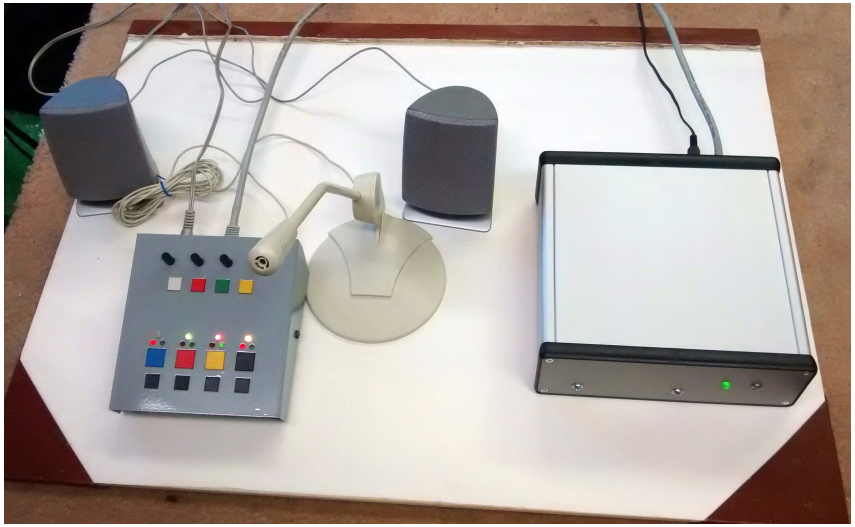
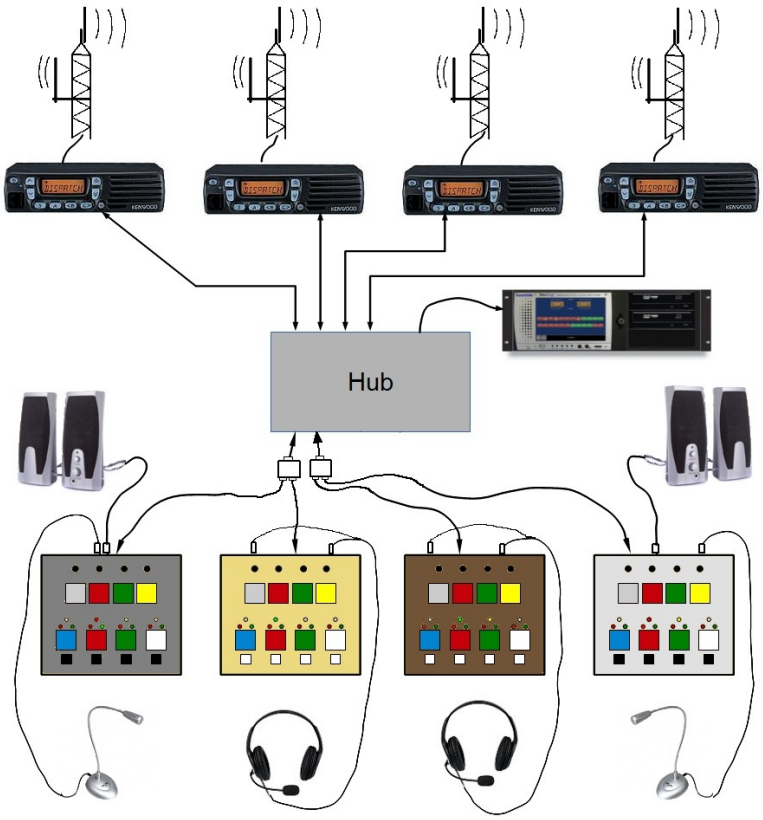
Purpose

STM Basic Dispatch permits operating four radios remotely, each with up to four channels. There is no limit on the number of operating points, although one to four would be typical. Functions provided are individual PTT, volume control, channel set and monitor (coded squelch defeat). Receive audio is sent to two speakers; one for the "selected" (last keyed) radio, the other shares the other three. Each station hears what other operators are saying and hearing.

The hub, the box on the right in the photo below, connects to the radios. It can have repeater setup switches for assigning two or more radios to repeat mode: when one receives, it keys the other(s) and repeats out what it is receiving. Crossband repeating is possible. (The box shown has none; they would be to the left of the green light). Four balanced pairs provide +4dBu transmit and receive audio to your logging recorder.

Desk unit with hub, radios not shown





Sample four-user system connection
Kenwood radios and Eventide logging recorder shown

Operation

Each desk unit can be connected either to a stereo headset with mike, or to a desk mike and computer speakers, as shown.

The typical inexpensive computer mike shown does not pick up well more than about 6 inches away. You can use a more sensitive mike, but this may cause feedback during transmit if the operators are too

close together. In that case components can be added in the desk units to reduce or mute the sound on that radio's line when the other operator keys. The operators would then rely on their proximity to overhear what the other is saying. Mike gain can be adjusted by reconfiguring jumpers for the preamp in the desk unit. One configuration is for a dynamic cartridge mike. For greater reach, use either a high-gain electret mike (such as the SMN4020A), or a dynamic mike with an internal preamp. Except in dynamic-only configuration, the mike jack provides 10 volts through 3300 ohms for powering an external mike or its preamp.

The speaker jack on the default unit supplies only enough output for a headset, so speakers used should be self-powered. Most common computer speakers are. One speaker plays audio from the selected radio (the last one keyed or set to monitor), while the other has combined receive audio from the other three radios. A reversible headset would allow you to choose which ear hears the selected side.

