RF Power Presentation
Broadcast (ISM), Microwave and Cellular

Richard Marlow: European Regional Marketing

February 2009

Microwave, Broadcast & ISM Markets

- Broadcast (TV and radio transmission)
  - NXP has a long history (as Philips) and excellent reputation in the market
  - Rugged performance is a critical factor where NXP scores over competition
  - New high power products for UHF (BLF87x/88x) and VHF (BLF57x)
  - Demo boards suited to TV and FM broadcast applications
  - These devices also fit into ISM applications e.g. VHF communications, laser driving, RF jamming and radar
- Microwave (civil and military radar applications)
  - NXP devices specified for radar applications (Avionics, L band, S band)
  - LDMOS has significant benefits (gain, stability etc) over Bipolar competitors
  - US suppliers suffer significantly with ITAR restrictions
  - New high voltage devices for higher power density in 2009
  - Pallet solutions to simplify customer developments

NXP RF Power Development and Assembly

Nijmegen, The Netherlands

- Headquarters, Quality & Application Lab

- Research & Development center

- Wafer fabs (4” and 8”)

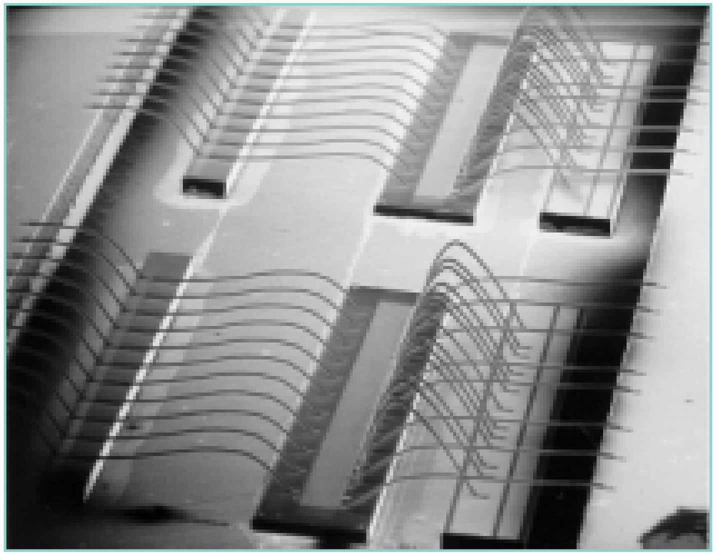
Manila, Philippines

- High-volume Assembly center

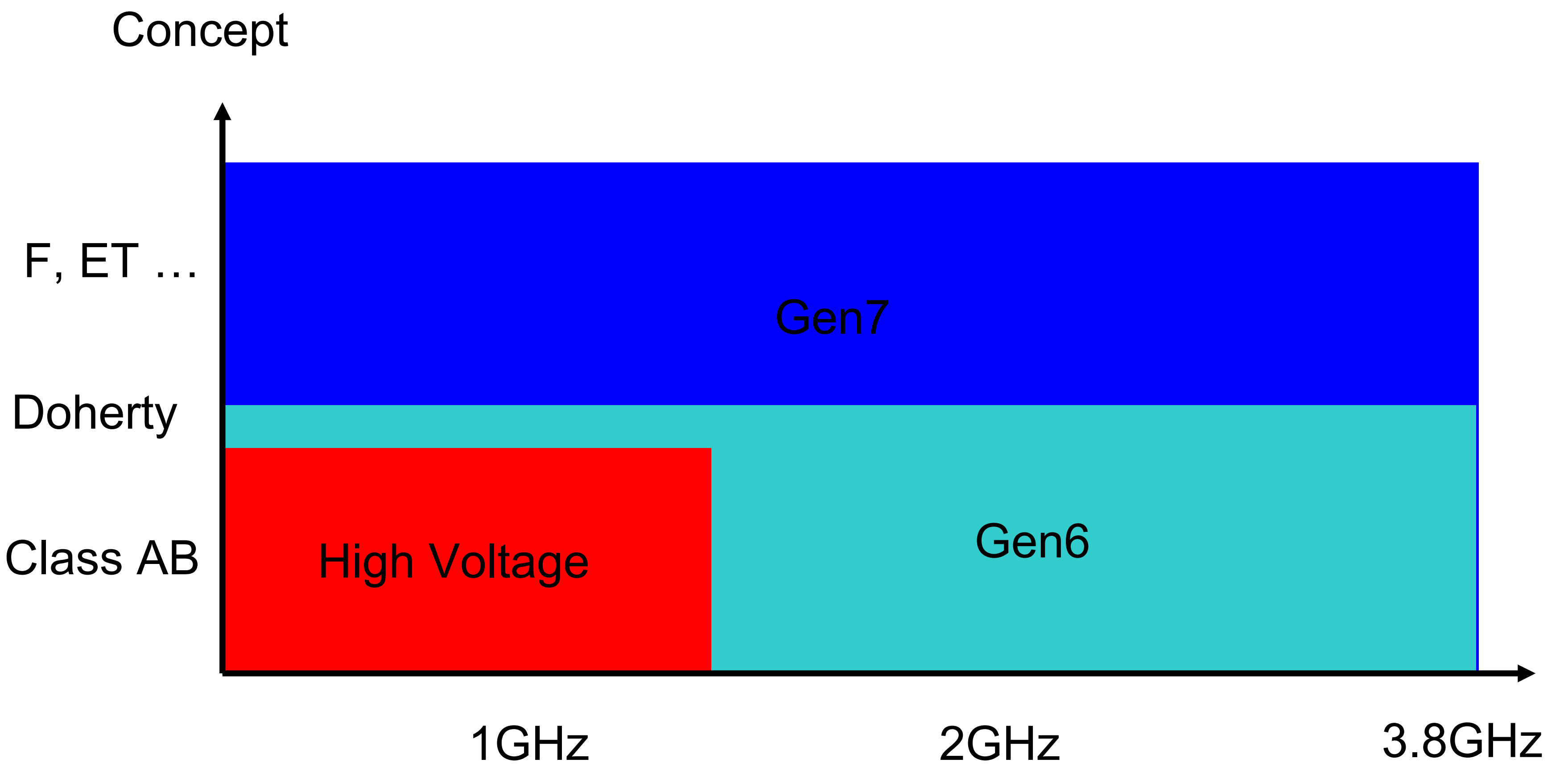
- Test center

NXP RF Power Manufacturing Capabilities

- High volume supply capability with flexible ramp-up and capacity extension
- RF Power wafer fabs in the Netherlands
  - 0.6 µm wafer fab
    - 4 inch
    - Gold-metallization
    - LDMOS Gen2, Gen3, Gen4
  - 0.14 µm CMOS fab
    - 8 inch, LDMOS 0.4 µm (Gen 6)
    - 8 inch, LDMOS **0.3 µm (Gen 7)**
    - Aluminum
- Fully automated world class off-shore assembly centers



Application areas for Different LDMOS Generations



Dedicated NXP RF Power Website

www.rfpower.nl/cdrom

Your portal to:

- The latest product info
- Datasheets
- Application Notes
- ADS Models
- Mounting instructions

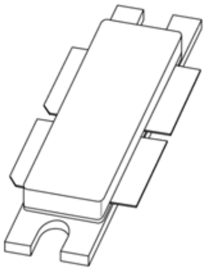
Support offices:

- Cumberland, USA
- Nijmegen, NL
- Shanghai, China
- Seoul, Korea
- Tokyo, Japan

Broadcast & ISM
Products Overview

NXP Broadcast & ISM Devices

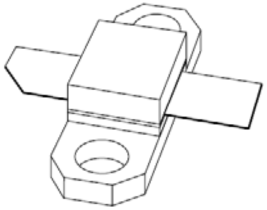
- For UHF transmitters (analog and digital TV)
  - **BLF878** and **BLF871** from 40V version of Gen6 LDMOS
  - **BLF888** and **BLF881** from 50V version of Gen6 process
  - Building upon NXP's BLF861A position as "UHF market standard" (BLF878 = double BLF861A)
  - Continues NXP excellence in ruggedness for broadcast appl



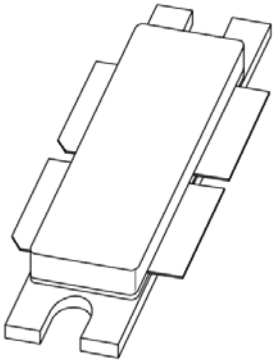
- For VHF transmitters (FM and digital TV/radio)
  - **BLF57x** from 50V version of Gen6 LDMOS process
  - Power output from 20W (**BLF571**) to 1200W (**BLF578**)
  - Demo boards for FM and broadband applications
- ISM applications
  - BLF57x also suitable for many ISM applications e.g. VHF radio communications (civil and military), driving industrial lasers, medical and scientific high power

UHF TV Broadcast Devices

- BLF871:
  - Po ≥ 100W for analog TV (efficiency ≥ 45%)
  - Po ≥ 24W average for digital TV (DVB-T efficiency ≥ 30%)
  - Used as low power UHF transmitter or high power driver

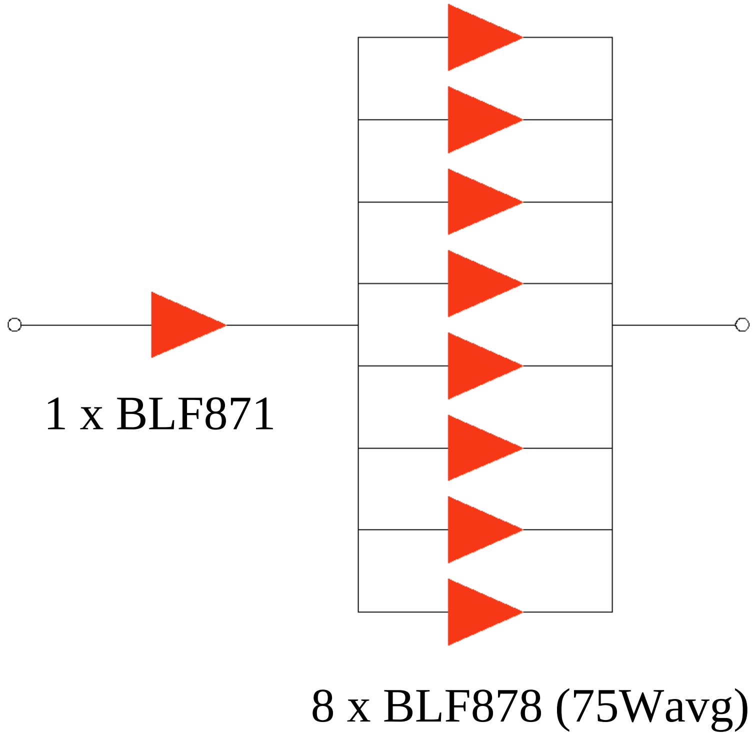


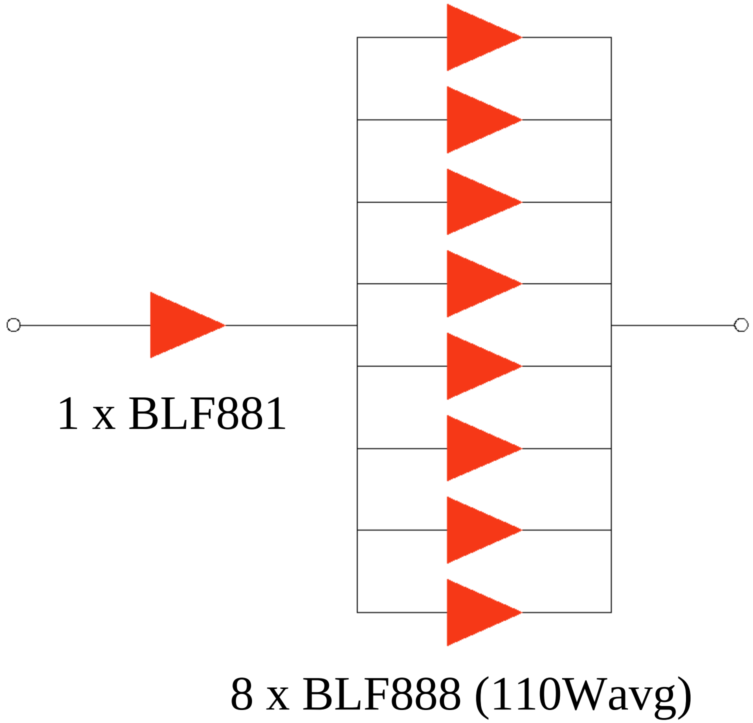
- BLF878:
  - Po ≥ 300W for analog TV (efficiency ≥ 42%)
  - Po ≥ 75W average (DVB-T efficiency ≥ 30%)
  - Broadband matching: 470 – 860 MHz



