NBEMS Digital Messaging Hardware Configuration Standard
Los Angeles County Disaster Communications Service

Summary. This paper describes the components and cabling standards established for configuring Los Angeles County Disaster Communication Service (DCS) radio rooms at Sheriff Stations countywide for the receipt and transmission of NBEMS messages. NBEMS is the digital Narrow Band Emergency Messaging System. The configuration described here enables NBEMS digital communication on any frequency using the radios in the DCS inventory—the Yaesu FT-8900 (10m/6m/2m/440), Alinco DR-235 MKIII (220) and Yaesu FT-897 (HF/6m/2m/440). These three radios will be interfaced to a computer using NBEMS software suite (FLDIGI, free download) via a single SignaLink USB sound card and a simple network switch. This paper focuses on the technical description of the digital SignaLink USB unit; its internal jumper board; essential cables for interfacing with all station radios; and, the network switch box for selecting which radio will be digitally active at any given time. The hardware components required for a typical DCS station are listed, along with approximate cost per station (excluding required computer). The Internet site from which to download free NBEMS software and minimum computer requirements are identified. Additional materials may be added later identifying registered LASD vendor sources and current pricing for purchasing required components.

Description of components. The central hub for communicating NBEMS messages to and from each DCS radio room will be the SignaLink USB unit, manufactured by Tigertronics. Stock photos, front and rear, of this unit are shown in figure 1.

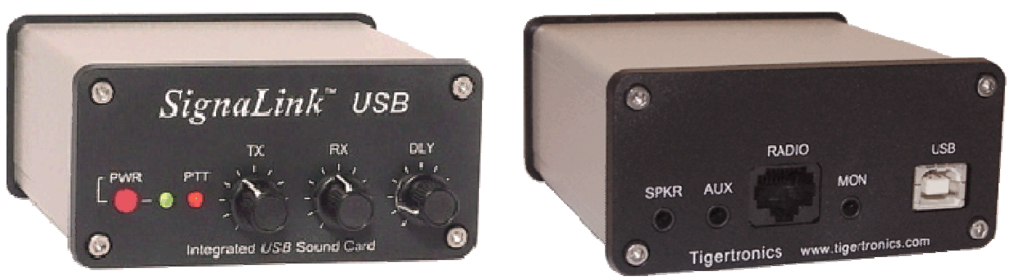


Figure 1. SignaLink USB integrated USB sound card by Tigertronics

This unit has virtually set the standard for interfacing between computer platforms and radio transceivers (HF, VHF and UHF) for digital messaging, due to its low noise, simple installation/setup and its ability to interface with virtually any radio. It is powered by the computer's own Universal Serial Bus (USB) port so no additional power supply or battery is required. Its functionality is quite simple: it takes received digital data from the transceiver (that might otherwise have gone to the speaker) and routes that data to the computer where it is processed and displayed using the software program, FLDIGI; conversely, it takes outgoing digital data generated by the computer and routes it over to the transceiver's microphone input so that it can be transmitted by the radio. Both of these digital data signals are referenced to a common ground. The only remaining interface requirement is a push-to-talk (PTT) signal, created by the computer and referenced to that same ground, which tells the radio when to transmit the outgoing data. Summarizing, only <u>four</u> wires are needed between the SignaLink USB unit and the radio: received data (DATA OUT of the radio, or speaker, or SPKR); transmit data (DATA IN to the radio, or microphone, or MIC); PTT; and ground.

Cabling is needed between the computer and SignaLink, as well as from SignaLink to the transceiver. The former is the standard USB cable with a Type A connector on one end and Type B connector on the other end. This ubiquitous cable, commonly used for computer-to-printer connectivity and included as part of the SignaLink USB purchase, is shown in figure 2.

Figure 2. Standard USB cable used between computer and SignaLink unit

The cable from the SignaLink USB unit to the radio depends on the selected radio's method for interfacing with digital data. Some transceivers have those four signals just described above (SPKR, MIC, PTT and GND) available via an auxiliary data connector at the rear of the radio. Other transceivers have access to at least three of those signals (MIC, PTT and GND) via the microphone connector at the front of the radio. Discussion will be confined to the three transceivers that have been identified for DCS radio rooms countywide: Yaesu FT-8900, Alinco DR-235 and Yaesu FT-897. And, for all of these transceivers, there is a data connector at the rear of the radio containing all four of these essential digital signals, for which cabling will need to be provided.

