HIGH EFFICIENCY AMPLIFIER

EVOLUTION & ADVANCEMENTS

Connecting for the Future

EVOLUTION AND ADVANCEMENTS

William H. Doherty an American electrical engineer, invented the first Doherty amplifier in 1936 in the Bell Telephone Laboratory.

The Doherty amplifier is not new, but with new semiconductor design techniques and advances in technology we can now leverage the Doherty amplifier design in the UHF broadcast transmitters of today.

GATESAIR

SEMICONDUCTOR DESIGN & PACKAGING

New high efficiency semiconductor Packaging and UHF Doherty amplifier design, has changed the way design amplifiers today

Advancements in how devises are packaged

75kW Average Power in < ½ the space as a Tube System

The semiconductor packaging innovation lead the way for higher power, higher efficiency amplifiers for broadcast transmitter design using Solid-State LDMOS (laterally-diffused metal-oxide semiconductor) transistors. The new devises are more robust devise using rugged LDMOS design.

The packaging advancements in LDMOS technology helped reduced space (footprint) utilized by the transmitter for the same amount or more power. Tubes type amplifiers took a lot of space in the broadcast transmitter room.

Tubes were a single point of failure, you lost a tube you were off the air, unless you were lucky to have more than one. Many Solid-State devises used in parallel can achieve the same high-power levels in a modular design with an extreme amount of redundancy and life span.

Tube transmitters are very complex and required a lot of maintenance to keep them operating. Solid-State circuits are less complex and required less maintenance.

Tubes required very high power and high voltages, which are dangerous to repair. Solid state devises only required 35V DC– 50V DC and with modular design & multiple power supplies easier to repair.

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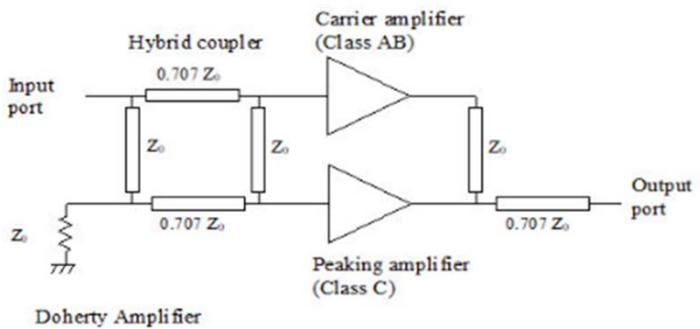
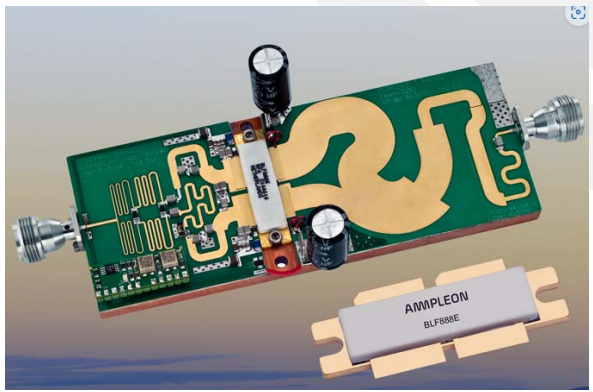
POWER AMPLIFIER DETAIL – WHAT IS DOHERTY AMP.

The Doherty High Efficiency amplifier provide improved efficiency compared to balanced amplifiers.