- BLF888:
  - Optimized for digital TV applications
  - Po ≥ 110W average (DVB-T @860MHz)
  - Same package as BLF878
- All devices extremely rugged – can withstand VSWR 1:10 with abrupt mismatch in transmitter

UHF (DVB-T) PA based on BLF87x or BLF88x





Po = 500W DVB-T (57dBm)
Ga = 18dB with coupler loss 0.8dB

Po = 700W DVB-T (58.5dBm)
Ga = 18dB with coupler loss 0.8dB

UHF Availability Schedule

Product UHF	Pout	Package	Preliminary samples	A-gate Design Frozen	V-gate Qualification samples
BLF871	100 W	SOT467	Available	Available	Available
BLF878	300W Analog (75W DVB-T)	SOT979A	Available	Available	Available
BLF881	35W DVB-T	SOT979A	1Q 09	Q2 09	Q3 09
BLF888	110W DVB-T	SOT979A	Available	Q1 09	Q2 09

- All devices designed for rugged operation (essential for broadcast reliability)
- High efficiency allows for smaller designs and more energy efficiency
- DVB-T optimized devices (BLF88x) specifically for growing digital TV market
- NXP continues market leading position for UHF (analog & DVB-T) broadcasting

VHF (FM & TV) Broadcast Devices

Product	Pout	Package	Gp (dB)	Dr Eff(%)	$Rth_{J\text{-}C}$ (K/W)	$Rth_{J\text{-}HS}$ (K/W)	VSWR
BLF571	20W (CW)	SE SOT467	26	70	3.2	4	> 13:1
BLF573S	300W (CW)	SE SOT502B3	26	70	0.18	0.57	> 13:1
BLF574	500W (CW)	PP SOT539A2	26	70	0.25	0.46	> 13:1 @400W
BLF578	1200W (pulsed)	PP SOT539A2	26	70	0.13	0.31	> 13:1 @1000W

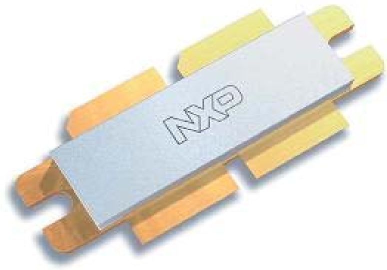
Typical Performance @ rated Power and frequency of **225 MHz**, PP=push-pull, SE = Single ended