For each of these transceiver-to-SignaLink cables, the end of the cable that plugs into the rear of the SignaLink uses the 8-pin RJ-45 connector (sometimes called an Ethernet connector). The most common pinout plan for this connector uses the wire color code and pin-numbering convention shown in figure 3.

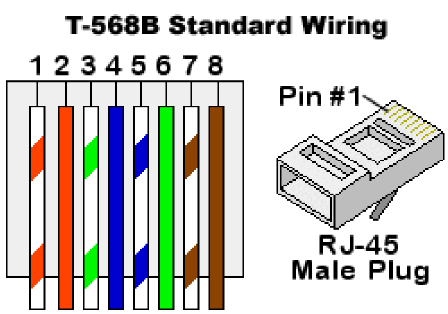


Figure 3. Most common wire color code and pin-numbering convention for the RJ-45 connector

Inside the SignaLink unit, there is a "jumper board" that must be created (either by the ultimate user or by the SignaLink supplier when the unit is purchased), dependent on the specific transceiver being interfaced. This jumper board can be of the type that is user-configured, such as the first two options in figure 4, or the preferred printed circuit board (PCB) version, the rightmost option in figure 4, which should be ordered directly from the SignaLink USB supplier when the SignaLink unit is purchased. The purpose of the jumper board is to present to the cable going to the radio those four signals that are needed by the transceiver to exchange digital message traffic. It must be configured properly, along with compatible cable wiring, for the selected transceiver in use. Paragraphs below provide specific pin wiring details for the three radios being described here for DCS.

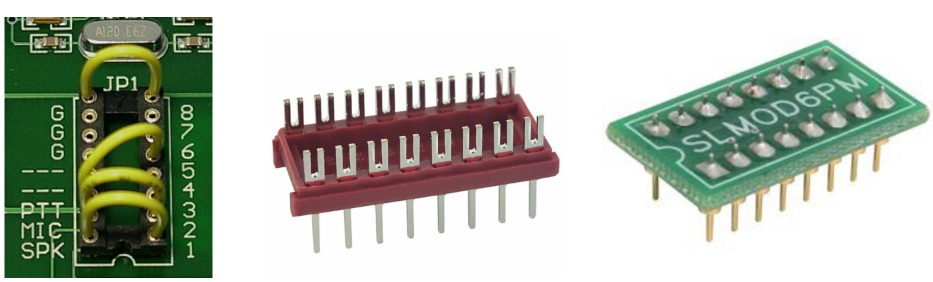


Figure 4. Internal jumper board options for SignaLink USB; rightmost photo is a sample of a prewired PCB that can be ordered for a specific transceiver (along with a compatible cable) and is the recommended option

Yaesu FT-8900 cable. There is a 6-pin mini-DIN data connector at the rear of this transceiver as shown in figure 5, along with the pin assignments for this connector.

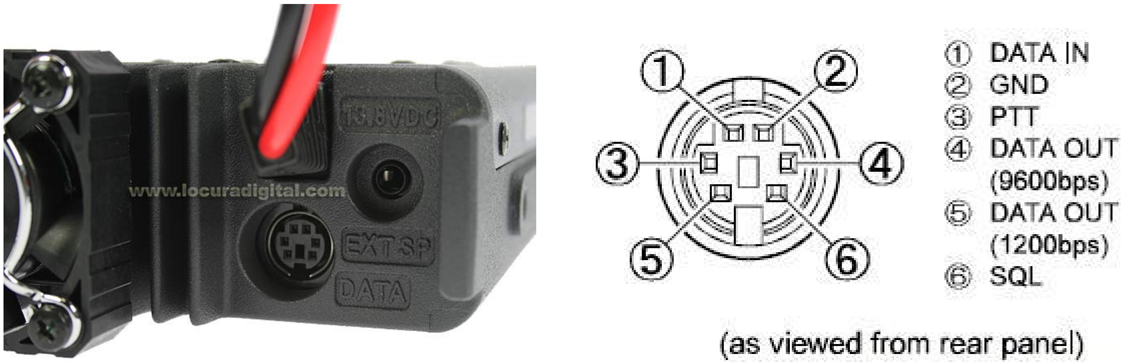


Figure 5. Data connector shown at rear of FT-8900 and pin assignments; note that DATA IN refers to digital data going into the radio to the microphone input and intended to be transmitted; DATA OUT is digital data received by the radio and available at this connector for external processing; of the two DATA OUT signals, only the 1200bps signal (pin 5) will be cabled to the SignaLink.

