AN1224
APPLICATION NOTE

LDMOS RF POWER TRANSISTORS FOR FM BROADBOARD APPLICATION

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1. ABSTRACT

LDMOS technology allows the manufacturing of high efficiency and high gain amplifiers for FM transmitters. LDMOS has proven advantages against bipolar devices in terms of higher gain, efficiency, linearity, biasing simpleness that lowers the overall system cost and makes them attractive for high volume businesses demanding low cost RF power transistor solutions. Due to these advantages, LDMOS RF power transistors are the proven mainstay in the power amplifier business of the cellular base station today. The device used for the present characterization, SD57045, an STMicroelectronics product, is a lateral current, double diffused MOS transistor that delivers 45 watts and 28 Volts. It is unmatched from DC to 1 Ghz making it eligible for a variety of applications, especially for high performance, low cost FM driver applications. This application note documents the feasibility of a low cost 900 MHZ cellular device as a commercial FM driver.

The key advantages of LDMOS technologies are improved thermal resistance and reduced source output inductance. The wire-bonded connections to the external circuitry (DMOS config.) are no longer required because the source at the chip surface is connected to the substrate by the diffusion of a highly doped p-type region. Consequently, LDMOS has excellent high frequency response because of its high f_T and superior gain due to the low feedback capacitance and reduced source inductance. An additional advantage of the LDMOS structure is that Beryllium oxide (BeO), a toxic electrical insulator required to isolate the drain with DMOS transistors, is no longer needed. Hence, not only the thermal resistance is improved, but package cost and environmental impact are significantly reduced. Finally, in an LDMOS, the parasitic bipolar has been nullified guaranteeing good ruggedness, efficiency and high current handling capability.

2. CIRCUIT DESIGN: DESCRIPTION AND CONSIDERATION.

Input and output impedances for the SD57045 are shown in the table below:

Table 1.

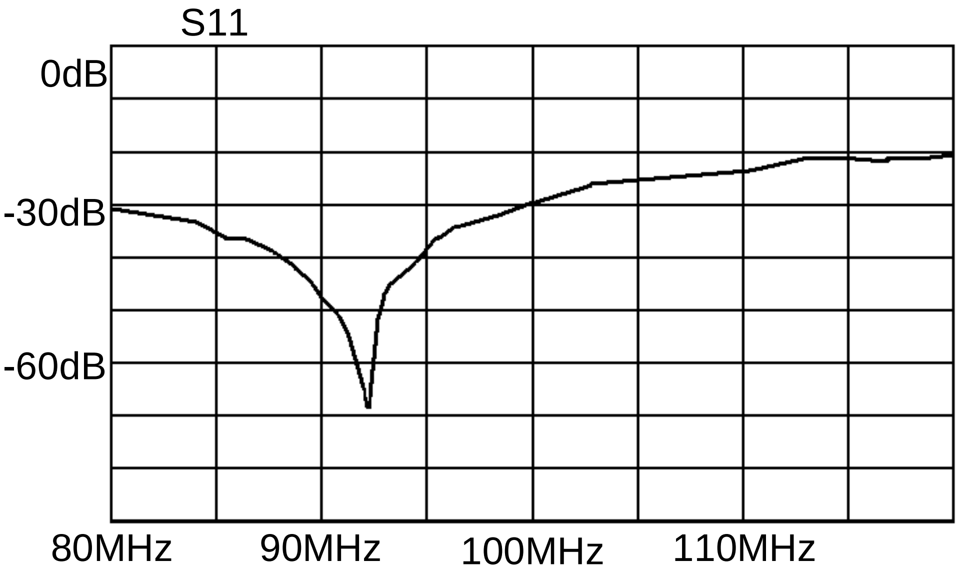
Frequency (MHz)	Z input	Z output
88	10.8-j7.60	7.5-j0.15
95	10.6-j8.36	7.8-j0.34
108	10.5-j9.87	8.1-j0.61

With respect to these impedances, two 4:1 transmission line auto transformers were designed using a 25 Ohm, 1/8 wavelength, semi rigid coaxial cable. To achieve this transformation across the band, a capacitor was added to the low impedance port of each transformer to cancel the leakage inductance. The frequency response is shown in figure 1. Simple L-sections were utilized to make the final transformation from the low impedance port of the transformers (12.5 Ohms) to the measured impedances of the device (see table 1). This design uses printed series inductors on a 30 mil Glass Teflon board.