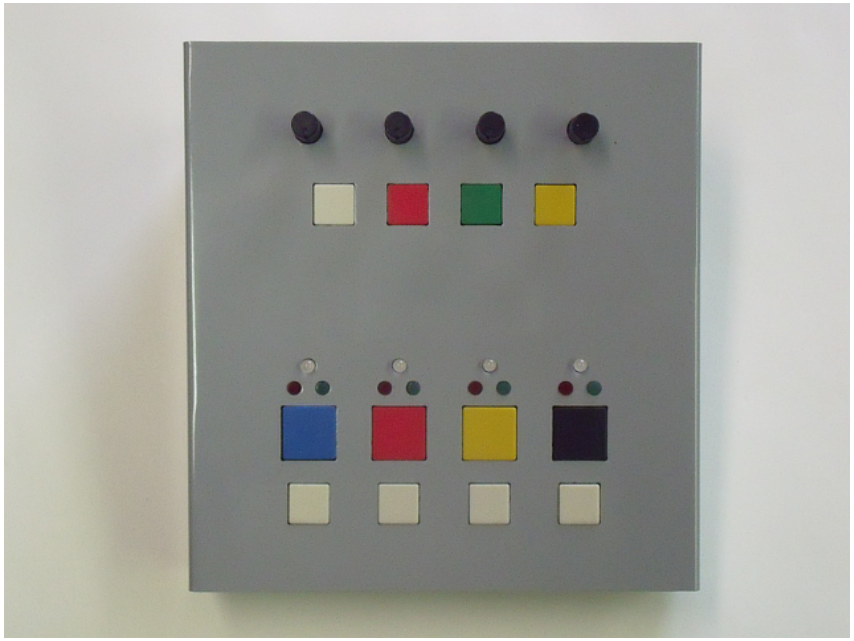
If the radios are mounted close by, the operators could adjust front panel settings, such as toggling scramble or scan, but usually the radios would be located further away. The desk units can change channels, adjust volume, transmit, and toggle monitor. You could toggle scan or scramble by dedicating a channel to that function in radio programming, and turn it on by going to that channel.

One arrangement could be four dispatchers, each sitting by one radio, interconnected so that everyone can communicate on all four radios.

Although many desk units can be connected in parallel, the hub has jacks for two. Use passive ethernet cable splitter blocks to add more.

The hub can only control four radios. To operate more, you could use more desk units and hubs. An integrated eight-wide system is not planned, but there may be a way to interconnect two 4-wide desk units so they share just two speakers and one mike. Inquire if interested.

The desk units are powder-coated for a more durable finish than paint. See http://www.allpowderpaints.com/ral-colors/ for colors. Gloss black, matte black, clear over brushed aluminum, cream, light blue, red and yellow are available now.



Closeup of desk unit

The volume controls are on top, with the channel set buttons just below. The white LED's are channel indicators; below them are the red and green status lights. The larger buttons are PTT keys, with Monitor-Intercom buttons at the bottom. Channel set button colors match the channel indicators: white for a dark indicator (channel 1), lit red for 2, green 3, yellow 4. For a full 16 channels you may want to have a printed list nearby to aid until they are memorized.

When a radio is set to channel 1*, its face channel buttons are free to be set to any channel in the radio. Changes made at the radio itself

are not shown on the desk indicators, so all users would need to be kept up to date what channel the white button means for each radio. This should not be changed often. When a radio is set to 2, 3, or 4, which are assigned by installer programming, its entire front panel is locked.

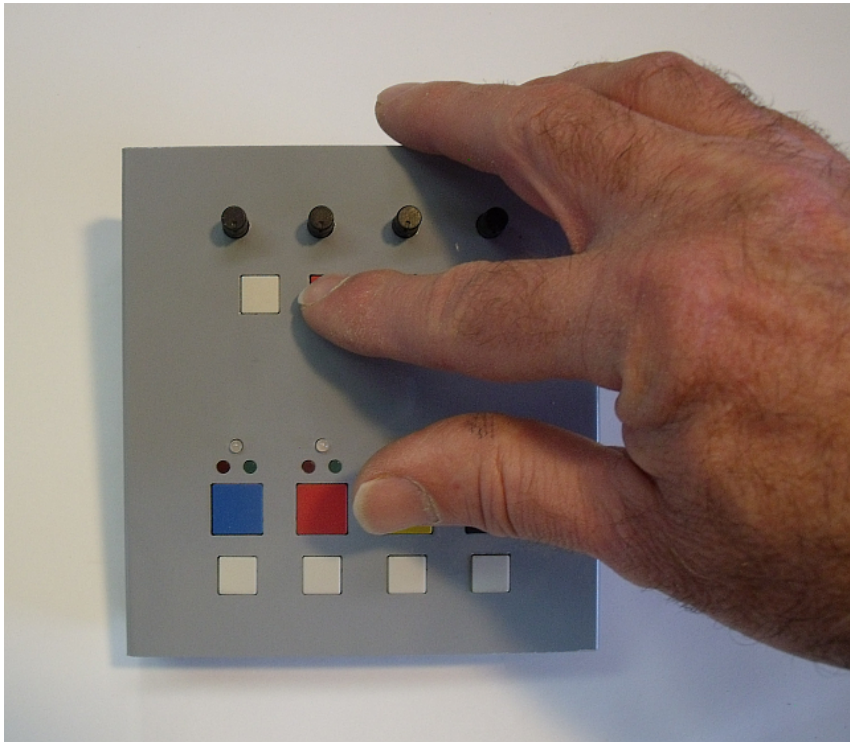
*On the Motorola M1225 the free button is #4, yellow, due to its channel-set input data requirements. This may also be true of other models.

To set a channel, hold down the desired channel color and briefly tap the PTT key of the radio you want to change. It will not transmit. While you hold down any channel button, all the radios not already keyed elsewhere are locked out (the red indicators on the other desk units will light up). No one can key those radios until you are done. Radios already keyed elsewhere are lit red on your unit, and you cannot change their channels until they are unkeyed.

After tapping the radio PTT, let off the channel button to return to normal mode. Confirm that the indicator shows the channel you wanted. Channel setting can be completed quickly, so there is no need to block radios from keying for long. It could be used to stop undesired keying at other stations, should the need ever arise. Do not hold two channel buttons down at once, it will not set properly.

On power up the radios will set to whatever channels the hub randomly comes up on (usually 1, but not always). This may not agree with that shown on the desk units. To synchronize the system, just set all the radios to any channel by hand: hold down one channel button and quickly tap each PTT in succession. This sets all of them the same. Only one desk unit needs to do this, the others will register accordingly. Then change them to the usual channel of operation, if needed. This syncing may be needed after a power glitch.

The red and green LED's are status/activity indicators. The red LED's flash with audio on its line, which helps to identify which unselected radio is active (the selected radio is identified by ear.)



Setting channel 2 on radio 3

This is not affected by the volume setting. When you transmit and speak, the red flashes to let you know you are speaking loudly enough. If you do not see flashes, you may be sounding low out in the field; speak up or get closer to the mike. The red stays on dimly when its radio is set to Monitor. It is bright when its radio is keyed by another station, which means you cannot use it until they finish. You will hear what they say in your speakers.

The green LED's indicate selection and your own keying. When you key, that green LED lights brightly, as a 'go ahead and speak' cue. The red LED will flash briefly on key-down. This does not stop you from speaking as soon as you key, but letting the first flash go away before speaking is good practice. After you release, the green LED

will stay dimly lit to show that the radio is now selected. Only one radio can be selected at a time. You can transmit on two, three, even four radios at once. Your voice will go out equally on all of them. In this case, it is the last PTT key released that gets selected. Tapping monitor also selects, so if a simulcast leaves the wrong radio selected, just briefly tap the correct monitor button.