Shown in figure 6 below is the jumper board configuration for this particular radio cable. Numbers on the right side of the jumper board refer to pin numbers on the 8-pin RJ-45 connector, but they also happen to correspond directly to the radio's 6-pin mini-DIN connector. Referencing figure 5 above, note that the four key SignaLink signals are jumpered to their respective pins on the radio's DIN connector, viz., SPKR to DATA OUT (1200bps)(orange or red wire); MIC to DATA IN (light yellow wire); PTT to PTT (dark yellow wire); and G to GND (black wire). Note that PWR is not connected, as the SignaLink unit gets its power directly from the computer via the USB cable; this option is not required for any of the radios being considered.

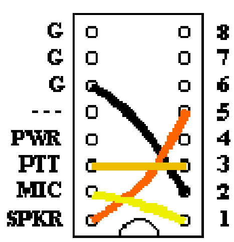


Figure 6. Internal jumper board wiring for the Yaesu FT-8900 rear 6-pin mini-DIN connector cable

In summary for the Yaesu FT-8900, the radio cable has the RJ-45 connector on one end and the 6-pin mini-DIN connector on the other end, where the corresponding pin assignments are indicated as follows:

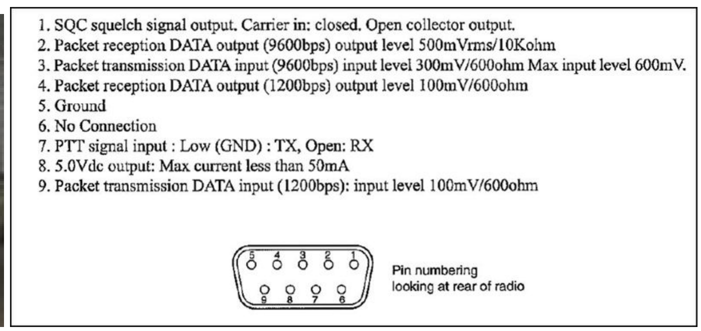
RJ-45 pin	DIN pin	Function
1	1	MIC (data in)
2	2	Ground
3	3	PTT
5	5	SPKR (data out)

Also, the internal jumper board wiring is as shown in figure 6, viz., SPKR to pin 5, MIC to pin 1, PTT to pin 3, and G (ground) to pin 2.

This is a standard jumper board and a standard cable (shown in figure 7), both of which are available as part of the purchase of a SignaLink USB unit. It is only necessary to specify the appropriate jumper board with corresponding cable (SLUSB6PM-P should be specified). This is the preferred approach, with less risk than constructing the jumper board and/or fabricating the cable.

Figure 7. SignaLink RJ-45 to Yaesu FT-8900 mini-DIN cable (should be specified and ordered when purchasing the SignaLink USB unit)

Alinco DR-235 cable. There is a 9-pin D-sub (also called DB9) connector on the rear of the DR-235 as shown in figure 8, along with a section of the user manual showing pin assignment information.



1. SQC squelch signal output. Carrier in: closed. Open collector output.
2. Packet reception DATA output (9600bps) output level 500mVrms/10Kohm
3. Packet transmission DATA input (9600bps) input level 300mV/600ohm Max input level 600mV.
4. Packet reception DATA output (1200bps) output level 100mV/600ohm
5. Ground
6. No Connection
7. PTT signal input : Low (GND) : TX, Open: RX
8. 5.0Vdc output: Max current less than 50mA
9. Packet transmission DATA input (1200bps): input level 100mV/600ohm

Figure 8. Alinco DR-235 rear DB9 data connector and pin assignments (Only pins 4, 5, 7 and 9 are of interest.)

There is not a standard internal jumper board and cable available from Tigertronics for this transceiver's data port, so it will be necessary to fabricate a cable. But, in order to fabricate the cable, it will be necessary to specify the pin assignments for the RJ-45 connector on the SignaLink. Since the jumper board ordered with the SignaLink USB unit is as specified in figure 6, fabrication of this DB9 cable will be based on that RJ-45 pinout information. For completeness, the pin assignment information applicable to the RJ-45 connector end of this DR-235 cable is repeated in figure 9.

