A HIGH POWER SINGLE CHANNEL AML MICROWAVE RELAY SYSTEM

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Theta-Com Theta-Com Theta-Com

A microwave transmitter and receiver are described which utilize the successful Theta-Com of California Amplitude Modulated Link concept. This newly developed product consists of a high power transmitter, which provides a translation of the VHF spectrum of a T.V. channel to an assigned microwave frequency channel with up to 5 watts of peak microwave power output, and a microwave receiver which faithfully downconverts the received signal to the desired VHF, T.V. channel and provides a stable, constant output over a wide range of atmospheric conditions.

In the transmitter the VHF input signal is upconverted by a unique single sideband suppressed carrier parametric upconverter. The receiver, which has a wide dynamic range AGC, may be utilized to receive many channels simultaneously without introduction of undesired crossmodulation.

Today, I shall describe for you the unique microwave transmitter and receiver developed by Theta-Com of California which utilizes the successful Theta-Com of California AML concept. This particular system has the advantage of requiring the minimum microwave spectrum for each TV channel, that is 6 mhz per channel, and operates with input and output signals at the VHF frequencies of the TV channels rather than at video baseband. The microwave frequency band allocated for local distribution service for CATV application is 12.700 to 12.950 ghz, a 250 mhz wide band, thus the AML system is capable of transmitting 40 channels of TV information in contrast to 10 channels as transmitted by conventional FM relay equipment. Since the requirement for increased channel capability is growing at a rapid rate in the CATV industry, the ability to add channels is considered to be an important advantage of the AML system particularly in urban areas with growing frequency congestion.

Figure 1 shows how the CARS band frequencies are allocated to specific VHF channels.

Figure 2 is a view of the front panel of the high power Single Channel Transmitter model AML-STX-141. A panel meter and selector switch are mounted on the panel to provide the user with the ability to monitor the important functions of the unit.

Figure 3 is a block diagram of the single channel transmitter. A solid state source with an output frequency of approximately 12.646 ghz is phase locked to an integral harmonic of an ultra-stable crystal controlled oscillator. The crystal oscillator is in a thermal enclosure, which holds the temperature of the oscillator within a few degrees over a wide temperature range. The resultant stability of the oscillator is better than $\pm$ .0001% over the ambient temperature range from -30°C to +50°C. The output of the solid state source is fed as a "pump" signal into a parametric upconverter thru a ferrite isolator. The upconverter is also fed the VHF signal information. A variable attenuator is provided to adjust the VHF input level to the upconverter. The VHF and microwave signals are combined in the upconverter and the upper sideband signal is passed through a microwave output filter to the klystron amplifier. Another ferrite isolator is provided between the upconverter and the klystron amplifier to prevent undesirable feedback effects. A test coupler is used for monitoring the microwave signals out of the upconverter. The klystron amplifier is a high power active filter. In this circuit it is operated in the linear region of its operating characteristic, having a gain of approximately 42 dB and a frequency bandwidth of about 25 mhz. The output of the klystron amplifier is then fed through another ferrite isolator into a bandpass filter. This filter is a narrow band microwave filter designed to pass only the frequencies of the particular TV channel being transmitted. It is primarily utilized to provide the necessary isolation when multiplexing channels, and to remove unwanted spurious outputs of the klystron amplifier. The signal then passes through a harmonic filter which eliminates 2nd and 3rd order harmonics and through a coupler which has a crystal detector output for monitoring the signal level of the output. The output is then ready for multiplexing with other channels or attachment to the antenna system.

Figure 4 is a top view of the transmitter unit. The output power which can be obtained from the transmitter is largely a function of the linearity of the upconverter and klystron amplifier.

Figure 5 shows the test set which we have used to measure the spurious outputs of the transmitter versus the power output.

Figure 6 is a typical measurement of the spectrum of the transmitter with a three tone VHF input signal and with 1 watt of output power. The audio subcarrier is adjusted to 17 dB below the video carrier and the color subcarrier to 20 dB below the video carrier at the TV modulator. As you can see, the results are quite good. The beat between video, audio and color subcarriers is down 68 dB and the video-audio beat is down 66 dB. To obtain 1 watt power, output typically requires 40 dBmV VHF signal input. If the VHF signal level is increased, the microwave power output shows a corresponding increase.

Figure 7 shows the spectrum of the transmitter with 5 watts of output power. The beat between video, audio and the color subcarriers has increased to a level 59 dB below the video carrier, while the beat between the video and audio carriers has increased to a level 56 dB below the video carrier. The transmitter has been type accepted by the FCC up to an output level of 5 watts, thus the level at which the user will operate the equipment will depend on his particular system requirements.