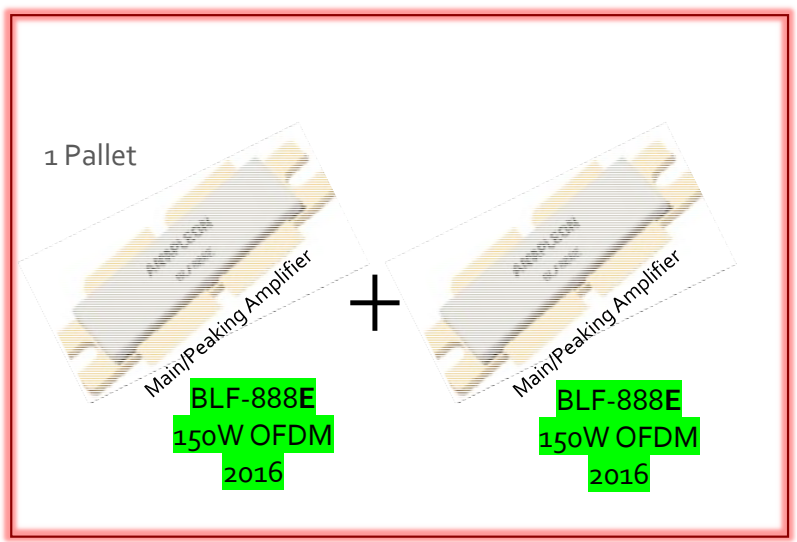
Doherty Amplifier

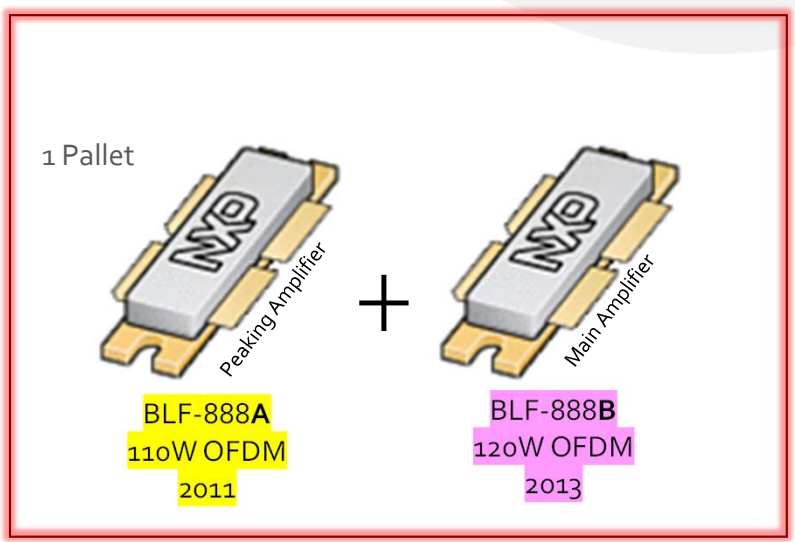


The Doherty amplifier power-combines two amplifier types, one is called the “Carrier or Average" amplifier while the second is called the “Peaking" amplifier. In many Doherty amplifiers the two amplifiers are biased differently, the carrier amp is at a normal Class AB, while the peaking amplifier is at Class C to control its conduction at only higher levels of the envelope. The beauty of the Doherty amplifier is it improves power-added efficiency, compared to a balanced amplifier, at backed off power levels.

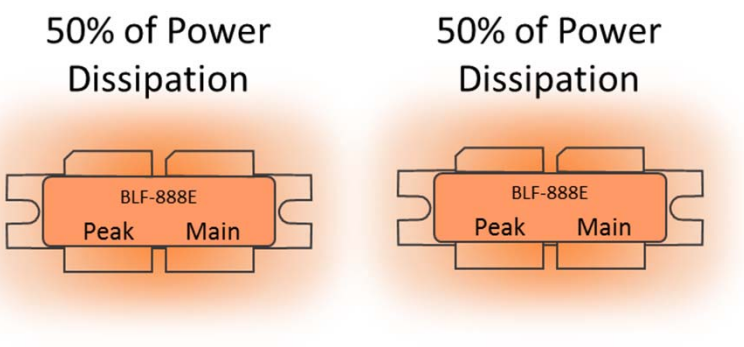
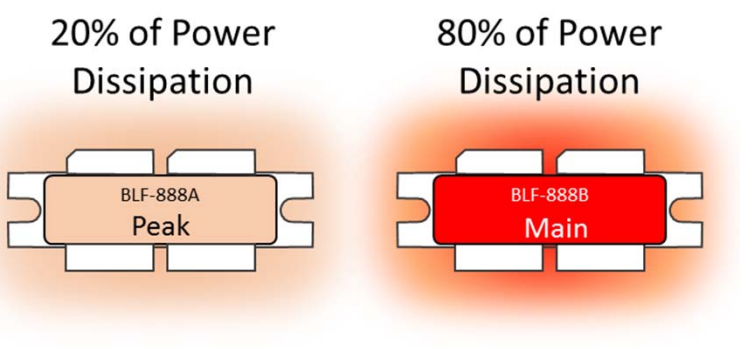
POWER AMPLIFIER EVOLUTION – RF DEVICES FOR TV (UHF)