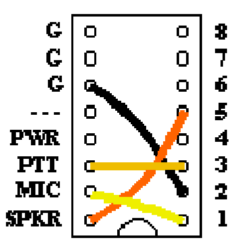


Figure 9. Internal jumper board wiring to the Alinco DR-235 rear 9-pin DB9 connector cable (same as for FT-8900, as there is only one SignaLink unit with its supplied jumper board already wired for the FT-8900); note that pin numbers on the right side of this board refer to the RJ-45 connector and NOT to the DB9

Summarizing for the Alinco DR-235 transceiver, the radio cable has the RJ-45 connector on one end and the 9-pin D-sub (DB9) connector on the other end where the corresponding pin assignments are indicated as follows:

RJ-45 pin	DB9 pin	Function
1	9	MIC (data in)
2	5	Ground
3	7	PTT
5	4	SPKR (data out)

This recommended SignaLink-to-DR-235 interface cable will be fabricated as follows. A special adapter is acquired that easily can be configured to any required DB9 pinout configuration. Shown in figure 10 is the inexpensive adapter as purchased, along with the completed adapter configured for this DR-235 application. Looking carefully at the center panel and comparing to the right side of figure 8, connections to DB9 pins 4, 5, 7 and 9 can be identified in the photo. These four DB9 pins correspond to the internal adapter RJ-45 pins 5, 2, 3 and 1, respectively, according to the table in the previous paragraph. A short RJ-45-to-RJ-45 standard cable then connects from this adapter to the SignaLink's rear "RADIO" jack (or network switch, as discussed later). Use of this easily configurable adapter with standard RJ-45 extension cable obviates the need for labor-intensive fabrication of a unique cable, such as shown in the right panel of Figure 10.

Figure 10. (Left) User-configurable DB9-male adapter; (Center) DB9 adapter wired for pins 4, 5, 7 and 9, as required for the Alinco DR-235 SignaLink cable; (Right) Labor-intensive alternative fabricated cable for SignaLink RJ-45 connector to Alinco DR-235 transceiver's rear DB9 data connector. The recommended option for this application is the adapter.

Yaesu FT-897 cable. There is a 6-pin mini-DIN connector on the rear of the FT-897 as shown figure 11, along with pin assignments. Note that pins 1, 2, 3 and 5 are needed in the interface cable.

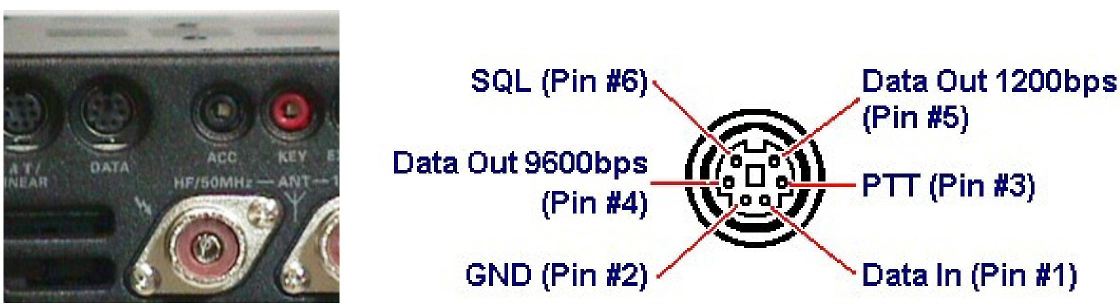


Figure 11. FT-897 6-pin mini-DIN data connector and pin assignments (Pins 1, 2, 3 and 5 are of interest.)

Note that the Yaesu FT-897 and the Yaesu FT-8900 have the same 6-pin mini-DIN connector and the same pin assignments for the four key signals needed. Therefore, a second cable identical to the one purchased originally with the SignaLink unit for the FT-8900 should be ordered and can be used without modification with the FT-897.

Summarizing for the Yaesu FT-897, the radio cable has the RJ-45 connector on one end and the 6-pin mini-DIN connector on the other end and the corresponding pin assignments are indicated as follows:

RJ-45 pin	DIN pin	Function
1	1	MIC (data in)
2	2	Ground
3	3	PTT
5	5	SPKR (data out)

Also, the internal jumper board wiring is the same as shown in figure 6 for the FT-8900, viz., SPKR to pin 5, MIC to pin 1, PTT to pin 3, and G (ground) to pin 2.

To repeat, this cable is identical to the cable for the FT-8900. So, two identical cables should be ordered when purchasing the SignaLink USB unit, one for the FT-8900 and the other for the FT-897.

Network switch. In order to eliminate time-consuming cabling reconfigurations when different transceivers at the station are used for digital operations, a manual pushbutton network switch is incorporated into the setup. A suitable network switch for the standard configuration is shown in figure 12. Depending on the County's approved source, another equivalent switch may be used. It is conceivable that the IT staff could supply such a switch at no cost.

