AN2048
# Application note

## PD54008L-E: 8 W - 7 V LDMOS in PowerFLAT packages for wireless meter reading applications

## Introduction

STMicroelectronics has been strongly involved in finding new package solutions for power integrated circuits to obtain a surface mount device (SMD). The PowerFLAT™ package introduced in this application note shows the new concept of chip-size packaging representing a fundamental step to reduce the costs of assembly and to shrink power amplifier modules. This package helps maximize board space with improved electrical and thermal performances over traditional packages with leads. This leadless package is an MLP (micro leadframe package) where the electrical connections are made through landing pads on the bottom surface of the component. These landing pads are soldered directly to the pc board.

**Figure 1. MLP cross section**

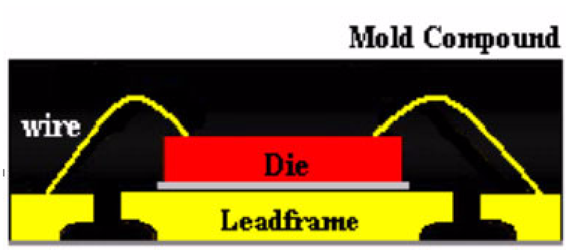
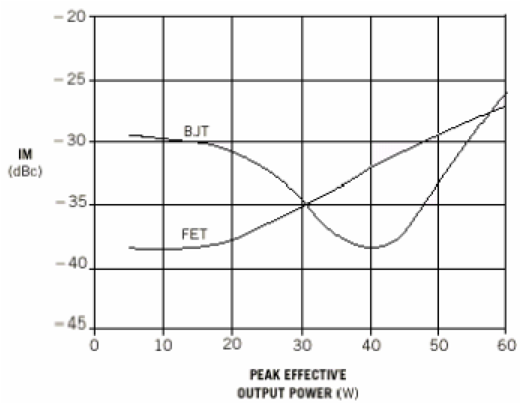



**Figure 2. Intermodulation distortion versus peak effective output power**




The standard MLP has an exposed die attach pad which enhances the thermal and electrical characteristics enabling high-power and high-frequency applications. For small and medium-power applications, such as wireless PMR (private mobile radio) LDMOS (Laterally Diffused MOS) transistors in PowerFLAT packages offer certain advantages compared to equivalent bipolar transistors, for example, better intermodulation (IMD3). Under certain conditions, an LDMOS transistor exhibits better intermodulation distortion than a bipolar junction transistor. *Figure 2* shows intermodulation distortion versus peak effective output power for equivalently rated bipolar and LDMOS transistors. As we can see, below 30 W, the LDMOS device has lower intermodulation distortion than the bipolar transistor.

- Good gain linearity
- Smooth saturation
- Simpler bias circuit
- Thermal stability. The drain current has a positive temperature coefficient, therefore the MOS transistor is not susceptible to thermal runaway.
- Better ruggedness

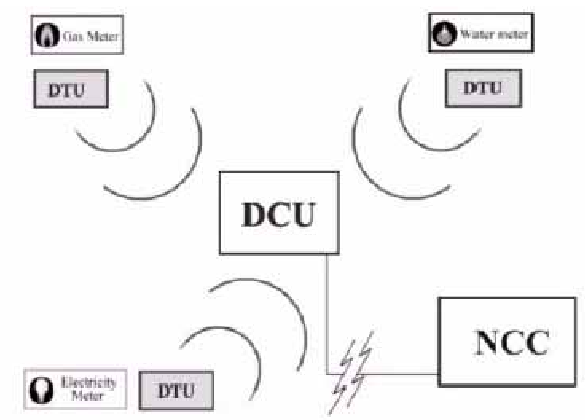
# Contents

# List of figures

# 1 Basic wireless meter reading system description

To reduce cost and difficulties associated with the reading of indoor utility meters for gas, water and electricity, a new automatic meter reading system has recently been introduced. It uses radio frequency networks and allows direct data communication between reading meters and services and/or the billing department. A DTU (Data Transmission Unit) module that contains a powerful UHF narrow-band radio transmitter is attached to gas, water and electric utility meters.

