20-28

Remote Termination Panel

Version 2.20

Printings

Version 1.00: 1/28/98
Version 2.00: 8/26/99
Version 2.10: 5/10/00
Version 2.11: 2/06/02
Version 2.20: 11/05/03

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SPECIFICATIONS

Input Voltage	10.7 Vdc - 18 Vdc
Standby current @ 13.8 Vdc with local control option	60 mA 90 mA
Maximum current @ 13.8 Vdc	260 mA
Temperature range	0 to +70 deg C
Relative humidity	90% at 50 deg C
Line impedance	600 ohms
Line control	2 or 4 wire audio
Receive to line audio output level	50 mVrms - 2.8 Vrms into 600 ohms
Receive to line S/N ratio	> 50 dB (ref. -10 dBm in to +10 dBm out)
Receive to line distortion	< 3%
Receive to line frequency response through de-emphasis	+1, -3 dB (300 to 3000 Hz) +1, -3 dB at 6 dB/octave (300 to 3000 Hz)
Receive to speaker S/N ratio	> 50 dB (ref. -10 dBm in to +10 dBm out)
Receive to speaker distortion	< 3%
Receive to speaker frequency response through de-emphasis	+1, -3 dB (300 to 3000 Hz) +1, -3 dB at 6 dB/octave (300 to 3000 Hz)
Line to TX audio output level	30 mVrms - 1.3 Vrms into 600 ohms
Line to TX S/N ratio	> 50 dB (ref. 0 dBm in to +2 dBm out)
Line to TX distortion	< 3%
Line to TX frequency response	+1, -3 dB (300 to 3000 Hz)
Line to speaker S/N ratio	> 50 dB (ref. 0 dBm in to +10 dBm out)
Line to speaker distortion	< 3%
Line to speaker frequency response	+1, -3 dB (300 to 3000 Hz)
Speaker audio output	1 W into 4 ohms
Weight	1.3 lb.
Dimensions	5.5" x 5.5" x 1.5"

1.0 GENERAL DESCRIPTION

1.1 Description

The Model 20-28 Remote Termination Panel is designed to control remotely located base stations or repeaters. The 20-28 Remote Termination Panel also sends update information back to the remotes and provides a two-way audio path in either the 2-wire or the 4-wire mode. The communication with the remote controllers uses one of two methods: MSK signaling (with the 20-28 MSK Control Board installed) or sequential tones (with the 20-28 Tone Control Board installed).

The characteristics that the 20-28 is to operate under can be selected and changed with a software program that can be run on a standard personal computer. When setting the 20-28 up for operation, the installer can choose how the different base station radio functions will be controlled. Interfaces to various different radios have been developed and radio interface cables are available for quick and easy installation.

For applications which require local operation of the base station, a local control option is available which includes a speaker jack, volume control, and a desk microphone.

1.2 Capabilities and Features

- 2 wire or 4 wire operation
- Remote update
- MSK or sequential tone signaling
- PC programmable
- Non-volatile memory
- 8 programmable open collector outputs
- 2 programmable open collector/relay outputs
- Up to 8 outputs can be selected as inputs
- Local control option
- Interfaces to various different radios

2.0 INSTALLATION AND SETUP

2.1 Inspection

Please refer to the checklist packed with the 20-28 in order to become familiar with the unit and to insure that everything ordered has been received. In the event a part is missing from the checklist, please call the Customer Services Department at 1-701-280-1122.

This unit was thoroughly inspected before leaving the factory. If the outer package appears damaged, please inspect the unit for possible damage immediately. Any dents, scratches, or marks suggest rough handling in shipping. Please notify the shipper if you find any indications of mishandling. If there are any concerns about the condition of the 20-28 when it is received, please don't hesitate to call the Customer Services Department.

2.2 Disassembly and Reassembly

When performing the alignment procedure or making changes to the jumpers on the 20-28, it is necessary to remove the printed circuit board from the case. This is accomplished by removing the two black screws from the front of the 20-28 and removing the front panel. Remove the top cover by sliding it off the 20-28. Since the printed circuit board contains sensitive circuitry, be sure to take the necessary precautions against static discharge.

To reassemble the 20-28, replace the top cover and the front panel making sure the front and back panels are seated properly with the case. Replace the two black screws but do not over-tighten them.

2.3 Installation Procedure

This section provides a basic step-by-step installation procedure for the 20-28. Refer to sections **2.4** - **2.10** for detailed installation information. Refer also to the 20-28 installation diagram in the back of this manual. Detailed information on adjusting the 20-28 audio levels can be found in section **4.0 Adjustment Procedures**.

1. The system should initially be set up and tested on the bench. Use only one remote at first. Additional remotes can be added later.

2. Connect the 20-28 to the base station radio. Be sure to program the base station radio as required.

3. Set the 20-28 jumpers as required.

4. Program the 20-28 and the remote to allow the remote to control the base station radio as desired.

2.3 Installation Procedure (cont.)

5. Connect the 20-28 to an earth ground and then connect the line from the 20-28 to the remote.

6. Receive audio from the base station radio should now be heard at the remote. Adjust the *RX Audio to Line Level* for the desired level to the line. Adjust the receive audio in the remote as necessary.

7. Press PTT on the remote. If the base station radio does not key, adjust the *Line Input Level* until the base station radio keys when PTT is pressed on the remote. The *2175 Hz Detect Level* may also need to be adjusted.

8. Once the remote is able to key the base station radio reliably, adjust the transmit audio in the remote as necessary. Then adjust the *Line to TX Audio Level* for the desired transmitter deviation from the base station radio.

9. The remote should now be able to change channels or systems and groups on the base station radio. The 20-28 should also be able to update the remote when the channel or the system and group are changed from the faceplate of the base station radio. If not, check the *2175 Hz Encode Level* on the 20-28 and the tone detect levels on the remote.

   20-28 MSK Control Only: Also check the *MSK Encode Level*.

   20-28 Tone Control Only: The panel must be programmed for 'Remote Update', and the remotes must be capable of decoding those tones for the panel to be able to update the remote.

10. If the local control option is installed in the 20-28, connect the desk microphone to the 20-28 and press the PTT button. Adjust the *Local Mic to TX Audio Level* for the desired transmitter deviation from the base station radio. Adjust the *Local Mic to Line Level* for the desired level to the line.

11. If the local control option is installed in the 20-28, connect a 4 ohm speaker to the 20-28. Remote audio should be heard in the speaker when PTT on the remote is pressed. Adjust *Line to Speaker Level* if necessary. If receive audio from the base station radio to the speaker is enabled, adjust *RX Audio to Speaker Level* for a comfortable listening level while the base station radio is receiving a transmission from another radio.

12. Program any additional remotes as required. Generally, they should be programmed the same as the first remote.

13. Connect additional remotes in parallel to the first remote. Make sure all remotes except for one are set to high impedance.

14. Adjust the transmit and receive levels of the remotes as required. Audio from all remotes should arrive at the 20-28 with the same level.

15. Verify that all desired functions of the base station radio can be controlled by all of the remotes. Also verify that all of the remotes are updated by the 20-28 when a change is made from the faceplate of the base station radio.

2.4 Radio Connection

The DB-25 connector labeled "RADIO" on the back of the 20-28 is used to interface the 20-28 to a base station radio. The function of each pin on the DB-25 connector is detailed in Figure 1. In addition, **Appendix A** contains procedures for connecting the 20-28 to certain radios using factory supplied cables.

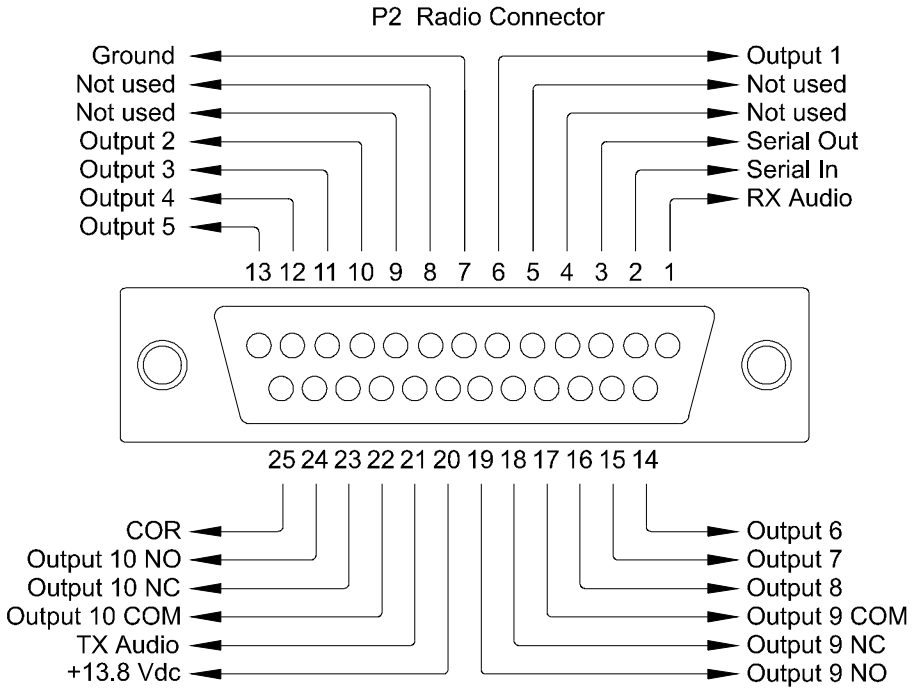


Figure 1

2.5 Line Connection

The 20-28 allows either 2-wire or 4-wire lines to be used when connecting the 20-28 to a remote. The line connection should be made to the modular jack labeled "LINE" on the back of the 20-28. The connections that need to be made are detailed in Figure 2. For 2-wire lines, audio to and from the remote share the same two wires, pins 4 and 5 of the modular jack. For 4-wire lines, pins 4 and 5 of the modular jack are used for audio to the remote while pins 3 and 6 are used for audio from the remote. Use only 2 or 4 conductor cable between the 20-28 and the remote. The use of 6 conductor cable can cause erratic operation.

2.5 Line Connection (cont.)

If a 4-wire line is being used, the transmit and receive pairs need to be reversed. The inside pair needs to become the outside pair and the outside pair needs to become the inside pair. This is done by cutting the cable and connecting the red wire to the black wire, the black wire to the red wire, the green wire to the yellow wire, and the yellow wire to the green wire. This should be done only to the cable connecting the 20-28 to the first remote. Additional remotes should be wired in parallel. If the line from the 20-28 is plugged into a wall jack, the transmit and receive pairs can be reversed on the back side of the wall jack.