While you are transmitting, your voice is not sent to your own headset or speakers, but you can still hear all traffic from other stations. Other stations do not see which radio you have selected, but they do see which ones are set to Monitor, and when any are keyed.

The PTT button colors can be chosen for different purposes. The colors available are light gray, white, black, red, orange, yellow, light green, green, and blue (light green and green are almost the same.) So for example, you could use a blue key cap for police, red for fire, white for medical, green for forest or parks. To reposition the colors, remove the desk box cover and pull the caps straight off by hand (do not twist or pry crooked), then push them back on in the order desired. Connect the radios accordingly. The channel set button colors should not be changed, as they should match the indicator colors.

Monitor turns off coded squelch so that any traffic, coded or not, will come through. To set monitor, press and hold the button for about ½ second. On release, note the red status light stays on dim. To reset, tap the same button briefly. Note the red status is now off.

The monitor buttons also function as Intercom, that is, mike audio is sent to the line but no radio is keyed. Unless they have you turned down, the other stations will hear your mike any time you hold a monitor button down. They can reply on a different line while you are talking. They could press the same radio's monitor button as you, but that would create a collision of mikes, and no one would hear anything. When you release, of course, they can reply on any line. Since pressing a monitor button selects that line, if they reply on the same line (as was indicated by the flickering red while you spoke), they will be addressing your selected ear or speaker. If they choose another line to reply, they will be sent to your unselected side.

If two desk units are close together and sensitive mikes are connected, pressing intercom or keying will likely cause feedback howl. Since in this case the two dispatchers can simply hear each other directly, the intercom feature can be defeated by installing jumpers in the desk units involved.

If power to the hub is lost, Kenwood radios, which accept active-low only, will lock to channel 4. If a Motorola is programmed for active-high input, yellow is channel 1. It will go to channel 4 if the hub loses power, but the radio will not be locked. Whether you name the channel colors "1-4" or any other order is arbitrary, but white=1 is assumed otherwise. To free the radios, restore power to the hub or unplug the radio interface cables.

Paging Encoder and Foot Switch operation

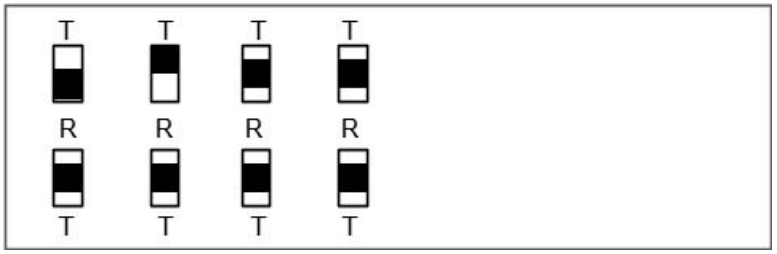
A jack for connecting a paging encoder and/or foot switch can be added to a desk unit. The basic option is a 3.5mm stereo jack (TRS, Tip Ring Sleeve): tip for paging tones, ring for page and/or foot switch key, sleeve ground. In this case, if a foot switch is needed, it will be configured to key whichever radio is selected. That means that paging, if connected too, will also go out on the selected radio. In this configuration, paging tones will swamp out the microphone, so no voice transmission will be possible from **this** desk unit on **any** radio while the tones are in progress. If you did key another radio, it would just send out the ongoing tones too. Other desk units are not affected.

The page encoder will swamp the mike only when paging is occurring, not when the foot switch is pressed, if it is connected correctly. See the installation section.

If your paging will always be on the same radio, the desk unit can be

configured to send page key and tones to one fixed radio. In this case the tones will not swamp the mike, and you can initiate voice transmissions on other radios while the one radio is paging out. But a foot switch is less useful if sent only to one radio, so it would then need its own line into the desk unit. To accomplish this, you can request (or install yourself) a TRRS (Tip Ring Ring Sleeve) jack in place of the TRS jack. Then tip will be tones, ring 1 tone key, ring 2 foot switch, sleeve ground. Ring 1 will key a jumper-selected radio while ring 2 will key the user-selected radio. Of course you will need to wire your encoder and footswitch to a corresponding TRRS plug. If not factory installed, the kit will have detailed instructions.

Finally, if you really must page out on two different radios, a simple mini SPDT toggle switch can be added to the back of the desk unit. Just throw the switch to the correct radio, and send your page. This switch may be needed if you are bridging two paging encoders to one desk unit, with the different encoders needing to go out on different radios. An easier method would be to send the encoders to the same radio (no switch needed), and set the radio to different channels depending on which encoder you use. Another solution is to connect the two encoders to different desk units, each hardwired to the appropriate radio.



Repeater setup on hub: one-way single repeater shown

Repeater Setup

With a repeater option board installed, the hub can be configured to interconnect any and all of the radios as repeaters. No repeating occurs with the switches all centered. Select the receive side radios by sliding those switches toward "R". Assign those for transmit toward "T". If only one pair will act as repeater, one switch will be set R and another T, as shown. The lower row of switches allow the same radios to repeat in the opposite direction, or a second pair to be an independent repeater. For a bidirectional repeater (typically crossband), those selected Rx>Tx on the top row would be set Rx<Tx on the second row.

More complex repeat configurations are possible: One radio set to R, all the others to T, means everything received on one goes back out on the others. Or three set to R and one to T, everything received on the three is sent back out on one. A complex arrangement will limit what can be set up on the second row of switches.

When a repeated radio receives, it keys the other just like a desk unit does, so dispatch stations will see bright red and be unable to key over the T side. They could, however, key over the R side (evident by the activity flicker and audio), interrupting the repeat. If this is never to be allowed, you could deprogram the PTT line on the R radio to fix it as R only. The better solution is operator awareness and training.

Beware: when set for repeating, the radios need to be able to receive well while another one (or more) nearby is keyed. That of course is somewhat true even when manually operated (no repeater), but repeating means there most certainly will be at least one transmit going on at the same time reception is needed. Therefore the respective antennas should be separated in such a way that transmit power is not directed right back into the receivers' antennas. If the repeating radios' channels are fixed (single frequency operation), notch filters or duplexers can aid the energy isolation. Of course if the radios are in different bands, the extreme frequency separation itself accomplishes the isolation.

