Achieving superior linearity in RF systems with HFET technology

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The Importance of Linearity in Modern RF Systems

RF communication technologies are evolving rapidly in response to relentless market demand for higher data throughput, improved spectral efficiency, and robust signal integrity. Wireless communication architectures increasingly deploy wideband, multi-carrier transmission schemes such as OFDM, together with high-order modulation formats (256QAM and 1024QAM). However, although these techniques provide capacity gains, they introduce linearity challenges.

Amplifier linearity is critical to overall system performance. Poor linearity directly degrades signal integrity, resulting in constellation distortion and increased error vector magnitude (EVM). Spectral efficiency is also affected, as non-linear behaviour increases adjacent-channel leakage (ACLR), making it more difficult to comply with stringent regulatory requirements. Intermodulation products further compromise system margins, particularly in multi-carrier environments.

Linearity also plays a vital role in phased-array and beamforming systems. Here, low phase distortion is essential to maintain beam alignment, array calibration, and sustained system coherence.

GaAs FET Evolution

The GaAs Field Effect Transistor (FET) has been the backbone of RF and microwave communications for decades, and has evolved significantly over that time.

MESFET

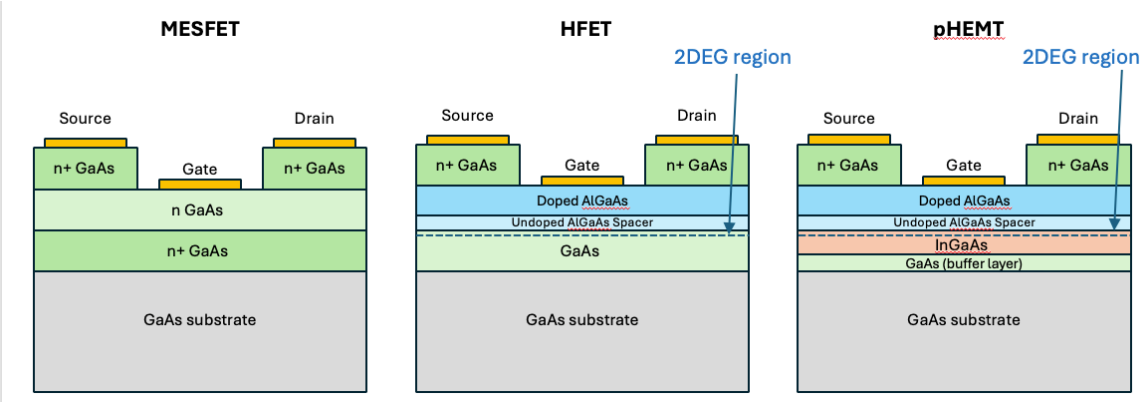
The MESFET (Metal–Semiconductor FET), also known as the Schottky Barrier FET, was the first practical RF GaAs transistor and is the foundation of all modern compound semiconductor technology. By using a Schottky gate on doped GaAs, MESFETs enabled higher frequency operation and lower gate forward voltage compared with earlier devices. The first MESFET-based MMIC was demonstrated in 1976 by Pengelly and Turner.

HFET / HEMT

HFET technology introduced an AlGaAs/GaAs heterojunction, forming a high-mobility two-dimensional electron gas (2DEG). This structure enables efficient carrier transport while maintaining highly linear device characteristics. This structure delivers improved gain, lower noise, and higher frequency RF performance compared to MESFETs.

pHEMT

The pHEMT further enhanced HFET performance by incorporating an InGaAs layer, increasing electron mobility and enabling higher gain, power, and frequency operation. While pHEMT offers superior RF capability for mmWave applications, linearity is compromised compared to HFET technology.



Advantages of HFET in Modern RF Architectures

While pHEMT devices are often selected for applications requiring higher frequency operation, HFET technology continues to excel in designs where linearity, phase stability, and distortion control are the dominant performance drivers. As a result, HFET is still widely deployed in demanding RF environments including:

- Satellite communications
- Professional digital radio systems
- High-capacity point-to-point broadband radios
- Phased array radar

As modulation schemes become more complex and bandwidths continue to expand, the inherent linearity of HFET devices supports high constellation fidelity even with advanced QAM formats, enabling low EVM performance across wide operating bandwidths.

