

New Design Techniques Enable Low Cost RF Power Amplifiers

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A new paradigm for low cost, reliable RF amplifier ‘pallets’ has been enabled by new circuit design, manufacturing and thermal management techniques

Power amplifier modules are the building blocks for many products in the MHz and low GHz frequency ranges. This portion of the RF market includes broadcasting,

RF heating, plasma and sputtering equipment, lasers and various military and aerospace systems. The terms “low cost” and “RF power” are rarely connected, but with a line of FM broadcast PA modules as a beginning, Power Module Technology (PMT) is applying patent-pending design methods to deliver high quality, reliable products at the lowest possible cost per watt of power.

Target Application Areas

Among the first applications addressed by PMT's low cost technology are FM, HDFM and Digital Radio Mondiale (DRM) broadcasting. As stations upgrade to digital transmission standards, many are choosing to modernize the transmitter plant with solid state equipment, replacing older tube-type transmitters. PMT offers a line of pallet amplifiers for both FM and DRM, using their proprietary design methods to get maximum performance from low cost vertical MOSFET and LDMOS devices.

The change to digital transmission is a worldwide phenomenon, with significant investment by broadcasters and equipment manufacturers. PMT's modular approach allows transmitter manufacturers to concentrate on the new, more complex digital portion of the system without needing to use scarce engineering resources to design the power amplifier stages.

Broadcast:	Digital television Digital FM (HDFM) Digital Radio Mondiale (DRM) Replace tube equipment
ISM:	Plasma generators Laser drivers RF heating RF Lighting Growing markets
Military:	HF Communications Replace older technology

Table 1 - Key markets targeted for low cost power amplifier module development.

ISM equipment is another area where high power and low cost are simultaneous goals. Plasma generating equipment is a growing market, supporting manufacturing of products such as flat screen displays, energy-saving glass for windows, decorative finishes and many other products.

Similarly, industrial lasers have proven their usefulness in both small- and large-scale systems. As the industrial use of lasers continues to grow, the need for RF laser drivers grows accordingly.

Even the established technology of RF heating remains a substantial market for power amplifiers. A key use of this equipment is accelerated curing of adhesives and resins. The growth of this market segment includes the manufacture of composite products, ranging from wood-based construction materials to advanced aerospace structural composites based on carbon and aramid fibers.

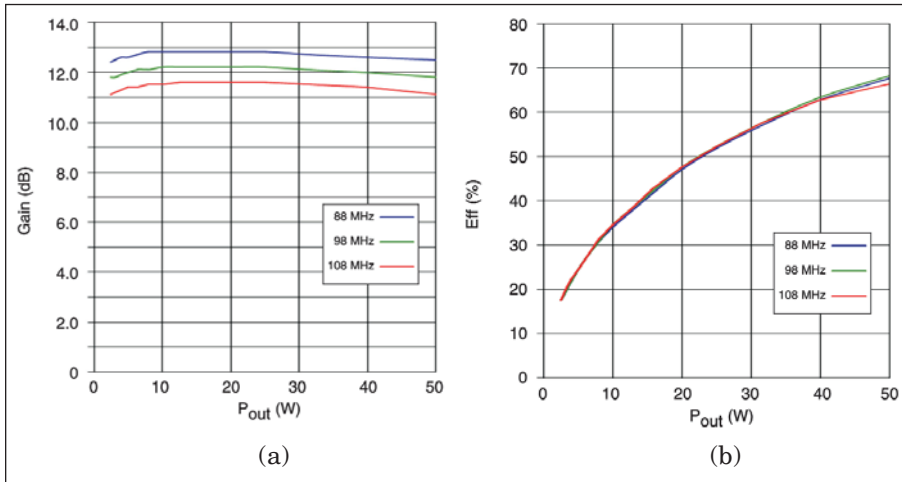


Figure 1 · CW performance of the LCFM-50: (a) gain vs. power output, and (b) efficiency vs. power output.

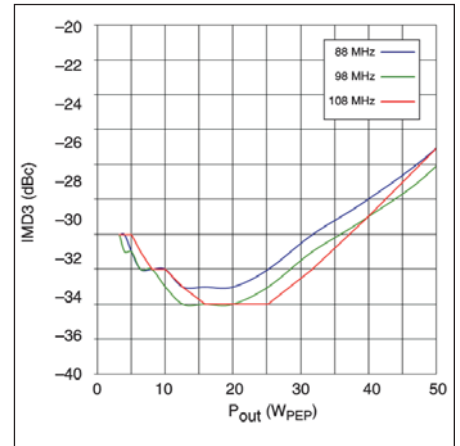


Figure 3 · IMD3 vs. power output under 2-tone test conditions.