Circuit Description - Desk Units

Nomenclature conventions: Q12.3 means Q12 pin 3; Qx2 means any one of Q12, Q22, Q32, or Q42; Q12b means half of dual transistor Q12, usually the right half as seen on the schematic; sf1-4 means each of sf1, sf2, sf3, sf4.

Starting from the microphone (schematic page 1): The input is designed for a common computer desktop microphone, so it uses a stereo jack to match. A typical computer mike is not very sensitive, so the simple on-board preamp can be jumpered in to increase gain about 10x. It can also be used for modest gain for a dynamic mike. Greater sensitivity may be achieved by using a mike with its own preamp.

Audio from the mike passes through Rm1, Cm1 and Cm2 across the shunting Qm2 to the input of Um1, which has a gain of 100 as set by Rm4 and Rm5. The output feeds back to Dm through Cm5 and Rm6. This charges Cm3 until it reaches the turn-on threshold of Qm2, about 2 volts. The drop in Dm is about .5v, so Qm2 begins to turn on when Um1 output is about 2.5v p-p. Qm2 shunts the incoming mike audio, so any stronger input than what produces 2.5v pp at Um1.1 is throttled, limiting output to that level. When you stop speaking, Rm3 bleeds off the charge on Cm3 within ½ second, restoring full sensitivity.

Rm16 gives Um1.1 its necessary DC load. Rm13 and 14 divide the 2.5v pp down to 1.0v pp. Cm6 prevents the DC level at Um1.1 from being divided, so Um1.5 sees 5v. Rm9, 10 divide 10v power to 5v to bias Um1.2 to set this DC level. Cm8, 9 filter out power rail noise. Um1.6 is tied to follower Qm1, so the audio at the mike bus is 1.0v pp (at AGC limit) at 5v DC. R3 provides a load to Qm1 when the mike bus is idle.

Intercom/Monitor switch Qi1b turns on only when a monitor button is pressed. Rm15 then bypasses Cm6 to divide the DC out of Um1.1, reducing it to about 3v, which is passed on to the mike bus. At the hub, the different DC levels (4.4v and 2.4v after Dx3) are translated to PTT and Mon respectively. Ci1 briefly extends the level set by Qm3 after the button is released, to prevent a pulse up to 5v, which would reset Mon toggle.

Qi1a also turns on with Qi1b; if Rim is installed, the mike path is muted through Cte. Install Rim if intercom is not needed; for example, if users are so close together that using intercom would cause feedback.

Paging option, Qte

If JuST (**Ju**mper **S**wamp**T**one) and jack Jte are installed, an external tone encoder can key the selected radio (through FSB, **F**oot **S**witch **B**us) and apply paging tones directly through Cte to Um1.5. This swamps mike audio from Rm13 as described in the Operation section. A different way to connect the paging encoder is described later. In that case only the foot switch passes through Qte, and JuST is not installed. If the foot switch is to key only one fixed choice of radio, Qte and FSB are not used.

If JuST is in and intercom needs to be muted, Rim should be at least 470 ohms (but not over 3900) to prevent Qi1a from shorting the tone encoder output, should both be activated at the same time. Higher Rim will allow more mike audio through if you want low intercom instead of no intercom. Without JuST, Rim can be a jumper. If full intercom is needed, leave Rim out.

Keying Logic (page 2, 3)

The mike bus is applied to the drains of Q11, 21, 31, and 41. Lines 1-4 are identical, so following line 1 as our model, if either switch S11 or S12 is closed, 10v is sent through R13 to the gate of Q11. The rise time at the gate is softened by C11, so the line (at D13 cathode) rises gently, so the speaker does not pop. C11 gives about a 5mS rise time, similar to that of a 50Hz sine wave, which is a low dull thump.

When Q11 turns on, it connects the mike bus 5v (or 3v, if S12 is pressed) to the line through D13, so the line sees about 4.4v DC (Tx) or 2.4v (Mon). The line now carries mike audio plus a DC level.

At the switches, Di1 sends 10v to Qi1 for Monitor/Intercom (S12) but not for PTT (S11). Both send 10v through R16 and D12 to charge up C12 (rise time much faster than C11). This turns on Q14. Line audio passes through Rau1 and C13 to the volume control VR1. It is shorted out when Q14 is on: you do not hear yourself in your headset when you key or call on intercom. This prevents feedback squeal, especially if speakers are used.

The Q11.2 (source) goes directly to Q12.5 (gate). At 1 volt, it turns on and lights up LG1 through R10. This is the green "go-ahead" keydown indicator. While not keyed, the leakage current through LG1 holds Q12.2 high, which grounds Q13.2 (emitters). When LG1 is lit, Q12.2 is low, Q12.6 is off, preventing Q13 from passing current to D11 and LR1, the red LED.

The line, at D13 cathode, goes through R19 to both sides of Q13. If Q13 were turned on, current would pass through R14 and 15 to LR1. With PTT on and Q12.6 off, this does not occur. Q13 turns on when the line is taken high (4.4v) by another station. In that case Q12.5 stays low, as D13 blocks DC arriving from the line. Q12.6 is on, both sides of Q13 turn on, and LR1 lights. When Q13.5 is low D11 shunts C11 to ground. This prevents Q11 gate from rising above .6v, which blocks S11 (PTT) and S12 (Mon/Int). Pressing either switch will still mute the line by Q14, however, should you want to suppress hearing the outgoing traffic. It will not interrupt the traffic itself. If the other station unkeys while you are still holding down, key or intercom will be transferred to you.

If the line is set to Monitor, its voltage is about 1.2v. D15 drops about 1.1v, so Q13.5 does not turn on. Q13.4 still turns on, only R15 feeds current to LR1, so it lights dimly. D11 is not involved and Q11 is not blocked. The hub discussion will explain the low level it sends back when toggled to Monitor.

See Channel Set Logic section for the explanation of OD, Dod1.

Select and Audio Logic

Q15 turns on with Q12.5, so LG1 is driven bright through both R10 and Rsi1. Q15 input also provides a bleeder to Q12.5 so it does not float high when idle. Q15 output goes by "SEL1 low" to page 4.

On page 4, SEL1 low ties to sf1.3. Sf1 is a simple RS flip-flop. So pin 3 going low takes pin 6 high and the flip-flop flips. This change is sent out through the diode matrix D1234, 2134, 4123, and 3124 to flop the other three flip-flops to the opposite state. This interlocking means only one can be SET at a time; all the others have to be RESET.