Asymmetrical Doherty – BLF-888E (GatesAir Currently Uses)	Older Multi-Package Symmetrical design
• Current technology Ampleon BLF-888E devices used • **Broadband** Doherty • Asymmetrical Doherty - optimized for UHF-TV, the most efficient design available.	• 2 to 3 generations older LDMOS device technology • **Narrowband** Doherty • 2 different devices, Ampleon (NXP) BLF-888A and BLF-888B.

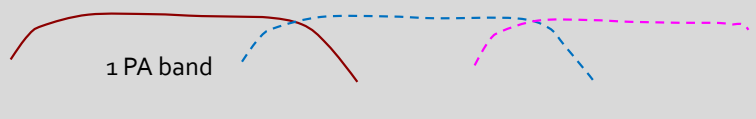
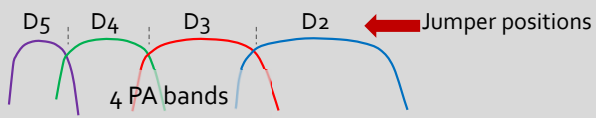
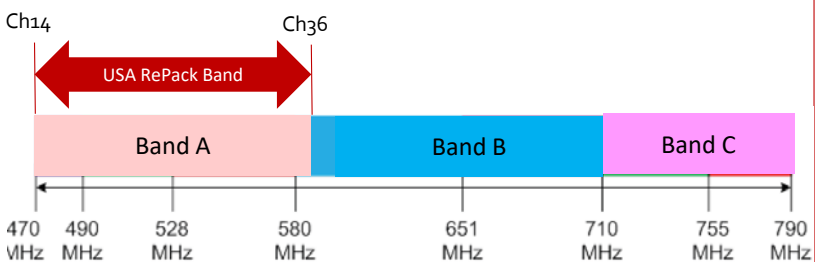
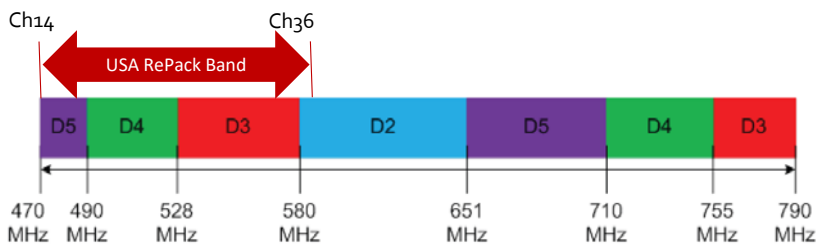




POWER AMPLIFIER EVOLUTION – RF DEVICES FOR TV (UHF)

GatesAir Asymmetrical Doherty – BLF-888E	Older Multi-Package Symmetrical design
• Thermally balanced design • Equal heat load between both devices on pallet • Easier to manage heat transfer to liquid or Air-cooling system	• Thermally unbalanced deign • One device dissipates 80% of the power (heat), the other 20% of the power • Questionable long-term reliability (MTBF)
 Each device split into Peak and Main amp	 Separate devices used for Peak and Main amp

POWER AMPLIFIER DETAIL – PA BANDWIDTH

Asymmetrical Single-Package Doherty – BLF-888E	Older Multi-Package Symmetrical design
• Broadband Asymmetrical Doherty • Broadband across FCC Repack channels (Ch14-36) 120-140MHz Band Width • Transmitter is frequency agile across this range – no tuning or jumper changes across the UHF Re-pack spectrum.	• Narrowband Doherty • 4 Bands across Repack channels • RF jumpers or different pallet designs are used to modify the Doherty network to allow channel changing in 4 or more groups across the UHF spectrum.
	