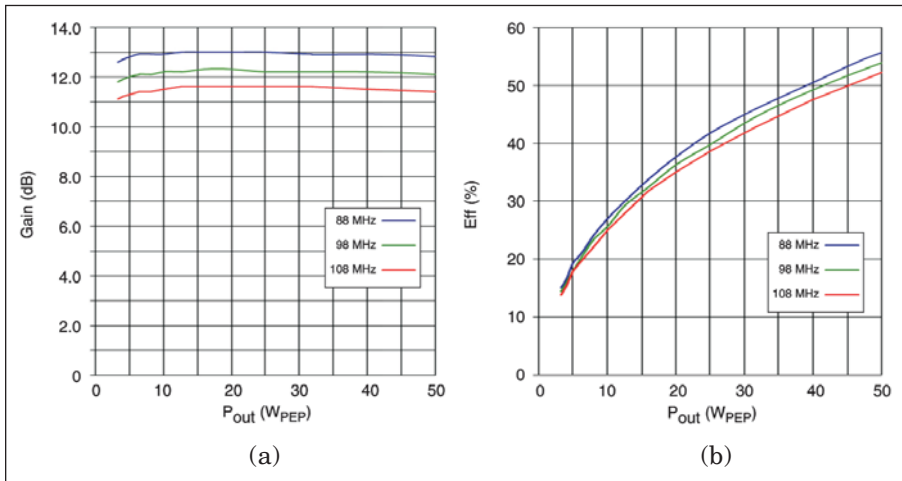


Figure 2 · 2-tone performance of the LCFM-50: (a) gain vs. power output, and (b) efficiency vs. power output.

Military and aerospace applications are sizable markets for RF power amplifiers. Although not usually considered as a low cost market,

well-established applications in lower frequency bands such as HF communications (2-30 MHz), can be addressed using PMT's cost-effective

techniques and manufacturing approach.

LCFM-50 50-Watt FM Module

PMT's FM broadcast modules are good examples of the performance that can be achieved with low cost devices. All modules feature a small footprint, solid metal base for excellent thermal performance, and 50 ohm input and output impedances to match standard components and transmission lines.

The smallest module is the LCFM-50, which provides 50 watts for driver or low power transmitter output stages. The module operates in class AB linear, with 12 dB gain and high efficiency.

The performance of the LCFM-50 is shown in Figures 1 and 2. Figure 1 shows the CW gain and efficiency, while Figure 2 shows gain and efficiency under 2-tone test conditions. Figure 4 is a graph of 2-tone, 3rd order IMD versus power output. A photo of the LCFM-50 pallet is shown in Figure 4.

LCFM-100 100-Watt FM Module

Providing a step up in linear power, the LCFM-100 FM module provides 100 watts of power with 11 dB gain and high efficiency. This module can be used in driver and out-

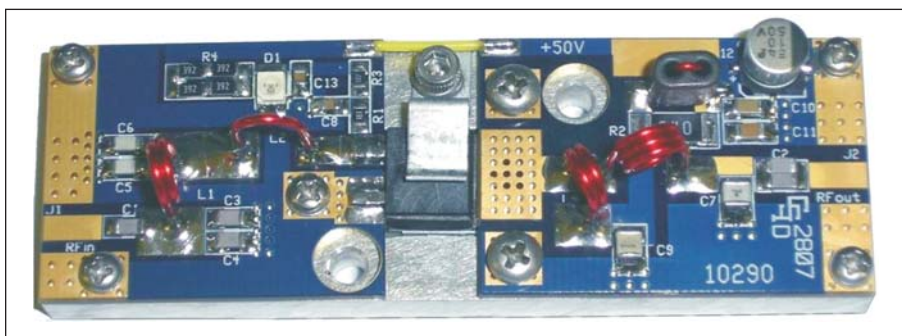


Figure 4 · Photo of the LCFM-50, 50-watt FM amplifier module.

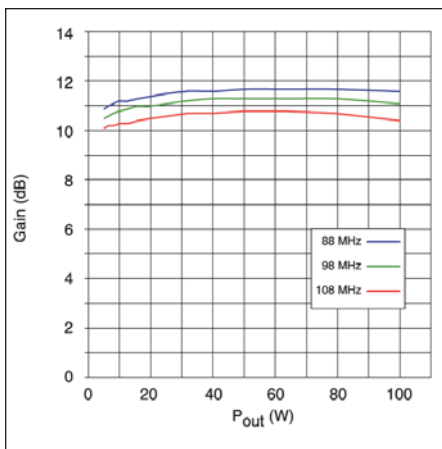


Figure 5 · Gain vs. power output (CW) for the LCFM-100 module.