Multiplexing of transmitters may be accomplished by conventional techniques utilizing ferrite circulators as combiners.

Figure 8 shows a typical multiplexing scheme. The output of channel 1 is circulated in circulator 2 to the output port of the number 2 transmitter. The band pass filter, in the unit previously discussed, reflects the channel 1 signal back to the circulator which then circulates the signals of channel 1 and 2 to the output port, and then on to circulator 3, where the process is repeated until the antenna port is reached.

The AML single channel receiver Model SRX 250 is capable of receiving and translating to VHF frequency any of the 40 channels operating in the 12 GHZ CARS band.

Figure 9 is a view of the front panel of the receiver. The front panel meter provides the user with the ability to monitor the important functions of the unit, including AGC voltage.

Figure 10 is a block diagram of the receiver.

The AML single channel receiver Model SRX 250 consists of 6 basic subsections. These are the preselector filter, mixer and pre-amplifier, microwave solid state source, crystal oscillators, AGC amplifier and ferrite attenuator, and the DC power supplies.

The received signal is passed through the bandpass filter which is designed to have minimal insertion loss in the passband, while providing in excess of 50 dB rejection of image frequencies. The microwave signal is then applied to a microwave mixer. The microwave mixer consists of a folded hybrid tee, utilizing two low noise, hot carrier mixer diodes. The diodes are arranged in a balanced configuration so as to minimize the effects of local oscillator noise. A solid state source phase locked to an integral harmonic of the crystal oscillator and identical to the one employed in the transmitter is utilized as a source of local oscillator power. The microwave received signal is thus downconverted to the VHF, TV channel which had been entered into the system at the input to the transmitter. The output of the mixer is fed into a low-noise VHF preamplifier. The pre-amplifier consists of a multistage, broadband hybrid amplifier design, featuring an exceptionally low noise figure, together with exceptionally low cross modulation characteristics. The amplifiers are operated in a push-pull configuration with a gain flatness of better than .2 dB per TV channel. A broadband frequency compensated briged-T attenuator is used to adjust the output power of the pre-amplifier, which is normally set at +24 dBmV. The noise figures of the receivers is usually on the order of 10 dB, as can be seen from figure 11.

The automatic gain control (AGC) system consists of an AGC threshold adjust, RF amplifier, RF detector, video amplifier, sync-pulse peak detector, DC amplifier and ferrite attenuator. AGC action is initiated when the received TV sync-pulse exceeds the AGC threshold setting of the receiver. This level may be adjusted from -50 dBm to -35 dBm by adjusting the AGC threshold control. The output of the AGC network is a DC voltage proportional to the peak sync-pulse. This voltage is applied to a solenoid coil encircling a ferrite slab and resistance card whose attenuation to a transverse electromagnetic field propagating through a waveguide is proportional to the strength of the magnetic field applied to the ferrite. Therefore, at any signal level exceeding the threshold setting of the AGC control, the received signal is held constant. As can be seen from figure 12, dynamic range of the AGC system is greater than 40 dB with a flatness of $\pm$ 1 dB and is capable of controlling signals greater than -5 dBm. A top view of the single channel receiver is shown in figure 13. Multiplexing of the receivers is accomplished in a fashion similar to that described for the transmitters, although usually a conventional AML broadband multi-channel receiver would be used in application requiring the reception of signals from a plurality of single channel transmitters.

Figure 14 is a graph of the signal to noise ratio of the VHF output signal as a function of path length for a transmitter power output of 1 watt. For a path length of 15 miles, the signal to noise ratio will be 78 dB if 10-foot antennas are used.

Figure 15 is a graph of the predicted hours per year the signal to noise ratio will be below 35 dB due to both multipath fading and rain attenuation in a dry area such as Albuquerque, New Mexico. For a ten foot antenna, the 1 watt equipment will have signal reception below a signal to noise ratio of 35 dB, over a 15 mile path, for less than 45 minutes a year.

Figure 16 is a similar graph for a wet area such as Mobile, Alabama. The time the received signal will be below a signal to noise ratio of 35 dB, for a 15 mile path, is less than 3.3 hours.

Figure 17 is a similar graph for a more typical area such as Washington D. C. for this location, the time the received signal will be below a signal to noise ratio of 35 dB, for a 15 mile path, is less than 2 hours.

The high power single-channel transmitters and receivers are utilized in a number of applications.

