



Technical Application Note #2

This Technical Application Note describes the Cactus Standard Audio Requirements for repeaters and links connected to the Cactus Intertie System. The following instructions are individually described:

- Audio Tailoring Requirements
 - Frequency Response Standards
 - Distortion Standards
 - Telemetry Tone Standards
- Deviation Adjustment Requirements
 - General Requirements
 - Transmitter Deviation Corrections
- Main 440 MHz Radio Requirements
- Link Radio Requirements

The various requirements described in this Technical Application Note are to ensure all remote base radios connected to the Cactus Intertie System maintain the same high standard of audio quality necessary for the Intertie. There are only two (2) currently available controllers that meet these audio standards, Palomar Telecom and Armadillo controller. All other controllers require modifications to meet these requirements.

This Technical Application Note #2 is available in electronic form, in its entirety, that can be read with the Adobe Acrobat Reader application. To obtain an electronic copy of this document, send an e-mail message to Ken Robbins, WA6PYJ, at ken@cactus-intertie.org and request an electronic copy of **Technical Application Note #2 - Cactus Standard Audio Requirements**.

Cactus Standard Audio Requirements

Audio Tailoring Requirements

(1) Frequency Response Standards

- (a) All measurements are made using a 900 Hz tone frequency as the reference level. A 1.0 KHz tone frequency is not to be used since it is within the attenuation curve of the ID notch filters required to be in the controller. Response measurements shall be made using 50% system deviation.
- (b) For Trunk Links, links that receive from other sites and retransmit to other sites, the receiver to transmitter audio response curve should be flat to within 0.5 dB from a 250 Hz (minimum or lower) to 4.0 KHz for wideband links, and 300 Hz (minimum or lower) to 3.5 KHz for narrowband links.
- (c) For Terminal links, links that receive from other sites and do not retransmit to other sites, and for the local site Repeater, the receiver to transmitter audio response curve should be flat to within 1 dB from 300 Hz (minimum or lower) to 3.0 KHz. Some high frequency audio rolloff at 3.0 KHz is acceptable in the local site Repeater transmitter only.
- (d) For Remote Base transmitters, i.e.: 2-meters, 6-meters etc., the audio response and deviation may be additionally limited by local frequency coordination standards for adjacent channel interference. It is often necessary to feed such transmitters through the original mike input and use the stock 16F3 commercial splatter filters, clippers, and audio response limiting circuits.
- (e) Remote Base receivers, i.e.: 2-meters, 6-meters etc., shall have the same audio response as the Terminal Links and local site Repeater, flat to within 1 dB from 300 Hz (minimum or lower) to 3.0 KHz, with a desired flatness of 0.5 dB at 3.0 KHz preferred. Many receivers with CTCSS filters have trouble making a flat audio response below 400 Hz, so the acceptable flatness at the lower frequencies can be 1dB.

(2) Distortion Standards

Precise distortion measurements are not usually made. Link deviation values **MUST** be chosen so as to prevent visible distortion of the waveform with a pure sinewave at 100% system deviation. The deviation value chosen for a link must take into account the necessary head room required by audio delivered to this link from other sources, such as a noisy mobile signal. Many narrowband receivers distort **SEVERELY** at 5.0 KHz due to the ringing of their crystal filters. Such receivers are best operated at 4.0 KHz (or less). It may be necessary to perform an IF sweep alignment with certain receiver types to obtain an acceptable bandwidth and distortion. Wideband receivers are generally quite clean up to 15 KHz or so, but in order to accommodate the occupied bandwidth of our modulation standard, 10 KHz is recommended. This allows the high frequency components and level "overshoots" to come through more cleanly.

(3) Telemetry Tone Standards

All dualtone multi-frequency (DTMF) tones and single tones must conform to Telecommunications (Bell Laboratory) standards. All frequencies shall be ± 2 Hz tolerance.

Deviation Adjustment Requirements

(1) General Requirements

- (a) All deviation level adjustments are set using a 900 Hz tone. DO NOT use a 1.0 KHz tone. The required ID notch filters in the controller will slightly attenuate the 1.0 KHz tone audio level as it passes through the controller.
- (b) Take any receiver using CTCSS out of decode mode and set all levels without the CTCSS tone.
- (c) With the instrument(s) that will be used for the deviation level setting, connect the generator output to the monitor input and set the deviation of the 900 Hz tone to 50% of full system deviation, 2.0 KHz for a narrowband receiver (4.0 KHz), 2.5 KHz for a narrowband receiver (5.0 KHz) or 5.0 KHz for a wideband receiver (10.0 KHz). Make sure both monitors agree on the deviation level.
- (d) All receiver to transmitter deviation adjustment ratios have been specified as either a 1 to 1, 1 to 2 or 2 to 1 ratio depending on the narrowband and wideband configurations. These ratio numbers must be adjusted slightly to match the maximum system deviation value chosen for each link based upon the specification in section 2 above. (i.e.: from the 4.0 KHz link receiver to the 5.0 KHz 440 transmitter, the ratio would be 1 to 1.25 instead of 1 to 1)
- (e) The link deviation standards for the following receivers are:

Motorola "L" (WB)	10.0 KHz	Motorola "M WB SP"	10.0 KHz
Motorola "M"	3.5 KHz	Motorola Micor	4.0 KHz
Motorola Mitrek	4.0 KHz	GE MASTR II	4.0 KHz
GE MASTR Pro (WB)	10.0 KHz	GE MASTR Pro (NB)	4.0 KHz

(2) Transmitter Deviation Corrections

- (a) Take any transmitter using CTCSS out of encode mode. If this is not possible, carefully measure the CTCSS peak deviation and add the deviation value to the target deviation levels specified in this procedure. Example: if the CTCSS peak deviation is 600 Hz and the audio target deviation specified is 2.5 KHz, the corrected deviation will be 3.1 KHz ($0.6 + 2.5 = 3.1$).
- (b) Measure transmitter noise by injecting a full quieting, on channel signal into a receiver. Adjust the monitor's frequency to measure the desired transmitter. Turn Off the 900 Hz tone deviation at the generator and accurately measure the deviation of noise generated by the transmitter.
- (c) The proper deviation level to be set is the value chosen as a result of this section and section 1 above and is 50% of full system deviation level plus the transmitter noise level measured plus the CTCSS level.