SE SOT467

Ceramic

SE SOT502B3

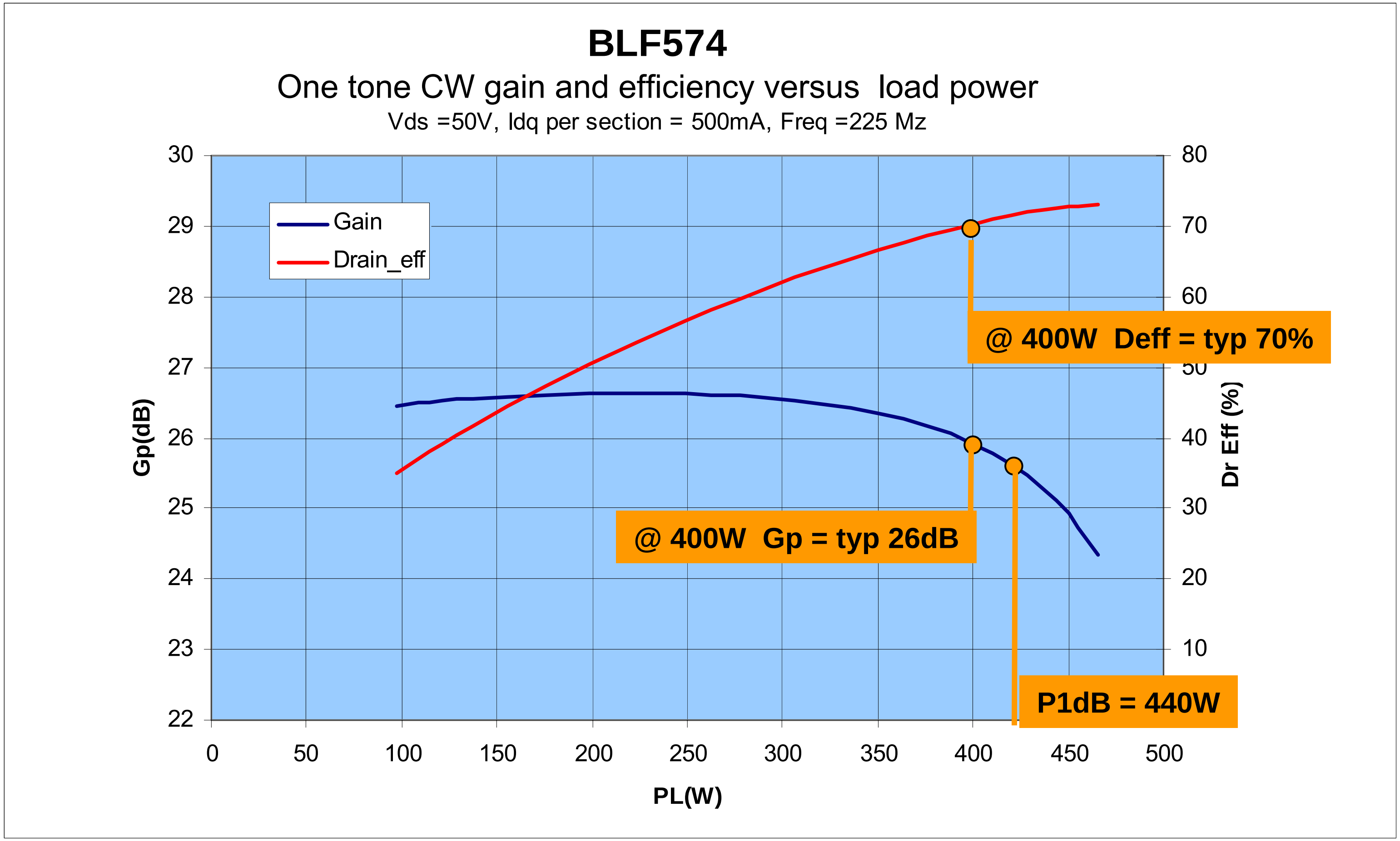
Ceramic



PP SOT539A2

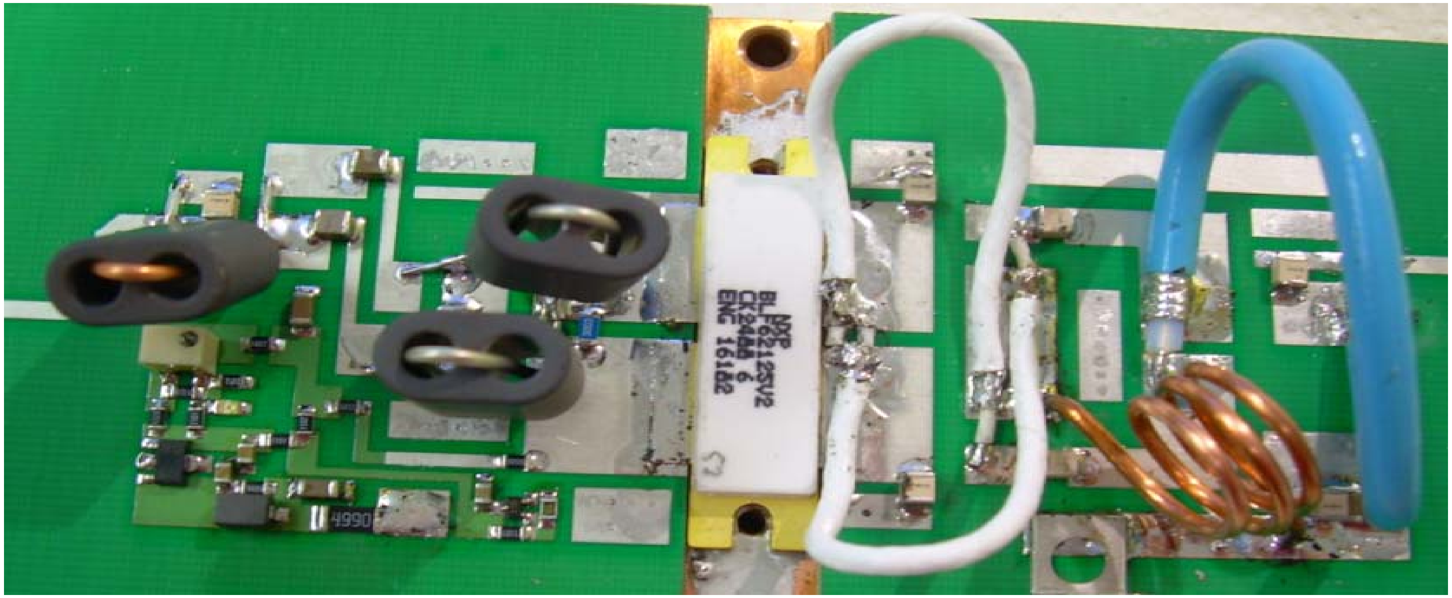
Ceramic

BLF574 Demo Performance @225MHz

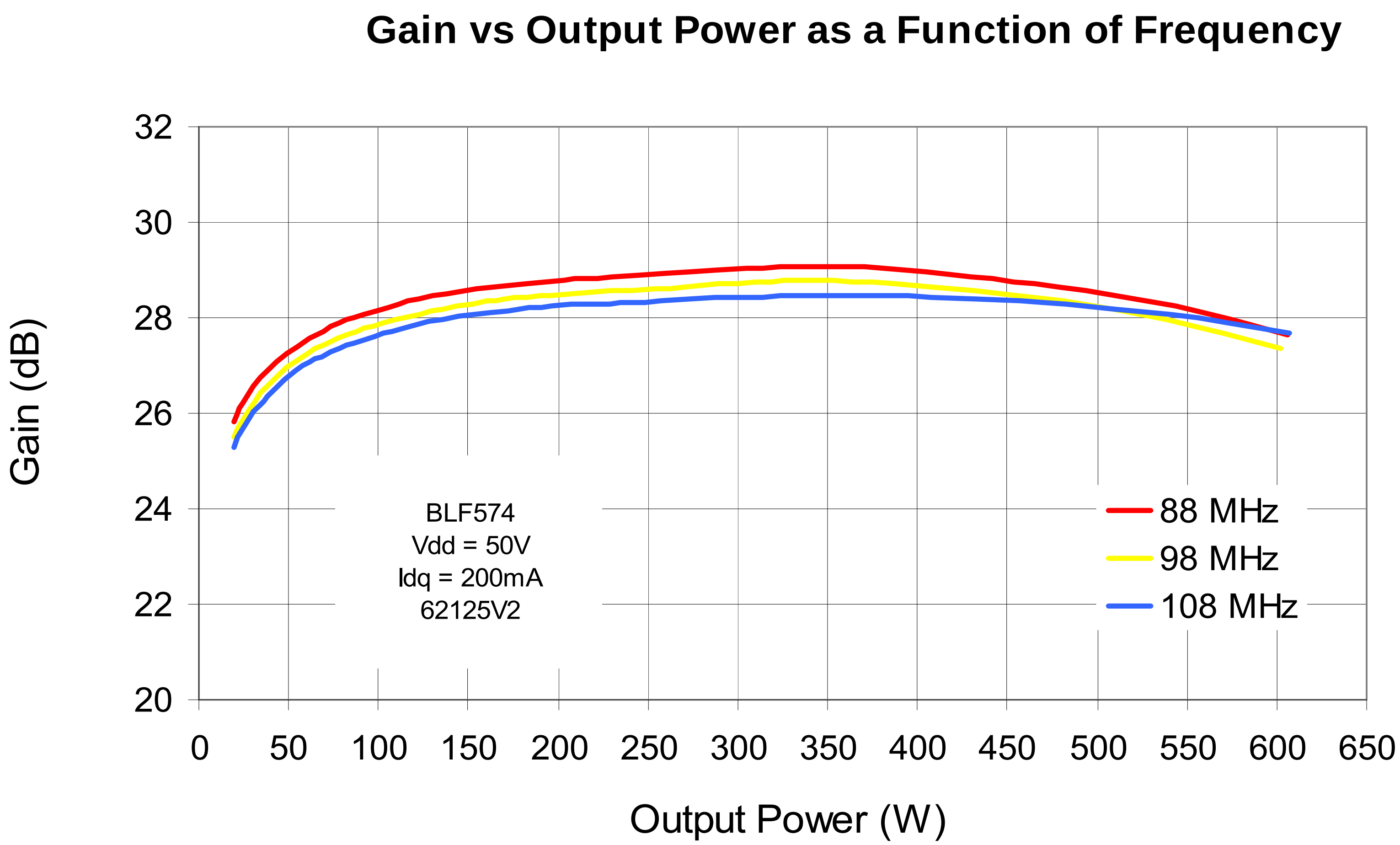


BLF574 Tuned for FM Band

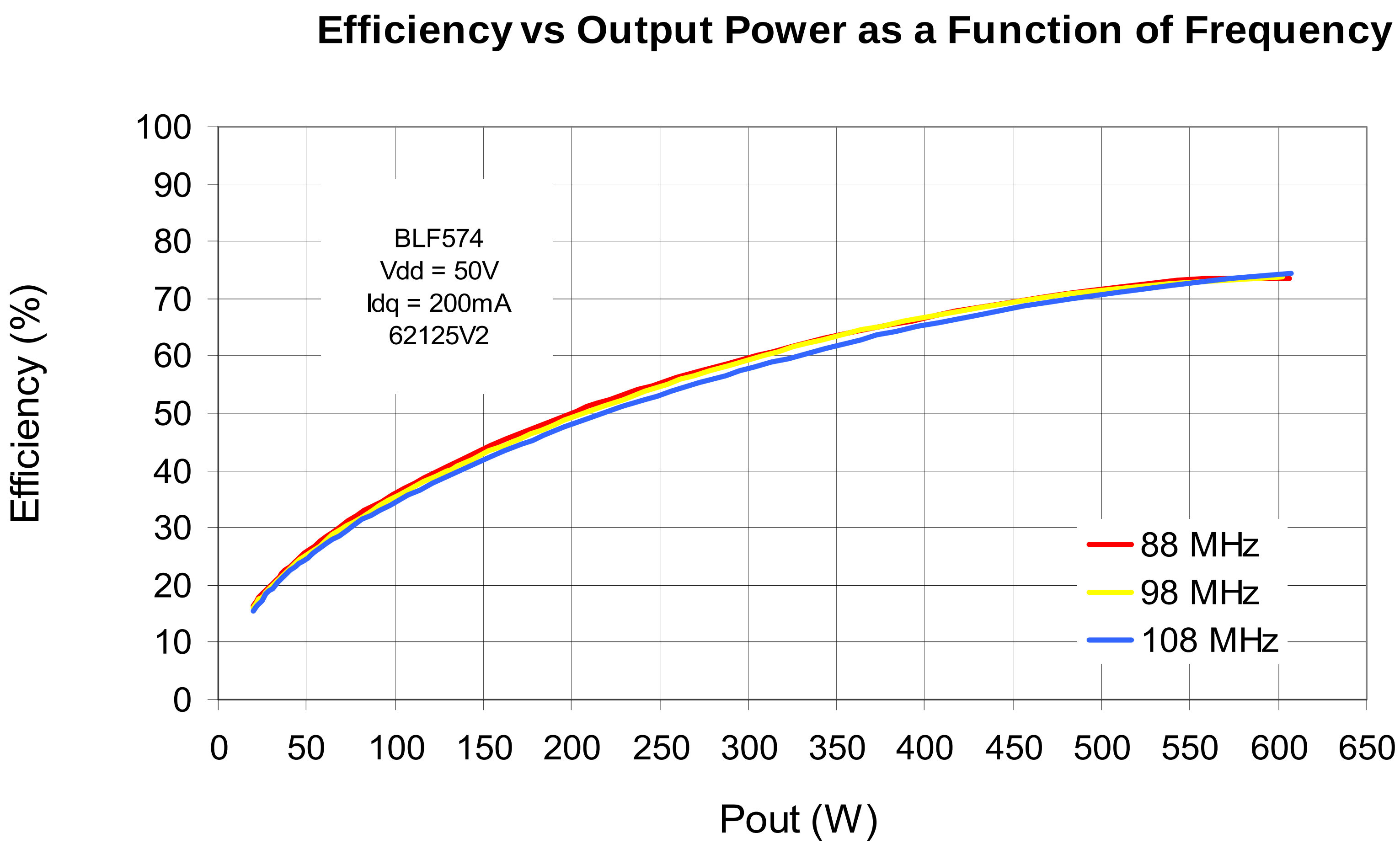
- 600W of CW power can be generated in board space smaller than 2” x 4”.
- Efficiencies greater than 73% are achieved, gain is 27dB at 600W.
- Compression, efficiency, and gain performance consistent over the FM band.



CW Gain in the FM radio Band



CW Efficiency in the FM radio Band



BU MMS Regional Marketing, Richard Marlow. February 2009

VHF (inc. FM) Availability Schedule

Product	Pout	Package	Preliminary samples	A-gate Engineering samples	V-gate Qualification samples
BLF571	20W (CW)	SE SOT467	Available	Available	Available
BLF573S	300W (CW)	SE SOT502B3	Available	Available	Available
BLF574	500W (CW)	PP SOT539A2	Available	Available	Available
BLF578	1200W (pulsed)	PP SOT539A2	Available	Q1 09	Q2 09

Performance @ rated Power and frequency of **225 MHz**, PP=push-pull, SE = Single ended

- All devices designed for rugged operation (essential for broadcast reliability)
- High efficiency allows for smaller designs and more energy efficiency
- Optimized for FM/DAB radio and VHF television transmitters
- Well suited to civil/military communication applications