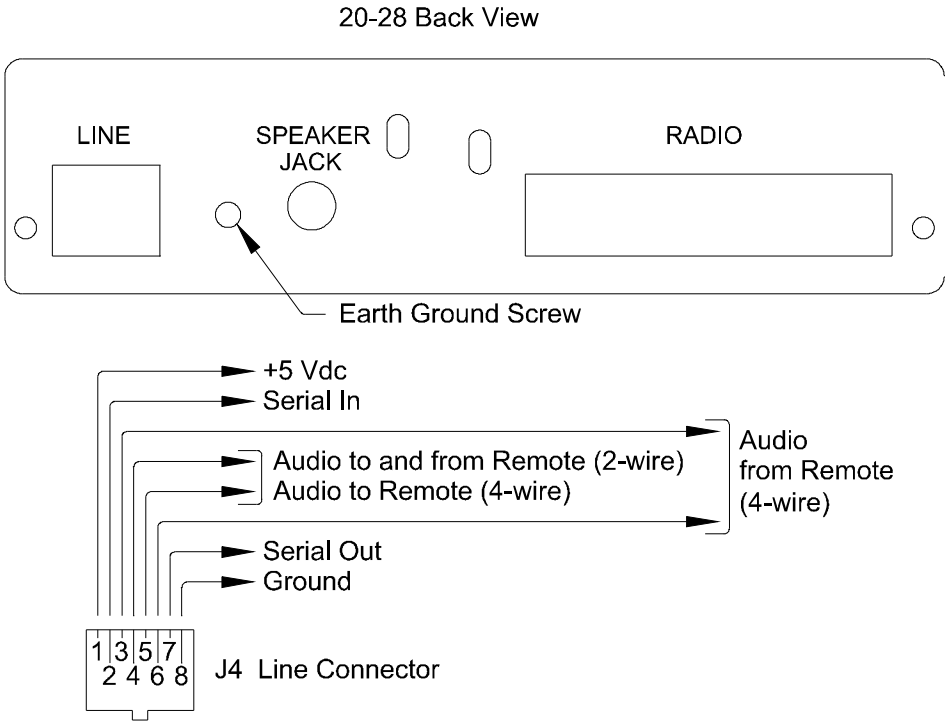


Figure 2

2.6 Earth Ground Connection

A good earth ground should be connected to the earth ground screw on the back of the 20-28 to allow the surge arresters to provide maximum protection from line transients. Without a good earth ground, the ability of the surge arresters to protect the internal circuits of the 20-28 from line transients will be limited. Refer to Figure 2 for the location of the earth ground screw.

2.7 Desk Microphone Connection

If the local control option is installed in the 20-28, the desk microphone should be connected to the modular jack labeled "LOCAL MIC" on the front of the 20-28. The connections that the local microphone jack provides are detailed in Figure 3.

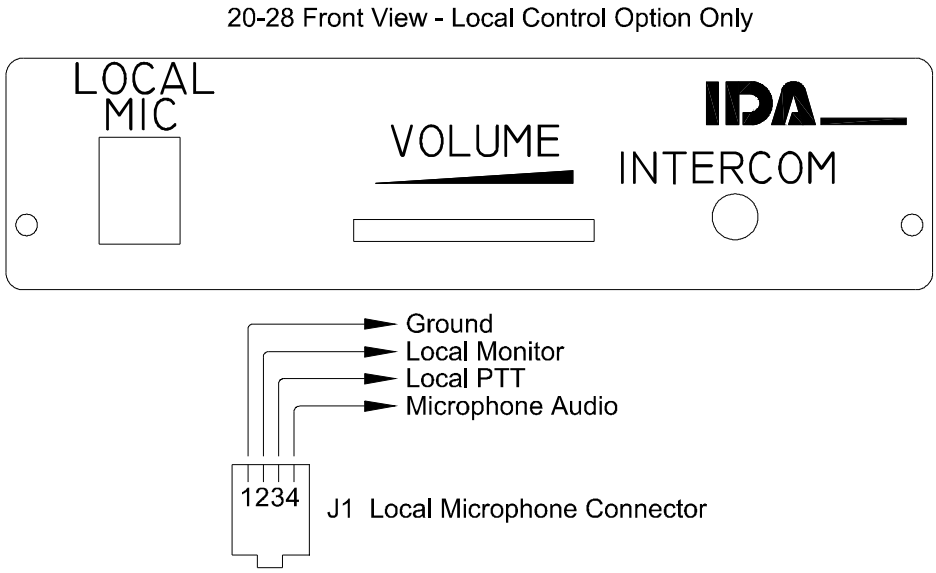


Figure 3

2.8 Speaker Connection

If the local control option is installed in the 20-28, a speaker can be connected to the 20-28 to allow audio from the line to be heard. When using a 4-wire line, audio received by the base station radio can also be heard if JP1 is installed. A 4 ohm speaker (supplied by the user) should be connected to the speaker plug supplied with the 20-28. The speaker plug should then be inserted into the jack labeled "SPEAKER JACK" on the back of the 20-28.

2.9 Computer Connection

A computer must be connected to the 20-28 in order to program setup data into the 20-28. Figure 2 details the connections that need to be made. To connect the computer to the 20-28, the modular plug end of the programming cable should be plugged into the modular jack labeled "LINE" on the back of the 20-28 (the line will need to be unplugged first). The DB-25 end of the programming cable should be plugged into the serial port of the computer. If the computer has a DB-9 serial port, the DB-25 to DB-9 adapter will need to be used.

Note: Before connecting the 20-28 to a computer with the programming cable, be sure to remove jumpers JP7 and JP8 on the 20-28 base board.

2.10 Jumper Settings

The 20-28 has a number of jumpers that control the operation of the 20-28. The 20-28 jumpers and their settings are described below.

20-28 Base Board

JP1 - This jumper determines if audio received by the base station radio and being sent to the line is also sent to the local speaker when a 4-wire line is being used. When JP1 is shorted, the audio will be sent to the speaker. When JP1 is not shorted, the audio will not be sent to the speaker. When using a 2-wire line, JP1 should not be shorted.

JP2 - This jumper is factory installed and should not be changed.

JP3 - This jumper determines the transmit audio output impedance. When JP3 is shorted, the impedance is 600 ohms. When JP3 is not shorted, the impedance is approximately 10k ohm.

JP4 - The setting of this jumper determines if the line audio passes through the automatic gain control circuit before being sent to the base station radio to be transmitted. JP4 should be jumpered to A-B to bypass the AGC and to B-C to use the AGC.

JP5 - The setting of this jumper is determined by the type of line being used, either 2-wire or 4-wire. JP5 should be jumpered to A-B for 2-wire operation and to B-C for 4-wire operation.

JP6 - This jumper determines if the audio received from the base station radio is de-emphasized. If JP6 is shorted, the audio is de-emphasized. If JP6 is not shorted, the audio is not de-emphasized.

JP7 - This jumper is used to enable serial data in from the base station radio. JP7 should be removed when the 20-28 is being programmed. If the 20-28 is not being programmed, JP7 should be shorted.

JP8 - This jumper is used to enable serial data out to the base station radio. JP8 should be removed when the 20-28 is being programmed. If the 20-28 is not being programmed, JP8 should be shorted.

JP9, JP10 - These jumpers determine if output 9 is an open collector output or a relay output. If JP9 is shorted, output 9 will be a relay output. If JP10 is shorted, output 9 will be an open collector output. Only one of JP9 and JP10 should be shorted at any time.

JP11, JP12 - These jumpers determine if output 10 is an open collector output or a relay output. If JP11 is shorted, output 10 will be a relay output. If JP12 is shorted, output 10 will be an open collector output. Only one of JP11 and JP12 should be shorted at any time.

2.10 Jumper Settings (cont.)

20-28 MSK Control Board

JP1 - JP8 - These jumpers determine if outputs 1 - 8 are used as outputs or as inputs. When jumpered to A-C and B-D (the normal setting), the corresponding output will be used as an output. When jumpered to A-B and C-D, the corresponding output will be used as an input.

JP9 - This jumper determines the operating mode of the 20-28. JP9 should be jumpered to A-B for Internal EEPROM mode and to B-C for Programming mode. In the Internal EEPROM mode, the operating characteristics of the 20-28 MSK Control Board are stored in an internal EEPROM. This EEPROM is programmed with the MSK Programming Software.

The Programming mode allows the 20-28 to be programmed by the MSK Programming Software. Programming of the 20-28 MSK is accomplished by using a PC linked serially to the "LINE" connector on the back of the 20-28 with the programming cable. The programming information is stored by the 20-28 in an internal EEPROM.

Note: Before connecting the 20-28 to a computer with the programming cable, be sure to remove jumpers JP7 and JP8 on the 20-28 base board.

JP10 - This jumper should not be installed.

20-28 Tone Control Board

JP1 - JP8 - These jumpers determine if outputs 1 - 8 are used as outputs or as inputs. When jumpered to A-C and B-D (the normal setting), the corresponding output will be used as an output. When jumpered to A-B and C-D, the corresponding output will be used as an input.

JP9 - This jumper determines the operating mode of the 20-28. JP9 should be jumpered to A-B for Internal EEPROM mode and to B-C for Programming mode. In the Internal EEPROM mode, the operating characteristics of the 20-28 are stored in an internal EEPROM. This EEPROM is programmed with the Tone Programming Software.

The Programming mode allows the 20-28 to be programmed by the Tone Programming Software. Programming of the 20-28 is accomplished by using a PC linked serially to the "LINE" connector on the back of the 20-28 with the programming cable. The programming information is stored by the 20-28 in an internal EEPROM.

Note: Before connecting the 20-28 to a computer with the programming cable, be sure to remove jumpers JP7 and JP8 on the 20-28 base board.

3.0 OPERATION

3.1 Update Sequences

Update sequences are sent from the remote to the 20-28 and from the 20-28 to the remote. These update sequences allow the remote to control the different base station radio functions, such as current channel and scan status, and to keep the remote (and any paralleled remotes) updated to the current base station radio status. Figure 4 shows the different components of the update sequence for the 20-28 MSK. The 20-28 Tone update sequence is similar except it uses sequential tone(s) in place of the MSK tone. It is important to note that the update sequence is defined by levels as well as tone frequencies. Line loss needs to be taken into consideration and will probably be a factor at installation. The levels shown in Figure 4 will most likely be less when they arrive at either the 20-28 or the remote, but in the same proportion. The 20-28 is setup for the correct tones and levels from a 600 ohm source with no line loss. However, due to loading of paralleled remotes on the same line, as well as line loss, some audio levels may need to be increased. In paralleled remote installations, all remotes should arrive at the 20-28 with the same levels.

The guard tone is defined as 2175 Hz at +10 dBm and is the first tone in an update sequence. The guard tone is used to signal the start of an update sequence. If the guard tone is not detected properly, the rest of the update sequence will be ignored. Following the guard tone in the update sequence is the MSK tones (or sequential tone) at a level of 0 dBm. The tones are decoded to determine the action required by the update sequence. When the update sequence is sent by a remote, the tones may be followed by the hold tone. The hold tone is defined as 2175 Hz at -20 dBm and indicates that the remote's PTT is being pressed. When the 20-28 detects the hold tone, it will key the base station radio and pass audio from the remote to the base station radio. The audio from the remote rides on top of the hold tone. The 20-28 will keep the base station radio keyed until the hold tone is no longer detected.