The gain of any power FET is extremely high from DC throughout the low HF frequency band. A feedback network is necessary to suppress the low frequency gain, as well as give a nominal amount of gain at the frequency of interest. This feedback also helps to increase the input impedance. Since LDMOS has such a high gain at low frequencies, a low value, high power, flange mount resistor must be comprised in the design. The capacitor in the feedback path (C3) provides negative feedback at low frequencies. This component was designed to be self-resonant.

Far below the FM band, at 100 MHz, the capacitor looks slightly inductive, reducing the amount of feedback in the band of interest.

Figure 1: Broad Band 4:1 Transformer



Unbalanced transformers offer an efficient matching method from 50 Ω to low impedance. Besides, auto transformers have a zero impedance point over a broad bandwidth, offering an ideal DC feeding point to the gate and drain circuits. In order to prevent high frequency oscillations, a bypass capacitor is used at the zero impedance point of the transformer. Capacitor value must be selected so that its self resonant frequency is above the frequency of interest. Depending on the application, additional low frequency bypass capacitors isolated with lossy elements (ferrite beads) may be required to prevent power supply noise affecting gate and drain circuits.

Circuit schematic is given in figure 2, and layout in figure 3 with component values in table 2.

Table 2.

L1,L3, L4, L7	50 Ω transmission line
C1,C13	1000 pF chip capacitor
C2	39000pF chip capacitor
C3	36pF chip capacitor
R1	1 kΩ resistor
C4,C6, C10	10000pF chip capacitor
R2	1.2 kΩ resistor
C5,C12	10uF, 50V electrolytic capacitor
R3	240 Ω / 40W resistor
C9, C11	1200pF chip capacitor
C8	33pF chip capacitor
C7	25-115pF variable cap-Arco trimmer
L2,L6	4:1 transformers, 10.7", 25 Ω.
Board	30mils, 2 ounces of copper, ε_r = 2.55