**Figure 3. Network system**




A DCU (Data Collector Unit) is placed in a convenient location within an apartment building or housing complex.

The DCU contacts daily an NCC (Network Control Computer) and forwards the meter reading information.

The NCC processes the information and provides billing data and customer support information. This paper describes a DTU solution using an STMicroelectronics 8 W - 7 V LDMOS device housed in a PowerFLAT and called PD54008L-E.

# 2 Electrical requirements

- $V_{DD}$=5 V IDQ = 10 mA frequency band [450 ÷ 470] MHz
- $P_{out}$ = 36 dBm gain flatness < 1dB

# 3 Circuit design and considerations

The PD54008L-E is an 8 W - 7 V LDMOS housed in a PowerFLAT plastic package (5x5 mm).

Being an internally unmatched device, the PD54008L-E can be used in different portable applications over HF, VHF & UHF frequency bands.

*Table 1* shows the source and load impedances of the PD54008L-E at 500 MHz.

**Figure 4. Source and load impedances of PD54008L-E**

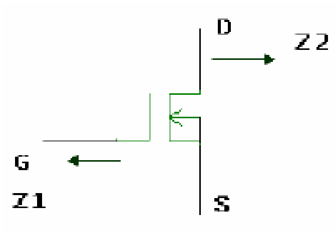



**Table 1. Source and load impedances of PD54008L-E at 500 MHz**

| F (MHz) | Z1 (Ω) | Z2 (Ω) |
|---|---|---|
| 500 | 0.3+j2.0 | 1.8+j0.7 |

The above impedances are taken as a starting point to design the input and output matching networks of the PD54008L-E amplifier. Microstrip lines and lumped elements are used.

## 3.1 Amplifier construction

The PCB is made of double-sided copper-clad fiberglass (THK 0.020") with the lowest dielectric constant ($\varepsilon r$ = 2.17) and dissipation factor available. The printed circuit board is glued to copper for dissipation purposes.

**Figure 5. Device footprint**

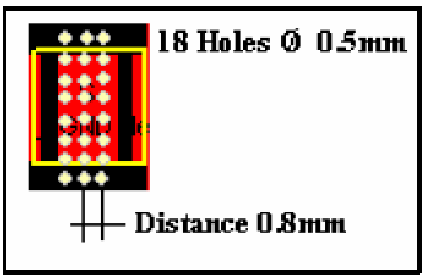
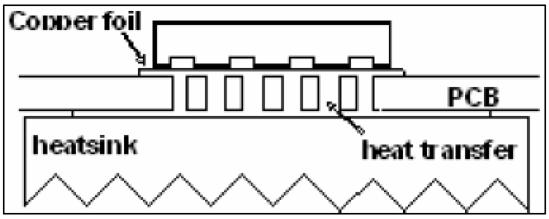


