LICENSING OF GMRR TECHNOLOGY

GMRR remains small by choice to allow us to continue to focus on high-level research and development and to provide top-quality design services and technical integrity to our clients. Our designs for high-efficiency amplifiers have many benefits, including reduced power consumption, reduced operating costs, less heat dissipation, and increased reliability. Our work is commercialized by licensing our patents and designs to companies for manufacturing.

PATENTS

GMRR holds three patents on technologies for improving the efficiency of power-amplifier systems. The techniques covered by these patents may be used only with permission from GMRR.

Drive Modulation for EER/ET Transmitters

U.S. Patent 6,256,482 covers a technique for modulating the driver as well as the final amplifier in an Envelope-Elimination-and-Restoration (EER) or Envelope-Tracking (ET) power amplifier. In an EER/ET transmitter, the maximum drive level is determined by the maximum output level of the final amplifier. Operation of the driver at the maximum power level not only wastes power, but causes unwanted feed-through of the drive signal to the transmitter output. This technique partially modulates the drive amplitude with the desired envelope, thus conserving power and ensuring that the final amplifier remains saturated at low signal levels.

Split-Band Operation of Power Amplifiers

Applications such as high-level modulators for EER/ET transmitters often require more bandwidth than can be attained with a switching amplifier alone. In a split-band amplifier system, the switching amplifier produces the lower-frequency portion of the signal with high efficiency and a linear amplifier adds the high-frequency portion of the signal. U.S. 6,252,461 covers a technique for combining the outputs of two amplifiers so that frequency coverage is continuous and the amplifiers are isolated from each other. The amplifiers are combined through a diplexer. The driving signals for the amplifiers are obtained by a "negative-component" or inverse filter that corrects the amplitudes and phases for the effects of the diplexer. A variation on this technique flattens the frequency response of an amplifier by adjusting the amplitude and phase to compensate for its natural frequency response.

Electronically Tuned Power Amplifier

Proper tuning and matching of the output of an RF power amplifier is essential to efficient and reliable operation. This becomes problematic when the frequency of operation varies, the load impedance varies (e.g., due to antenna movement or changes in the load), or the desired output power changes. U.S. Patent 7,202,734 covers the use of RF power amplifiers that are tuned by electronically variable components such as varactor diodes, MEMS capacitors, BST capacitors, and inductors using variable-permeability ferrite.

Load-Modulated Power Amplifier

High-level amplitude modulation of an RF power amplifier can be achieved by variation of its reactive tuning components. With proper design, the locus of the variable load impedance thus generated provides amplitude variation while maintaining high efficiency. U. S. Patent 7,202,734 also covers the use of electronically variable reactive components to modulate the output of an RF power amplifier.

CIRCUITS

GMRR has developed a variety of high-efficiency power amplifiers for frequencies from LF to L band. These proven designs can generally be reconfigured for other applications with a minimum of NRE.

High-Efficiency Class-D Power Amplifier for LF and MF

This simple class-D RF-power amplifier can be configured for operation at frequencies up to 2 MHz. It provides 200 to 300 W peak with an efficiency of about 87 percent. The amplitude-modulation linearity is excellent and good efficiency is maintained at virtually all amplitudes.

High-Efficiency Class-E Power Amplifier for HF and VHF

This RF power amplifier has been configured for frequencies between 1.8 and 162 MHz. It provides an output of 200 W with efficiencies ranging from 86 percent at 14 MHz to 80 percent at 42 MHz to 75 percent at 162 MHz. The amplitude-modulation linearity is excellent and high efficiency is maintained over more than 10 dB of amplitude range.

High-Efficiency Amplifiers for 13.56-MHz ISM

This relatively simple amplifier can be configured for outputs of 200 or 400 W. The efficiency is 80 to 85 percent.

High-Efficiency Class-F Power Amplifier for VHF and UHF

This RF power amplifier has been configured for various frequencies between 161 and 935 MHz. A single amplifier module provides an output of 120 W with an efficiency between 80 and 85 percent. High efficiency is maintained over a wide range of amplitudes and the amplitude-modulation linearity is excellent.

Class-S Modulators

GMRR has developed a variety of class-S modulators to support high-efficiency EER transmitters. These modulators typically have an amplitude-modulation linearity that fits a straight line to better than 1-percent rms error. The efficiency is better than 90 percent over most of the amplitude range and about 95 percent at full output.1.