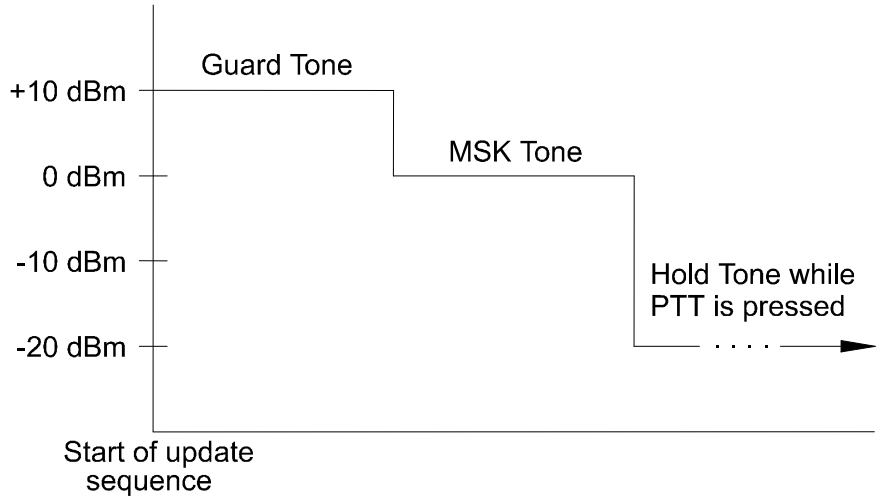


Figure 4

3.2 MSK Control

The MSK control board contains an MSK modem that allows bytes of data to be transferred between the 20-28 and the 24-66 MSK remote by encoding and decoding the MSK tones that are sent and received in the update sequences. These bytes of data are used to indicate an action to be taken such as enabling scan or changing to a different channel or system and group.

3.3 Outputs

The 20-28 contains 10 open collector outputs. Two of these outputs, outputs 9 and 10, can also be switched to relay outputs. The outputs are available as general purpose outputs and can be programmed as active high or active low and also as timed outputs. The outputs are controlled by the remote which can enable or disable any number of outputs with a single update sequence.

3.4 Local Control Option

The local control option allows local control of the base station radio. This option provides a speaker jack, volume control, a desk microphone, and other associated circuitry. When PTT is pressed on the desk microphone, the 20-28 will key the base station radio. Audio from the desk microphone will be passed to the base station radio for transmission and will also be sent to the line so that the remote users can hear the transmission. If the intercom switch on the front panel of the 20-28 is depressed, the 20-28 will not key the base station radio when PTT is pressed on the desk microphone. Instead, the audio from the desk microphone will only be sent to the line to allow the local user to intercom to the remotes.

A 4 ohm speaker can be connected to the speaker jack to allow the local user to hear audio from a remote that is transmitting. Audio from a remote in intercom mode will also be heard through the speaker. Receive audio from the base station radio can also be passed to the speaker. This allows the local user to hear transmissions from other radios through the local speaker instead of through the speaker of the base station radio. The volume control on the front of the 20-28 allows the local user to adjust the speaker volume to a comfortable listening level.

4.0 ADJUSTMENT PROCEDURES

4.1 Audio Measurements

The common term that is used to express audio power levels in a communications system is the decibel referenced to 1 mW of power (dBm). Another term, which is often misused, is the decibel (dB). It is important the correct term, or unit of measurement, be used as determined by its application.

dB - Power or Voltage Ratio

The decibel or dB is a ratio and is defined as a measure such that:

$$dB\ (power) = 10 \log (Pa/Pb)$$

or

$$dB\ (voltage) = 20 \log (E1/E2)$$

where Pa and Pb are two values of power, E1 and E2 are two values of voltage. Note that since dB is a ratio, it has no unit value such volts, amps, or watts.

dBm - Decibel referenced to 1 mW

The symbol dBm indicates a power level with respect to 1 mW of power. (0 dBm is equal to 1 mW). Although this definition does not imply a 600 ohm impedance, most AC voltmeters are calibrated in terms of dBm across 600 ohms. In this case using the formula:

$$E^2 = PR$$

gives

$$E = 0.77 \text{ Vrms or } 2.2 \text{ Vp-p}$$

with P = 1 mW and R = 600 ohms. Therefore, 0 dBm is equal to 0.77 Vrms. It can also be shown that +10 dBm is equal to 2.45 Vrms and -20 dBm is equal to .08 Vrms.

4.2 Adjustment Potentiometers

The functions of the adjustment potentiometers are described below. Refer to section **4.3 Audio Adjustments** for detailed instructions on adjusting these pots. Refer to the adjustment locator diagram in the back of this manual for the location of the adjustment potentiometers. An asterisk (*) indicates the potentiometer has been factory set and should not need adjusting. Potentiometers without an asterisk may need to be adjusted for the best audio quality and performance on a particular system.

20-28 Base Board

R2*	2175 Hz Bandpass Adjust
R3*	2175 Hz Detect Level
R22*, R23*	RX 2175 Hz Notch Filter Adjust
R42	RX Audio to Line Level
R51*, R52*	TX 2175 Hz Notch Filter Adjust
R78	4-Wire Intercom Level
R79	Line to TX Audio Level
R87	Line Input Level

20-28 Base Board - Local Control Option

R9	RX Audio to Speaker Level
R88	Local Mic to Line Level
R91	Local Mic to TX Audio Level
R94	Line to Speaker Level

20-28 MSK Control Board

R9*	2175 Hz Encode Level
R14*	MSK Encode Level

20-28 Tone Control Board

R15*	2175 Hz Encode Level

4.3 Audio Adjustments

20-28 Base Board

2175 Hz Bandpass Adjust - This adjustment sets the center frequency of the 2175 Hz bandpass filter. Potentiometer R2 has been factory adjusted for a maximum level at U3 pin 1 with a 2175 Hz tone applied across pins 4 and 5 (2-wire) or pins 3 and 6 (4-wire) of the "LINE" connector J4. Adjust R2 only if the guard and hold tones are not being detected reliably.

2175 Hz Detect Level - This is the level of audio sent into the guard and hold tone detectors. Potentiometer R3 has been factory adjusted so that U4 pin 1 just goes high with a 2175 Hz tone at 0 dBm applied across pins 4 and 5 (2-wire) or pins 3 and 6 (4-wire) of the "LINE" connector J4. Adjust R3 only if the guard and hold tones are not being detected reliably and only after the *2175 Hz Bandpass Adjust* and the *Line Input Level* have been set.

4.3 Audio Adjustments (cont.)

RX 2175 Hz Notch Filter Adjust - This adjustment sets the notch frequency of the RX audio 2175 Hz notch filter. Potentiometers R22 and R23 have been factory adjusted for a minimum level at U5 pin 1 with a 2175 Hz tone applied to pin 1 of the "RADIO" connector P2. Adjust R22 and R23 only if 2175 Hz tones from the base station radio are not being filtered out. For best results, alternate between R22 and R23 while adjusting.

RX Audio to Line Level - This is the level of the audio from the base station radio that is sent by the 20-28 to the line. While the base station radio is receiving a transmission from another radio, adjust potentiometer R42 to provide the desired level of audio to the remote through the line taking into account any line loss. Do not turn R42 up too high since this will cause distortion and clipping.

TX 2175 Hz Notch Filter Adjust - This adjustment sets the notch frequency of the TX audio 2175 Hz notch filter. Potentiometers R51 and R52 have been factory adjusted for a minimum level at U7 pin 1 with a 2175 Hz tone applied across pins 4 and 5 (2-wire) or pins 3 and 6 (4-wire) of the "LINE" connector J4. Adjust R51 and R52 only if 2175 Hz tones from the line are not being filtered out. For best results, alternate between R51 and R52 while adjusting.

4-Wire Intercom Level - This is the level of the audio sent from one remote to the other paralleled remotes when using a 4-wire line. Potentiometer R78 should be adjusted to provide the desired level of audio to the paralleled remotes when one of the remotes is transmitting. Do not turn R78 up too high since this will cause distortion and clipping.

Line to TX Audio Level - This is the level of the audio received from the line that is sent by the 20-28 to the base station radio for transmission. Potentiometer R79 should be adjusted to provide the desired transmitter deviation when transmitting from a remote. Do not turn R79 up too high since this will cause distortion and clipping. Adjust R79 only after the *Line Input Level* has been set.

Line Input Level - This is the level of audio received from the remote through the line by the 20-28. Potentiometer R87 has been factory adjusted to provide +10 dBm at U7 pin 8 with a 2175 Hz tone at +10 dBm applied across pins 4 and 5 (2-wire) or pins 3 and 6 (4-wire) of the "LINE" connector J4. The guard tone from the remote may arrive at the 20-28 with a level less than +10 dBm due to line loss between the remote and the 20-28. If this is the case, adjust R87 to provide +10 dBm at U7 pin 8 when guard tone is being received from the remote.

4.3 Audio Adjustments (cont.)

20-28 Base Board - Local Control Option

RX Audio to Speaker Level - This is the level of the audio from the base station radio that is sent to the local speaker when a 4-wire line is being used and JP1 is installed. While the base station radio is receiving a transmission from another radio, adjust potentiometer R9 so that audio in the local speaker is at a comfortable listening level. Do not turn R9 up too high since this will cause distortion and clipping. Adjust R9 only after the *Line to Speaker Level* has been set.

Local Mic to Line Level - This is the level of local microphone audio that is sent by the 20-28 to the line. While transmitting from the local microphone, adjust potentiometer R88 to provide the desired level of audio to the remote through the line taking into account any line loss. Do not turn R88 up too high since this will cause distortion and clipping.

Local Mic to TX Audio Level - This is the level of local microphone audio that is sent by the 20-28 to the base station radio for transmission. Potentiometer R91 should be adjusted to provide the desired transmitter deviation when transmitting from the local microphone. Do not turn R91 up too high since this will cause distortion and clipping.

Line to Speaker Level - This is the level of the audio received from the line that is sent to the local speaker. Potentiometer R94 has been factory adjusted to provide 2 Vrms across a 4 ohm speaker load at J3 with a 1 kHz tone at 0 dBm applied across pins 4 and 5 (2-wire) or pins 3 and 6 (4-wire) of the "LINE" connector J4 with the volume control at maximum. Adjust R94 only if necessary and only after the *Line Input Level* has been set. Do not turn R94 up too high since this will cause distortion and clipping.

20-28 MSK Control Board

2175 Hz Encode Level - This is level of the 2175 Hz tone sent to the line by the 20-28. Potentiometer R9 has been factory adjusted to provide +10 dBm of encoded 2175 Hz tone into a 600 ohm load across pins 4 and 5 of the "LINE" connector J4. R9 can be adjusted if a level other than +10 dBm is desired.

MSK Encode Level - This is the level of the MSK tones sent to the line by the 20-28. Potentiometer R14 has been factory adjusted to provide 0 dBm of encoded MSK tones into a 600 ohm load across pins 4 and 5 of the "LINE" connector J4. R14 can be adjusted if a level other than 0 dBm is desired.

20-28 Tone Control Board

2175 Hz Encode Level - This is level of the 2175 Hz tone sent to the line by the 20-28. Potentiometer R15 has been factory adjusted to provide +10 dBm of encoded 2175 Hz tone into a 600 ohm load across pins 4 and 5 of the "LINE" connector J4. R15 can be adjusted if a level other than +10 dBm is desired.