**Figure 6. Cross section**




# 4 Circuit schematic and bill of material

**Figure 7. Broadband power amplifier**

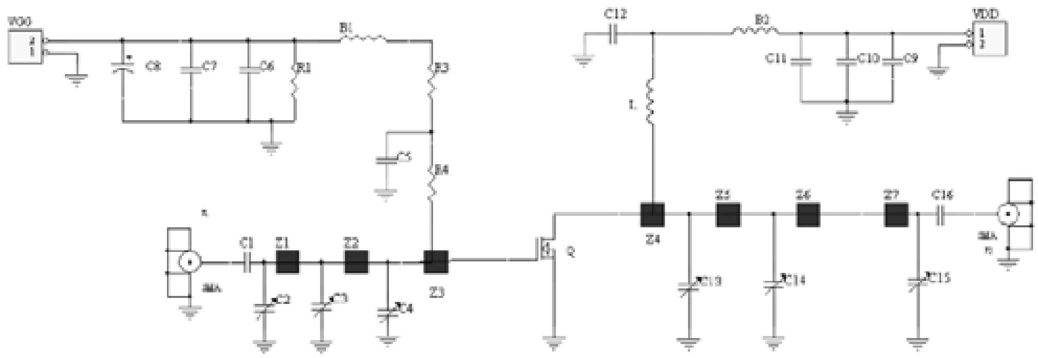



**Table 2. Bill of material**

| Components | Description |
|---|---|
| B1, B2 | Ferrite bead |
| C1, C16 | 300 pF, 100 B ATC chip capacitor |
| C2, C15 | 0.8 ÷ 8 pF var. cap. Gigatrim Johanson |
| C3, C14 | 4 ÷ 25 pF var. cap. Murata TZBX4Z250AA110 |
| C4 | 7 ÷ 50 pF var. cap. Murata TZBX4R500AA110 |
| C5, C12 | 120 pF, chip capacitor Murata |
| C6, C11 | 0.1 nF, chip capacitor Murata |
| C8, C9 | 10 µF, 50 V electrolytic capacitor |
| C7, C10 | 1 nF, CHIP capacitor Murata |
| C13 | 6.5  30 pF var. cap. Murata TZBX4P300AA110 |
| L | 56 nH coilcraft |
| R1 | 33 kΩ chip resistor 1/4 W |
| R4 | 15 Ω melf resistor 1/4 W |

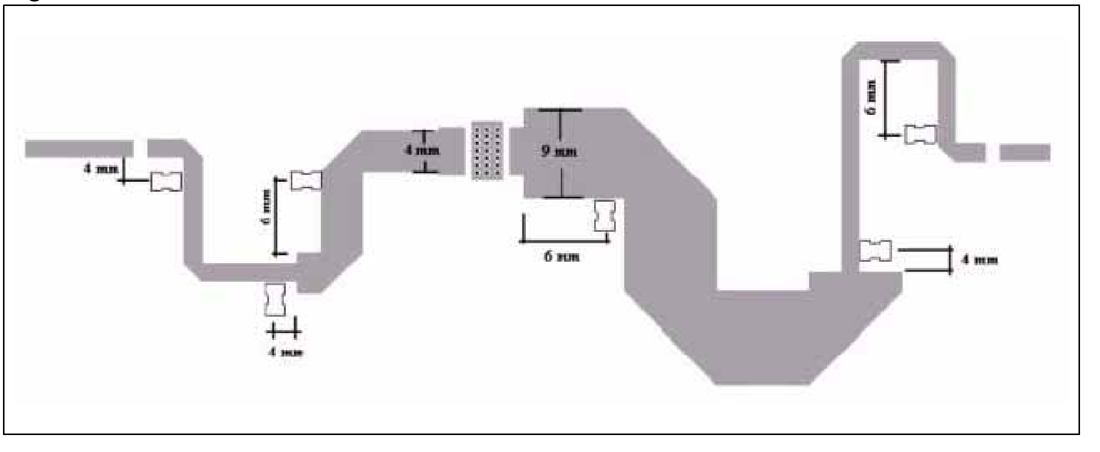
Table 2. Bill of material (continued)

| Components | Description |
|---|---|
| R3 | 1 kΩ chip resistor 1/4 W |
| J1, J2 | SMA connector |
| Board | Arlon DiClad 880 THK 0.020“ $\varepsilon r$= 2.17 2OZ ED Cu both sides |

# 5 Transmission line

The microstrip layout (gerber files available on request) is shown below in *Figure 8*.

Figure 8. Transmission line




## 5.1 Characterization results

After tuning for the best performance the results are as shown in *Figure 9*.