Figure 2: Broad Band Power Amplifier

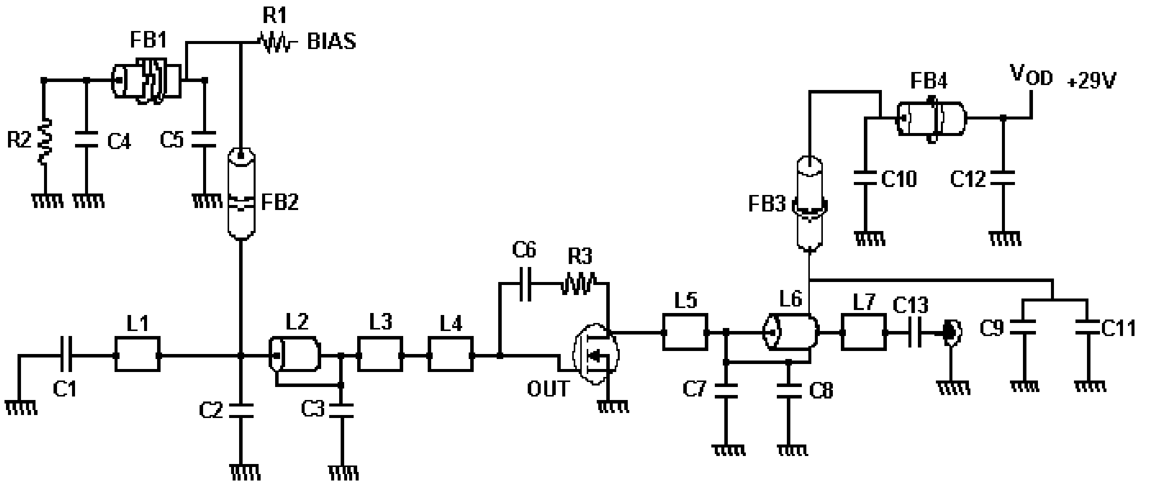
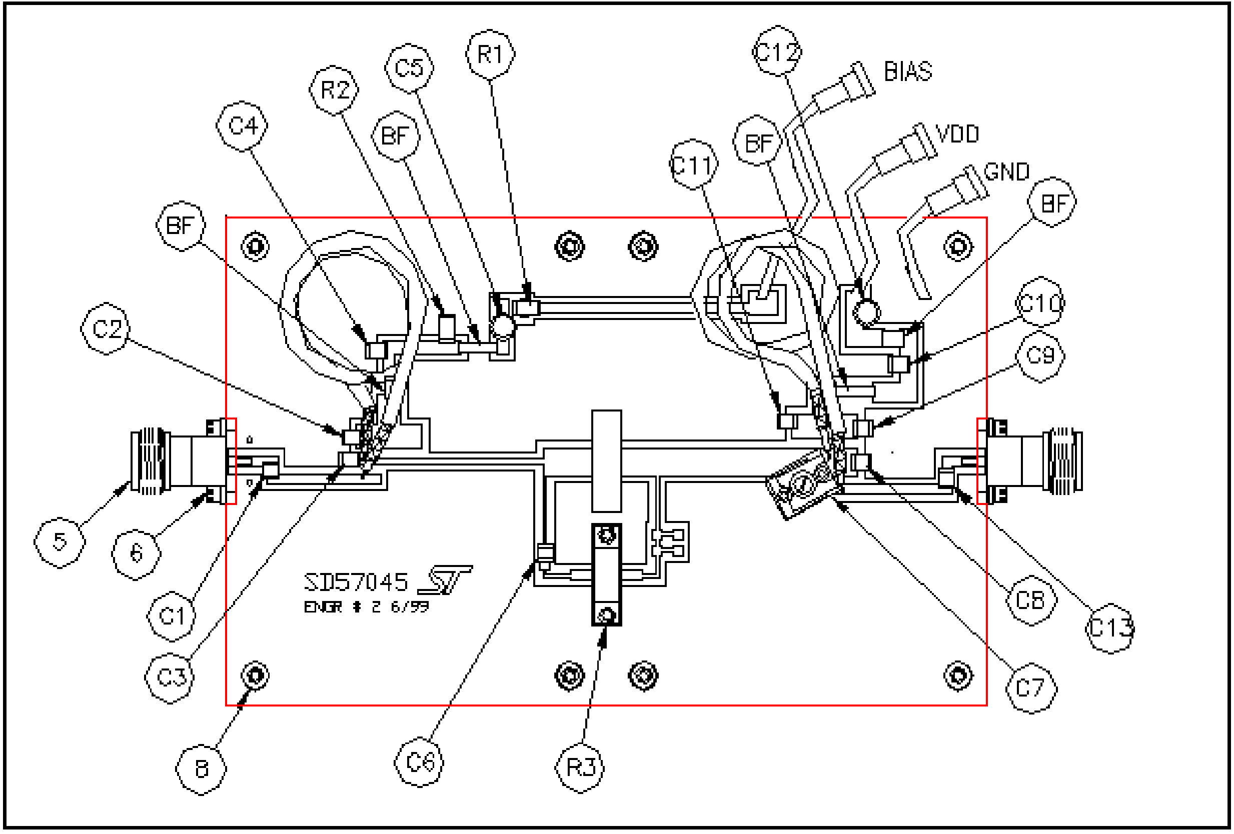


Figure 3: Layout for Broad Band Power Amplifier



3. CHARACTERIZATION RESULTS.

Absolute maximum ratings (T_{CASE} = 25ºC)

Table 3.

Symbol	Parameter	Value	Unit
$V_{(BR)DSS}$	Drain-Source Voltage	65	V
V_{DGR}	Drain-Gate Voltage (RGS = 1 MΩ)	65	V
V_{GS}	Gate-Source Voltage	+/-20	V
I_D	Drain Current	5	A
P_{DISS}	Power Dissipation (@ TC=70 ºC)	93	W
T_{JMax}	Operating Junction Temperature	200	ºC
T_{STG}	Storage Temperature	-65 to 200	ºC