Microwave
Products Overview

RF Power Devices for Microwave

- **Civil Aircraft LDMOS**
  - BLA0912-250

  - BLA1011-2
  - BLA1011-10
  - BLA1011(S)-200
  - BLA1011-300

- **L-Band Radar LDMOS**
  - BLL1214-35
  - BLL1214-250

- **S-Band Radar LDMOS**
  - BLS2933-100

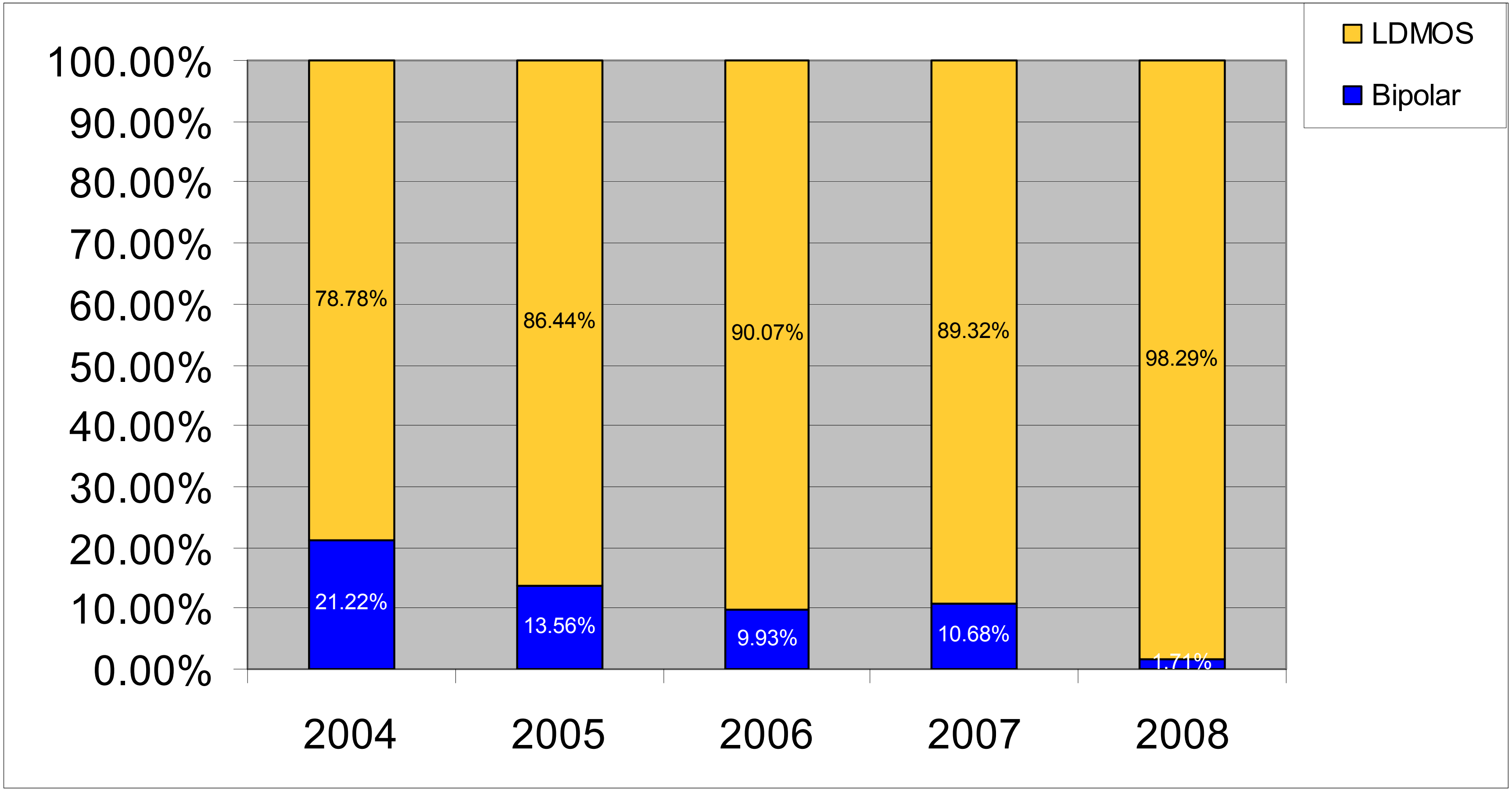
  - BLS6G2731-6
  - BLS6G2731(S)-120

  - BLS6G3135(S)-20
  - BLS6G3135(S)-120

LDMOS Advantages vs Bipolar

- No BeO any more means lower Zth, lower die-temperature.
    - MX0912B251(Bipolar): Zth = 0.28 (10 μs – 10%).
    - BLA0912-250 (LDMOS): Zth = 0.13 (10 μs – 10%).
- Improved MTTF With LDMOS:
    – Gen6 LDMOS approx. 10 to 15 times better than Bipolar
- LDMOS has better flexibility w.r.t pulse formats:
    – Bipolar tends to oscillate at low pulse durations (ruggedness !)
    – Bipolar shows variation in performance over various pulse widths
- No thermal runaway for LDMOS:
    – Bipolar shows local heating (a sort of thermal oscillation)
    – LDMOS does not have this disadvantage
- Standard LDMOS-packages can be used **(no toxic Beryllium)**
    – Cost of BeO-packages continues to increase
    – In the future BeO-packages are expected to be phased out

LDMOS Now Replaces Bipolar in the Market



NXP Civil Aircraft Devices

- BLA1011-200, BLA1011-10, BLA1011-2 series
  - Designed for Civil Aircraft applications
  - Qualified in latest TCAS equipment
  - Successfully introduced market-first LDMOS transistors for the Civil Aircraft market.
  - Complete line-up available:
    - BLA1011-2
    - BLA1011-10
    - BLA1011-200
  - Key features:
    - High gain: typical 14 – 15 dB at 200W
    - High efficiency: typical 50% at 200W
    - High VSWR capability: VSWR 5 at 200W

Key Product Highlights: Civil Aircraft

- BLA0912-250 Performance summary
  - High power 250 W
  - High gain 13 dB
  - Efficiency > 45 %
  - Excellent ruggedness
  - Easy power control
  - Various applications (TCAS, JTIDS, Mode-S)

Building on the successful BLA1011 range the BLA0912-250 LDMOS transistor is an asset to the Civil Aircraft portfolio covering the entire Civil Aircraft band from 960 to 1215 MHz.

- BLA1011-300
  - Higher output power: > 300 W
  - High gain: typical 16 – 17 dB
  - High efficiency: typical 55%
  - Extremely rugged: Capable of withstanding VSWR 11 – 14
  - Intended for TCAS applications

L-Band Radar Devices

- BLL1214-250 Performance summary
  - High power 250 W
  - High gain 13 dB
  - Efficiency > 42 %
  - Excellent ruggedness
- BLL1214-35 Performance summary
  - 35W driver transistor for BLL1214-250
  - High gain 13 dB
  - Efficiency > 43 %
  - Excellent ruggedness
- Released for production
  - designs at EU & US customers
- Better behavior than Bipolar
  - Low Z_{TH} → lower junction temp, no thermal runaway
  - Greater flexibility for different pulse formats (e.g. short 200nsec, as well as longer pulses of 1msec)
  - Less susceptible to oscillations.

Successfully introduced market-first LDMOS transistor line-up for the L-Band Radar market.

S-Band Radar Devices (2.7-3.5GHz)

- BLS6G2731-120 performance summary
  - 2.7 – 3.1GHz frequency band
  - High power 120W and high gain (13.5 dB)
  - Efficiency > 48 %
  - Excellent ruggedness
  - 6W driver device BLS6G2731-6G
- BLS6G3135-120 performance summary
  - 3.1GHz – 3.5GHz frequency band
  - High power 120W and high gain (11dB)
  - Efficiency > 43 %
  - Excellent ruggedness
  - 20W driver device BLS6G3135-20
- Released for production
  - designs at EU & US customers
- Better thermal behavior than Bipolar
  - Low ZTH → lower junction temperature, no thermal runaway.

Successfully introduced market-first LDMOS transistor line-up for the S-Band Radar market.

High Voltage Devices and Pallets

- Higher voltage (50V) LDMOS operation gives higher output power
  - BLA1011-300 300W typical @ 32V (50µs pulse 2% duty cycle)
  - **BLA6H1011-600 600W typical @ 50V (50µs pulse 2% duty cycle)**
  - BLL1214-250 250W typical @ 36V (1ms pulse 10% duty cycle)
  - **BLA6H1214-500 500W typical @ 50V (1ms pulse 10% duty cycle)**
  - BLA0912-250 250W typical @ 36V (100µs pulse 10% duty cycle)
  - **BLA6H0912-500 500W target @ 50V (100µs pulse 10% duty cycle)**
- BLL6H0514 common 50V driver device for Gen6 high power devices
- RF Pallet technology for easier end customer application
  - High output power in small form factor
  - input/output matched to 50Ω to simplify interfacing
  - 200W pallet using 2x BLS6G2933-120
- Long term roadmap developments for higher power and frequency
  - Gen7 LDMOS for higher power output
  - GaN technology for higher frequency

BLA6H1011-600: Objective Specification

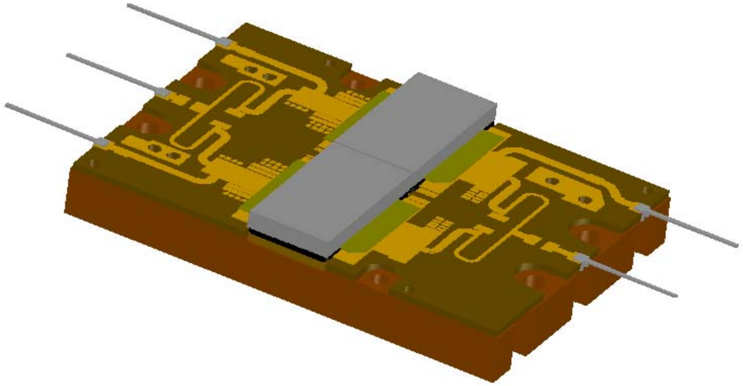
Symbol	Parameter	Conditions	Min	Typ.	Max.	Unit
V_{DS}	Supply voltage				50	V
f	Frequency		1030		1090	MHz
P_{OUT}	Output Power	V_{DS} = 50 V	600			W
P_{1dB}	Output power at 1dB compression	V_{DS} = 50 V		700		W
t_P	Pulse duration			50		µs
δ	Duty cycle			2		%
G_P	Gain	P_{OUT} = 600 W	17	19		dB
P_D	Pulse droop	V_{DS} = 50 V			0.3	dB
η_D	Efficiency	V_{DS} = 50 V	48	52		%
R_L	Return loss	P_{OUT} = 600 W		-10		dB
t_R	Rise time			20	30	ns
t_F	Fall time			6	30	ns
$VSWR_{LOAD}$	Load miss-match capability	P_{OUT} = 600 W	10:1			-

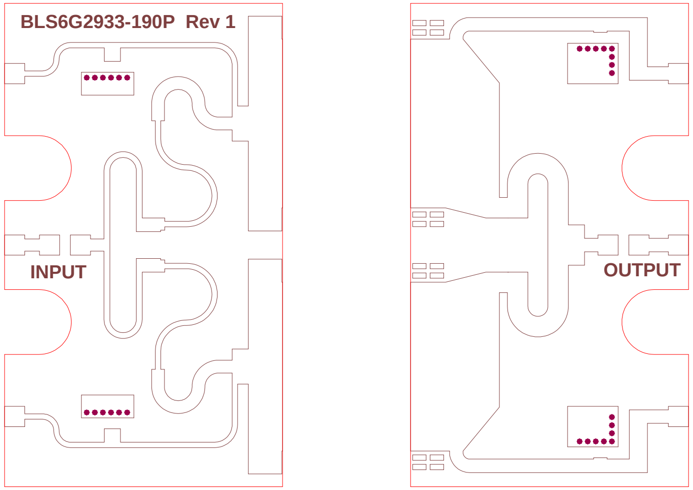
BLA6H1214-500: Objective Specification

Symbol	Parameter	Conditions	Min	Typ.	Max.	Unit
V_{DS}	Supply voltage				50	V
f	Frequency		1.2		1.4	GHz
P_{OUT}	Output Power	V_{DS} = 50 V	500			W
P_{1dB}	Output power at 1dB compression	V_{DS} = 50 V		600		W
t_P	Pulse duration			300	1000	µs
δ	Duty cycle			10		%
G_P	Gain	P_{OUT} = 500 W	15			dB
P_D	Pulse droop	V_{DS} = 50 V			0.3	dB
η_D	Efficiency	V_{DS} = 50 V	45	50		%
R_L	Return loss	P_{OUT} = 500 W		-10		dB
t_R	Rise time			20	50	ns
t_F	Fall time			6	50	ns
$VSWR_{LOAD}$	Load miss-match capability	P_{OUT} = 500 W	10:1			-

NXP Developing RF Pallet Technology

- 200W S-band pallet 2900MHz-3300MHz in small form factor
- Composed out of two BLS6G2933-120 discrete LDMOS transistors
- Target spec: Pout > 215W, Gain > 11 dB, Efficiency > 40%
- Matched to 50 Ω I/O to simplify customer application design





Target Specification of 200W S-band Pallet

Item	Symbol	Condition	Min	Max	Unit
Frequency bandwidth	f		2.9	3.3	GHz
Pulse width	Pw		0.5	600	us
Duty Cycle	Dc		1	20	%
Peak 1dB comp power	P1dB		190		Watt
Drain current	Id max			16	A
Power supply voltage	Vs		31	33	V
Gain flatness	GF			1	dB
Pulse droop	Adroop		-0.5	0.5	dB
PAE	N		40		%
Gain	G		11		dB
Return loss	RL		10		dB
Input VSRW	VSWR		1.92:1		

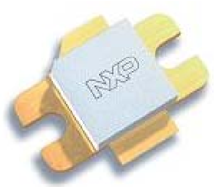
Cellular & WiMAX

Products Overview

NXP 1GHz Base Station Portfolio (Gen6)

Product	Package	Matching (I/O)	Mode of Operation	Frequency Band (Min - Max) (MHz)	Vds (V)	Output Power (W)	Power Gain (dB)	Efficiency (%)	Adjacent Channel Leakage Ratio -ACLR (dBc)
800-1000MHz									
BLF6G10S-45	SOT608B	I / O	2C-WCDMA	800-1000	28	1	23	8	-48.5
BLF6G10-45	SOT608A	I / O	2C-WCDMA	800-1000	28	1	22.5	7.8	-49
BLF6G10LS-135R	SOT502B	I	2C-WCDMA	800-1000	28	26.5	20.2	27	-40
BLF6G10LS-160	SOT502B	I	2C-WCDMA	800-1000	28	32	22	26	-42
BLF6G10LS-200	SOT502B	I	2C-WCDMA	800-1000	28	40	20	27	-41
BLF6G10LS-200R	SOT502B	I	2C-WCDMA	800-1000	28	40	20	27	-40

Note: Test signal: 3GPP; test model 1; 64 DPCH; PAR = 7.5 dB at 0.01% probability on CCDF per carrier; carrier spacing 5MHz.