	

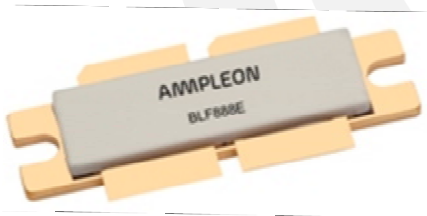
UHF RF DEVICE TECHNOLOGY ADVANCEMENTS

Simplified Symmetrical Doherty

BLF888D Features and benefits (from data sheet):

- Symmetrical Doherty (Single Package)
- 50 Volts
- 115W-130W OFDM TV Average Power (Freq. dep)
- Pallet Efficiency OFDM ~ 42% to 48%
- Typical Gain 18dB
- Doherty back-off (peak/main) 6dB
- Excellent ruggedness (VSWR > 40:1
- Excellent thermal stability
- One Doherty design covers UHF band from 470MHz to 750MHz, or banded operation

Asymmetrical Doherty

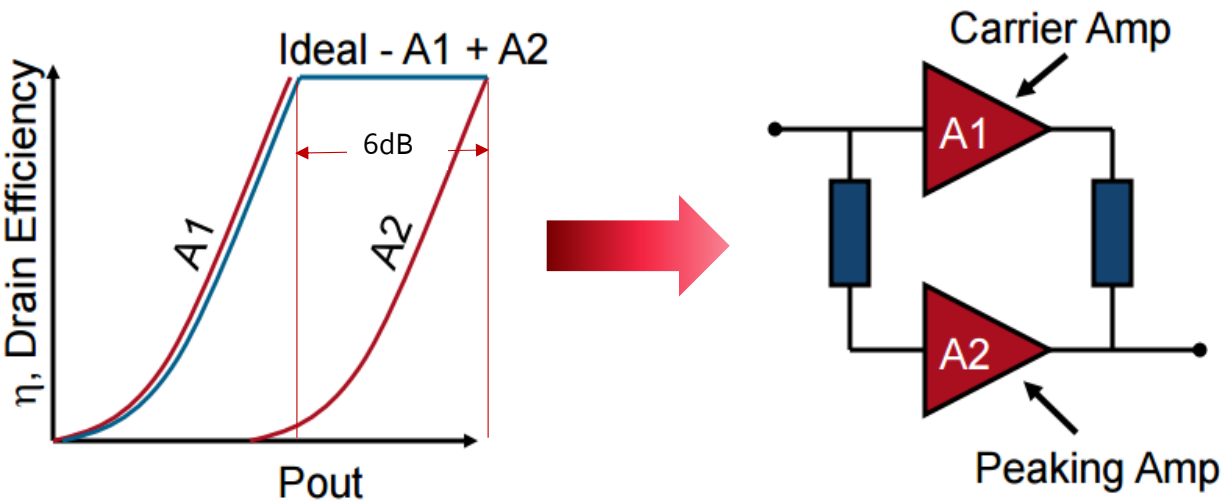


BLF888E Features and benefits (from data sheet):