5.0 CIRCUIT DESCRIPTION

5.1 Power Supply

The 20-28 is powered from a 13.8 Vdc supply connected across pin 20 (13.8 Vdc) and pin 7 (ground) of P2. The 13.8 Vdc supply is fed into the voltage regulators U9 and U10 through D6 and F1. D6 prevents a reverse voltage from harming the 20-28 and F1 is a 1 amp fuse that provides protection from excessive current draw. U9 is a 5 Vdc regulator that provides power for the digital circuits of the 20-28. U10 is a 10 Vdc regulator that provides power for the analog circuits of the 20-28. C51, C55, and C56 provide filtering for the power supplies. In addition, U5B is used to provide a 5 Vdc reference for the analog circuits of the 20-28.

5.2 Transmit Audio

Audio appearing on the line enters the 20-28 on pins 4 and 5 of J4 when using a 2-wire line and on pins 3 and 6 of J4 when using a 4-wire line. SG1 - SG4 are surge arresters that protect the 20-28 from line transients. Line audio is coupled into the 20-28 by T1 (4-wire) or T2 (2-wire). R82 (2-wire) and R86 (4-wire) are used to provide a 600 ohm impedance to the line. Audio from T1 and T2 goes to JP5 which determines if a 2-wire or a 4-wire line is being used. The audio then passes to U7C which is an amplifier stage that is used to compensate for line loss. Potentiometer R87 controls the gain of this amplifier stage.

The audio then enters the automatic gain control (AGC) circuit which compensates for varying input levels by providing a constant output over an input range of 30 dB. The AGC circuit is comprised of U2B and U1A and their associated components. The audio signal on pin 13 of U2 is rectified internally and is used to control the gain of the internal gain cell connected between pins 9 and 11 of U2. The attack time of the AGC is determined by C26 and the recovery time is determined by C25. The AGC output is at pin 1 of U1.

The audio then enters the TX 2175 Hz notch filter through jumper JP4. JP4 determines if the transmit audio comes from the AGC output or if it bypasses the AGC through R66 and R67. The notch filter is comprised of U7A and U7B and their associated components. Potentiometers R51 and R52 are used to tune the notch filter to 2175 Hz. The notch filter removes the 2175 Hz hold tone from the transmit audio to prevent it from being heard.

The audio will then pass through the bilateral switch U6A when this switch is enabled by the control section. The audio passes to U7D which is a summing amplifier stage that is used to provide the proper level of audio to the base station radio. Potentiometer R79 controls the gain of the transmit audio through this stage. The audio then passes to pin 21 of P2 which is the transmit audio output. Jumper JP3 determines if the transmit audio output is a high or a low impedance.

5.3 Receive Audio

Receive audio from the base station radio enters the 20-28 on pin 1 of P2. The audio passes to U5C which is a buffer stage for the receive audio. Jumper JP6 determines if the receive audio is de-emphasized or not.

The audio then enters the RX 2175 Hz notch filter. The notch filter is comprised of U5A and U5D and their associated components. Potentiometers R22 and R23 are used to tune the notch filter to 2175 Hz. The notch filter removes any 2175 Hz component present in the receive audio to prevent falsing any 2175 Hz detectors in the remote.

The audio will then pass through the bilateral switch U6B when this switch is enabled by the control section. The audio passes to U1C which is a summing amplifier stage that is used to provide the proper level of audio to the line. Potentiometer R42 controls the gain of the receive audio through this stage. The audio then passes to line driver U8 which drives the line coupling transformer T2 when enabled by the control section. Audio coupled to the line by T2 appears across pins 4 and 5 of J4. Resistor R83 is used to provide a 600 ohm impedance to the line when U8 is enabled.

5.4 Guard and Hold Tone Detect

Line audio from U7C is passed into the 2175 Hz bandpass filter through potentiometer R3. R3 adjusts the level of audio into the bandpass filter and therefore into the guard and hold tone detect circuits. The bandpass filter is comprised of U3A, U3B, and U3C and their associated components. Potentiometer R2 is used to tune the bandpass filter to 2175 Hz.

The 2175 Hz tones that come out of the bandpass filter are passed into the guard and hold tone detect circuits. The guard tone detect circuit is comprised of U4A and its associated components. Diodes D2 and D5 pass only the positive transitions of the 2175 Hz tones to capacitor C16 which causes C16 to charge up. During negative transitions, C16 is discharged by resistor R11. The charge on C16 is passed to U4A which is a comparator that compares the charge on C16 to a reference level. U4A outputs a high to the control section when the charge on C16 exceeds the reference level which indicates that guard tone is being detected.

The hold tone detect circuit is comprised of U3D and U4B and their associated components. U3D is an amplifier stage that provides approximately 30 dB of gain. Diodes D3 and D4 pass only the positive transitions of the 2175 Hz tones to capacitor C15 which causes C15 to charge up. During negative transitions, C15 is discharged by resistor R10. The charge on C15 is passed to U4B which is a comparator that compares the charge on C15 to a reference level. U4B outputs a high to the control section when the charge on C15 exceeds the reference level which indicates that hold tone is being detected.

5.5 4-Wire Intercom

Line audio from U7C passes through the bilateral switch U6D when this switch is enabled by the control section. The audio passes back to the line through the summing amplifier U1C. Potentiometer R78 controls the gain of the 4-wire intercom audio through the summing amplifier. The 4-wire intercom circuit allows audio from a remote that is transmitting to be received by paralleled remotes when using a 4-wire line.

5.6 Outputs

The 20-28 provides 10 outputs on connector P2. Pins 6 and 10 - 16 of P2 are outputs 1 - 8 and are passed directly to the control board. Jumpers JP9 and JP10 determine if pins 17 - 19 of P2 are the common, normally closed, and normally open relay outputs for output 9 or if pin 19 of P2 is output 9. Jumpers JP11 and JP12 determine if pins 22 - 24 of P2 are the common, normally closed, and normally open relay outputs for output 10 or if pin 24 of P2 is output 10.

5.7 Local Control

The monitor and the PTT signals from the local microphone enter the 20-28 on pins 2 and 3 of J1 and are passed to the control board. The audio from the local microphone enters the 20-28 on pin 4 of J1. Resistors R6 and R7 provide power to the local microphone and R6 also provides a 600 ohm impedance to the local microphone. The microphone audio passes to U1B which is a buffer for the microphone audio that also provides some gain. The audio will then pass through the bilateral switch U6C when this switch is enabled by the control section. The audio then passes to the base station radio through the summing amplifier U7D and to the line through the summing amplifier U1C. Potentiometer R91 controls the gain of the microphone audio through the summing amplifier U7D and potentiometer R88 controls the gain of the microphone audio through the summing amplifier U1C.

Line audio will pass to summing amplifier U1D when bilateral switch U6A is enabled by the control section. Jumper JP1 determines if receive audio from the base station radio will also pass to the summing amplifier U1D when bilateral switch U6B is enabled by the control section. U1D sums together the two sources of speaker audio and also provides some gain. Potentiometer R9 controls the gain of the receive audio through the summing amplifier U1D. The speaker audio then passes to the volume control potentiometer R1. Resistor R15 sets the minimum volume level. The speaker audio then passes to U11 which is a speaker driver. Potentiometer R94 controls the level of audio to the speaker driver and therefore, to the speaker. U11 and its associated components are capable of driving 1 W of audio into a 4 ohm speaker connected to speaker jack J3.

5.8 MSK Control Board

The 20-28 is controlled by U15 which is an 8-bit microcontroller. The microcontroller continuously executes instructions from the program code that is stored internally. Crystal X2 provides a 11.0592 MHz clock to the microcontroller. U1 is a voltage monitor that will reset the microcontroller on power-up and under low voltage conditions. The programmable operating characteristics of the 20-28 are stored in U2 which is a serial EEPROM. The microcontroller reads data out of U2 as required.

Port 0 on the microcontroller (pins 36 - 43) is used for controlling outputs 1 - 8. Resistor network R1 provides pull-up resistors for the port 0 pins. Jumpers JP1 - JP8 are used to configure the port 0 pins as either outputs or inputs. When configured as an output, a port 0 pin is connected to a driver input of U3 which contains 8 open collector drivers. That driver's output is then connected to the corresponding pin of J1. When configured as an input, a port 0 pin is connected to a driver output of U3 and that driver's input is connected to the corresponding pin of J1.

Port 2 on the microcontroller is used to transfer bytes of data to or from U4, U6, and U11. U4 is an 8-bit input latch that the microcontroller reads to determine the state of various inputs. The microcontroller will then take specific actions based upon the state of these inputs. U6 is an 8-bit output latch that is connected to the driver inputs of U8. The driver outputs of U8 are connected to outputs 9 and 10 and to the various bilateral switches. By writing data to the output latch, the microcontroller can enable and disable outputs 9 and 10 and the various bilateral switches.

U11 is an MSK modem and is used to encode and decode the MSK data. Crystal X1 provides a 4 MHz clock to U11. The output of the AGC on the 20-28 base board is passed to pin 10 of J1. This audio is fed into pin 4 of U11 which decodes MSK data from this audio. The decoded data is then read from U11 by the microcontroller. Data to be transmitted is written to U11 by the microcontroller. U11 converts this data to MSK tones which then appear on pin 2 of U11. Pins 17 - 21 of U11 are connected to pins on the microcontroller. These pins are used to control the transfer of data between U11 and the microcontroller.

U7 is a switched capacitor filter. It is clocked by pin 2 of the microcontroller. It is used to filter the 2175 Hz square wave generated by pin 5 of the microcontroller. U7 also contains a summing amplifier which sums the filtered 2175 Hz tone with the MSK tones generated by U11. Potentiometer R9 controls the gain of the 2175 Hz tone through the summing amplifier and potentiometer R14 controls the gain of the MSK tones through the summing amplifier. These tones are passed to pin 18 of J1 when the bilateral switch U9 is enabled by the microcontroller through U6 and U8. The tones will then pass from pin 18 of J1 to the line through the summing amplifier U1C on the 20-28 base board.

5.9 Tone Control Board

The 20-28 is controlled by U4 which is an 8-bit microcontroller. The microcontroller continuously executes instructions from the program code that is stored internally. Crystal X2 provides a 11.0592 MHz clock to the microcontroller. U1 is a voltage monitor that will reset the microcontroller on power-up and under low voltage conditions. The programmable operating characteristics of the 20-28 are stored in U2 which is a serial EEPROM. The microcontroller reads data out of U2 as required.

5.9 Tone Control Board (cont.)

Port 0 on the microcontroller (pins 36 - 43) is used for controlling outputs 1 - 8. Resistor network R1 provides pull-up resistors for the port 0 pins. Jumpers JP1 - JP8 are used to configure the port 0 pins as either outputs or inputs. When configured as an output, a port 0 pin is connected to a driver input of U3 which contains 8 open collector drivers. That driver's output is then connected to the corresponding pin of J1. When configured as an input, a port 0 pin is connected to a driver output of U3 and that driver's input is connected to the corresponding pin of J1.