SOT608A

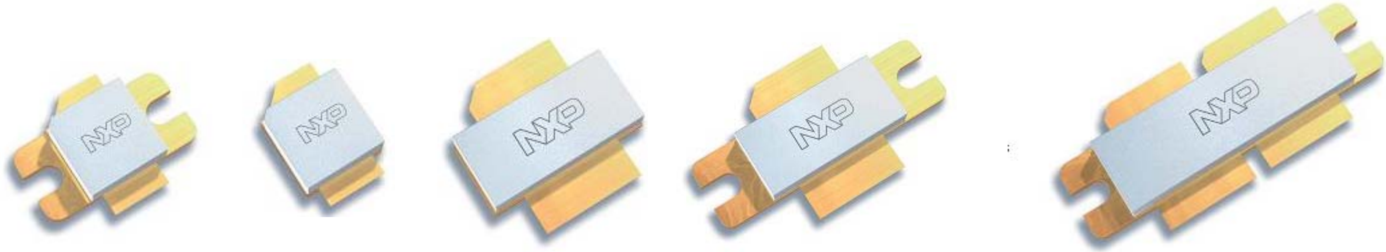
SOT608B

SOT502B

NXP 2GHz Base Station Portfolio (Gen6)

Product	Package	Matching (I/O)	Mode of Operation	Frequency Band (Min - Max) (MHz)	Vds (V)	Output Power (W)	Power Gain (dB)	Efficiency (%)	Adjacent Channel Leakage Ratio -ACLR (dBc)
1800 - 2000 MHz									
BLF6G20S-45	SOT608B	I / O	2C-WCDMA	1800-2000	28	2.5	19.5	14	-49
BLF6G20-45	SOT608A	I / O	2C-WCDMA	1800-2000	28	2.5	19.2	14	-50
BLF6G20-75	SOT502A	I / O	GSM/EDGE	1800-2000	28	29.5	19	37.5	-
BLF6G20LS-75	SOT502B	I / O	GSM/EDGE	1800-2000	28	29.5	19	37.5	-
BLF6G20-110	SOT502A	I / O	2C-WCDMA	1800-2000	28	25	19	31	-40
BLF6G20LS-110	SOT502B	I / O	2C-WCDMA	1800-2000	28	25	19	31	-40
BLF6G20LS-140	SOT502B	I / O	2C-WCDMA	1800-2000	28	35.5	16.5	30	-40
BLF6G20LS-180	SOT502B	I / O	IS95	1800-2000	27	35.5	16.5	27	-46
BLF6G20-180PN	SOT539A	I / O	2C-WCDMA	1800-2000	32	50	18	27.5	-35

Note: Test signal: 3GPP; test model 1; 64 DPCH; PAR = 7.5 dB at 0.01% probability on CCDF per carrier; carrier spacing 5MHz.



SOT608A **SOT608B** **SOT502B** **SOT502A** **SOT539A**

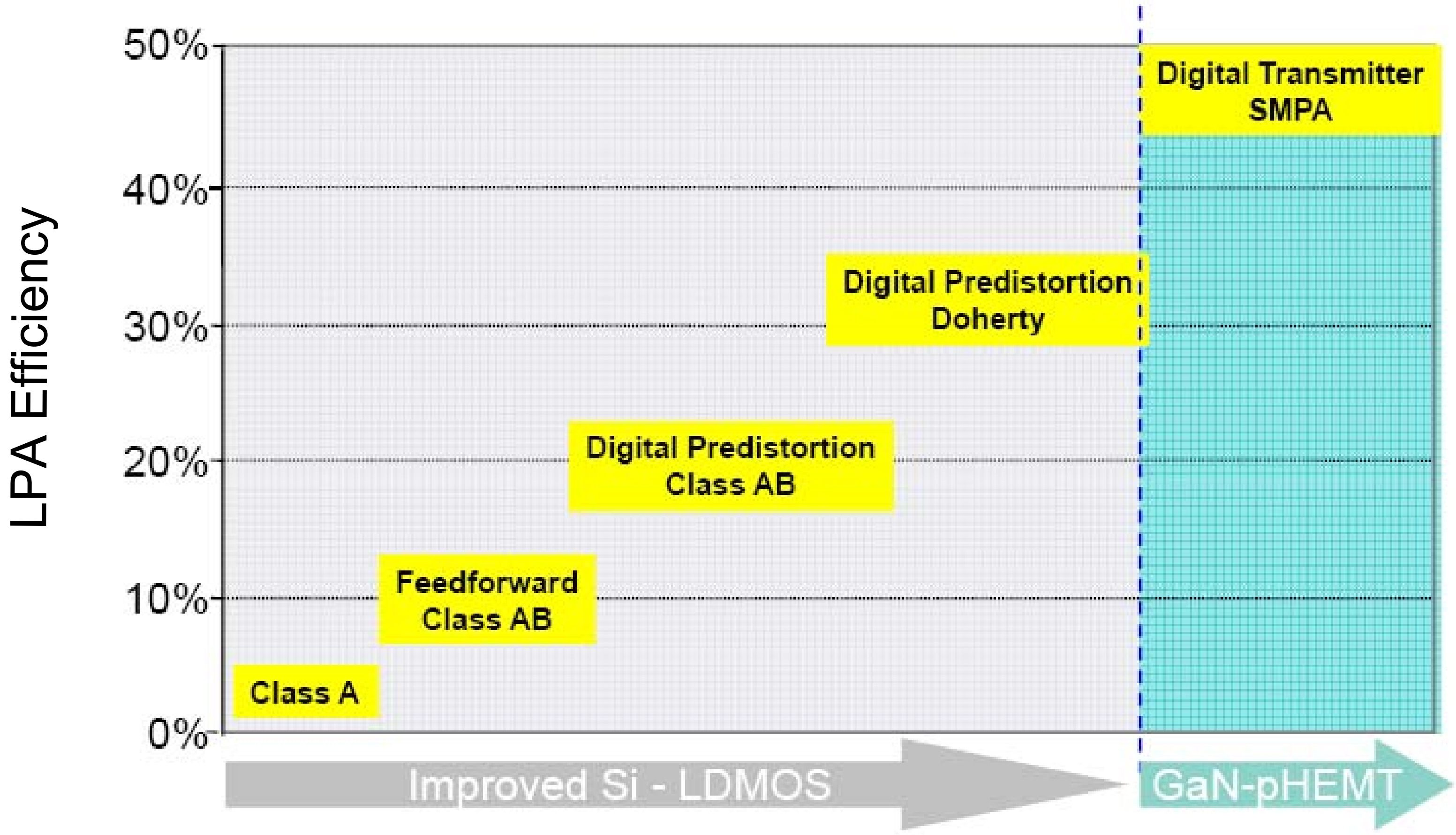
NXP 2.2GHz Base Station Portfolio (Gen6)

Product	Package	Matching	Mode of Operation	Frequency Band (Min - Max)	Vds	Output Power	Power Gain	Efficiency	Adjacent Channel Leakage Ratio -ACLR
		(I/O)		(MHz)	(V)	(W)	(dB)	(%)	(dBc)
1800 - 2000 MHz									
BLM6G22-30(G)	SOT822-1	I / O	2C-WCDMA	2000-2200	28	2	29.5	8.7	-51
BLF6G22S-45	SOT608B	I / O	2C-WCDMA	2000-2200	28	2.5	18.5	13	-49
BLF6G22-45	SOT608A	I / O	2C-WCDMA	2000-2200	28	2.5	18.5	13	-49
BLF6G22-75	SOT502A	I / O	2C-WCDMA	2000-2200	28	17	18	28	-43
BLF6G22LS-75	SOT502B	I / O	2C-WCDMA	2000-2200	28	17	18	28	-43
BLF6G22LS-100	SOT502B	I / O	2C-WCDMA	2000-2200	28	25	18	32	-40
BLF6G22LS-130	SOT502B	I / O	2C-WCDMA	2000-2200	28	30	17	28.5	-40
BLF6G22LS-180	SOT502B	I / O	IS95	2000-2200	27	40	16	27	-
BLF6G22-180PN	SOT539A	I / O	2C-WCDMA	2000-2200	32	50	17.5	27.5	-35

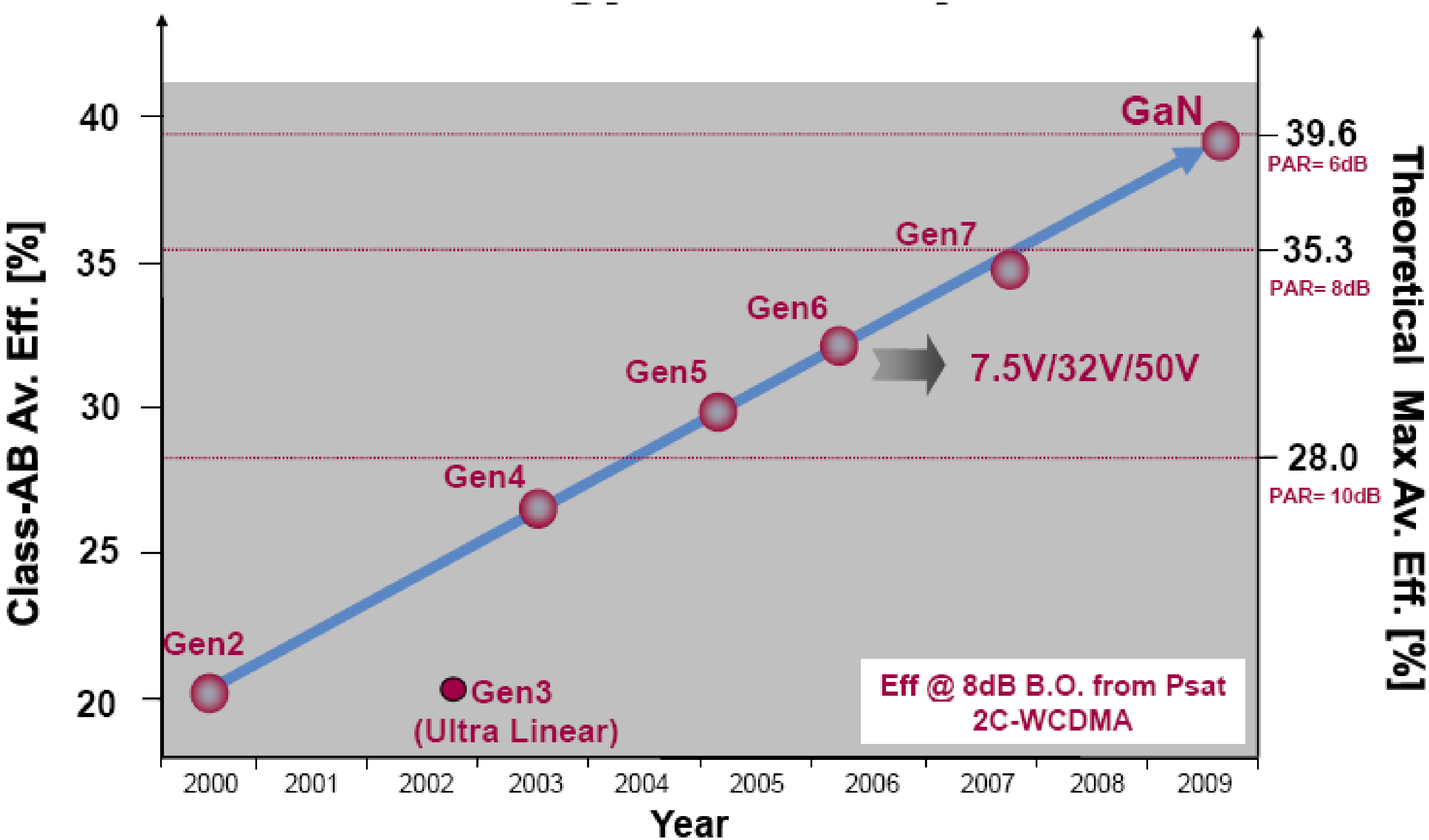
Note: Test signal: 3GPP; test model 1; 64 DPCH; PAR = 7.5 dB at 0.01% probability on CCDF per carrier; carrier spacing 5MHz.