**Figure 9. Power gain vs. frequency**

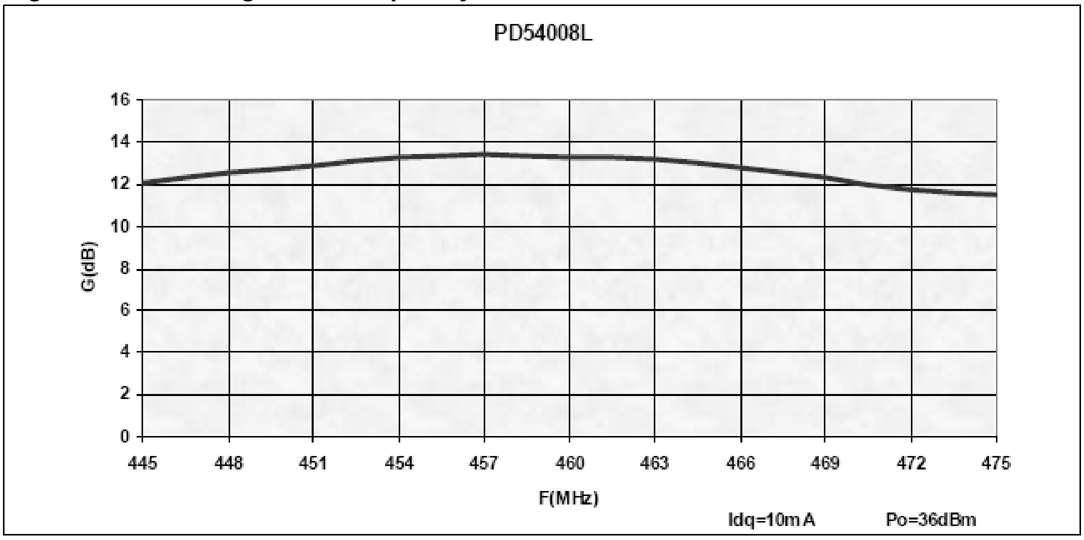



**Figure 10. Input return loss vs. frequency**

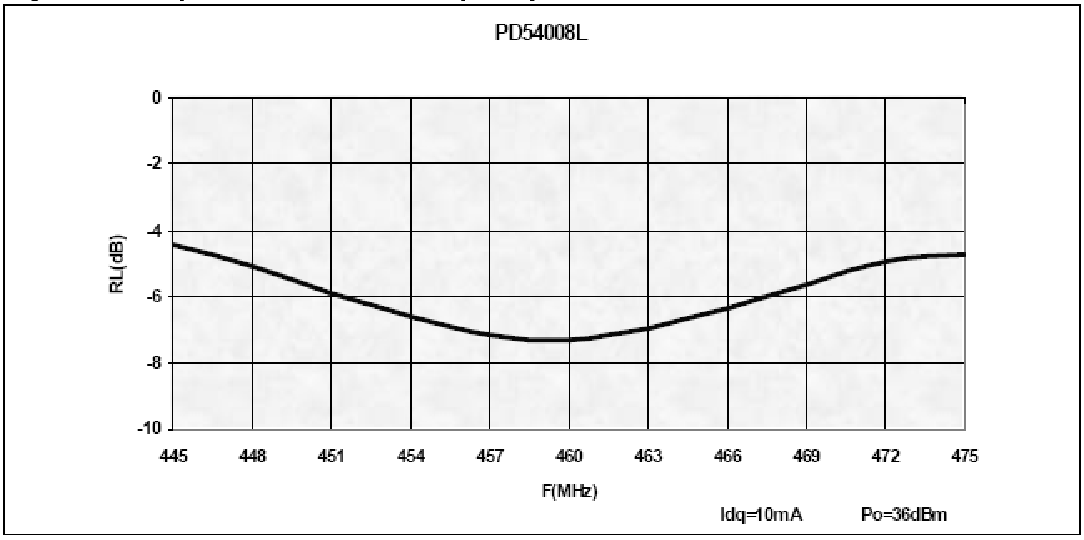


Figure 11. Drain efficiency vs. frequency