The flip-flop outputs are sent to sg1-4. Looking at sg1, its inputs are softened by Rq1a and b and Cq1a and b. Without these, sg1 leaks a "tick" sound through to the audio as the toggling flip-flop switches. Tag "Rx1" is the audio from the wiper of the volume control. When sg1b is on, audio is sent to RRx1. RRx1-4 are tied together at "UnSel Aud", the unselected speaker driver. When sg1 is flipped by sf1, audio goes to "Sel Audio", the selected speaker driver. RRx1-4 and R3s on the UnSel side, and R1s and R2s on the Sel side, divide the levels down for the speaker driver inputs. C1s and C3s block DC.

Flipflop state is also sent to Qfs1, 2, which are used to direct foot-switch keying to the selected line. See Footswitch subheading.

Audio Output

U1s is a high-output op amp meant for a 32Ω headset or to drive external amplified speakers, which can be as massive as you want, but you supply them yourself.

Channel Setting Logic (page 6)

The channel set switches cS1-4 are fed 5 volts through Qd1 and sR4. D1-4 diodes encode button presses into 2-bit binary at "Data A"

(LSB) and "Data B" (MSB). Rd1 and the input of Qad load these so they do not float open if a data lines are disconnected. Uc1 and Uc2 are 74HC75 dual 2-bit latches. When latched, the data levels are sent to cLED1-4, red/green common-cathode bicolor LED's. 00 is dark, 01 is red, 10 is green, and 11 is yellow. At the hub end, an identical set of latches send the 2-bit data to the radios to set the channels. Kenwood radios use only active-low data, meaning the unplugged/free channel is 11. Data 00 is sent to the radio as 11 at the hub by using the not-Q outputs there. Program Motorolas active-low for compatibility, or accept reverse order of channel numbers.

Returning to the channel set switches, any press sends power through sR1 to sLED, which sends 2v to Qhd.3, turning it on. This keeps Qhd.5 off when Qad turns on. The 2v sent to Qhd also goes to "Data B" via D4b. So any channel button press sends about 1.4v (after D4b's drop) to Data B. The latches do not respond to this, as they interpret anything less than about 2v as a "0", but it does go out the Data B line to the hub, which uses it to detect that a channel button is down. It also appears at the Data B lines of all other stations. This turns on Qad at all stations, which takes "AnyData" high. This passes through Rod1 to OD (OtherData). In the unit that is sending data, this is shorted out by Qhd; in all other stations, OD goes high, Qhd.5 turns on, Qd1 is turned off, and power is denied to the channel buttons. So, whoever starts a channel change seizes the job and others cannot interfere. OD is taken through Dod1-4 (see pages 2, 3) to Q13.1-Q43.1, turning them all on. If the PTT is already keyed on any radio x at another station, its Qx2.6 is off and the OD high is ineffective: the transmit is not stopped, and its red LED is lit at the channel setter's station. But on all idle lines, Qx3.5 turns on, Dx1 shunts its mike gate Qx1, the red LEDs light, blocking all new keying, so the channel setter can select a radio for a channel change without being interrupted. Having done so quickly, the channel button is released and the system returns to normal.

During channel set, tapping the PTT key sends a latch command to the latch IC's. On page 7, EN 1 is normally held low by Q3e1, its pin 5 at 2v due to R1e1 (dividing 5v by Q3e1's input resistor). If Line 1 goes to 4.4v (ordinary PTT) Q1e1.2 goes high enough to turn Q1e1 on, passing the line 4.4v through R4e1 to Q2e1.1, which turns on and pulls Q1e1.1 down through e1D. This snaps them hard on, so audio on the line does not modulate its state. Q3e1.6 does not drop, as R4e1 bypasses enough current so it does not reach its input threshold, so EN 1 stays low. Q2e1.5 low through e1D also shorts AnyData at Q2e1.3, so that pressing Channel-PTT in the wrong order (as PTT-Channel) does not set a channel; it just keys the radio, and the channel press is ignored.

But, if any channel button anywhere is pressed first, AnyData goes high, turning on Q2e1-4 (all four), taking Q3ex.1's low. Then if any line *x* goes to 4.4v (PTT button x is pressed), when Q1e*x* turns on, so does Q3e*x,* taking Q3e*x*.5 low. This snaps on via e1D fed back to Q1e*x*, and turns off Q3ex.3, so that EN x goes high. This tells the latch to transfer the AB data to its output, setting the channel indicator for the x radio. If you have the dexterity and will, you can set two (or more) radios to a channel at once. It just takes more fingers. At the hub end the same logic occurs, sending data to the radio to set the channel.

Audio Indication (Page 9)

The lines are sent through Raix/Caix1 to Daix, which detects activity and charges Caix2. If charged above the input threshold of Qaix, it turns on, grounding Redx through Rx5b. Tracing Redx to pages 2 and 3, this drives the red LED's, so they flash if audio is loud enough to turn on Qaix. The threshold matches the optimal level on the line, just below the AGC limit, so flashing does not occur at suboptimal levels.

Paging encoder input (page 10)

An optional stereo jack accepts PTT and tones from an external paging tone generator. If configured for fixed radio paging (JuTK

[**Ju**mper **T**one **K**ey] in), PTT turns on Qte1, powering Qte2, an emitter-follower interface that submits the tones to the attached line at low impedance and about 5v DC, i.e., just like a 5th button (four being on the desk unit). Cte2, Cte3 (if present) soften the abruptness of keying and unkeying to prevent speaker pop. You will hear the tones as they go out. Which radio transmits is selected by a wire jumper from TFB (**T**one **F**ollower **B**us) to the appropriate radio line. An optional SPDT toggle switch can allow a choice of two radios for paging, provided there is room to install it on the desk unit.

Foot Switch

Footswitch input is connected to ring 2 of a TRRS plug (see jack Jte-alt, pin 3, SK) if it is to follow the radio selection. SK is sent to Qte (page 1). This takes FSB (**F**oot **S**witch **B**us) high, which takes the four emitters of Qfs1, Qfs2 (page 4) high. One base is low, by its select flipflop being set, so that transistor will turn on. This sends +10 to the PTT switch of its radio (at FS1-4), the same as if that switch was pressed by hand.

If a TRS jack is used and the paging encoder key is connected in **parallel** with the foot switch, either the encoder will send out on the selected radio via FSB (JuST in), or the footswitch will key the fixed radio via TFB (JuTK in). Installing both jumpers would cause both the fixed and the selected radio to key together, which you are unlikely to want.