Port 2 on the microcontroller (pins 24 – 31) is used for controlling outputs 9 – 10, and to the various bilateral switches. Resistor network R13 provides pull-up resistors for the port 2 pins.

U5 is an audio signaling processor and is used to encode and decode the sequential tones. Crystal X1 provides a 4 MHz clock to U5. The output of the AGC on the 20-28 base board is passed to pin 10 of J1. This audio is fed into pin 13 of U5 which decodes the tone. The decoded tone is then read from U5 by the microcontroller. Tones to be transmitted are written to U5 by the microcontroller. U5 converts this data to tones which then appear on pins 16, 17, or 20. The level of the output signal is controlled by potentiometer R15, and sent to the 20-28 base board through pin 18 of J1. The tones will then pass through the summing amplifier U1C on the 20-28 base board to the line. Pins 3 – 7, and 23 of U5 are connected to pins on the microcontroller. These pins are used to control the transfer of data between U5 and the microcontroller.

APPENDIX A - RADIO INTERFACES

This appendix contains instructions for interfacing the 20-28 panel to various radio models.

EFJ Summit DM Interface

This appendix section contains instructions for interfacing the 20-28 to the EFJ Summit DM radio. The following items are included in the EFJ Summit DM interface kit:

1. EFJ Summit DM to 20-28 interface cable assembly.
2. Instruction sheet.

The following steps outline the procedure for interfacing the EFJ Summit DM radio to the 20-28:

1. The EFJ Summit DM radio must have firmware version 2.19 or later. The most current version of firmware can be obtained by contacting E.F. Johnson.

2. When programming the Summit DM radio, be sure the following selections in the Main Radio Parameters screen are set as indicated:

    - Scan Revert Mode: Set to “Temporary” or “Last Received”
    - Mic Hanger: Set to disabled if mic not present or not in grounded hanger
    - Remote Trunk Mount: No
    - Disable UI Bus: No
    - Audio_RX: Mode 1
    - Audio_TX: Mode 1

3. Connect the DB-25 end of the Summit DM interface cable to the DB-25 connector on the back of the 20-28.

4. Connect the DB-15 end of the Summit DM interface cable to the DB-15 connector on the radio's accessory pigtail cable (EFJ Part No. 597-2002-230).

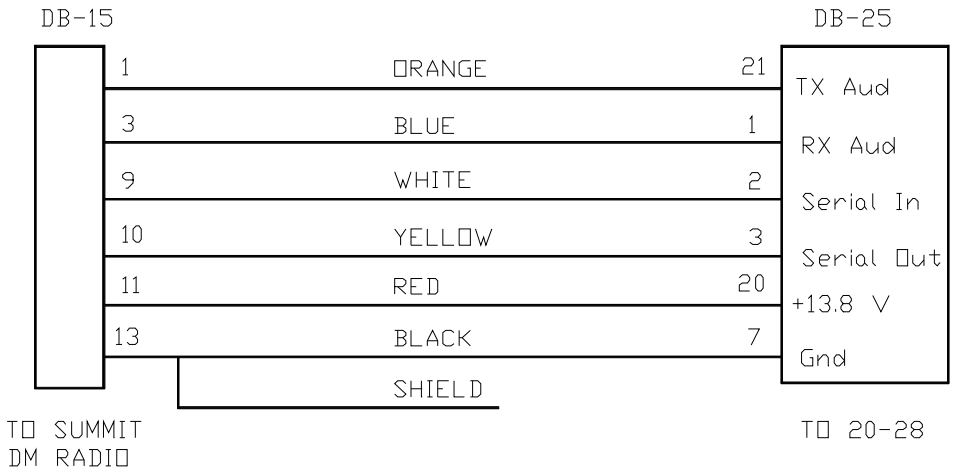
5. Configure the following 20-28 base board jumpers as indicated:

    - JP3: Shorted
    - JP6: Not shorted

6. Configure the remaining jumpers based upon system requirements. The audio level adjustments will also need to be checked.

Appendix A - EFJ Summit DM Interface (cont.)

EFJ Summit DM Interface Cable



EFJ Summit DM Interface Cable Kit
106-EFJ28SUM

Item	Description	Part No.	Qty.
1	DB25 CONNECTOR MALE	231-0005	1
2	SCREW/CLIP KIT	231-0014	2
3	4-40 X 1/2 SCREW	199-4035	2
4	DB25 COVER ASSEMBLY	231-0015	1
5	DB15 CONNECTOR MALE	231-0035	1
6	DB15 COVER ASSEMBLY	231-0036	1
7	22AWG SHIELD 10C CABLE	800-1115	8”

SEA ESP520 Interface

This appendix section contains instructions for interfacing the 20-28 to the SEA ESP520 radio. The following items are included in the SEA ESP520 interface kit:

1. SEA ESP520 to 20-28 interface cable assembly.
2. Instruction sheet.

The following steps outline the procedure for interfacing the SEA ESP520 radio to the 20-28:

1. Connect the DB-25 end of the SEA ESP520 interface cable to the DB-25 connector on the back of the 20-28.

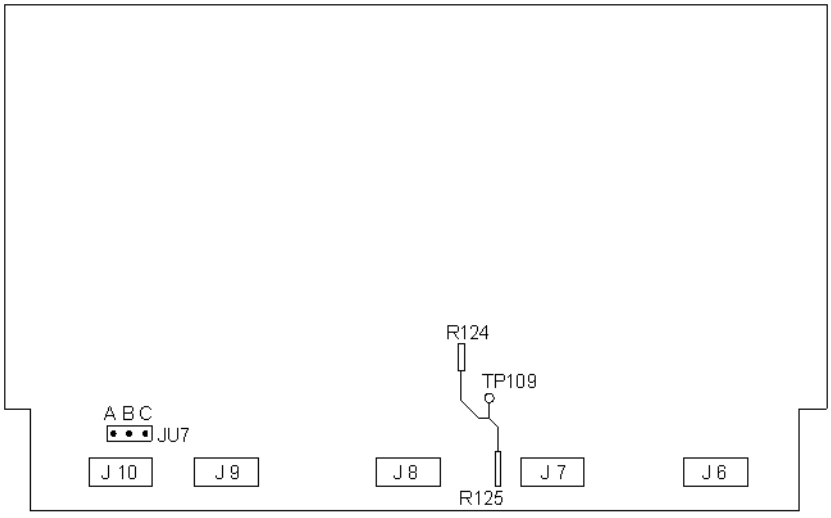
2. Connect the modular plug end of the SEA ESP520 interface cable to microphone jack on the radio.

3. Set the radio volume by one of the following methods:

   - Remove the top cover of the radio and move the shorting block on JU7 to B-C on the personality PCB. Set the volume control on the radio to obtain a good audio level to the 20-28. It should not be set too high or the audio will start to cut out. Once the volume control is set, it should not be changed.

   - Bypass the volume control in the radio to obtain a constant audio level from the radio. This can be accomplished by removing the top cover of the radio and connecting a jumper from TP109 to JU7-B on the personality PCB. The shorting block on JU7 should be removed. Refer to the following diagram for the locations of JU7 and TP109.

PERSONALITY PCB



SEA ESP520 Interface (cont.)

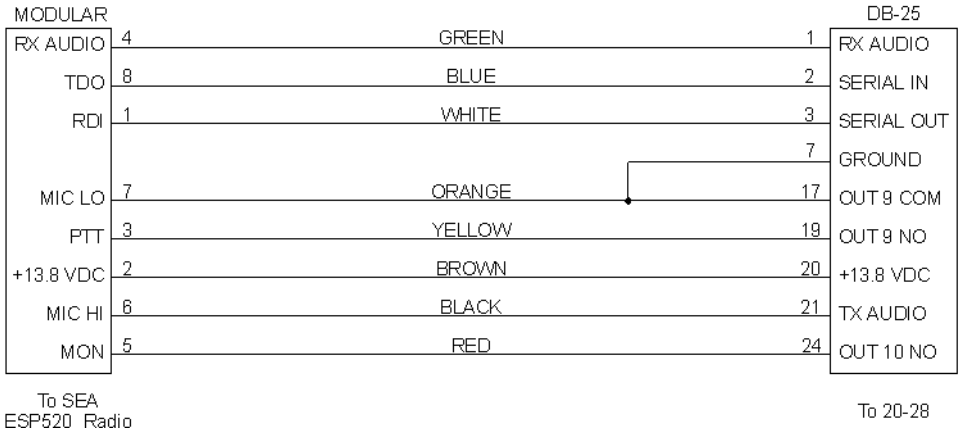
4. Configure the following 20-28 base board jumpers as indicated:

   - JP3: Not shorted
   - JP6: Not shorted
   - JP9: Shorted
   - JP10: Not shorted

5. The supplied cable is wired to control the microphone hook status with Output #10. (Additional programming is necessary.) If Output #10 is required for a different application, disconnect the red wire from pin #24 on the DB25 connector. The microphone hook status may be controlled with another output if desired.

6. Configure the remaining jumpers based upon system requirements. The audio level adjustments will also need to be checked.

SEA ESP520 Interface Cable



SEA ESP520 Interface Cable Kit
106-SEA27CBL

Item	Description	Part No.	Qty.
1	DB25 CONNECTOR MALE	231-0005	1
2	SCREW/CLIP KIT	231-0014	1
3	4-40 X 1/2 SCREW	199-4035	2
4	DB25 COVER ASSEMBLY	231-0015	1
5	8 POS MODULAR PLUG	231-0052	1
6	8 COND FLAT TELE WIRE	800-1006	2'

Kenwood TK940 Interface

This document contains instructions for interfacing the 20-28 to the Kenwood TK940 radio. The following items are included in the Kenwood TK940 interface kit:

1. Kenwood TK940 to 20-28 interface cable assembly.
2. Instruction sheet.

The following steps outline the procedure for interfacing the Kenwood TK940 radio to the 20-28:

1. Connect the DB-25 end of the Kenwood TK940 interface cable to the DB-25 connector on the back of the 20-28.

2. Connect the molex end of the Kenwood TK940 interface cable to the molex connector on the radio's accessory pigtail cable.

3. Configure the following 20-28 base board jumpers as indicated:

    - JP9: Shorted
    - JP10: Not shorted

4. Configure the remaining jumpers based upon system requirements. The audio level adjustments will also need to be checked.

The microphone hook status will always be on hook when using the supplied cable. Follow the steps below if it is desired to control the hook status from the remote.

1. Disconnect the green wire from pin 17 on the DB25 connector. This wire controls the hook status of the radio.

2. Connect the green wire to any unused output pin on the DB25 connector.

3. Program the remote's On Hook and Off Hook buttons to a momentary command and assign each a command number. This is changed from the 'Edit Buttons' item under the 'Remote' menu in the programming software.

