

EMCEE PA-20U Application Note

The PA-20U is designed to provide reliable and stable UHF DTV reception in harsh multi-channel signal environments with extremely low input signal levels. EMCEE's entire product line of UHF DTV pre-amplifiers utilizes design techniques incorporating all high quality surface mount components, micro-strip circuits, and the latest E-pHEMT amplifier device technology.

Enhancement Mode Pseudomorphic High Electron Mobility Transistor (E-pHEMT) technology provides an improvement over traditional GaAsFET device designs. E-pHEMT technology can also facilitate a combination of high gain, low noise, and wide dynamic range in high-linearity LNA applications, such as UHF pre-amplifiers for commercial communication systems.

For UHF DTV pre-amp applications, the performance of E-pHEMT technology offers many performance enhancing characteristics, including:

1. Extremely low noise figure.
2. Superior output power (P^1_{dB}) and high efficiency with low bias voltages and current demand.
3. Superior power handling and third order distortion (IP^3) performance.
4. No thermal runaway effects (common to bipolar transistors).
5. No secondary breakdown mechanism.
6. The ability to survive under high mismatch conditions.

Receive System Design Considerations and Noise Contribution

System noise is not a factor when working with high input signal levels. However, when working with very low input signal power levels, the pre-amplifier noise figure is an important consideration because all contributors of noise add directly to the required input signal power level. From the perspective of the system designer, diligent link assessment calls for careful examination of all the elements of the entire link, and the complete link budget should be evaluated and calculated.

8VSB (ATSC) receivers have a C/N threshold of 15dB. The entire RF link must provide a C/N level which is above that threshold (15dB). DTV RF links do not fail gracefully as do traditional analog links. Consequently, to provide reliability the link must be designed with sufficient noise budget cushion to prevent complete link failure in case signal fades or other link anomalies occur which push the link C/N to or below 15dB, causing total failure of the link.

Generally speaking, the system C/N is established at the first active stage of the receive system which is usually the pre-amplifier. As such, the pre-amplifier noise figure sets the minimum noise figure of the system with contribution from subsequent stages being reduced by the pre-amplifier gain. In a well designed system, the noise figure can approach but never be lower than the pre-amplifier noise figure. Any noise contribution adds directly to the input signal level required to achieve the 15dB C/N ratio.

The minimum system (pre-amp) input level may be expressed as follows:

Required C/N (15dB) – ATSC Channel Noise Floor (-107dBm) – Pre-Amp Noise Figure (.5dB) = -91.5 dBm.
The required input power may be converted to dBmV using $-91.5 \text{ dBm} + 48.75 = -42.75 \text{ dBmV}$.

One can calculate the link noise performance by obtaining and using following link element values...

Transmitter EIRP (In dBm)
Path Loss ($PATH_{LOSS}$)
Receive Antenna Gain (ANT_{GAIN})
Cable Loss (RX Antenna to Pre-Amp) (C_{LOSS})
Pre-Amp Noise Figure (AMP_{NF})
Channel Noise Floor (C_{NF}) (-107 @ 5 Mhz Occupied Bandwidth)

Using known link element noise values, the system C/N performance can be calculated as follows:

$$\text{EIRP} - \text{Path}_{\text{LOSS}} + \text{ANT}_{\text{GAIN}} - \text{C}_{\text{LOSS}} - \text{AMP}_{\text{NF}} - \text{C}_{\text{NF}} = \text{C/N (at the pre-amplifier output)}$$

As demonstrated by the above formula, an increase in pre-amplifier noise figure is a one-for-one decrease in system C/N.

The Importance of Power Handling In Pre-Amp Designs

Another important issue when evaluating a pre-amplifier is the power handling capability of the device. This is particularly true in multi-carrier signal environments where combinations of the signals will cause intermodulation products to be produced, which may fall in or very near the desired channel causing interference and an increase in the noise floor. Additionally, extremely strong signals will saturate the amplifier also causing interference to the desired signal. To minimize the effect of unwanted input signals the system designer can add a pre-selector filter before the pre-amplifier to remove the unwanted signals, however the insertion loss of the filter adds directly to the system noise figure and the filter adds expense. Another solution is to use a pre-amplifier which can handle larger signal levels. The PA-20U pre-amp has a power output capability ($P_{1\text{dB}}$) of 21dBm (69.75dBmV) with an output 3rd Order Intercept (IP^3) specification of 35 dBm. The IP^3 of the amplifier is a figure of merit for the linearity of the amplifier, the higher the IP^3 the more linear the amplifier, which for a given set of input signals will produce less distortion. System designers should be very concerned with the IP^3 of the amplifiers they use, because this help them determine how large an undesired signal (at the antenna) the amplifier can handle.

The actual maximum channel loading of the amplifier will depend on the number of input carriers and their relative levels (the combination of which in the real world yields infinite possibilities and cannot be pre-calculated without knowing the number of carriers, carrier frequency, and the level of each carrier).