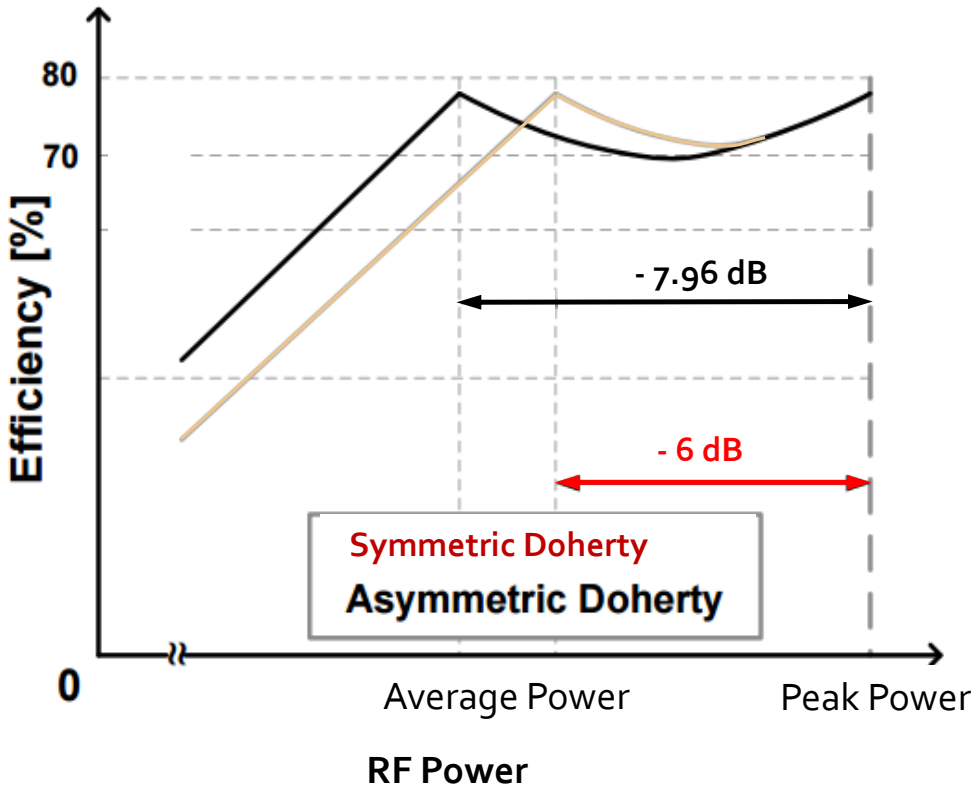
- Asymmetrical Doherty
- 50 Volts
- 150W OFDM TV Average Power (25% higher)
- Pallet Efficiency OFDM ~ 52%
- Gain 17dB
- Doherty back-off (peak/main) 7.96dB
- Excellent ruggedness (VSWR > 40:1)
- Excellent thermal stability
- Bandwidth 470-608MHz (Ch 14 to 36)
- Three Doherty designs cover all UHF Band

SIMPLIFIED 2-STAGE SYMMETRICAL DOHERTY PA

- **A1 operates most of the time - handles average signal**
- **A2 operates only when peak power is needed**
- **A1 and A2's operation is dependent on each other**



ASYMMETRICAL 2-STAGE DOHERTY



- Asymmetrical Doherty optimizes system efficiency towards higher Peak to Average Power ratio's such as in OFDM modulation (e.g. ATSC 3.0), which is ~ 8dB
- PAR calculation for symmetrical device:

= 20 x log(1+peak/main) = 20 x log(1+(1/1)) = **6.0dB**

- PAR calculation for asymmetrical device:

= 20 x log(1 = peak/main) = 20 x log(1+(1.5/1)) = **7.96dB**

- Device average power difference (asymmetrical vs. symmetrical):

= 10 x log(2.5/2) = 10 x log(2.5/2) = **+0.97dB (+25%)**

NEW ADVANCEMENTS FOR UHF TV

BLF989E

&

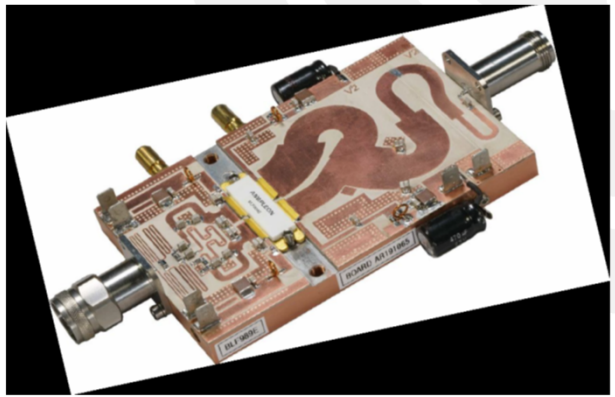
GaN on SiC die

NEW ADVANCES IN ASYMMETRICAL DOHERTY

A-symmetric ultra-wideband Doherty Design with BLF989E
for 470 to 700 MHz UHF Broadcast Applications

Best UHF RF performance at 180 W average power

- Excellent load mismatch capability of VSWR 40:1
- Optimal gain flatness and planar PCB design
- Standard ceramic SOT539 package
- >Pavg Power
- >Efficiency – COFDM 48%