SOT608A **SOT608B** **SOT502B** **SOT502A** **SOT539A** **SOT822-1**

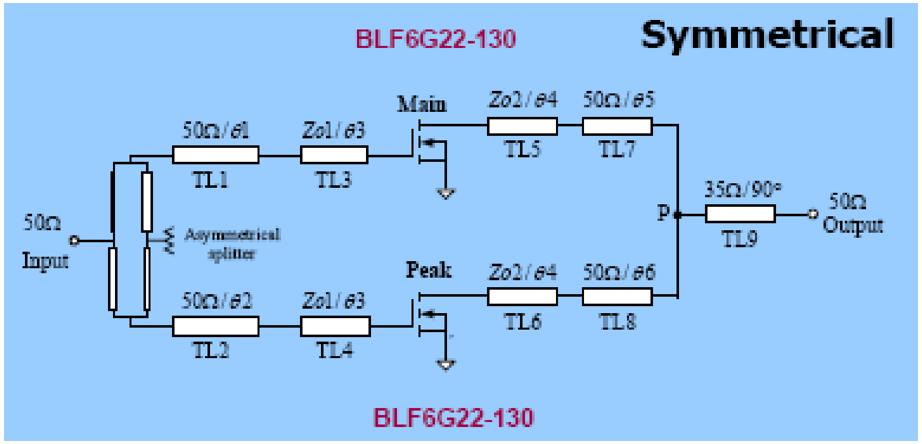
Power Amplifier Efficiency Evolution

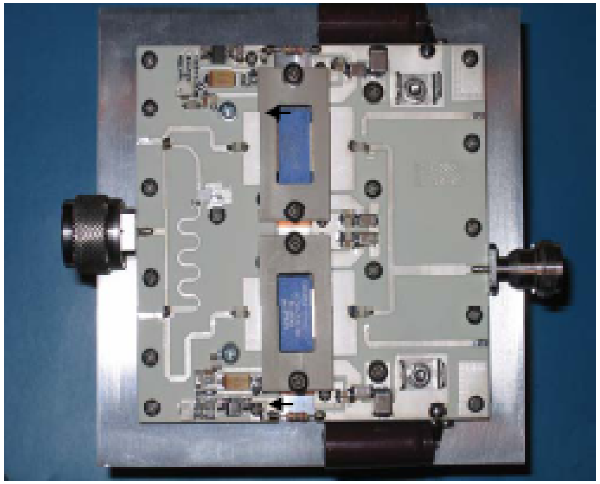


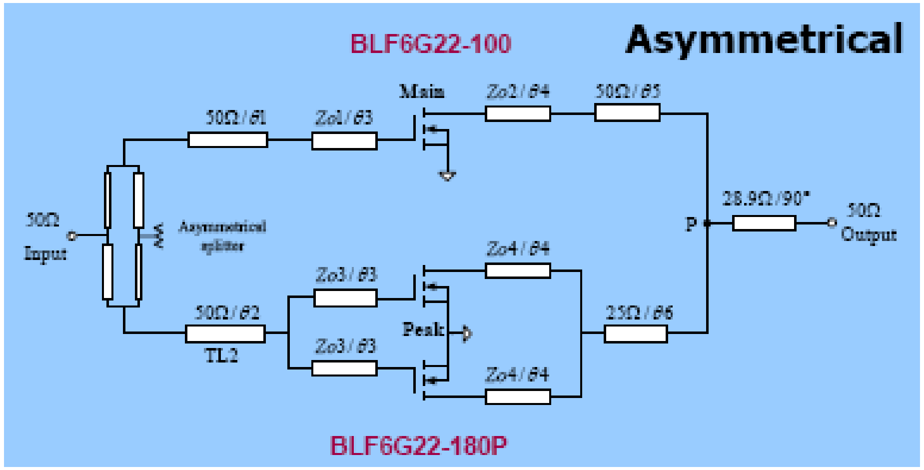
NXP's Technology Efficiency Evolution

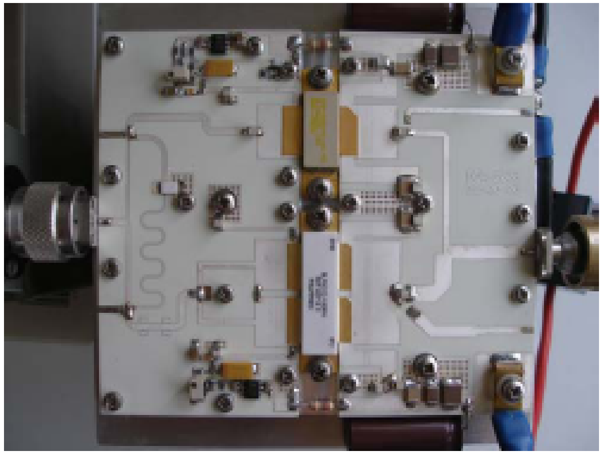


2.2GHz Doherty demo boards

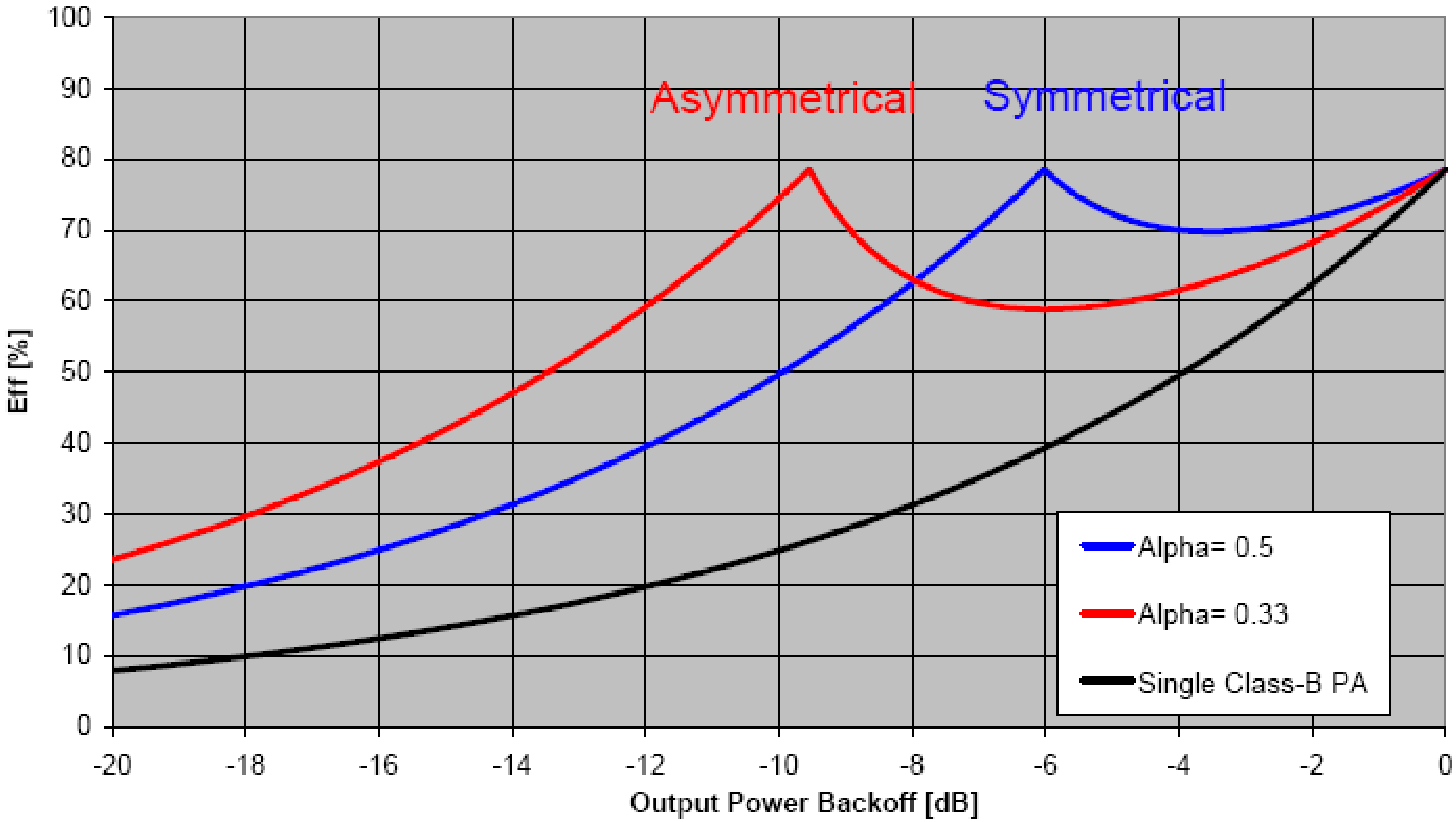








Theoretical Instantaneous Efficiency of Two-Way Doherty versus Back-off



Two-Way Doherty Result comparison

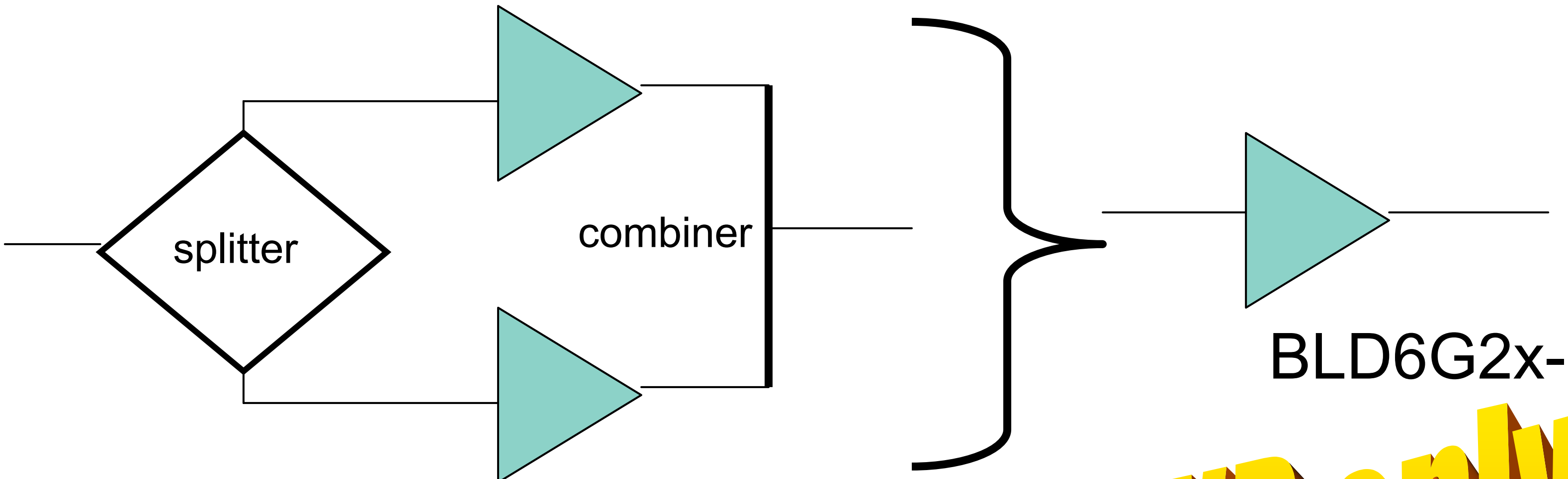
2C WCDMA Performance @ **9dB Back-off!**