1. Where propagation and path considerations indicate marginal systems performance with lower power multi-channel and single channel equipment.

2. Where user requirements demand extrodinary fade margins to reduce propagation outage times to a minimal level.

3. Where user requirements exist for a few channels now, he can obtain single channel equipment at a comparative low price, and can add channels to the system as he needs them. If he is utilizing the broadband composite receiver, he can even add channels at the transmitter without the need for additional receivers.

4. As the uplink microwave system for a two-way CATV system.

5. For studio to transmitter links.

6. For industrial and governmental transmission of video information.

7. For repeater applications where it is desirable to tie a number of distant locations to a single video system.

Figure 19 shows a 10 channel system utilizing the high power single channel transmitters.

FREQUENCY LOCATIONS OF TV CHANNELS

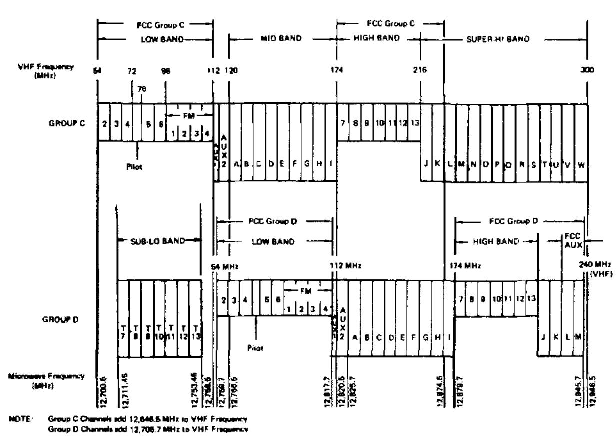


FIGURE 1

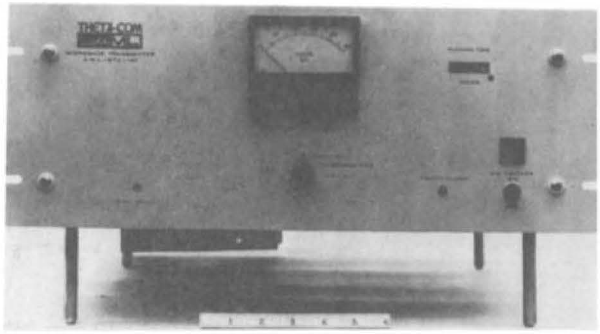


Figure 2. Front View AML-STX-141 Transmitter

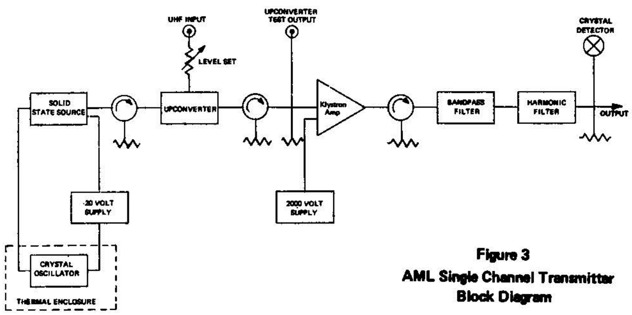


Figure 3
AML Single Channel Transmitter Block Diagram

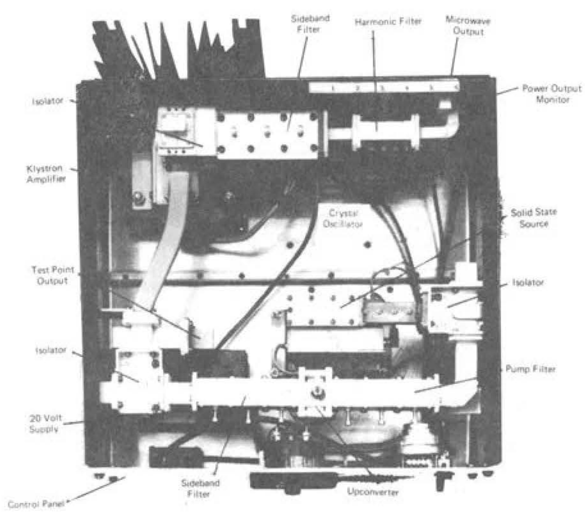


Figure 4 Top View AML-STX-141 Transmitter

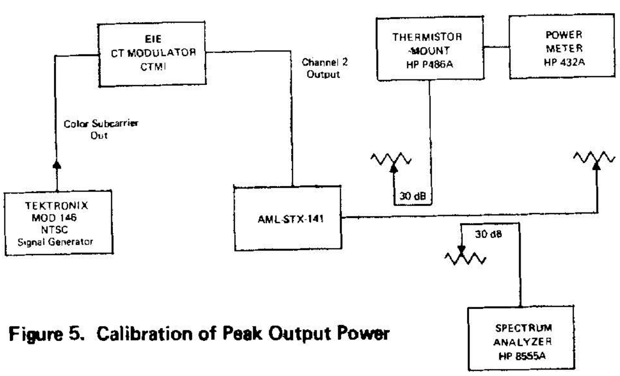
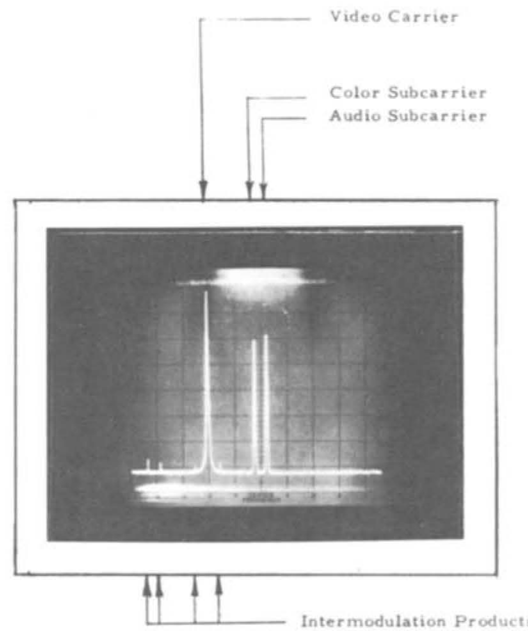
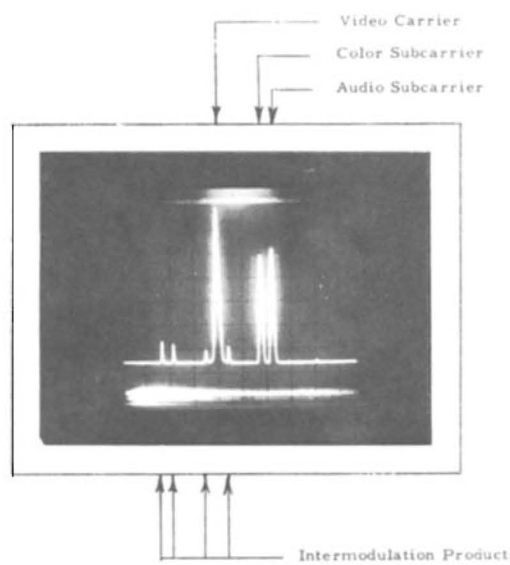