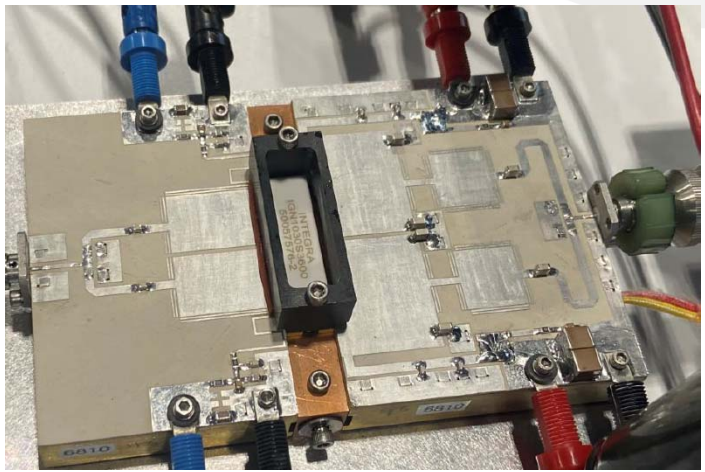
@50 V DVBT (8K OFDM)	
P_{PEAK} (W)	1000
P_{AVG} (W)	180
Gain (dB)	14.5 - 17
Efficiency (%)	46 - 54

NEW ADVANCES IN GaN ON SiC DIE

GaN, or Gallium Nitride, is a semiconductor material that maximizes power density. By using GaN devices in a UHF frequency (RF) amplifier, high-output power can be achieved without increasing size and weight. This is ideal for applications requiring maximum RF power density.

Efficiency ~>60% @ 1000MHz
Gain ~> 19dB

This is a new technology looks very promising and may provide higher power density and efficiency in future TV transmitter systems.



VHF / FM AMPLIFIER

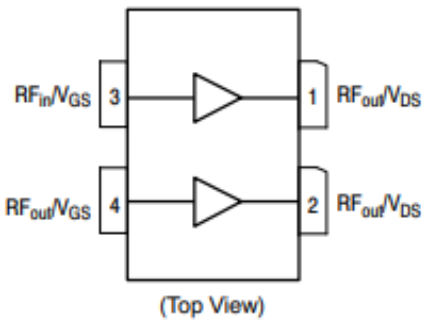
Flexiva (FAX & FLX) Air & Liquid cooled

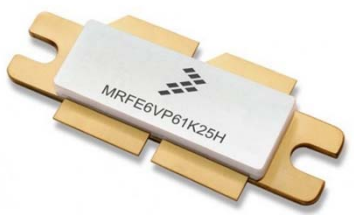
VHF / FM RF POWER LDMOS TRANSISTORS

The Current FAX-HP LDMOS for FM application is a Freescale design

PRFE6VP61K25H Features and benefits (from data sheet):

- 50 Volts
- 1250 CW
- Efficiency ~ 75%
- Typical Gain 25dB
- Excellent ruggedness (VSWR > 65:1)
- Excellent thermal stability
- One design covers VHF band from 1.8MHz to 600MHz, banded operation

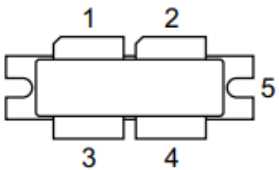




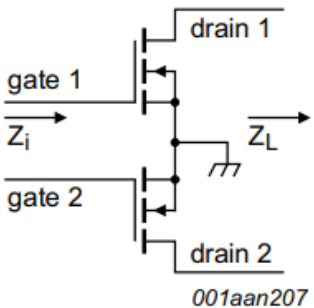
VHF / FM RF POWER LDMOS TRANSISTORS

The Current FLX-HP LDMOS for FM application is a Ampleon design

BLF188XR Features and benefits (from data sheet):



- 50 Volts
- 1320 CW at 88-108MHz
- Efficiency ~ 85%
- Typical Gain 22.5dB
- Excellent ruggedness (VSWR > 65:1)
- Excellent thermal stability
- One design covers VHF band from 2MHz to 230MHz, banded operation