Circuit Description - Hub

Radio Interface cables (pages 1, 2)

R2k1-4 pull up PTT so that if power to the hub dies, the radios will not lock in transmit. Only one Motorola cable is shown. The default cables are about 15 inches long.

For Kenwood, receive audio must be taken from the speaker output IC. The DETO output provided at the accessory jack could be used, except it is neither squelched nor unscrambled. With some work, external squelching could be provided (combining the COR [Carrier Operated Relay] and TOR [Tone Operated Relay] outputs) but there is no easy way to access unscrambled audio except at the speaker output. This should be jumpered to the accessory jack through a resistor (see the installation section). Speaker out has the disadvantage of being subject to the front panel volume control, so that has to be programmed so it cannot be turned down too low (it still can be turned up too high). In Motorola radios, clear squelched receive audio is an accessory pin function.

Power distribution and Channel Set (page 3)

Raw 13.6v is sent through resettable fuse F2 to the desk units. Fuse F1 may be external, part of the power cable. U2p supplies 10v DC to the hub. From that is derived the 5v power rail, which is also used as half-10v reference for the audio sections. Regulation may be imperfect if the system is powered by a 12.0v brick. It is designed for the standard radio power of 12.6 to 14v, which can be a lead-acid battery in the field.The channel set latches are identical to those in the desk units, except the not-Q outputs drive the radios and there are no LED's. There is no spark protection on these. The cables to the radios are not intended to be very long, typically less than 20 feet, in fact usually only about 1 foot if all the radios are in one rack.

Channel set logic on page 5 will be explained later.

Receive Audio

Page 4 shows the receive AGC. This is similar to the microphone's, except R2#x is a trimmer to allow adjusting for different inputs. Although the radio interface cable can send COR and TOR if it is programmed, this is only used for the repeater option, not audio path squelching. Pads are provided for diodes between Rsqx and Qsqx; if installed, COR+TOR will squelch the audio path (high = squelched). The radio provides squelch when Rx comes from the speaker output.

The Rx AGC output is 2.5v pp at 5v DC, the same as from the mike AGC. This is used just like the mike bus for repeater keying, to be explained later.

Receive Audio Logic (pages 5, 6)

Audio is divided down by R5#1/Ra#1 to 1v pp, 2.1v DC. Follower Q2#1 puts out 1v pp, 1.5v DC at Rb#1. The audio portion passes out to the line (L1) through C5#1, and on to the dispatchers at a low impedance.

Monitor latch

If the line rises to 2.5v (Intercom/Monitor button pressed), the up ramp passes first through C2mr1 to Qmr1, turning it on quite briefly. This shorts out Cmr1. If the line stays at 2.5v for more than about 1/3 second, after a brief delay set by Rd#1 and Cmr1, Qmf1b turns on, taking Mon1 low, turning off coded squelch. Qmg1 dual PNP turns on, pin 1 being high from the line 2.5v. While the Intercom button is held down, Qmg1a (the upper half) stays on, sending the 2.5v line voltage to Qmf1a, which is turned on, shorting out the input of Q2#1. Q2#1 emitter drops to zero, snapping Qmg1a on. The receive audio is muted by Qmf1a, so it does not collide with mike audio: this is Intercom. When the Intercom button is released, the line voltage quickly drops, but Qmf1b stays on longer as Cmr1 discharges back through Rd#1. Qmf1a turns off first, restoring 1.5v DC at Rb#1. This passes out through Qmg1b and Schottky diode Dmf1 to the line at about 1.2v. This is halts the discharge of Cmr1 and is enough to hold Qmf1b on, so Monitor stays set. The 1.2v on the line turns on Q13.4 in all desk sets, which lights red LR1 dimly, telling all users that radio 1 is set to monitor.

If the line is now briefly pulsed to 2.5v by tapping the Monitor button, Qmr1 turns on again, emptying Cmr1, turning off Qmf1b. (C2mr1 had long ago emptied out back through the input of Qmr1, readying it for another pulse.) Since the line is not held high long enough, Cmr1 does not charge up and Qmf1b stays off after the pulse. Mon1 is now high and the radio is in coded mode again. Qmg1b is off again, and the 1.5v at Rb#1 is disconnected from the line, and the dim red indicators go off.

In all of this, Qof1.2 never rose high enough to turn Qof1 on, so none of the circuit below it was activated. This area is the same as the priority logic in the desk units, except that Qk1 (Q2e1 in the desk) does two more things: it is sent to the radio as PTT (K1) and to Cmr1 as monitor reset, through Dk1. Dk1.1 can be left unconnected if Mon-reset-on-PTT is not desired.

Data B is used directly as hub AnyData. If Data B is at least .9v, Qk1.5 is low, preventing PTT and sending PTT to Qen1, so that hEN1 goes high, setting the latch, as in the desk unit.

Recording Buffers / Modulation Out (page 7)

A quad high-output op amp takes audio off the line through C1bx and R1bx, with gain set to 3.8 by R3bx/R1bx. Output goes to 600:600 ohm isolation/balancing transformers to the logging recorder. If the recorder is on the same rack there is no need to use the transformers; see the impedance balancing alternate at the bottom of the page. Transformers allow for hum-free long lines to a recorder at another location.

Record audio also goes through R4b1-4 to the modulation set trimmers VRT1-4, and on to the radios through C3b1-4. Q2k1-4

hold these shorted out except during PTT. Kenwoods require this because its receive and mike circuits are shared in the radio; receive audio going to the recorder would loop back into the radio via TXAFI and cause howl. The Q2k's prevent that.

Repeater Function (page 8)

R1p1 and R2p1 divide the 2.5v pp audio and 5v DC at Rx1 to 1v pp and about 5.6v DC, the step **up** in voltage due to R2p1 being taken to +6v, not ground. At Qrp1.1, this will be 1v pp and 5v DC when Qrp1.4 is turned off, but it is not connected to anything if neither repeat switch S1r1 or S2r1 are set to "R". When switched to "R", Qrp1.4 is held on by CTOR (COR+TOR) high (no traffic) through Rt1, so Qrp1.1 is low (0v out). R3p1 holds CTOR high if it gets disconnected, so the T radio does not get keyed if the R radio should die or be pulled. CTOR must go true low on traffic to turn Qrp1.4 off, sending 5v DC and 1v pp audio to the other side of S1r1 (or S2r1), which connects it to the T1 (or T2) bus. If another radio is switched to the same T bus (not shown, imagine S1r2), this goes out to line 2 through DL2, which drops the DC to about 4.5v. This is the same as from a keying desk unit, and the rest of the circuit acts as described earlier.