Figure 5. Calibration of Peak Output Power



Peak Power Output	1 Watt
Vertical Scale	10 dB/cm
Horizontal Scale	2 MHz/cm

Figure 6 Output Spectrum of AML-STX-141 Transmitter
1 Watt Output



Peak Power Output	5 Watts
Vertical Scale	10 dB/cm
Horizontal Scale	2 MHz/cm

Figure 7 Output Spectrum of AML-STX-141 Transmitter
5 Watts Output

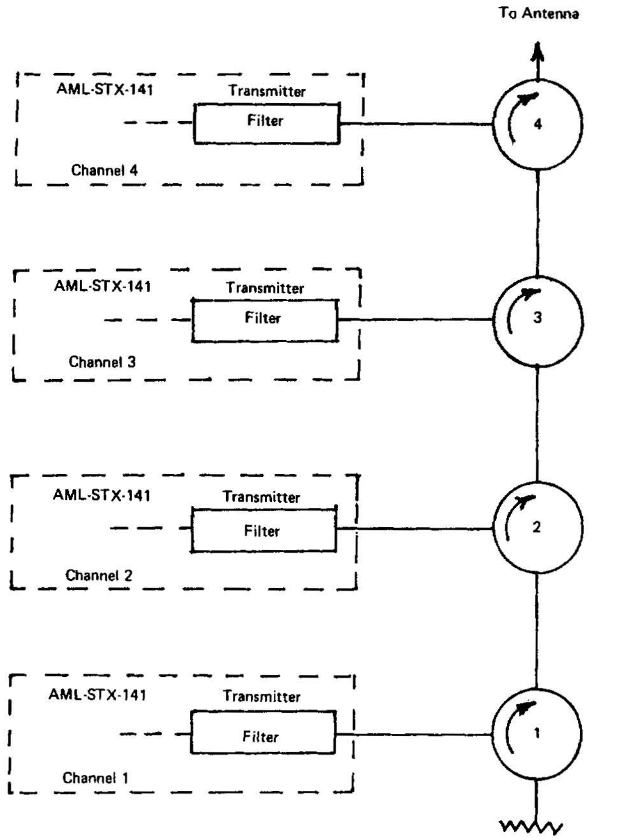


Figure 8 TRANSMITTER MULTIPLEXING

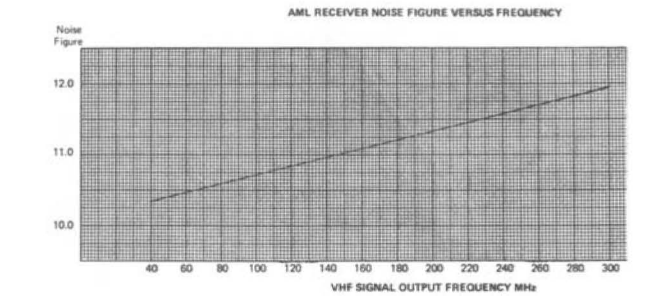


FIGURE 11

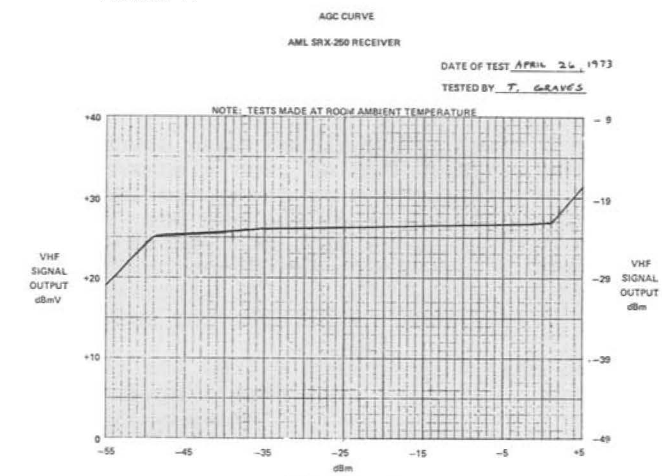


Figure 12

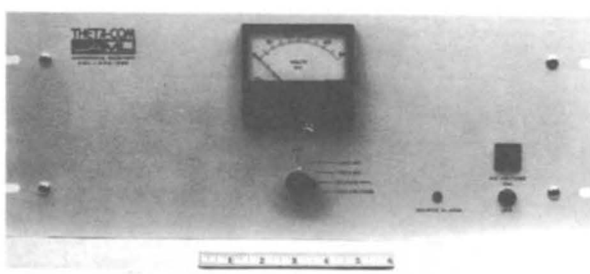


Figure 9. Front View AML-SRX-250 Receiver

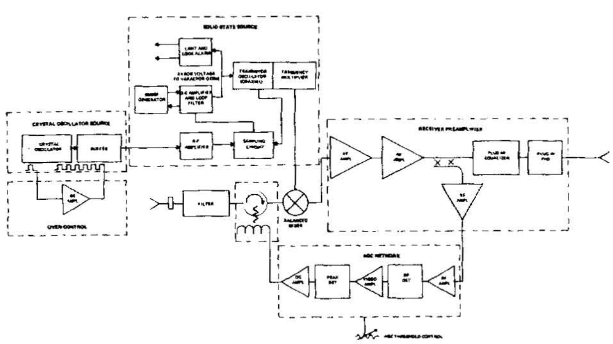


FIGURE 10 BLOCK DIAGRAM OF AML SRX-250 RECEIVER

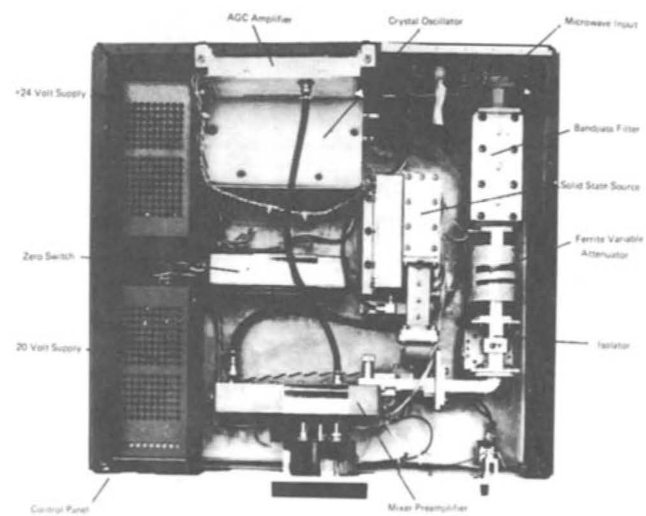