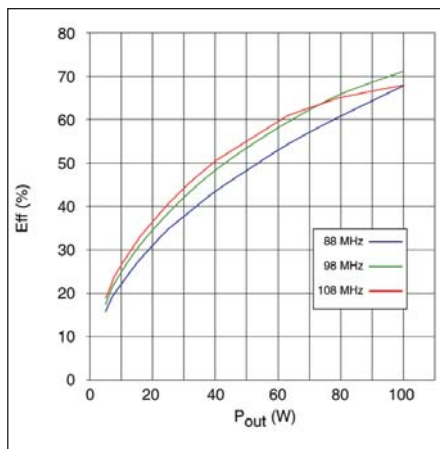


Figure 6 · Efficiency vs. power output (CW) for the LCFM-100 module.

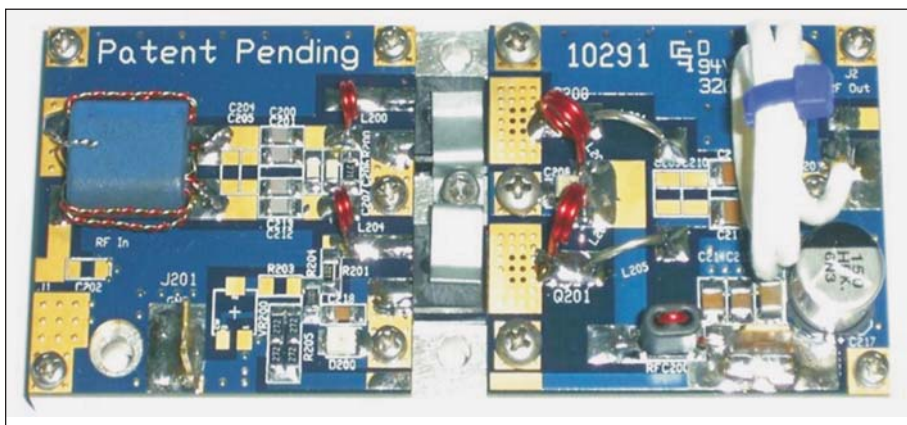


Figure 7 · Photo of the LCFM-100 FM amplifier module.

put amplifier applications where more power is required than is provided by the LCFM-50.

Performance graphs for the

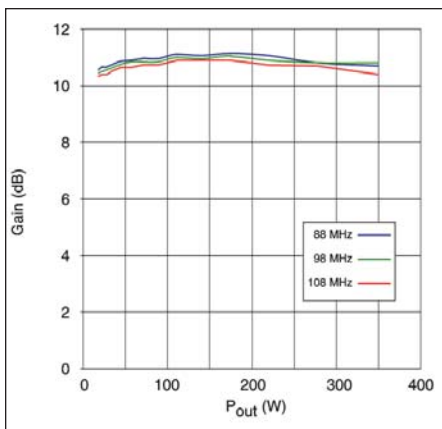


Figure 8 · Gain vs. power output (CW) for the LCFM-350 module.

LCFM-100 are presented in Figures 5 and 6, which show gain and efficiency versus power output, respectively. A photo is provided in Figure 7.

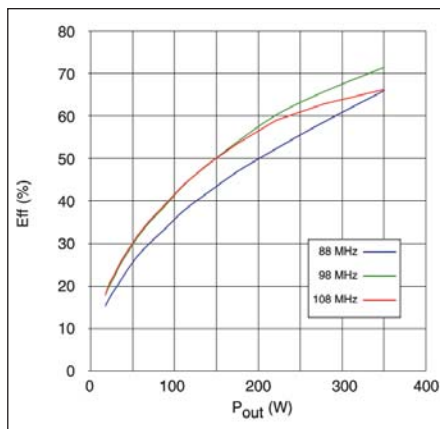


Figure 9 · Efficiency vs. power output (CW) for the LCFM-350 module.

At 100 watts output, the LCFM-100 draws 2.9 A from a +55 VDC power supply. The amplifier's mismatch tolerance is a VSWR of 5:1 over all phase angles.

LCFM-350 350-Watt FM Module

For higher power, the 350-watt LCFM-350 offers the same low cost and high performance of the smaller pallet amplifiers, with a small gain tradeoff for additional power dividing and combining circuitry. This module is ideal as a low power final amplifier, or multiple building blocks can be combined for use in higher power transmitters.

Figure 8 is a graph of gain versus power output and Figure 9 shows the efficiency versus power output. Maximum current draw is 10.8 A from a +55 VDC power supply. Like the LCFM-100, the LCFM-350 is also rated to handle an output VSWR of 5:1 at all phase angles. Input VSWR is 1.5:1 (max.).

A photo of the amplifier module is shown in Figure 10 (on the following page). The pallet measures 5.67 × 7.625 inches, with a height of 1.5 inches. Although compact in overall size, the solid aluminum base plate provides ample contact area for a heat sink.

88 to 92 MHz Amplifiers

The LCFM-350 is intended primarily for commercial FM broadcasting in the 88-108 MHz range. In part, this is because PMT offers two amplifier modules optimized specifically for the lower portion of the FM band, the non-commercial segment of 88 to 92 MHz.