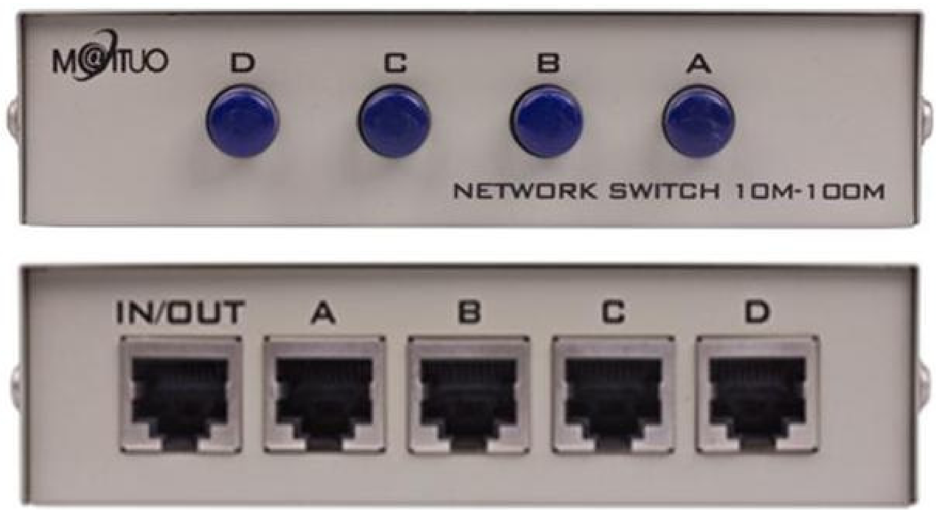


Figure 12. Network data switch for selecting which transceiver connects with SignaLink

A short standard cable with an RJ-45 connector on each end is connected between the SignaLink USB unit and the network switch port labeled IN/OUT. Then, each transceiver with potential for digital operations (Yaesu FT-8900, Alinco DR-235 and/or Yaesu FT-897) will be cabled into ports A, B and C. If only two transceivers are available for digital operations, then ports A and B would be used. The appropriate button would be pushed to select the transceiver required for digital operations. Only one transceiver would be selected at any time.

Microphone usage during digital operations. A consequence for many transceivers of connecting to the radio's rear data port is that the SignaLink circuitry places a low-impedance load on the microphone if microphone usage is attempted while the transceiver is configured for digital operations. The load is such that the microphone output may be somewhat low, very low or even non-existent, depending on the transceiver. Yet, there will be many times when it is desired to communicate using voice mode without disconnecting cabling between the radio and the SignaLink unit. That mode of operation can be accommodated by simply pushing a button on the network switch corresponding to an unused port. In the photo of the Station 17 Lomita network switch, shown in figure 13, a note has been added to the front panel of the network switch to push the OFF button to use the microphone. This "OFF" button simply corresponds to one of the unused ports of the network switch. Pushing the OFF button disconnects any/all radios from the SignaLink, thus eliminating any low-impedance load due to the SignaLink, as just described.

J. Kendrick, T-03, NG6R
Version 5, 02 August 2017

Figure 13. SignaLink USB unit and network switch stack securely shelf-mounted at Station 17 Lomita with labels for three transceivers and instructions for operating microphone when configured for digital operations

So, a typical scenario might be as follows: Initially, the net control operator (NCO) has either not pushed any button on the network switch or has pushed the OFF button for the port to which no transceiver data cable has been connected. The NCO announces via the active transceiver's microphone that "an NBEMS message will be sent in 5 seconds, so please stand by to receive the message." The NCO then immediately pushes the appropriate network switch button—the one corresponding to the transceiver currently in use. The outgoing message on the computer is activated by the NCO and the NBEMS message is sent. When the transmitted message has completed, the NCO then pushes the OFF button (for the port not connected). That action disconnects the transceiver's rear data port from the SignaLink and eliminates any microphone loading that might occur otherwise. The NCO then uses the microphone to announce that this concludes the outgoing NBEMS message and asks for questions or comments. Taking the SignaLink unit offline in this manner permits the use of the transceiver's microphone for relevant communications and also obviates the need to manually disconnect any cabling between the transceiver and the SignaLink unit. After just a couple of uses of this technique, the operator will gain facility with integrating digital messaging and microphone usage. As a result, integrated voice and digital operations will occur smoothly with no awkward or time-consuming hardware configuration changes.

