed to the "on-hook" condition, the TMS should deflect to approximately $-24$ dBm and then drop to a steady $-36 \pm 2$ dBm.
<b>NOTE:</b>	If the 665 FWA M-lead is not connected to a connecting circuit, alternately connect a source of external battery, and then ground to the M-lead test point on the 665 front panel while observing the TMS.	When the M-lead test point is connected to battery, the TMS should drop "off-scale." When the M-lead test point is connected to ground, the TMS should momentarily deflect to approximately $-24$ dBm and then return to a steady $-36 \pm 2$ dBm.
5	With ground on the M-lead as in step (4) connect the VFO (set to 1000 Hz at $-16$ dBm and the proper impedance) and inject tone into the transmit channel on the drop side of the 665 FWA.	
6	Place an insulated wire jumper (with stripped ends) across the RCV LINE test points. This will cut-off the idle-circuit tone from the distant terminal and simulate seizure of the local terminal.	The 665 FWA cut and terminate relay (K1) should restore passing the test tone. The TMS should change from $-36 \pm 2$ dBm to $-16 \pm 2$ dBm.  <b>NOTE:</b>  If this requirement is not met, determine that the cut and terminate relay has not been disabled. See paragraph 7.04. If this requirement is still not met, change out and retest.

STEP	ACTION	VERIFICATION
7	Remove the wire jumper from the RCV LINE test points.	The TMS reading should change from $-16 \pm 2$ dBm to $-36 \pm 2$ dBm.  NOTE:  If this requirement is not met, change out and retest.
8	Reconnect any leads that have been removed from the connector for testing purposes.	
9	This concludes the 665 FWA transmit testing procedure. If additional testing is required, remove the VFO and proceed to paragraph 9.03. If no further tests are required, remove the test equipment and restore all equipment to normal.	

**receive**

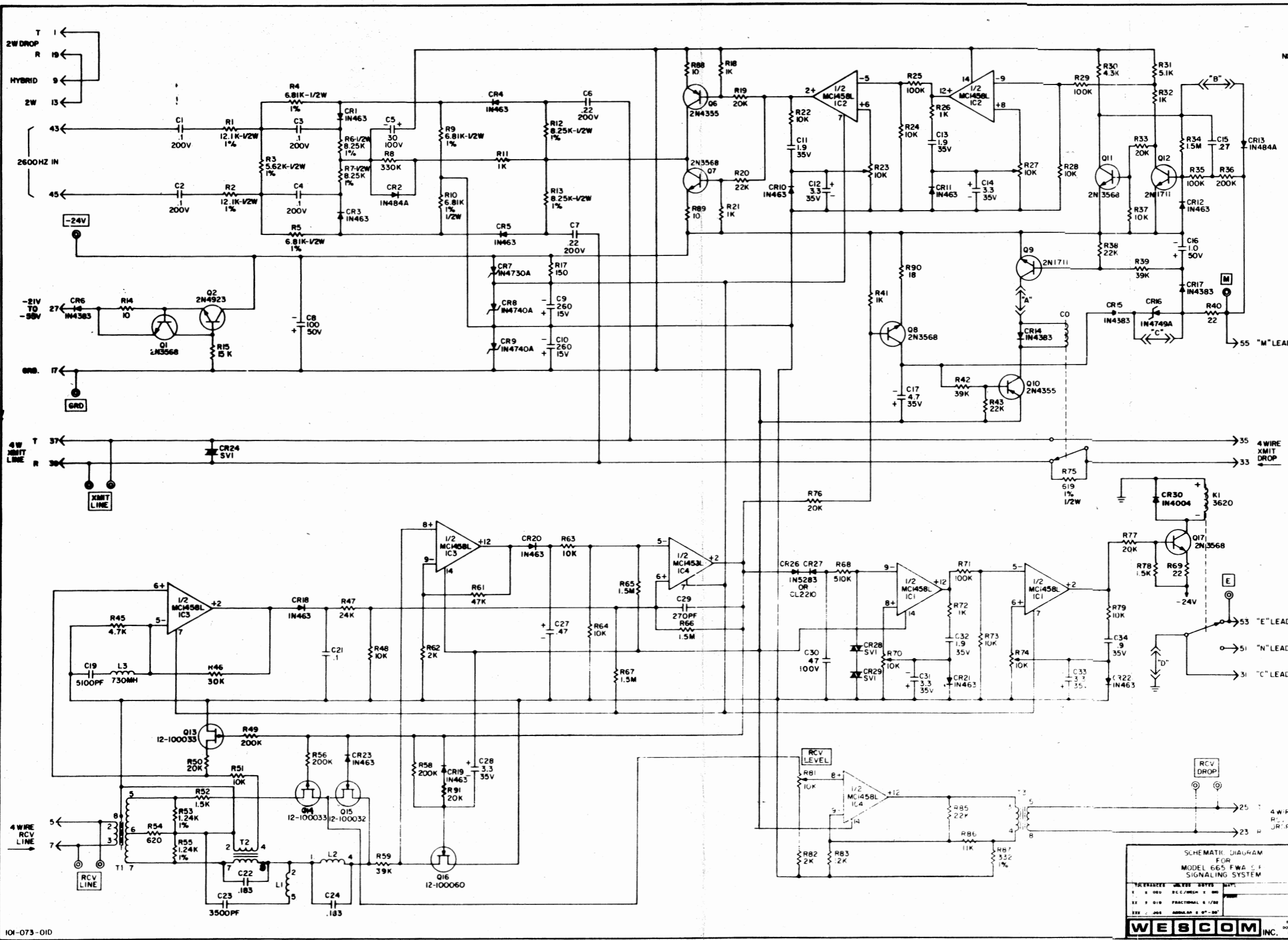
9.03 Test the receive section of the 665-FWA as follows:

**RECEIVE TEST PROCEDURE**

STEP	ACTION	VERIFICATION
1	With both terminals in the idle circuit condition, connect the multimeter (set for 50 Vdc) across the E and GRD test points on the 665 FWA front panel.	The multimeter should indicate -24 or -48 volts depending upon the battery supply of the associated trunk equipment.
2	Connect the TMS (set for bridging measurement) to the RCV LINE test points.	The TMS should indicate $-13 \pm 2$ dBm.
3	Request the distant terminal to place a call through the channel under test.	When the distant terminal goes off-hook the local TMS should drop "off-scale" and the multimeter should indicate zero. As dialing is received the TMS should indicate pulsed signaling tone at approximately -7 dBm.
4	This completes the receive testing procedure for the 665 FWA. Disconnect the test equipment and restore all equipment to normal.	

**CAUTION:** When testing units equipped with a pulse corrector, accurate calibration of pulse sending and receiving equipment is essential. Tests have shown that a variation in pulsing speed from 10 pps to 9.5 pps at a 50% break input may cause a change in output of 7% break. This points up the need for accurate calibration before assuming that pulse correctors are not performing properly.

9.04 Field repairs involving the replacement of components within a module are not recommended. If a module is found to be defective, contact Wescom, Inc., by telephone or TWX, for instructions regarding replacement or repair. If a replacement module is required, it will be shipped the fastest way. Upon receipt of a replacement module, return the defective module, using the shipping label provided, to Wescom, Inc., 501 Rogers Street, Downers Grove, Illinois 60515.



- NOTES:
- 1- ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE SPEC'D.
  - 2- ALL RESISTORS ARE 1/4 WATT ±5% UNLESS OTHERWISE SPEC'D.
  - 3- ALL CAPACITORS ARE IN MFD UNLESS OTHERWISE SPEC'D.
  - 4- REMOVE "D" STRAP FOR "C" LEAD CONTROL.
  - 5- ADD "B" AND "C" STRAP FOR 24V "M" LEAD.
  - 6- REMOVE "A" STRAP TO DISABLE "CO" RELAY.

Q	2-22-71	ECO 1968	AJM
P	7-6-71	R26 & R72 WERE 100K R58 WAS 100K R81 WAS 30K	JSP
O	4-5-71	ECO 1760	AJM
N	4-5-71	T3 CHANGED ECO 1753 ADD RCV LEVEL	AJM
M	3-8-71	ECO 1711 C23 WAS 3300PF IC3 WAS MC458L DELETED R44, R60, C18, C20, C25, C28	JSP
L	2-10-71	ECO 1696 R59 WAS 20K	AJM
K	2-10-71	ECO 1677 ADD CR30 IN4004 DELETE C37 I MF	AJM
J	1-6-71	ECO 1666 IC4 WAS 1457 DELETE R80 R84, C35, B, C36	AJM
I	10-7-70	ECO 1608 R88 WAS 200K	JSP
H	9-23-70	ECO 1590 ADD R81-30K	JSP
G	7-27-70	ECO 1582 R84 WAS 1457 DELETE R80 R84, C35, B, C36	ERK
F	7-27-70	ECO 1581 R84 WAS 1457 DELETE R80 R84, C35, B, C36	ERK
E	7-27-70	ECO 1580 R84 WAS 1457 DELETE R80 R84, C35, B, C36	ERK
D	12-6-69	ECO 1449	RTM
C	12-6-69	ECO 1448	RTM
B	12-6-69	ECO 1447	ERK
A	12-6-69	ECO 1321	ISS CHANGE ERK

SCHEMATIC DIAGRAM  
FOR  
MODEL 665 FWA-C1  
SIGNALLING SYSTEM

DATE: 8-13-69

ISSUE 2

WESCOM INC. 191-066500