The LC8892-150 is a 150 watt pallet amplifier, while the LC8892-550 is a 550 watt unit on a pallet size that is the same as the LCFM-350. The 550 watt unit has 10 dB gain and a typical CW efficiency of 68 percent. With the specified +55 VDC power supply, current consumption at 550 watts is 16.9 A. Quiescent current (bias) draw is 1.0 A, maximum.

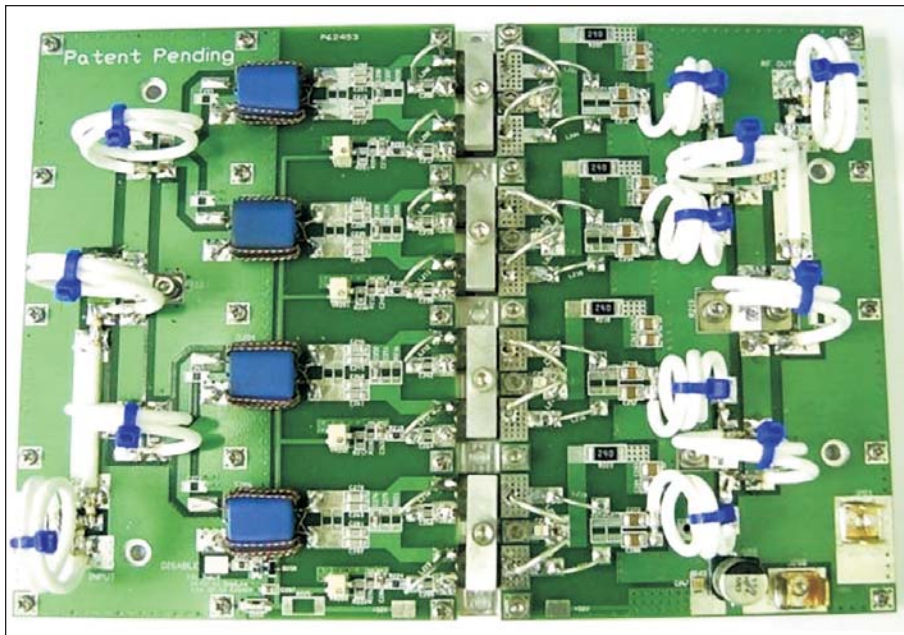


Figure 10 · The LCFM-350 pallet amplifier, which measures 5.67 × 7.625 × 1.5 inches.

These amplifiers give designers new options for the high power stages of FM transmitters, allowing simple integration of a standard 50 ohm module with known performance characteristics.

Potential Additional Products

Table 2 lists a number of pallet amplifier possibilities that would take advantage of PMT's low cost

techniques. Some of these are already in development, others have been identified as product candidates and are being discussed with potential customers. The list represents only the most obvious applications; there will be other systems requiring high power in these frequency ranges.

The range of frequencies and power levels illustrates the exceptional diversity of the RF power

P _{out} (W)	Freq (MHz)	V _{DC}	Comments	Target Application
550	88-92	50	CW, AB	FM Broadcast
1,000	26	50	Pk, OFDM	Digital Radio Mondiale
900	27.12	50	CW, AB	ISM RF Power Supply
2,500	27.12	50	Pk, Pulsed	ISM Plasma Driver
800	40.68	50	CW, AB	ISM RF Power Supply
1,750	40.68	50	Pk, Pulsed	Laser Driver
1,000	13.56	50	CW, AB	ISM RF Power Supply
2,500	13.56	50	Pk, Pulsed	ISM Plasma Driver
700	81.36	50	CW, AB	ISM FM Power Supply
1,000	81.36	50	Pk, Pulsed	Laser Driver
500	2-30	50	Linear, AB	Communications

Table 2 · Potential applications for PMT low cost amplifier pallets.

amplifier market. There are many applications that could benefit from PMT's low power design and manufacturing expertise.

Summary

Available RF Power Amplifiers have, for many years, remained very similar in design with expensive RF power transistors at the heart of the modules. PMT has broken out of the design doldrums with a truly revolutionary approach completely eliminating the traditional high cost power transistors.

PMT's ultra low cost RF amplifier pallets are very inexpensive building blocks of power presently covering FM and ISM frequencies. Superior linearity makes them an ideal match for the latest requirements of FM, HDFM, and DRM applications.

Until now high power and very high power ISM solid state tube replacement, while technically possible, has simply been too expensive. PMT's ultra low cost amplifier pallet building blocks are the answer. Solid state tube replacement in ISM RF power supplies is now a fiscal reality bringing added reliability and reduced maintenance costs to power supply manufacturers, system integrators, and users. High power, high gain, and low cost at ISM frequencies are now available in PMT's ultra low cost amplifier pallets.

Author Information

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