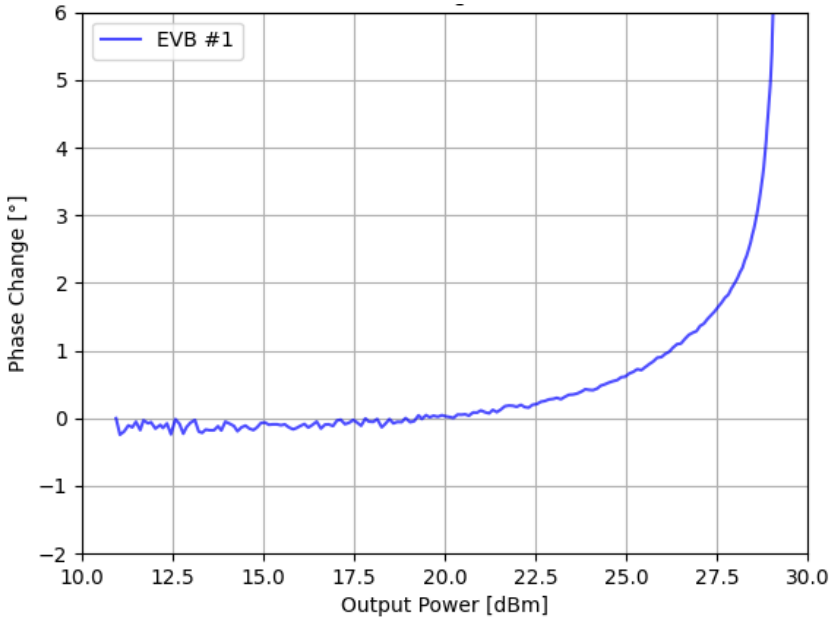


Figure 1: AM-PM distortion of MMA-495930-Q4

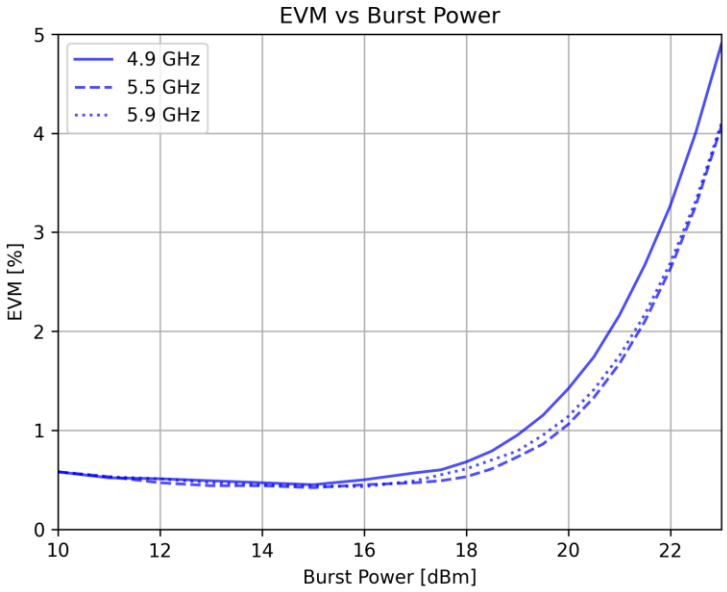


Figure 2: EVM of MMA-495930-Q4

Low adjacent-channel leakage and IM3 performance allow designers to meet tighter spectral masks without excessive back-off, improving overall system efficiency. Predictable distortion behaviour also reduces the overhead required for digital predistortion (DPD), simplifying signal processing requirements and reducing system complexity.

HFET technology further ensures a stable phase response across power levels, supporting consistent beam alignment and calibration.

Why HFET matters to CML Micro customers

CML Micro has extensive experience in HFET device design, characterisation, and production, enabling strong support for customers whose RF designs place critical demands on linearity and performance.

CML Micro HFET product portfolio

CML Micro offers two principal HFET product types, enabling designers to select the level of integration and flexibility best suited to their application requirements.

MIMIC Linear Power Amplifiers

HFET-based MIMIC linear power amplifiers are highly integrated and optimized for specific frequency bands and applications. These devices feature 50 Ω input and output matching, simplifying RF integration, and are well suited as linear driver stages for sub-6 GHz power amplifier architectures where low distortion and spectral compliance are critical.