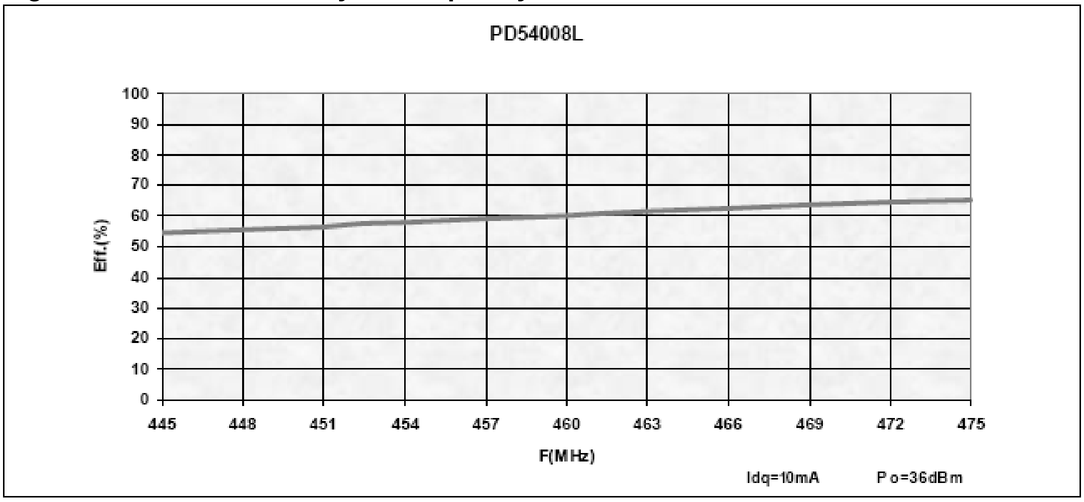



Figure 12. Drain efficiency vs. frequency at different drain voltages

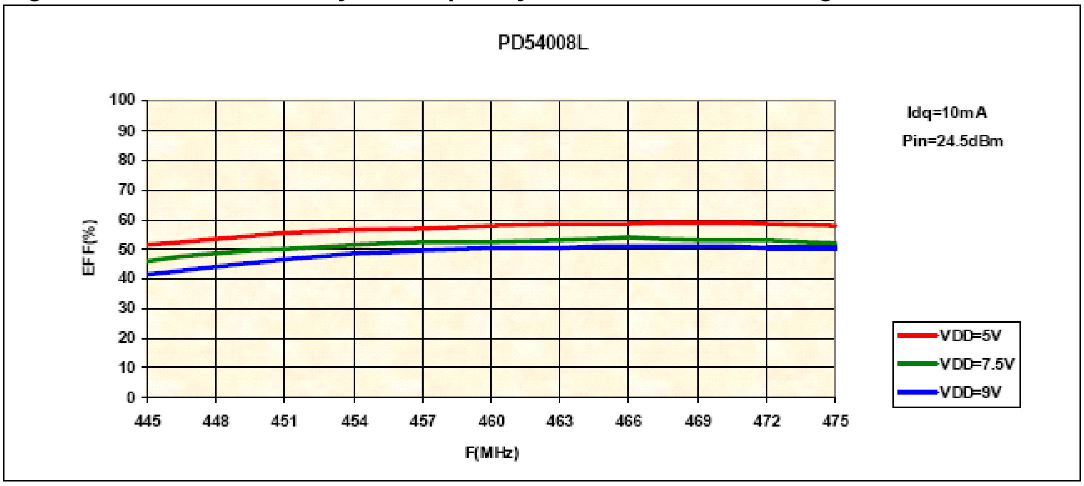
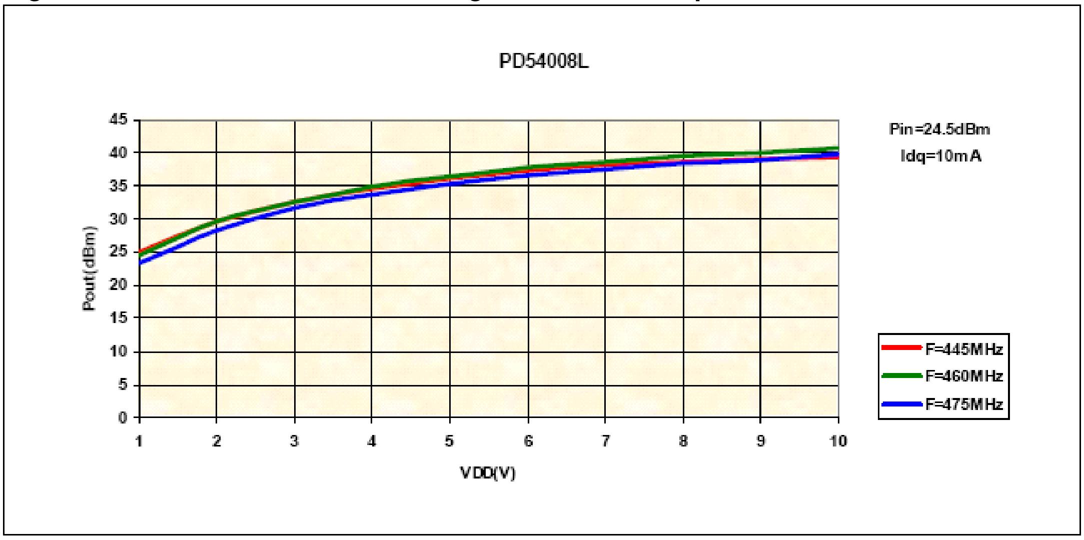