Required components for a typical station and approximate cost. The following list recaps the hardware requirements for a typical station. (The assumption is made that the typical station either has now, or will have at some time in the future, a full complement of three radios, Yaesu FT-8900, Alinco DR-235 and Yaesu FT-897.)

	Component	Approx. $
1.	SL-USB-6PM SignaLink USB sound card with 6 Pin Mini DIN cable for FT-8900 included	115
2.	USB A/B (3 ft) cable, supplied with SignaLink USB (from SignaLink to network switch)	N/C
3.	SLMOD6PM Jumper Module for 6 Pin Mini DIN Data Port Radios	8
4.	SLCAB6PM Extra Cable for 6 Pin Mini DIN for FT-897 (identical to FT-8900)	22
5.	DB9 adapter for DR-235 radio cable	3
6.	RJ-45-to-RJ-45 (3 ft) cable (from DR-235 DB9 adapter to network switch)	3
7.	Network switch (manual, 4-position)	15
8.	RJ-45-to-RJ-45 (3 ft) cable (from SignaLink to network switch)	3
9.	Portable or desktop computer with FLDIGI software suite installed (free download)	TBD*
10.	Inexpensive standalone printer	TBD**

*Computer availability varies by station; might initially necessitate use of personally owned computer
**To obviate need to hand-copy outgoing and incoming NBEMS messages onto DCS message handling forms
Suitable standalone computer and printer could probably be supplied from County IT resources.

NBEMS software and computer requirements. NBEMS uses the FLDIGI suite of software modules that includes FLDIGI, FLWRAP and FLMSG, available for Windows, Macs and UNIX platforms. Here is the URL for a safe and free download: https://sourceforge.net/projects/fldigi/. Numerous NBEMS tutorials are available on the Web, easily accessed by searching for NBEMS tutorials using Google or other search engines.

Although minimum system requirements are not generally cited, virtually any modern laptop or desktop computer with a USB port for communicating with the SignaLink USB unit will suffice. The SignaLink USB unit functions as the essential sound card. Processor speeds above 700MHz are recommended to avoid configuring FLDIGI for “slow CPU” mode of operation. Although operation across various operating systems is possible, Windows 7 is desirable.

APPENDIX A. NBEMS Two-meter Operation Using ICOM IC-2200H Transceiver

Summary. A few Los Angeles County Sheriff Station DCS radio rooms still rely on the ICOM IC-2200H transceiver for 2m operation. These stations have not been upgraded to either of the DCS standard radios capable of 2m operation, the Yaesu FT-8900 or the Yaesu FT-897. Until or unless these stations are upgraded to conform to the standard, this appendix provides interim guidance on how to configure the IC-2200H for NBEMS digital operation using the SignaLink USB unit and a simple network switch.

Unlike the three DCS transceivers discussed earlier in this document, the ICOM IC-2200H does not have a digital data jack at the rear of the radio containing the signals needed for digital operations. Three of the four signals that are essential for digital operation must be accessed via the microphone jack at the front of the transceiver. The fourth essential signal can be accessed from the speaker jack at the rear of the radio. The paragraphs below provide details on how to configure the 2m transceiver for digital operation.

Detailed description. The radio front microphone jack accommodates the RJ-45 plug with the following pin assignments:

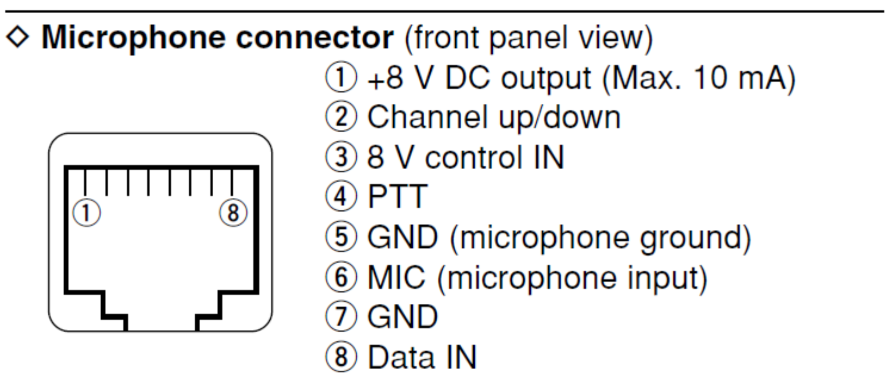


Figure A-1. Front panel view of the RJ-45 microphone jack with pin assignments for accessible signals; note that three of the four signals essential for the SignaLink unit (PTT, GND and MIC) are available via this connector. [The fourth essential signal, SPKR, is available from a 3.5mm speaker jack at the rear of the radio.]