Installation - Radio modification

The accessory in/out port must provide, or be programmed or modified to provide, the following:

Squelched, unscrambled receive audio between 0.1 and 1.0 volt pp (nominal 0.2v pp), DC blocked:

Kenwood sends raw discriminator audio to pin 4 (labeled "DO" or Data Out, also DETO and DATO), neither squelched **nor unscrambled**. Since this is unsuitable, the radio should be modified to send speaker output to pin 4:

In the radio, jumper a resistor between audio output IC705 (IC706 in TK7360/8360) pin 1 and the small round pad just above the FNC7 pad. Cut the fine trace between this pad and the square pad labelled DETO to the right (see page 17). Program the volume control as minimum 4, so that when it is at its lowest setting the system will be sent the correct audio level.

The Motorola mobile 16-pin accessory jack puts receive audio on pin 11. Program it for de-emphasized/muted. In some models this is selected by a jumper. Be sure this point is post-descramble.

Monitor, active low input:

Kenwood: program pin 6, FNC1, to Ext Mon, not Ext Hook. Select "off hook decode" in Optional Features for coded squelch with the mike unplugged, else a mike (or a shorting plug) must be plugged in and hung up for coded squelch.

Motorola: Program pin 12 to Ext Mon. There may be a similar 'off hook decode' tick box to set for the same reason.

Carrier Operated Relay (COR):

Kenwood: program FNC4 (pin 9) to COR (only act low).

Motorola: Program pin 4 to CSQ Detect, act high.

Tone-operated relay (TOR):

Kenwood: program TOR to pin 11, FNC6 (only act low).

Motorola: program pin 12 to "PL/CSQ/Talkgroup Detect", active high if carrier repeat is needed when in Monitor, act low if only tone repeat is needed.

Note: neither TOR nor COR need to be programmed if you do not have the repeater option. Program only TOR if you do not need Monitor to cause carrier repeat. For carrier repeat only, program the Rx channel involved to carrier squelch, and COR to TOR's pin, act low. Use the regular cable to the radio.

For repeater switched by Monitor between COR and TOR, the cable to the radios involved must combine carrier and coded squelch detection into one output, CTOR. Cable part numbers are KCTR (Kenwood) and MCTR (Motorola). These can be used on all four radios but are only needed for those involved with CTOR repeating.

For Kenwoods, use the KCTR cable if you have no scramble and use native open-squelch DETO from the radio. Do not modify the radios to obtain Rx from the PA. The hub does the squelching.

PTT, active low input:

Kenwood: program pin 10, FNC5, to Ext PTT.

Motorola: pin 3, no programming needed. Program pin 4 to Null, active low, to supply +B to the PTT pullup in the cable.

Audio modulation input, electret mike level (0.1-0.25v pp):

Kenwood accessory input pin 5, TXAFI or DI, Data In, no programming needed. Accepts ~0.2v pp.

Motorola: Use either pin 2, External Mic Audio, 0.1v pp for full mod, or pin 5, Flat Tx Audio Input, about 0.2v pp. The "M" cable uses pin 5. If this sounds harsh to you move the wire to pin 2 and adjust the mod trimmer down some. A pin extractor tool is required to do this.

For channel change option:

Program two pins to accept binary data to set radio channels. Point the data to the channels you desire using the radio software. For Motorola, select active low.

For the Kenwood "KW" cable, assign accessory pin 7 (Port 2) to Channel Select B (MSB) and pin 8 (Port 3) to A (LSB). There is no need to program C or D as they are not used. Only active low.

Active low data means that 11 is default. So if the hub power goes off, the radio will be locked to the 00 channel. Unplug the cable or restore hub power to release the radio panel.

The Kenwood TK7160/8160 does not use binary data. It just has four direct-to-channel lines. To access all four the data will need to be decoded to 1-of-4 at the hub end. There are no plans presently to provide this, as these are older radios, but an enterprising technician could design an add-on for this. As it is, these radios will see 00 the same as 01, for a total of three channels (11, 10, 01).

If you do not need 4-channel capability on all four radios, just program the radio to ignore unneeded channel commands. For example, one of the four radios might not respond at all, another might respond only to 1 and 2, and so on. The controller will not know this and will dutifully indicate the color chosen, whether the radio changed or not.

If you do not need to change channels, a savvy technician could repurpose the data for other functions, with suitable radio programming or added interface relays/transistors. The chip that drives the output data can supply at most 25mA per bit (both low and high), and high is 5 volts. Of course the buttons would have to be labeled for the purpose installed.

Tone Encoder

Prepare a cable to connect your encoder output (see the encoder's manual for its end). On a TRS (stereo) 3.5mm miniphone plug, use tip for tones, ring for PTT. PTT is active low, and inactive OFF (or at least +9.5v, not +5v), for standby. If your encoder's not-keyed is active high but less than +9.5v, put in a series diode so only low is seen by the jack. Adjust tones to 1v p-p (a little less should work fine). There is no AGC on this input, so too much level may cause issues.

If your desk unit is configured to page on the selected radio rather than a single fixed radio (JuST in), the tone output must be switched

open in the encoder when it is not active. When active it will connect and swamp out (suppress) the desk mike. Most encoders should do this natively. If the desk is configured to page on a fixed radio (JuTK and JuFT in), disconnecting the inactive tone line is not necessary.

Footswitch

If you want to key by foot, likely you will want the foot switch to follow the radio selection. In that case, you can simply parallel it to the paging encoder key if it is connected to also follow the selection.

If you have paging hard-wired to a single radio, you may want the foot switch to have its own input. You can change the TRS jack for a TRRS jack as described in the operation section (or request this option when ordering) and assign the foot switch to the second ring. Then in the desk unit connect this to the FSB pad (see diagrams) for selected key or to a different FS pad for a fixed choice different from paging.

Installation - physical

Mount the radios into the positions desired, connecting antennas and power.

Place the hub and connect the control cables between it and the radios in the order desired.

Run the key box cable(s) from the hub to the operator positions. If needed, install splitters and desk power bricks.

Plug up the key boxes. The PTT and Mon buttons will be in the same order that the radios are connected to the hub.

Run the cable to the logging recorder. Set it to accept +4dBm at its inputs. (You may need to tweak this later.)

Plug power to the hub and turn on the radios. Check that the desk units are powered.

Synchronize the channels by setting all the radios to channel 1 at any desk unit. Confirm that all desk units agree.