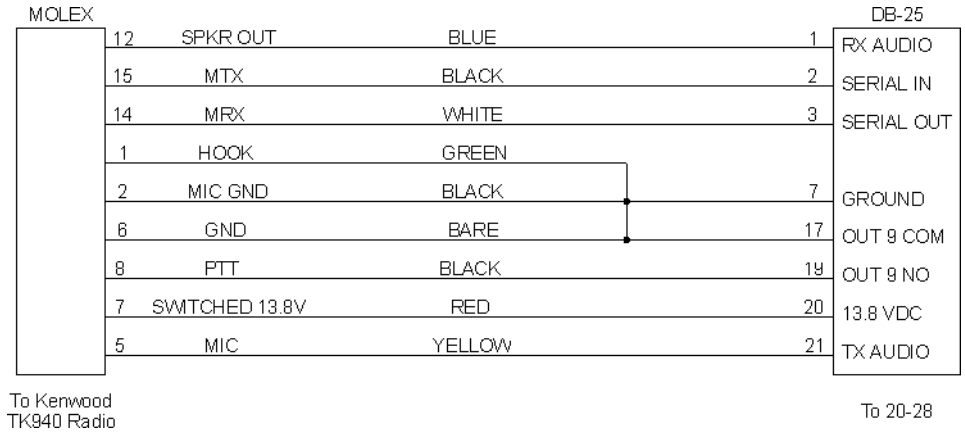
4. Program the panel to set the hook status output to Inactive for the On Hook command number used on the remote, and Active for the Off Hook command number. This is changed from the 'Edit Commands' item under the 'Panel' menu in the programming software.

5. Program the panel's hook status output to Active High. This is changed from the 'Edit Outputs' item under the 'Panel' menu in the programming software.

CAUTION: Do not program the 20-28 with jumpers JP7 and JP8 on the base board shorted. See manual for further information.

Kenwood TK940 Interface (cont.)

Kenwood TK940 Interface Cable



Kenwood TK940 Interface Cable Kit
106-KEN27CBL

Item	Description	Part No.	Qty.
1	DB25 CONNECTOR MALE	231-0005	1
2	SCREW/CLIP KIT	231-0014	1
3	4-40 X 1/2 SCREW	199-4035	2
4	DB25 COVER ASSEMBLY	231-0015	1
5	MOLEX MALE PIN	231-0034	9
6	15 POS MOLEX CONNECTOR	231-0054	1
7	5 PAIR SHIELDED CABLE	800-1108	1'

Conventional Pulse Interface

This appendix section outlines the procedure for interfacing a conventional radio requiring pulsed control signals to the 20-28:

1. Identify which radio functions should be controlled by the 20-28. The available functions of the conventional pulse interface on the 20-28 are described below.

   - **COR:** Control signal from the radio that is active while receiving audio.
   - **PTT:** Control signal from the 20-28 that is active when the radio should transmit.
   - **Channel Up:** Control signal from the 20-28 to increase the channel on the radio by one. This control will pulse to an active state for a user-defined amount of time before switching to the inactive state.
   - **Channel Down:** Control signal from the 20-28 to decrease the channel on the radio by one. This control is pulsed similar to Channel Up.
   - **Radio Reset:** Control signal from the 20-28 to activate the radio's home function. In addition to pulsing the Radio Reset output, the 20-28 also updates the remote units with the Radio Reset Channel (programmable by the user).
   - **User Defined Outputs:** Several additional open collector outputs are available for controlling other radio functions.

2. Construct the cable end that will connect to the 20-28's P2 Radio connector. A generic cable kit is available from IDA Corporation (Part No. 102-OPT371). The following table lists the connections required to a DB25 male connector for each 20-28 function.

Connection	Function
Pin #1	RX Audio
Pin #7	Ground
Pin #20	+13.8 VDC
Pin #21	TX Audio
Pin #25	COR
Output #1-8 User-programmable	Channel Up
Output #1-8 User-programmable	Channel Down
Output #1-8 User-programmable	User Defined Outputs
Output #9	PTT
Output #10	Radio Reset

3. Connect the other end of the cable to the radio. This may require modifications to the radio. Consult the radio manual for details.

4. Configure the jumpers on the 20-28 based on the system requirements. Check the audio level adjustments (refer to the maintenance manual).

Conventional Binary Interface

The following steps outline the procedure for interfacing a conventional radio requiring binary control signals to the 20-28:

1. Identify which radio functions should be controlled by the 20-28. The available functions of the conventional binary interface on the 20-28 are described below.

   - **COR:** Control signal from the radio that is active while receiving audio.
   - **PTT:** Control signal from the 20-28 that is active when the radio should transmit.
   - **Channel Control Outputs:** Control signals from the 20-28 to change the channel on the radio through binary output patterns. The number of outputs used for channel control can be programmed from 1 to 7. Consult the table below for the number of outputs required. Note that output #1 will always be the least significant output. Outputs #2 to #7 not used for channel control are available as user defined outputs.

Number of Channel Outputs	Max. # of Channels
1	2
2	4
3	8
4	16
5	32
6	64
7	99

   - **User Defined Outputs:** Several additional outputs are available for controlling other radio functions.

2. Construct the cable end that will connect to the 20-28's P2 Radio connector. A generic cable kit is available from IDA Corporation (Part No. 102-OPT371). The following table lists the connections required to a DB25 male connector for each 20-28 function.

Connection	Function
Pin #1	RX Audio
Pin #7	Ground
Pin #20	+13.8 Vdc
Pin #21	TX Audio
Pin #25	COR
Output #1-7 User-programmable	Channel Output Pattern
Output #8	User Defined
Output #9	PTT
Output #10	User Defined

Conventional Binary Interface (cont.)

3. Connect the other end of the cable to the radio. This may require modifications to the radio. Consult the radio manual for details.

4. Configure the jumpers on the 20-28 based on the system requirements. Check the audio level adjustments (refer to the maintenance manual).

EFJ 9800 Interface

This appendix section contains instructions for interfacing the 20-28 to the EFJ 9800 radio. The following items are included in the EFJ 9800 interface kit:

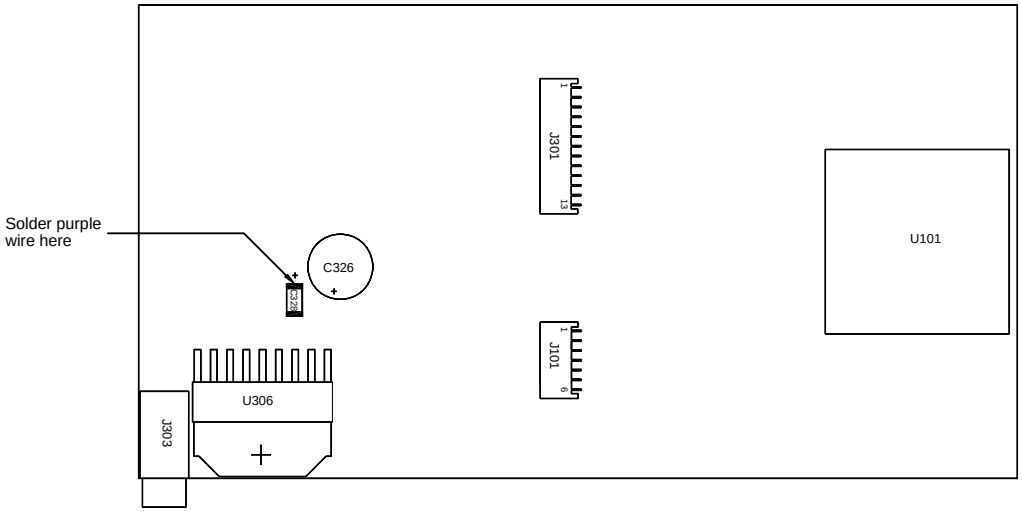
1. EFJ 9800 to 20-28 interface kit.
2. Instruction sheet.

The following steps outline the procedure for interfacing the EFJ 9800 radio to the 20-28:

1. The EFJ 9800 must have firmware version 210 or later. The current version of firmware can be obtained by contacting E.F. Johnson.

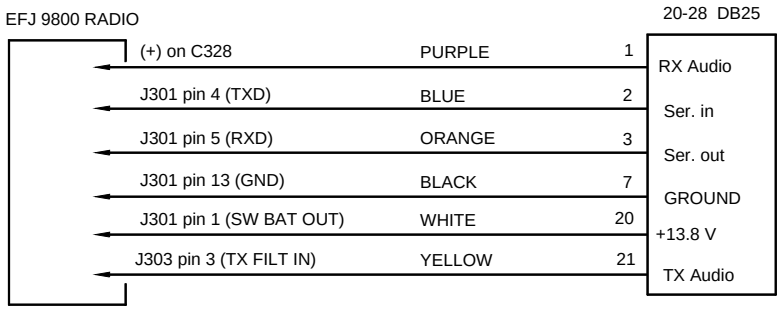
2. Connect the Data Modem Cable (EFJ Part No. 597-9800-005) or the Data Modem Cable w/Aux. Cable (EFJ Part No. 597-9800-001) as described in the 9800 Radio Service Manual.

3. Connect the purple user-definable wire in the data modem cable to the positive terminal of capacitor C328. (C328 is located on the Audio/Logic board on the bottom of the radio.)



4. Connect the DB25 connector to the data modem cable, using the pinout shown on the block diagram:

EFJ 9800 Interface (cont.)



5. Configure the following 20-28 base board jumpers as indicated:

    - JP3: Not shorted
    - JP6: Not shorted

6. Configure the remaining jumpers based upon system requirements. The audio level adjustments will also need to be checked.

EFJ 9800 Interface Kit
105-2028EFJ98KIT

Item	Description	Part No.	Qty.
1	DB25 CONNECTOR MALE	231-0005	1
2	SCREW/CLIP KIT	231-0014	1
3	4-40 X 1/2 SCREW	199-4035	2
4	DB25 COVER ASSEMBLY	231-0015	1

Kenwood TK880 Interface

This appendix section contains instructions for interfacing the 20-28 to the Kenwood TK880 radio. The following items are included in the Kenwood TK880 interface kit:

1. Kenwood TK880 to 20-28 interface cable assembly.
2. Instruction sheet.

The following steps outline the procedure for interfacing the Kenwood TK880 radio to the 20-28:

1. The Kenwood TK880 radio firmware must have the checksum [1DAF]. Consult the radio manual to determine the installed firmware version.

2. The following modifications must be made to the radio:

   - Resistor R94 (0 ohm) removed
   - Resistor R24 (0 ohm) installed

3. The radio must be programmed with the COM 1(Internal Port) set to REM optional features menu in the Kenwood radio programmer.

4. Connect the DB-25 end of the Kenwood TK880 interface cable to the DB-25 connector on the back of the 20-28.

5. Connect the molex end of the Kenwood TK880 interface cable to the molex connector on the radio's accessory pigtail cable.

6. Install (short) jumper JP3 on the 20-28 base board.

7. Configure the remaining jumpers based upon the system requirements. The audio level adjustments will also need to be checked.

Kenwood TK880 Interface Cable

Kenwood TK880 Interface (cont.)