	Asymmetrical BLF6G22-100 + BLF6G22-180P	Symmetrical BLC6G22-130+ BLC6G22-130
Freq	2.14 GHZ	2.14GHz
Po-peak	56dBm	55dBm
Po-avg[1)]	47dBm	46dBm
Eff	42%	35%
IM3[2)]	-32dBc	-33dBc
Gain	14.5dB	15dB

Note 1: at 9dB back-off w.r.t Po-peak
Note 2: based on 3GPP Testmodel I 64DPCH clipped to 67% for each carrier

Key benefits of integrated Doherty

- 2 Ldmos's (so 2 packages), input splitter and combiner at output are combined into one package

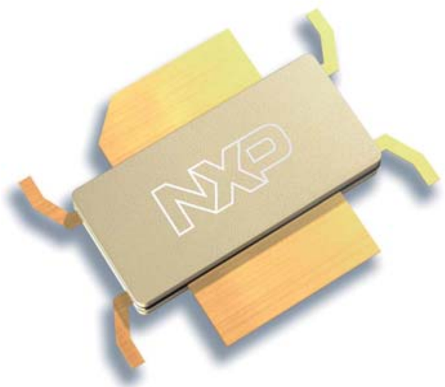


NXP only

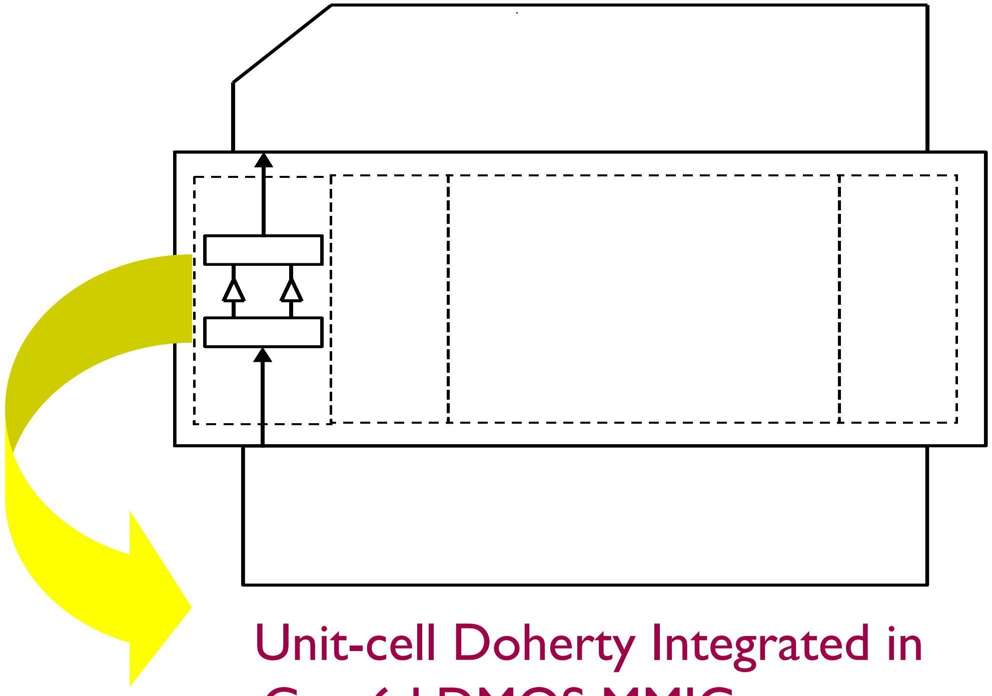
- Results
  - Over all cost reduction in application
  - Smaller form factor
  - Higher reproducibility
  - Faster time to market

Integrated 2W-DPA Prototype

Integrated Doherty
in Standard Package

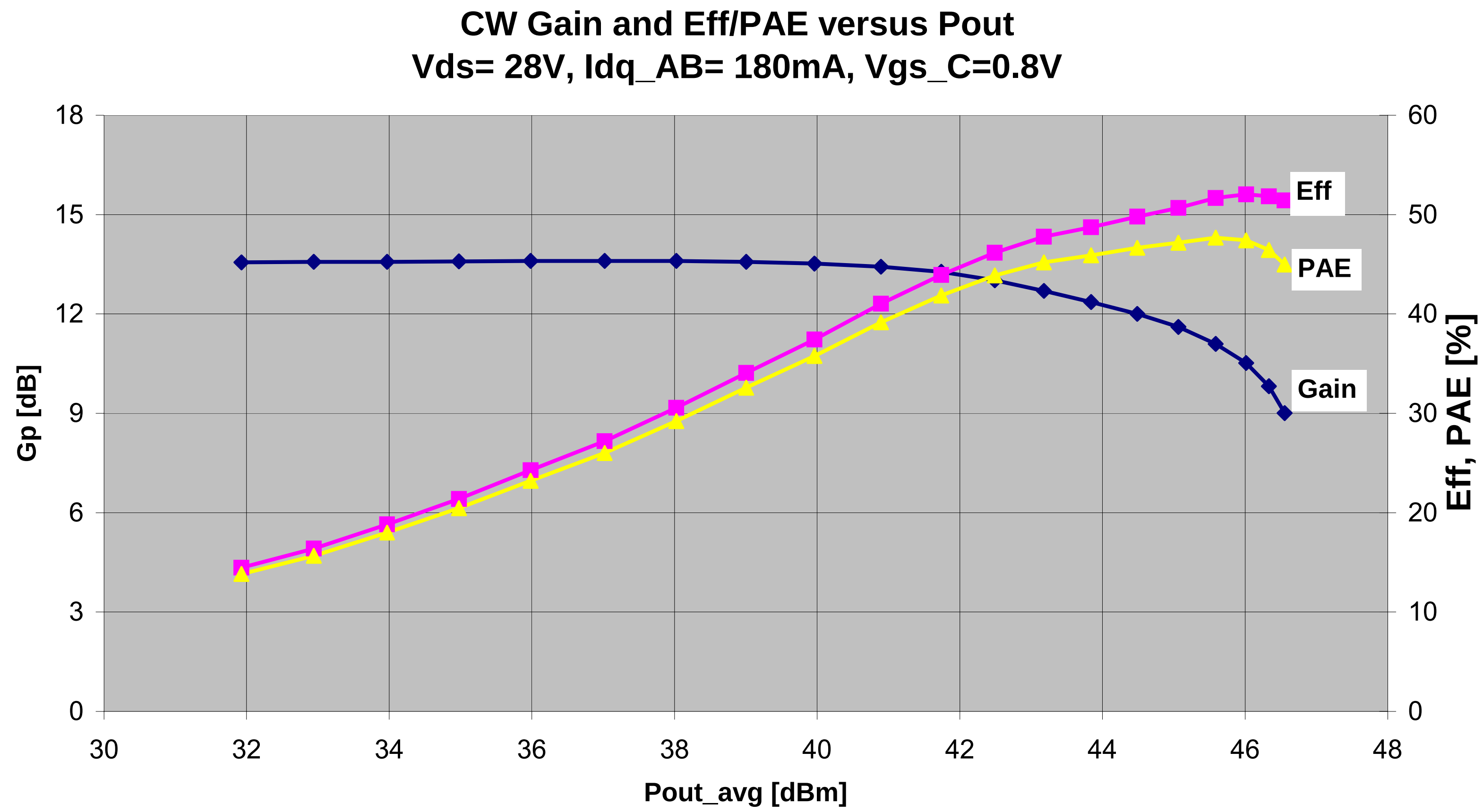


Multiple Low Power Unit-cell
Doherty's in a package



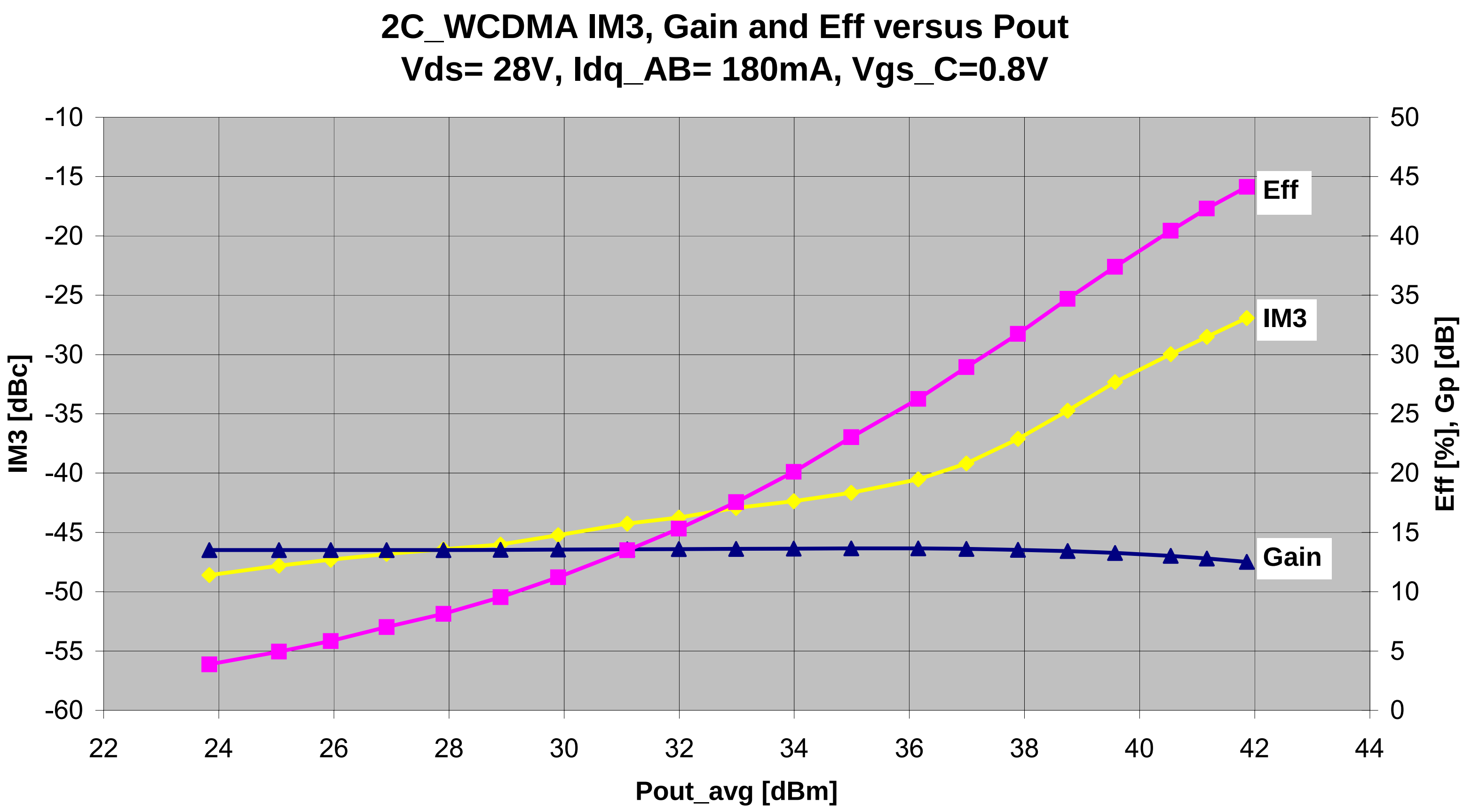
Unit-cell Doherty Integrated in
Gen 6 LDMOS MMIC process