Try it out to see if any adjustment is needed.

Adjustments

The Rx AGC input can be trimmed for very strong or moderately weak receive audio, but as delivered should be acceptable for the radios discussed in this manual. Only rather significant deviation from the expected level would necessitate adjustment.

Connecting a logging recorder

The line outputs to the recorder provide approximately standard line level (+4dBu) or more, that is, between 4 and 5 volts pp. This will survive lengthy cabling if need be, such as telephone line. It is 600Ω balanced and isolated and can be connected to a dedicated leased phone line (not one with DC used for dialing), or your own in-house cable. It does not have lightning protection, so that should be provided, usually at the punch block, if sending it out of the building. Adjust the recorder's input sensitivity accordingly. A typical *computer* audio line input takes only -10dB; use a 15dB pad to match the levels. A computer's line input is also unbalanced; the lines from the hub can be unbalanced just by grounding one side directly. To pad it down, use a 5:1 resistor pair, for example series 4700Ω followed by a shunt 1000Ω. Most recorders should be able to accept the full level without padding, but will need to be adjusted for it. The hub output is not adjustable.

Modulation adjustment

Using a service monitor, measure the transmit deviation of each radio in turn as you key and speak. Watch that the audio indicators are lighting, which means you are reaching the AGC level. Adjust VRT1 through VRT4 in the hub to obtain full but undistorted modulation. First speak up close and loud, adjusting for full deviation. Then gradually speak more softly and confirm that the AGC still gives you nearly full deviation. At about the same point

that the red LED's stop flashing the modulation should be lower but still clearly readable. If your end user is likely to prefer the soft voice (or tends to lean back and mumble) you may want to increase the setting a little, but it cannot compensate for improper miking. The mike AGC is designed for about 0.1V pp and has no adjustment. If you need more sensitivity the best solution is move the mike closer or get a better mike. As a last resort Rm1 can be reduced.

If you do not have a service monitor, you should be able to just plug and play, as the factory settings are approximately correct. The radios themselves have modulation limiting, which is not the same as AGC, so trying to drive the radio hard will only cause distortion. The "full deviation" mentioned above is a judicious balance between the deviation meter and the audio quality as judged by the ear, assisted by the scope on the service monitor.

Desk Power

The control line is intended for runs of less than 100 feet, but it works for somewhat more. Desk units can be bridged together, then one cable sent to the radio room, but the power for all the desk units will then be supplied by a single cable. Each desk set draws about 50 mA in standby, 100 mA with all four radios keyed on channel 4. A 12.6v (auto/marine) battery can be used in the field to supply everything.

Servicing

The system is designed to be repairable by any competent technician, which means one who can read and understand the schematics and has the skill to replace small surface mount components without damaging the board or adjacent parts. The parts most likely to fail (switches and output IC's) are through-hole mount or socketed so that they are easier to replace.

All repair parts can be ordered from STM Radio or from supply houses such as Mouser or Digikey.

To open the desk unit, remove the side screws and pull the cover up. To lift the switch board, press back gently on the top rail to pop the board out of the slot. The harness is long enough to set the board aside or over the top while fully connected. If to be powered while open, be sure to protect the board from getting shorted to the lower cover. The lower board is mounted on two blocks at the sides and the jack nuts at the rear.

Use a small screwdriver or pry tool to unplug the harness when needed. Do not pull on the wires. The smaller plugs can be removed by hand, but the larger ones tend to turn as they come loose; watch for bent pins and straighten them before replugging. Lost pins can be replaced with 26 awg German silver wire (or any solderable .025" wire, but pure copper will tarnish).

When putting the cover back on, watch for buttons that get caught on the holes, and help them all come through.

To service the hub, unplug the power and remove the four screws on the LED panel. Push on the jacks to slide the board out. Unplug the inside power and pull the board clear. You can reconnect the power to do live signal tracing. Do not put the board on top of the metal box without protecting it from getting shorted. The enclosure also has a removable top panel. To slide it off, remove the four screws that restrain it, and the plastic bezel.

Default features are channel change, no repeat. When ordering, you can specify no channel change, and add repeat. These changes do not affect the price much, so order to your needs, not by cost.

Repeat Options

Half-repeat leaves off the lower four switches, for one-way repeat only. Single repeat has only two switches mounted; specify which radios (default 3 and 4). You can even get a repeat board hard-jumpered (no switches) for fixed repeating.

Paging add-on options

-P1 - (default) no paging or foot switch (no jack installed)

-P2 - Fixed tone key, no foot switch

-P3 - Select-directed tone key and foot switch. See caveat mentioned in Circuit Description/Desk Unit/Footswitch.

-P4 - Fixed tone key, selected foot switch

Your tech can reconfigure paging in the field later if needed. For P4 a TRRS jack is installed and matching plug without wire is supplied.

Accessories

RK - Repeater add-on kit. Consists of a repeat board and a panel for the hub box. *Soldering ability required.* You can request half-repeat, single, or hard-wired as mentioned above. Order CTOR cables if carrier/tone repeat switched by monitor is desired. See install notes.

KCTR - CTOR repeater cable for Kenwood

MCTR - CTOR repeater cable for Motorola

Note, cables for other radios can be designed and built on request; allow time for this. You may need to supply a radio for testing. Your tech may be able to design and build the cables for you, especially if CTOR is not needed.

Damage caused by improper installation is not covered by warranty. Pay especial attention to your cabling. Do not run it too close to strong electrical fields, including RF. You might need to use shielded ethernet cables, grounding the shield to the boxes. That will involve some hardware not supplied with the system.

Channel setting circuitry cannot be easily added in the field, but you can return your system for revision. It is more cost-effective to have this from the start, even if you do not use it at first.

This system is warranted only to work as described in suitable conditions. You accept that it may not work properly when very humid (approaching 100%), very hot (over 110º F) or very cold (below 20º F). It certainly will not work when wet or burnt. You accept that we cannot be held liable for consequent damage should the system quit, so if used for life-critical services, you should have a backup plan for staying in operation. This system is designed so that it can be quickly unplugged from the radios, making them available for direct use. Know where your hand mikes are.

We are eager for its success, so if you have any difficulty that stumps your local technician, call or email.

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Price list (2016)

Desk unit	_____
Hub	_____
Radio cable, KW	_____
Radio cable, Mot	_____
sub KCTR	_____
sub MCTR	_____
+Repeat (8 sw)	_____
+Repeat (4 sw)	_____
+Repeat (<4 sw)	_____