Referring to figure A-1, the essential signals in the cable to be connected from the radio microphone jack are pin 4 (PTT), pins 5/7 (GND, connected together) and pin 6 (MIC input). Additionally, access to the Data Out or SPKR signal is obtained by connecting a simple monaural cable (with 3.5mm or 1/8" male plugs on either end) between the speaker jack (SP) at the rear of the radio and the SignaLink rear jack (SPKR). This cable is very common and is shown in figure A-2. A two-foot version of this cable is supplied with each SignaLink USB unit ordered.

Figure A-2. Commonly available monaural cable to connect speaker jack at rear of radio to SPKR jack at rear of SignaLink USB unit (supplied with each SignaLink USB unit); this connection provides the Data Out signal that will be routed via the SignaLink unit to the computer for NBEMS digital data processing in FLDIGI

A characteristic of the IC-2200H is that an audio plug inserted into the rear speaker jack will mute the internal speaker. So, in order to hear the radio audio using an external speaker and also send the Data Out signal to the SignaLink rear SPKR jack, a “Y” audio splitter must be inserted into the radio rear speaker jack. A stock photo of such a splitter is shown in figure A-3. The audio cable shown in figure A-2 will be plugged into that “Y” splitter only when the IC-2200H is being used for digital NBEMS operation, i.e., it is left unplugged from the splitter when other radios are being used for digital operation.

Figure A-3. Audio 3.5mm “Y” splitter plugged into the IC-2200H rear speaker jack, enabling both an external speaker and an audio cable to the SignaLink rear SPKR jack to be connected

The operator at a station at any point during DCS nets must choose whether to operate the IC-2200H radio in voice mode, or operate in digital NBEMS mode, as both of these modes interface to the microphone connector directly. The operator can use a two-position switch, selecting either voice or digital data, with the simple throw of a manual RJ-45 network switch, as depicted in figure A-4.

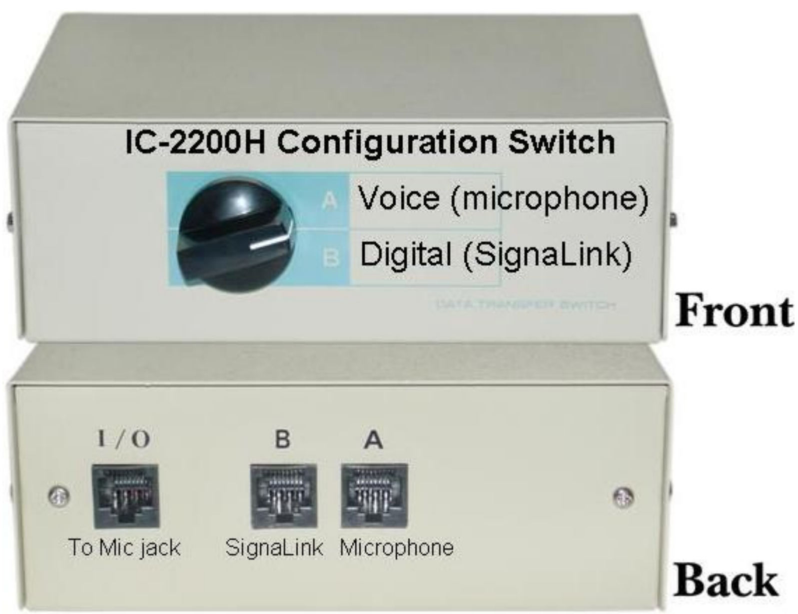


Figure A-4. Notional concept for a network switch to select either voice (microphone) operation or digital operation from the IC-2200H 2m transceiver with a simple and inexpensive RJ-45 two-position rotary switch

Note that a short standard RJ-45-to-RJ-45 cable is attached from the I/O (common) jack to the microphone jack on the radio front panel. Then, the existing radio microphone with its RJ-45 connector is plugged into the “A” input jack. The remaining connection is a uniquely fabricated RJ-45-to-RJ-45 “crossover” cable, connected from the rear of the SignaLink unit to the “B” input of the network switch. The description of that uniquely fabricated cable follows below.

Recall the discussion earlier in this document about the choice of the internal "jumper board" in the SignaLink unit, i.e., both the Yaesu FT-8900 and the Yaesu FT-897 have the same pin assignments for the four key signals. Those two radios benefit from sharing the same jumper board wiring. Since the same jumper board will be placed in all supplied SignaLink units, that jumper board pin assignment needs to be accommodated for the ICOM IC-2200H. [Note that if the IC-2200H were the only radio ever to be connected to the SignaLink unit, the jumper board could be changed to make the interface cabling simpler.]