50W CW Gain and Efficiency



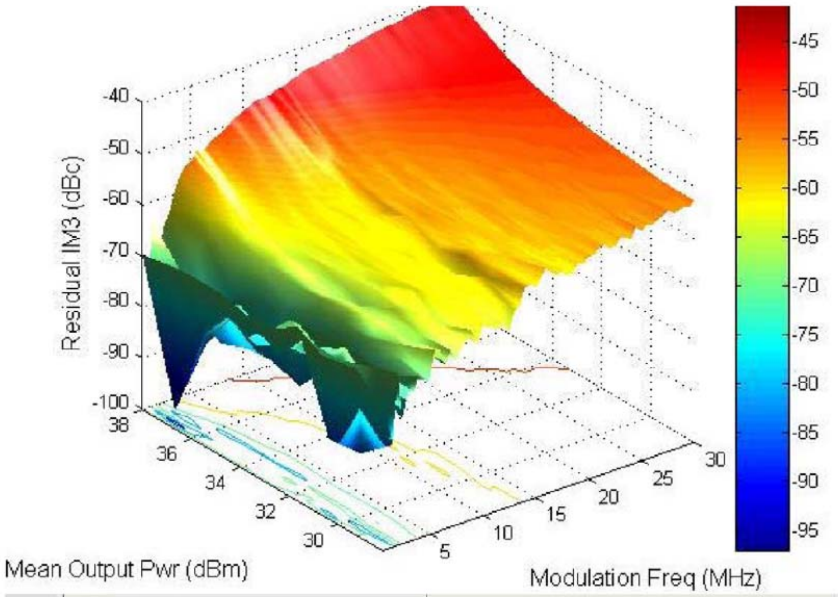
Freq=2140MHz

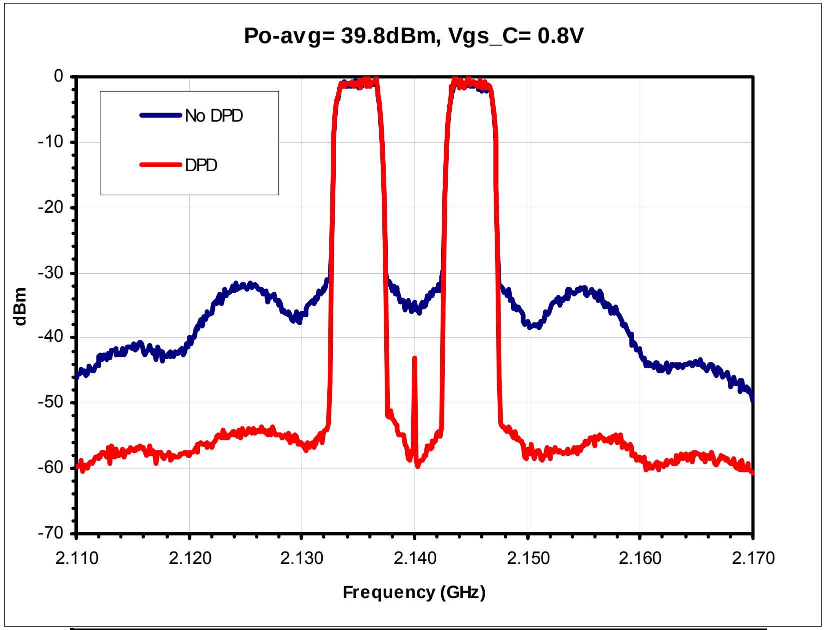
50W 2C-WCDMA Performance



Freq=2140MHz, TM1 64DPCH PAR= 7.5dB

50W Memory and DPD Results





Residual Memory Level	Performance description for a PA output stage
-40dBc	Poor memory performance, memory compensation may struggle, dependent on phase flatness.
-50dBc	Good memory performance, most customer specifications met with memory compensation, dependent on phase flatness.
-60dBc	Excellent memory performance, negates the need for memory compensation in the DPD.

Test Waveform	TM1_64DPCH_101_PAR_7.5dB	
Centre Freq	2140	MHz
Peak Pout	47.19	dBm
Average Pout	39.84	dBm
PAR out	7.35	dB
Supply Volts	28.00	V
Total Current	0.81	A
Efficiency	42.5	%
PA Gain	13.6	dB
PAE	40.6	%

Integrated Doherty versions

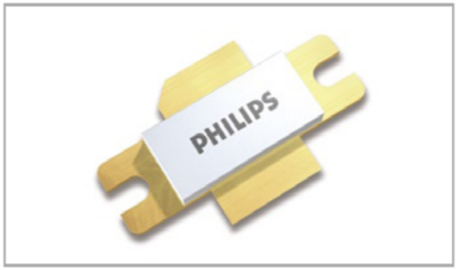
Tentative schedule

- TD-SCDMA-version
  - BLD6G21-50
    - Sample available: December 2008
    - Validated device May 2009 (product is ready for volume ramp up)
    - Fully released July 2009
- WCDMA-version
  - BLD6G22-50
    - Sample available: December 2008
    - Validated device: June 2009 (product is ready for volume ramp up)
    - Fully released Augst 2009

NXP WiMax Portfolio (Gen6 LDMOS)

Product	Package	Matching (I/O)	Mode of Operation	Frequency Band (Min - Max) (MHz)	Output Power (W)	Power Gain (dB)	Efficiency (%)	Adjacent Channel Leakage Ratio -ACLR (dBc)
WiMAX 2500 - 2700 MHz								
BLF6G27LS-135	SOT502B	I / O	IS-95	2500-2700	19	16.5	24	-47
BLF6G27-135	SOT502A	I / O	IS-95	2500-2700	19	16.5	24	-47
BLF6G27S-45	SOT608B	I / O	IS-95	2500-2700	7	17	25	-47
BLF6G27-45	SOT608A	I / O	IS-95	2500-2700	7	17	25	-47
BLF6G27-10	SOT975A	I	IS-95	2500-2700	2	15	22	-47
WiMAX 3400 - 3800 MHz								
BLF6G38LS-100	SOT502B	I / O	IS-95	3400-3800	18.5	13	23	-47
BLF6G38-100	SOT502A	I / O	IS-95	3400-3800	18.5	13	23	-47
BLF6G38LS-50	SOT502B	I / O	IS-95	3400-3800	9	14	25	-47
BLF6G38-50	SOT502A	I / O	IS-95	3400-3800	9	14	25	-47
BLF6G38S-25	SOT608B	I / O	IS-95	3400-3800	5	15	27	-47
BLF6G38-25	SOT608A	I / O	IS-95	3400-3800	5	15	27	-47
BLF6G38-10	SOT975A	I	IS-95	3400-3800	2	13	20	-47

Note: IS-95 signal with pilot, paging, sync and 6 traffic channels (Walsh codes 8-13). PAR=9.7dB @ 0.01% probability on the CCDF

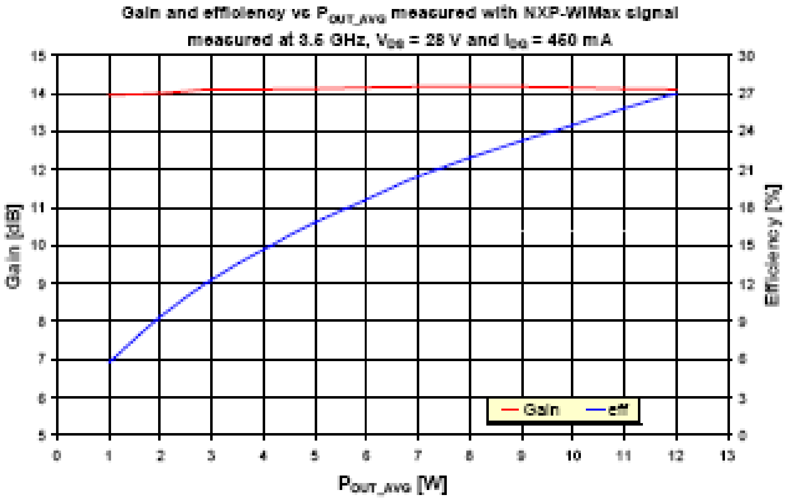


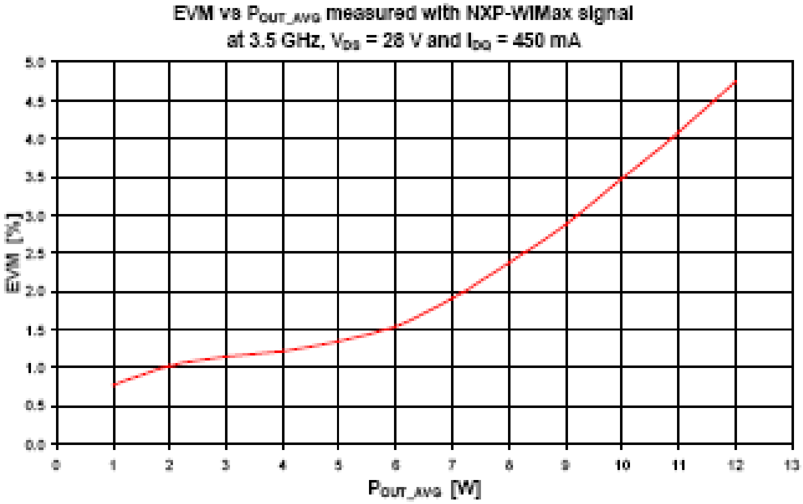
SOT502A

SOT608A

SOT975A

BLF6G38-50 under WiMAX conditions





Po_avg = 39.5dBm
Po_peak = 48dBm
Gain = 14dB
Eff = 22%
EVM = 2.8%
ACLR = -36dBc