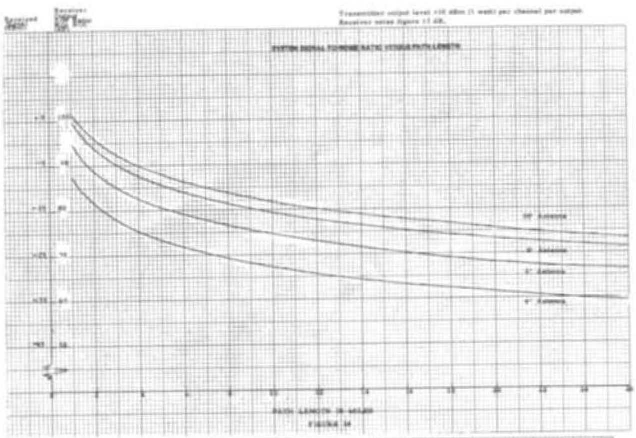
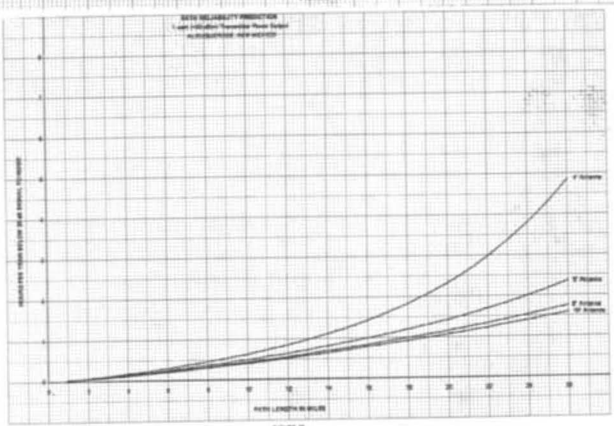
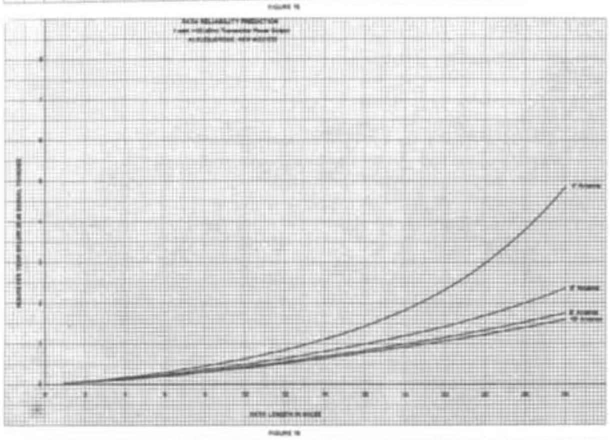
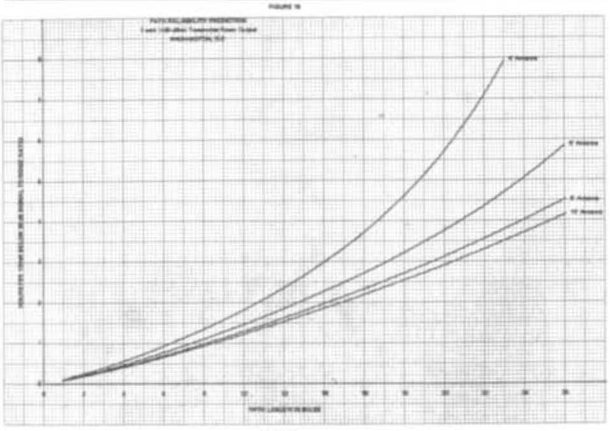


Figure 13 Top View AML SRX 250 Receiver









APPLICATIONS FOR HIGH POWER SINGLE CHANNEL AML SYSTEMS

1. Propagation and path considerations exclude lower power equipment.
2. Systems requiring higher than normal propagation reliability.
3. Systems requiring a few channels now, but flexibility to add channels later at minimal cost.
4. As the uplink microwave system for two-way CATV systems.
5. Studio to transmitter links.
6. Industrial and governmental systems.
7. Systems requiring repeaters.

Figure 18

SAN LUIS OBISPO 10 CHANNEL SYSTEM