CML Micro's HFET MIMIC linear power amplifier portfolio includes:

Part Number	Frequency Range	Output Power	Package
MMA-020624-M4	2.0 – 6.0 GHz	24 dBm	4 × 4 mm QFN
MMA-053223-M4	0.5 – 3.2 GHz	23 dBm	4 × 4 mm QFN
MMA-054025-M4	0.5 – 4.0 GHz	25 dBm	4 × 4 mm QFN
MMA-445933H-M5	4.4 – 5.9 GHz	33 dBm	5 × 5 mm QFN
MMA-495930-Q4	4.9 – 5.9 GHz	30 dBm	4 × 4 mm QFN

Discrete HFET Transistors

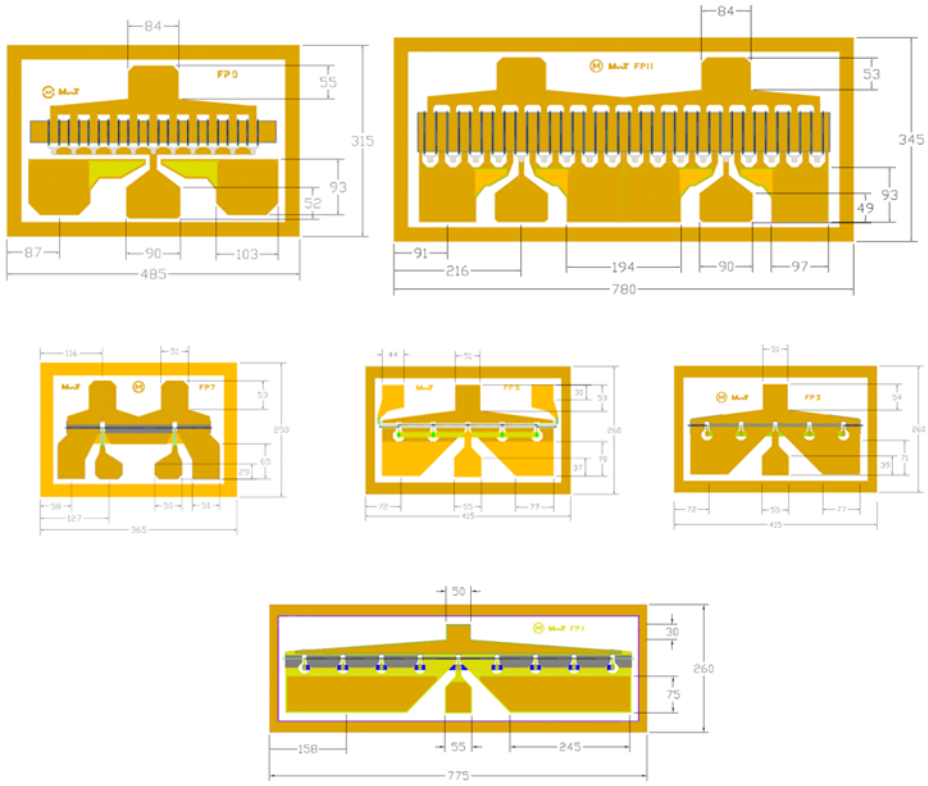
For designs requiring greater flexibility, CML Micro also offers discrete HFET transistors, available as packaged devices or bare die. These devices can be externally matched and tuned across different frequency bands and operating conditions, providing maximum flexibility for custom RF and microwave designs, where linearity and spectral performance are optimized at the system level.

Six discrete HFET transistor models are available:

- MwT-1F
- MwT-3F
- MwT-5F
- MwT-7F
- MwT-9F
- MwT-11F

Beyond HFET, CML Micro supports an extensive portfolio of compound semiconductor technologies, including GaAs pHEMT, GaAs HBT, and GaN. This cross-process capability enables technology-agnostic recommendations, ensuring customers receive the most appropriate solution for their specific application.

For HFET-dependent platforms, CML Micro provides long-term continuity and supply confidence, reducing the risk of forced redesigns or unplanned technology migration. This translates into consistent system performance across the product lifecycle and high confidence in component availability.



HFET replacement challenges

HFET devices exhibit electrical behaviours that are not directly replicated by alternative semiconductor technologies. As a result, replacing HFET with pHEMT or HBT solutions is rarely a straightforward component substitution.

Such replacements typically require:

- significant RF chain redesign, including re-optimisation of gain structure, compression characteristics, and linearity performance
- Re-evaluation of biasing schemes and load-line conditions
- Matching network redesign due to different impedances and capacitances
- Reassessment of thermal behaviour and stability margins

- Re-evaluation of AM–PM performance for modulation accuracy and beamforming stability

These challenges underline the value of the continual availability of HFET technology offered by CML Micro.

Conclusion

HFET technology delivers the linearity and phase stability required by modern wideband and high-order modulation RF systems. Its intrinsic device characteristics remain unmatched in applications where signal fidelity and distortion control dominate system requirements.

CML Micro provides the expertise and long-term commitment necessary to sustain and evolve HFET-dependent designs. Through extensive design experience, multi-technology capability, and engineering support spanning device, module, and system levels, CML Micro enables customers to maintain performance while managing risk.

HFET remains a best-in-class solution where linearity is critical, and CML Micro ensures customers can depend on HFET performance today and into the future.