Main 440 MHz Radio Requirements

- (1) All 440 MHz band mobile relay (user) channels shall use narrow band frequency modulated deviation, 16KØF3E (± 5 KHz). Continuous Tone Coded Squelch System (CTCSS) must be used on the 440 MHz receiver input. The CTCSS frequency shall be assigned by, or approved by, the Board of Directors of the CACTUS Radio Club, Inc.
- (2) The 440 MHz receiver to 440 MHz transmitter audio repeat level shall be set to a 1 to 1 ratio. The repeat deviation level shall be set using 50% of full system deviation, 2.5 KHz plus corrections.
- (3) For wideband links, the 440 MHz receiver to 420 MHz transmitter audio repeat level shall be set to a 1 to 2 ratio. The repeat deviation level shall be set using 50% of full system deviation, 2.5 KHz for the narrowband 440 MHz receiver and adjust the transmit deviation level to the corresponding 50% of full system deviation, 5.0 KHz for the wideband transmitter (10.0 KHz) plus corrections.
- (4) For narrowband links (4 KHz), the 440 MHz receiver to 420 MHz transmitter audio repeat level shall be set to a 1 to 0.8 ratio. The repeat deviation level shall be set using 50% of full system deviation, 2.5 KHz for the narrowband 440 MHz Receiver, and adjust the transmit deviation level to the corresponding 50% of full system deviation, 2.0 KHz, for the narrowband transmitter, plus corrections.
- (5) The 440 MHz receiver to other narrowband FM transmitters (not link) audio repeat level shall be set to a 1 to 1 ratio. The repeat deviation level shall be set using 50% of full system deviation, 2.5 KHz plus corrections.
- (6) The other narrowband FM (not link) receivers (5 KHz) to 440 MHz transmitter audio repeat level shall be set to a 1 to 1 ratio. The repeat deviation level shall be set using 50% of full system deviation, 2.5 KHz plus corrections.

Link Radio Requirements

- (1) All link radios shall be in the amateur radio spectrum above 420 MHz. There shall be no links contained within the mobile relay band of 440 to 450 MHz. Reference to a 420 MHz band link within this document implies the definition above.
- (2) All 420 MHz band links for use in the CACTUS Intertie System shall be full duplex links.
- (3) All 420 MHz band link channels used for the CACTUS Intertie System shall use wideband frequency modulated or phase modulated deviation, 30KØF3 (± 10 KHz) where-ever possible. Continuous Tone Coded Squelch System (CTCSS) shall not normally be used on the 420 MHz link channels unless interference to the link receiver requires the use. If receive CTCSS is deemed to be required, the CTCSS decoder shall have a decode response time of no greater than 150 milliseconds.
- (4) As a goal, all 420 MHz links shall have receiver sensitivities and transmitter output power that provides at least a 20dB path fade margin above a 30 dB quieting signal in both directions.
- (5) For wideband to wideband (10 KHz) or narrowband to narrowband (4.0 KHz) links, the 420 MHz receiver to 420 MHz transmitter audio repeat level shall be set to a 1 to 1 ratio. The repeat deviation level shall be set using 50% of full system deviation, 5.0 KHz for wideband to wideband (10.0 KHz) or 2.0 KHz for narrowband to narrowband (4.0 KHz) plus corrections.
- (6) The 420 MHz receiver to 440 MHz transmitter audio repeat level shall be set to a 2 to 1 ratio for wideband links (10 KHz) (a 1 to 1.25 ratio for narrowband (4.0 KHz) links). The repeat deviation level shall be set using 50% of full system deviation, 5.0 KHz for the wideband receiver (10.0 KHz) or 2.0 KHz for the narrowband receiver (4.0 KHz) and adjust the transmit deviation level to the corresponding 50% of full system deviation, 2.0 KHz for the narrowband transmitter (4.0 KHz) plus corrections.
- (7) The 420 MHz receiver to other narrowband FM transmitters (5.0 KHz) (not link) audio repeat level shall be set to a 2 to 1 ratio for wideband links (a 1 to 1.25 ratio for narrowband links). The repeat deviation level shall be set using 50% of full system deviation, 5.0 KHz for the wideband receiver (10.0 KHz) or 2.0 KHz for the narrowband receiver (4.0 KHz) and adjust the transmit deviation level to the corresponding 50% of full system deviation, 2.5 KHz for the narrowband transmitter (5.0 KHz) plus corrections.
- (9) The other narrowband FM (not link) receivers (5.0 KHz) to 420 MHz transmitters audio repeat level shall be set to a 1 to 2 ratio for wideband links (a 1 to 0.8 ratio for narrowband links). The repeat deviation level shall be set using 50% of full system deviation, 2.5 KHz for the narrowband receiver (5.0 KHz) and adjust the transmit deviation level to the corresponding 50% of full system deviation, 2.0 KHz for the narrowband transmitter (4.0 KHz), 2.5 KHz for the narrowband transmitter (5.0 KHz) or 5.0 KHz for the wideband transmitter (10.0 KHz) plus corrections.