Kenwood TK880 Interface Cable Kit
106-28KEN880

Item	Description	Part No.	Qty.
1	DB25 CONNECTOR MALE	231-0005	1
2	SCREW/CLIP KIT	231-0014	1
3	4-40 X 1/2 SCREW	199-4035	2
4	DB25 COVER ASSEMBLY	231-0015	1
5	MOLEX MALE PIN	231-0034	6
6	15 POS MOLEX CONNECTOR	231-0054	1
7	CBL 6 COND/22 AWG	800-1112	1'

Kenwood TK790 Interface

This appendix section contains instructions for interfacing the 20-28 to the Kenwood TK790 radio. The following items are included in the Kenwood TK790 interface kit:

1. Kenwood TK790 to 20-28 interface cable assembly.
2. Instruction sheet.

The following steps outline the procedure for interfacing the Kenwood TK790 radio to the 20-28:

1. The Kenwood TK790 radio firmware must have the checksum [353E]. Consult the radio manual to determine the installed firmware version.

2. The following modifications must be made to the radio:

   - Short the 'SB' pads for switched battery on the DB-25.
   - Resistor R641 (0 ohm) removed
   - Resistor R640 (0 ohm) installed

3. Connect the DB-25 end of the Kenwood TK790 interface cable labeled '20-28' to the DB-25 connector on the back of the 20-28.

4. Connect the DB-25 end of the Kenwood TK790 interface cable labeled 'Radio' to the DB-25 connector on the back of the radio.

5. Install (short) jumper JP3 on the 20-28 base board.

6. Configure the remaining jumpers based upon the system requirements. The audio level adjustments will also need to be checked.

Kenwood TK790 Interface Cable

Kenwood TK790 Interface (cont.)

Kenwood TK790 Interface Cable Kit
106-28KEN790

Item	Description	Part No.	Qty.
1	DB25 CONNECTOR MALE	231-0005	2
2	SCREW/CLIP KIT	231-0014	2
3	4-40 X 1/2 SCREW	199-4035	4
4	DB25 COVER ASSEMBLY	231-0015	2
5	CBL 6 COND/22 AWG	800-1112	1'

EF Johnson 5300 Interface

This appendix section contains instructions for interfacing the 20-28 to the EFJ 5300 radio. The following items are included in the EFJ 5300 interface kit (IDA Part Number 105-28EF5300).

1. EFJ 5300 to 20-28 interface cable assembly (106-28EF5300).
2. 20-28 RS-485 conversion board (101-28RS485).
3. Instruction sheet.

The following steps outline the procedure for interfacing the E.F. Johnson 5300 radio to the 20-28:

1. Configure the following 20-28 base board jumpers as indicated:
   JP3: Shorted
   JP11: Shorted
   JP12: Not shorted

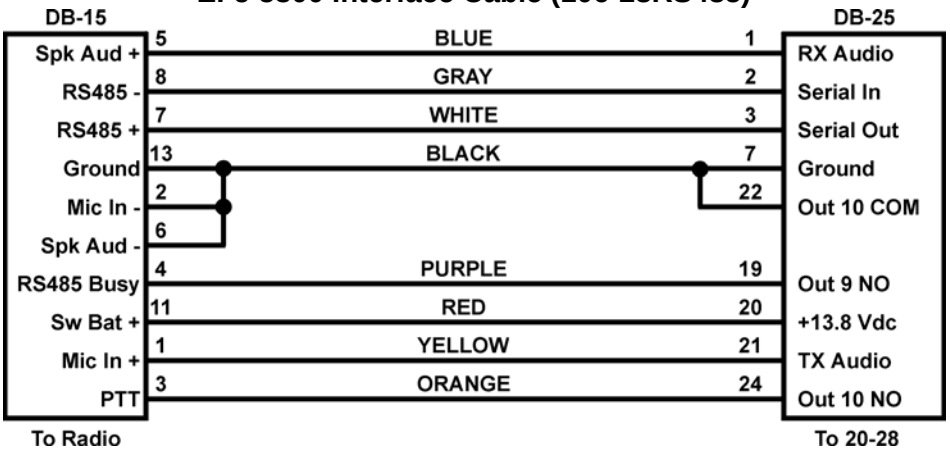
2. Install the RS-485 conversion board into the 20-28 panel by removing jumpers JP6 – JP10 on the 20-28 base board. Insert the RS-485 conversion board into those jumper posts and into J2 on the 20-28 base board.

3. Connect the DB-25 end of the EFJ 5300 interface cable to the DB-25 connector on the back of the 20-28.

4. Connect the DB-15 end of the EFJ 5300 interface cable to the DB-15 connector on the radio accessory cable.

5. Configure the remaining jumpers based upon the system requirements. Jumpers JP6, JP7, and JP8 on the 20-28 base board are covered by the RS-485 conversion board. These jumpers can be set by changing the jumper with the same number on the RS-485 board. The audio level adjustments will also need to be checked.

EFJ 5300 Interface Cable (106-28RS485)



EF Johnson 5300 Interface (cont.)

20-28B RS-485 Conversion Board
101-28RS485

Item	Reference	Description	Part No.	Qty.
1		PC BD, 2028 CVTR	900-0285	1
2	C1	Cap Mono .1uF	362-0001	1
3	J6, 7, 8, 11	2 Pos .100 Connector	234-0032	4
4	J4	Conn, F5P-HVQ	231-3316	1
5	JP 6, 7, 8	Conn, 2 Pos Gold Post	231-1002	3
6	Q1	Trnstr MPS8098	180-0009	1
7	R1, 2, 3	Res 10K 5% 1/4 W	312-0011H	3
8	R4	Res 301 Ohm 1% 1/4W	311-0005H	1
9	U1	IC, DS1487N	130-0373	1
10	U1	8 Pin DIP Socket	220-0003	1

EFJ 5300 Interface Cable Kit
106-28EF5300

Item	Description	Part No.	Qty.
1	DB25 Connector Male	231-0005	1
2	DB15 Connector Male	231-0035	1
3	Screw/Clip Kit	231-0014	2
4	4-40 X 1/2 SCREW	199-4035	1
5	DB25 Cover Assembly	231-0015	1
6	DB15 Cover Assembly	231-0036	1
7	CBL, 10C 24AWG Shield	800-1115	1'

PARTS LIST

20-28 Base Board
101-0265

Item	Reference	Description	Part No.	Qty.
11	C1,2,3,6,38,46,47,52, 53,54,57,58,59	NOT INSTALLED	000-0000	13
12	C4,20,25,49	1uF TANT CAP	390-0003	4
13	C5,8,10,11,16,22,26, 27,29,30,42,43,44	.1uF MONO CAP	362-0001	13
14	C7,9,12,17,18,19,32, 33,34,35	.01/50V ULTRA MONO CAP	362-0019	10
15	C13,14,45	.22uF/50V MONO CAP	362-5224	3
16	C15,23,24,40,41	.47uF MONO CAP	362-0002	5
17	C21	2.2uF/35V TANT CAP	390-0005	1
18	C28,37	100pF MONO CAP	362-0016	2
19	C31	.01uF MONO CAP	362-0003	1
20	C36	2.2uF NP ELEC CAP	361-0002	1
21	C39	330pF MONO CAP	362-0004	1
22	C48	4.7uF/35V TANT CAP	390-0004	1
23	C50,56	10uF/16V TANT CAP	390-0010	2
24	C51	220uF/16V ELEC CAP	360-0007	1
25	C55	10uF/50V ELEC CAP	360-5106	1
26	D1	3.3V 1N5226/4728 ZENER DIODE	111-0015	1
27	D2,3,4,5	1N914/1N4148 DIODE	110-0001	4
28	D6	1N4003 DIODE	110-0002	1
29	F1	1 AMP FUSE PC MOUNT	290-0008	1
30	J1,3	NOT INSTALLED	000-0002	2
31	J2	5 POS HEADER LOCKING	231-3313	1
32	J4	6 to 8 UNIVERSAL JACK	231-0007	1
33	JP1	NOT INSTALLED	000-0002	1
34	JP2	.100 STAPLE JUMPER	265-0016	1
35	JP3,6,7,8,9,10,11,12	2 POS GOLD POST CONN.	231-1002	8
36	JP4,5	3 POS GOLD POST CONN.	231-1003	2
37	JP3,4,5,7,8,10,12	SHORTING JUMPER	234-0046	7
38	K1,2	MINI RELAY, SPDT	700-0005	2
39	P1	28 POS HEADER .1 X .1	231-1083	1
40	P2	DB25 CONN.	231-0004	1
41	P3	GROUNDING BRACKET	200-0012	1
42	P2	4-40 X 3/8, SCREW	199-3056	2
43	P2	4-40 HEX NUT	199-0010	2
44	P3	4-40 X 1/4, SCREW	199-3055	1

45	P3	#4 STAR WASHER	199-2001	1
46	R1,4,6,7,8,9,14,15,16,24,26,27,32,69,88,89, 90,91,92,93,94,95,96	NOT INSTALLED	000-0002	23
47	R2,22,23,51,52	2K 22 TURN POT	352-0050	5
48	R3	25K 1 TURN POT	351-1253	1
49	R5	1K 5% 1/4 W RES	312-0019	1
50	R10	2.2K 5% 1/4 W RES	312-0007	1
51	R11,36,41	3.9K 5% 1/4 W RES	312-0070	3
52	R12,13	12K 5% 1/4 W RES	312-0021	2
53	R17,18,45	7.15K 1% 1/4 W RES	311-7151	3
54	R19	220K 5% 1/4 W RES	312-0012	1
55	R20,47,66,67,81,85	22K 5% 1/4 W RES	312-0015	6
56	R21,57,76	6.8K 5% 1/4 W RES	312-0018	3
57	R25,56,77	24K 5% 1/4 W RES	312-0064	3
58	R28,30,63,64,65,72	47K 5% 1/4 W RES	312-0020	6
59	R29	5.1K 5% 1/4 W RES	312-0024	1
60	R31,44,59,60,62,70, 80,84	10K 5% 1/4 W RES	312-0011	8
61	R33,34,73	100K 5% 1/4 W RES	312-0003	3
62	R35,43	470K 5% 1/4 W RES	312-0046	2
63	R37	6.2K 5% 1/4 W RES	312-0041	1
64	R38,82	100 5% 1/4 W RES	312-0010	2
65	R39	3K 5% 1/4 W RES	312-0023	1
66	R40	4.7K 5% 1/4 W RES	312-0040	1
67	R42,78	100K 1 TURN R/A POT	351-1104A	2
68	R46,53,61,74	46.4K 1% 1/4 W RES	311-4642	4
69	R48	750K 1% 1/4 W RES	311-7503	1
70	R49,58	7.32K 1% 1/4 W RES	311-7321	2
71	R50,55	2.67K 1% 1/4 W RES	311-0017	2
72	R54,75	1.78K 1% 1/4 W RES	311-1781	2
73	R68	430K 5% 1/4 W RES	312-0026	1
74	R71	560 5% 1/4 W RES	312-0069	1
75	R79,87	100K 1 TURN POT	351-1104	2
76	R83	470 5% 1/4 W RES	312-0028	1
77	R86	680 5% 1/4 W RES	312-0017	1
78	SG1,2,3,4	150V VARISTOR	300-0001	4
79	SW1	NOT INSTALLED	000-0002	1
80	T1	AUDIO TRANSFORMER	410-0005	1
81	T2	2-COIL TRANSFORMER	410-0006	1
82	U1,3,5,7	TL064, IC	130-0251	4
83	U2	NE572, IC	130-0240	1
84	U4	LM393, IC	130-0139	1
85	U6	4066, IC	130-0067	1
86	U8	MC34119, IC	130-0352	1