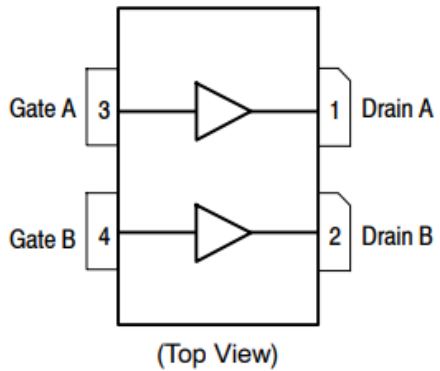


VHF / FM RF POWER LDMOS TRANSISTORS

The Current GX-1K-10K LDMOS for FM application is a NPX design

MRFX1K80 Features and benefits (from data sheet):

- 65 Volts
- 1600 CW at 87.5-108MHz
- Efficiency ~ 82.5%
- Typical Gain 23.6dB
- Excellent ruggedness (VSWR > 65:1)
- Excellent thermal stability
- One design covers VHF band from 1.8MHz to 400MHz, banded operation



(Top View)

$I_{DQ(A+B)}$ = 200 mA, P_{in} = 7 W, CW

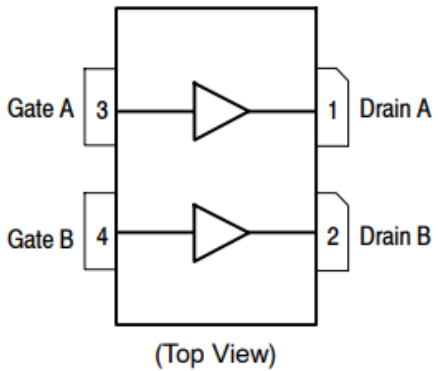
Frequency (MHz)	V_{DD} (V)	P_{out} (W)	G_{ps} (dB)	η_D (%)
87.5	60	1521	23.4	84.9
98	60	1600	23.6	82.5
108	60	1556	23.5	80.0

VHF RF POWER LDMOS TRANSISTORS

The Current VAXTE VHF LDMOS for TV application is a NPX design

MRFX1K80 Features and benefits (from data sheet):

- 50 Volts
- 1500 CW at 230MHz
- Efficiency ~ 75.1%
- Typical Gain 23.4dB
- Excellent ruggedness (VSWR > 65:1)
- Excellent thermal stability
- One design covers VHF band from 1.8MHz to 500MHz, banded operation

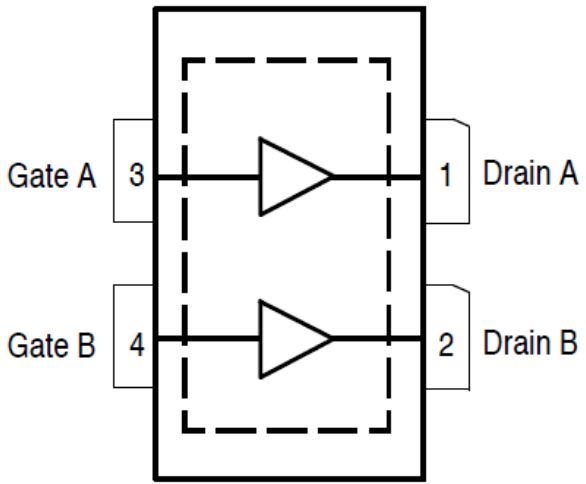


VHF / FM RF POWER LDMOS TRANSISTORS

The Newest LDMOS for VHF application is a NPX design

MFRX1K80N Features and benefits (from data sheet):

- 60 Volts typical - Qualified up to a maximum of 65 VDD operation
- 1670 CW
- Efficiency ~ 84%
- Typical Gain 23.8dB
- Excellent ruggedness (VSWR > 65:1)
- Excellent thermal stability
- One design covers VHF band from 1.8MHz to 400MHz, banded operation



$I_{DQ(A+B)}$ = 200 mA, P_{in} = 7 W, CW

Frequency (MHz)	V_{DD} (V)	P_{out} (W)	G_{ps} (dB)	η_D (%)
87.5	60	1580	23.5	84.6
98	60	1670	23.8	83.5
108	60	1600	23.6	80.6

THANK YOU

www.gatesair.com

Connecting for the Future