Applications and Requirements for Passive Gain Equalizers

Nathanael Bewick, Design Engineer, Spectrum Control

Modern Demands: Spectrum Control Solutions

In modern RF systems, as platforms evolve to higher frequencies, wider bandwidths, and distributed architectures, every component in the chain reveals slope, ripple, and dispersion that once seemed negligible. Cables that are flat over 500 MHz can show multiple decibels of tilt across wide bandwidths, and modern low-noise amplifiers require chain-level compensation to maintain link margin and calibration up to K-band (26.5-34 GHz) and beyond. In cables, equalization can reduce VSWR and counter conductor and dielectric losses. In LNA-based front ends, equalization compensates for frequency-dependent variations in the signal chain and improves the system linearity of the amplified signal. The need for gain equalization in today's high-speed, high-frequency systems is nearly ubiquitous.

Modern RF and microwave systems operate from DC through millimeter-wave frequencies, demanding precise and adaptable equalization technology. Spectrum Control has advanced this field by extending its tubular equalizer designs from DC to 35 GHz, delivering industry-leading 2-watt power handling and broadband linearity within ±0.75 dB. These equalizers are available with SMA or 2.9 mm connectors, with custom options including Type N, TNC, SMP/GPO™, and 2.4 mm connectors. Spectrum Control supports custom environmental requirements, such as thermal, vibration, shock, and average power, following MIL-DTL-3933 and MIL-STD-202 procedures, and is capable of meeting rugged airborne and defense application demands.

Principles of Equalization

Equalization corrects amplitude distortion by applying a loss profile opposite to the system's natural frequency response. Consider a high-resolution radar link operating in the K-band, where the transmitted signal must maintain precise amplitude for accurate target detection. Even small variations in amplitude linearity introduced by the transmission path, such as cable losses, can degrade performance, and these losses increase with frequency. In this example, a 20 ft length of high-frequency-rated cable operating up to 35 GHz exhibits relatively low loss at DC, where skin effect and conductor losses are minimal, but the 35 GHz signal component can experience insertion loss exceeding 20 dB.

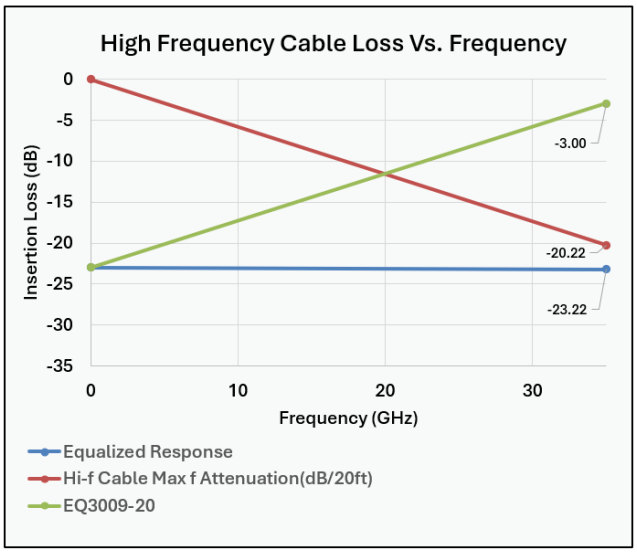

Figure 1: *Gain frequency correction for a 20 ft length of high-frequency cable.*

These losses can push system performance out of tolerance. Equalization compensates for this loss, ensuring the transmitted signal maintains a flat amplitude response and preserving the radar's ability to distinguish targets and maintain detection accuracy under stringent conditions.

Spectrum Control Equalization Solutions

With over 50 years of experience in passive component manufacturing and more than 2,500 gain-equalizer designs supporting unique customer slope requirements, Spectrum Control offers unmatched flexibility for mission-critical systems. Building on this legacy, Spectrum Control has introduced a next-generation Q-band rectangular equalizer for emerging satellite and high-data-rate applications requiring correction from 40 to 50 GHz. Additionally, the EQ3007 and EQ3009 series K-band coaxial equalizers extend frequency coverage from 18 GHz to 26.5 GHz and up to 35 GHz, respectively.

These solutions accelerate next-generation connectivity by enabling broadband compensation of frequency-dependent loss across transmission

lines while maintaining system linearity through a flattened frequency response. Spectrum Control also offers custom equalization curves from DC to 35 GHz upon request. Below is a graph highlighting some of Spectrum Control's newest and most popular equalizer offerings.

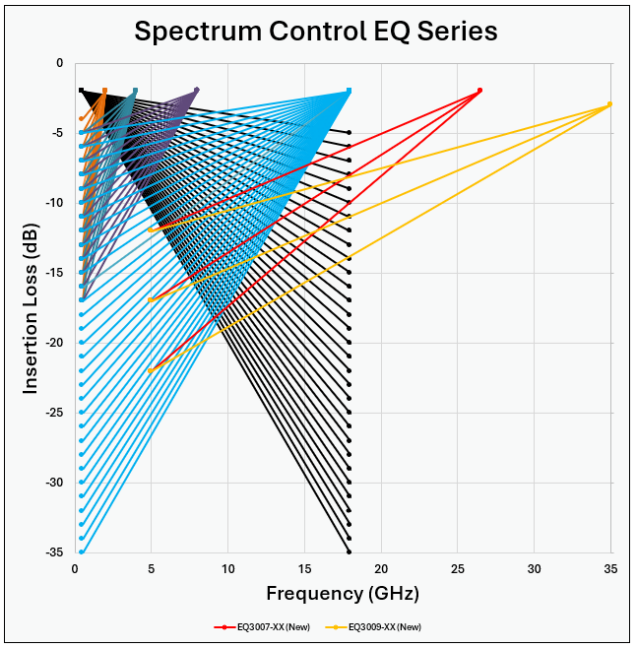

Figure 2: Spectrum Control Gain Equalizer Series