87	U9	UA7805 TO-220, IC	130-0022	1
88	U10	LM2940 TO-220, IC	130-0277	1
89	U11	NOT INSTALLED	000-0002	1
90	U9	HEAT SINK	210-0002	1
91	U9,10	INSULATOR	210-0103	2
92	U1,3,5,6,7	14 PIN DIP SOCKET	220-0002	5
93	U2	16 PIN DIP SOCKET	220-0001	1
94	U4,8	8 PIN DIP SOCKET	220-0003	2
95		PC BOARD, 20-28	900-0265	1
96		4-40 X 1/2 SPACER	200-0304	2
97		4-40 X 1/4 SCREW	199-3055	2

20-28 Local Control Option
101-0265

Item	Reference	Description	Part No.	Qty.
1	C1,57	10uF/16V TANT CAP	390-0010	2
2	C2,3,6,38,46,47,58,59	.1uF MONO CAP	362-0001	8
3	C52	470uF/16V ELEC CAP	360-2477	1
4	C53	1uF/35V TANT CAP	390-0003	1
5	C54	1000uF/16V ELEC CAP	360-0012	1
6	J1	4 POS. MODULAR JACK	231-0021	1
7	J3	SPEAKER JACK	234-0091	1
8	JP1	2 POS. GOLD POST CONN.	231-1002	1
9	JP1	SHORTING JUMPER	234-0046	1
10	R1	50K SLIDE POT	340-0003	1
11	R4	22K 5% 1/4 W RES	312-0015	1
12	R6	620 5% 1/4 W RES	312-0045	1
13	R7	1K 5% 1/4 W RES	312-0019	1
14	R8,16,26,69	100K 5% 1/4 W RES	312-0003	4
15	R9,88,91	100K 1 TURN POT	351-1104	3
16	R14,32	10K 5% 1/4 W RES	312-0011	2
17	R15	6.8K 5% 1/4 W RES	312-0018	1
18	R24	5.1K 5% 1/4 W RES	312-0024	1
19	R27	220K 5% 1/4 W RES	312-0012	1
20	R89	47 5% 1/4 W RES	312-0068	1
21	R90	220 5% 1/4 W RES	312-0052	1
22	R92	45.3 K 1% 1/4 W RES	311-4532	1
23	R93	47.5 K 1% 1/4 W RES	311-4752	1
24	R94	2K 1 TURN POT	351-1202	1
25	R95,96	2.2 5% 1/4 W RES	312-1229	2
26	SW1	PUSHBUTTON SWITCH	611-0044	1
27	U11	TDA2003V, IC	130-0248	1
28	U11	INSULATOR	210-0103	1

20-28 MSK Control Board
101-0273

Item	Reference	Description	Part No.	Qty.
1	C1,2,4,5,6,8,9,15,21	.1uF 50V 10% MONO CAP	265-5104	9
2	C3	2.2uF/35V TANT CAP	390-0005	1
3	C7	3300pF MONO CAP	362-0018	1
4	C10,16	33pF MONO CAP	362-5330	2
5	C11,12	.1uF MONO CAP	362-0001	2
6	C13,14	18pF 100V 5% MONO CAP	365-7180	2
7	C17,18	1uF/50V ELEC CAP	360-0001	2
8	C19,20	10uF/16V TANT CAP	390-0010	2
9	C22	.0047uF MONO CAP	362-0008	1
10	D1,2	6.8V 1N5235, ZENER DIODE	111-0012	2
11	J1	28 POS SOCKET .1 X .1	234-0100	1
12	JP1,2,3,4,5,6,7,8	4 POS GOLD POST CONN	231-1078	8
13	JP9	3 POS GOLD POST CONN	231-1003	1
14	JP1,2,3,4,5,6,7,8,9	SHORTING PLUG	234-0046	17
15	R1	3.3K 9 ELM RES NETWORK	316-0008	1
16	R2	17.8K 1% 1/4 W RES	311-1782	1
17	R3	232K 1% 1/4 W RES	311-2323	1
18	R4,6,7,12,13,26,27	10K 5% 1/4 W RES	312-0011	7
19	R5	93.1K 1% 1/4 W RES	311-9312	1
20	R8,10,11,19,22	47K 5% 1/4 W RES	312-0020	5
21	R9,14	100K 1 TURN POT	351-1104	2
22	R15,23,24	4.7K 5% 1/4 W RES	312-0040	3
23	R16,17	100 5% 1/4 W RES	312-0010	2
24	R18,20,29	1M 5% 1/4 W RES	312-0047	3
25	R21	100K 5% 1/4 W RES	312-0003	1
26	R25,28	33K 5% 1/4 W RES	312-0014	2
27	U1	7665, IC	130-0242	1
28	U2	24C02P, IC	130-0340	1
29	U3,8	ULN2803, IC	130-0302	2
30	U4	74HC573, IC	130-0362	1
31	U5	N83C51, IC	131-3002	1
32	U6	74HC574, IC	130-0363	1
33	U7	MF6C-N50, IC	130-0271	1
34	U9	4501, IC	130-0361	1
35	U10	CD4049, IC	130-0111	1
36	U11	MX429, IC	131-3003	1
37	U1,2,9	8 PIN DIP SOCKET	220-0003	3
38	U3,8	18 PIN DIP SOCKET	220-0004	2
39	U4,6	20 PIN DIP SOCKET	220-0009	2
40	U5	44 PIN PLCC SOCKET	220-0011	1
41	U7	14 PIN DIP SOCKET	220-0002	1
42	U10	16 PIN DIP SOCKET	220-0001	1
43	X1	4 MHz CRYSTAL	305-0007	1
44	X2	11.0592 MHz CRYSTAL	305-0012	1
45	X1,2	1/8” PORON	201-2013	2
46		MSK CONTROL PC BOARD	900-0273	1

20-28 Tone Control Board
101-2028TONE

Item	Reference	Description	Part No.	Qty.
1	C1,3,6,9,12	CAP M .1Uf 50V 10%	365-5104	5
2	C2	CAP, TANT 2.2uF/35V	390-0005	1
3	C4,5,7,8	CAP M 18pF 100V 5%	365-7180	4
4	C10	CAP, TANT 1uF/35V	390-0003	1
5	C11	CAP, 100 pF MONO	362-0016	1
6	C13,14	CAP, TANT, 10uF/16V	390-0010	2
7	D1,2	ZENER, 1N5235, 6.8V	111-0012	2
8	J1	14POS SOCKET .1 X .1	234-0098	2
9	JP1,2,3,4,5,6,7,8	CONN 4 POS .1 X .1	231-1078	8
10	JP9	CONN 3 POS GOLD POST	231-1003	1
11	JP1,2,3,4,5,6,7,8,9	SHORTING PLUG	234-0046	9
12	R1,13	RES NTWRK 3.3K 9 ELM	316-0008	2
13	R2	RES, 17.8 K1% 1/4W	311-1782H	1
14	R3	RES, 232 K1% 1/4W	311-2323H	1
15	R4	RES, 93.1 K1% 1/4W	311-9312H	1
16	R5,6,8,12	RES, 10 K5% 1/4W	312-0011H	4
17	R7,14	RES, 1 M5% 1/4W	312-0047H	2
18	R9,11	RES, 4.7 K5% 1/8W	310-1472	2
19	R10	RES, 47 K5% 1/4W	312-0020H	1
20	R15	POT 25K 1 TURN MINI	351-1253	1
21	R16	RES, 40.2 K1% 1/4W	311-4022H	1
22	R17	RES, 374 K1% 1/4W	311-3743H	1
23	R18	RES, 11.8 K1% 1/4W	311-1182H	1
24	R19	RES, 220 K5% 1/4W	312-0012H	1
25	R20,21	RES, 100 5% 1/4W	312-0010H	2
26	U1	MAXIM ICL 7665	130-0242	1
27	U2	IC, 24LC16	130-0359	1
28	U3,7	IC ULN2803	130-0302	2
29	U4	IC N83C51 (SMD)	131-3002	1
30	U5	IC MX803J	130-0304	1
31	U6	IC, CD4049	130-0111	1
32	U1,2	SCKT, DIP, 8 PIN IC	220-0003	2
33	U3,7	SCKT, DIP 18 PIN IC	220-0004	2
34	U4	SCKT 44 POS. PLCC	220-0011	1
35	U5	SCKT, DIP, 24 PIN IC	220-0005	1
36	U6	SCKT, DIP, 16 PIN IC	220-0001	1
37	X1	CRYSTAL 4 MHz	305-0007	1
38	X2	CRYSTAL 11.0592 MHz	305-0012	1
39	X1,2	PORON 1/8”	201-2013	2
40		PC BD 20-28 TONE OPT	900-0272	1

20-28 Cabinet
103-0265

Item	Description	Part No.	Qty.
8	4-40 HEX, NUT	199-0010	1
9	#4 STAR, WASHER	199-2001	1
10	4-40 X 1/4, SCREW	199-3055	1
11	4-40 X 3/8, SCREW	199-3056	1
12	IDA PRODUCT S/N LABEL	199-6009	1
13	.250 HOLE PLUG BLACK	203-1150	1
14	20-28 FRONT PLATE	900-6062A	1
15	20-28 BACK PLATE	900-6064S	1
16	20-28 CABINET	900-6071	1

20-28 Local Control Option Cabinet
103-0265

Item	Description	Part No.	Qty.
1	4-40 HEX, NUT	199-0010	2
2	#4 STAR, WASHER	199-2001	2
3	4-40 X 1/4, SCREW	199-3055	2
4	4-40 X 3/8, SCREW	199-3056	1
5	IDA PRODUCT S/N LABEL	199-6009	1
6	#DCP 3.5, MOLDED PLUG	234-0050	1
7	IDA REMOTE DESK MIC	900-0399	1
8	20-28 FRONT PLATE	900-6063S	1
9	20-28 BACK PLATE	900-6064S	1
10	20-28 CABINET	900-6071	1

Option 371 Installation Kit
102-OPT371

Item	Description	Part No.	Qty.
1	4-40 X 1/2, SCREW	199-4035	2
2	DB25 CONNECTOR MALE	231-0005	1
3	4 PIN MODULAR PLUG	231-0006	2
4	SCREW/CLIP KIT	231-0014	1
5	DB25 COVER ASSEMBLY	231-0015	1
6	4 COND. TELEPHONE WIRE	800-1002	6’
7	9 CONDUCTOR CABLE	800-1105	4’

10 Foot Telephone Cable Assembly Option
800-2016

Item	Description	Part No.	Qty.
1	6 POS 6 COND MOD PLUG	231-0008	2
2	6 COND. TELEPHONE WIRE	800-1003	10'

INSTALLATION DIAGRAM

Insert

Installation Diagram

here.

ADJUSTMENT LOCATOR DIAGRAM

Insert

Adjustment Locator Diagram

here.

SCHEMATICS

Insert

Schematics

here.