Repeated in figure A-5 is the configuration of that jumper board, the same diagram that was shown earlier in figure 6 and figure 9.

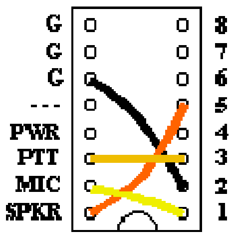


Figure A-5. SignaLink internal jumper board wiring, configured specifically for the Yaesu FT-8900 and Yaesu FT-897

For the ICOM IC-2200H, the RJ-45 microphone pin numbers for the three essential signals (PTT, MIC and GND) in figure A-1 are different for those same signals exiting the SignaLink unit shown in figure A-5. As a result, a special "crossover" cable must be fabricated that translates the three signals needed from the SignaLink (PTT, MIC and GND) over to the appropriate pins on the radio microphone jack via the network switch. Figure A-6 shows the appropriate pin wiring assignments for this special RJ-45-to-RJ-45 crossover cable (refer to figure A-1 and figure A-5).

RJ-45, SignaLink	RJ-45, Network switch "B"	Function
1	6	MIC (data in)
2	5 and 7	Ground
3	4	PTT
5 (not used)	N/A	SPKR (data out via radio rear connector)

Figure A-6. Pin assignments for RJ-45-to-RJ-45 crossover cable that connects from the SignaLink jack to the network switch jack "B"

Care must be taken to cut and correctly splice the wires of the crossover cable to enable the connections shown in figure A-6. Since both ends of this short crossover cable appear identical, care also must be taken to appropriately label each end ("To SignaLink" and "To network switch input B") so that the cable ends will not be inadvertently reversed during setup.

Just as described earlier in this document regarding interlacing voice and digital modes, the operator will use the "Voice" position of the network switch for normal voice operations including coordinating among stations that are preparing to receive an NBEMS message. When all voice coordination is complete, the operator announces that a digital message will follow; the operator then rotates the network switch knob to "Digital" position and sends the digital message from the computer. Upon completion of the outgoing digital message, the operator again rotates the switch back to voice mode and completes the post-message voice traffic. The procedure is very simple and easy to self-train. There is no rewiring of associated electronics, no complicated automatic switching relays to configure and no requirement for rapid cable change-outs. This method will work as an interim solution for operating NBEMS digital mode on 2m until one of the standard radios (FT-8900 or FT-897) is acquired for station operation.

Each County station DCS radio room will be equipped with a SignaLink USB sound card, as shown in figure 1 on page 1. The primary network switch for selecting a particular radio for digital operation at any given time is shown in figure 13 on page 7. It is expected that eventually one or both of the two standard DCS radios capable of 2m operation (FT-8900 and FT-897) will be at all stations. Until that occurs, one of the unused positions on the primary network switch (shown in figure 13) can be temporarily relabeled “IC-2200H” and the uniquely fabricated crossover cable described above can be inserted into that position at the rear of the primary network switch. Then, when digital operations are carried out on 2m using the IC-2200H, there will be two network switches involved: The primary network switch (figure 13) will have the button pushed in (and left pushed in) for whichever of the positions has been relabeled “IC-2200H”; and, the secondary network switch (figure A-4) will be used as described in the previous paragraph for switching between voice and digital operation. Of course, only the secondary network switch needs to be operated when switching between voice and digital modes on 2m; the primary network switch is simply left set on the relabeled IC-2200H position. In this manner, the ICOM IC-2200H radio for 2m digital NBEMS operation, temporary though it may be, can be integrated into the standard station configuration.

Note that <u>if</u> the station relying solely on the IC-2200H for 2m operation opts to integrate the secondary network switch into the standard station configuration as described in the preceding paragraph, then the crossover cable must connect between the “B” input on the secondary network switch and the unused (relabeled-“IC-2200H”) jack on the primary network switch (not to the SignaLink unit itself as described earlier).

As should be evident, the unique manner in which the ICOM IC-2200H accesses digital data signals (via the microphone connector and speaker jack instead of through a dedicated digital data jack as do all of the other radios in the standard configuration) makes any attempt to smoothly integrate this radio into the standard configuration difficult at best. The sooner this radio can be replaced with either/both of the other two standard radios with 2m capability, the more smoothly digital NBEMS operations at these stations will proceed.