Thermal data

$R_{TH(j-c)}$	Junction-Case Thermal Resistance	1.4	C/W

Figure 4: Drain Current vs. Gate-Source Voltage

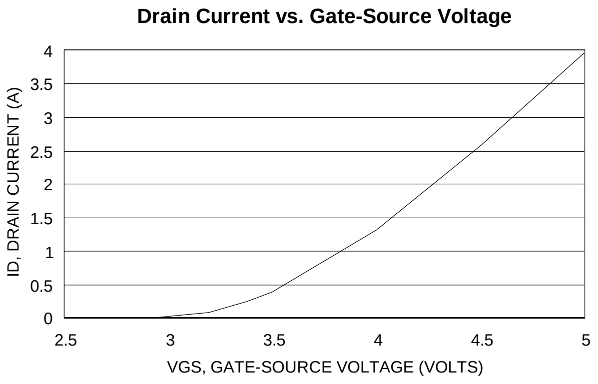


Figure 5: Gate-Source Voltage versus Case Temperature

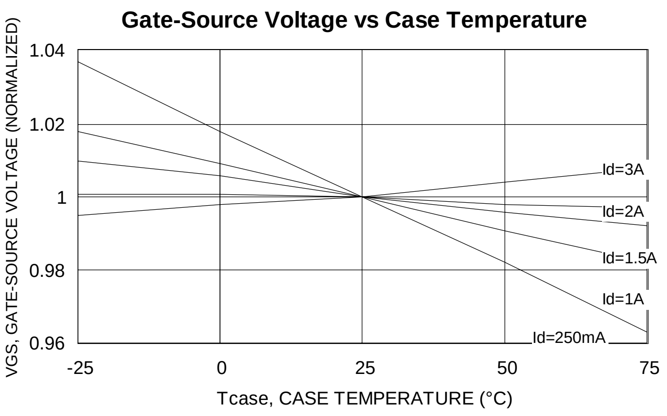


Figure 6: Output Power and Effeciency versus Input Power

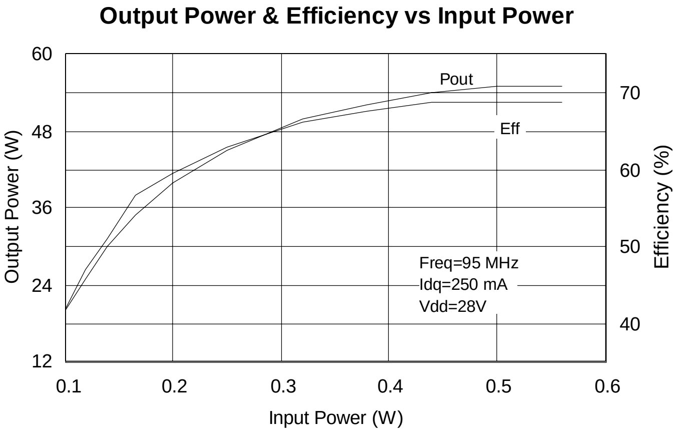


Figure 7: Power Gain and Efficiency vs. Output Power

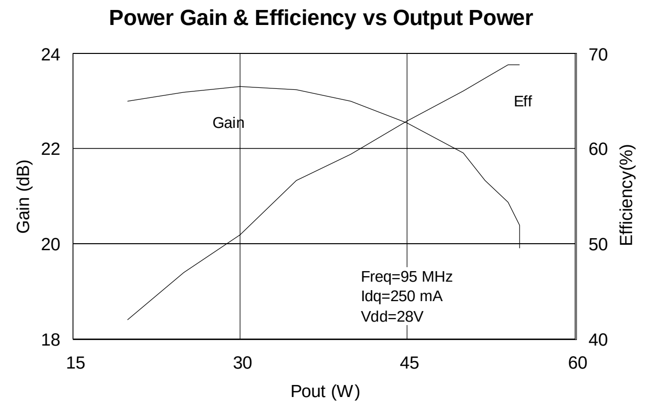
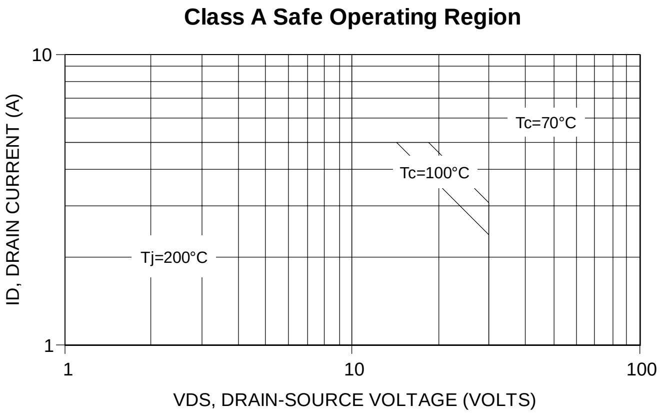


Figure 8: Class A Safe Operating Area



4. CONCLUSION

In this application note we have demonstrated the feasibility of a low cost, 900 MHZ cellular device as a commercial FM driver. One can conclude that ST LDMOS technology offers viable solutions for power amplifiers at frequencies covering the high HF throughout the high UHF bands. More information about these devices can be found at http://www.st.com.

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