Figure 13. Power out vs. drain voltage at different frequencies



After the electrical analysis, the PD54008L-E was removed from the pcb and the input/output impedances were measured.

**Figure 14. Impedance data schematic**

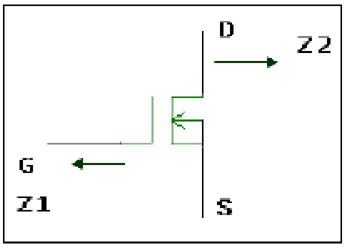



**Table 3. Impedance data**

| F(MHz) | Z1 (Ω) | Z2 (Ω) |
|---|---|---|
| 450 | 1.0+j2.9 | 1.8+j0.5 |
| 460 | 0.9+j3.0 | 1.9+j0.7 |
| 470 | 0.9+j3.4 | 1.9+j0.9 |

# 6 Components layout

Figure 15. PCB layout

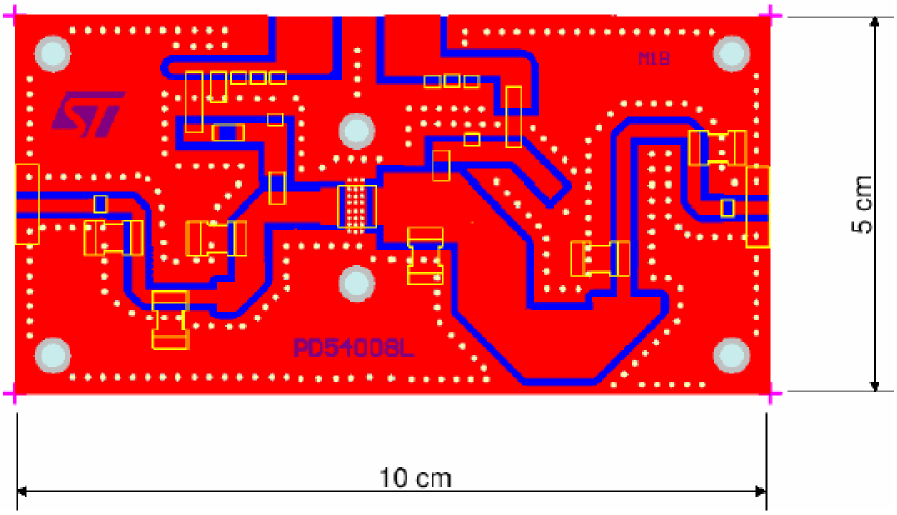
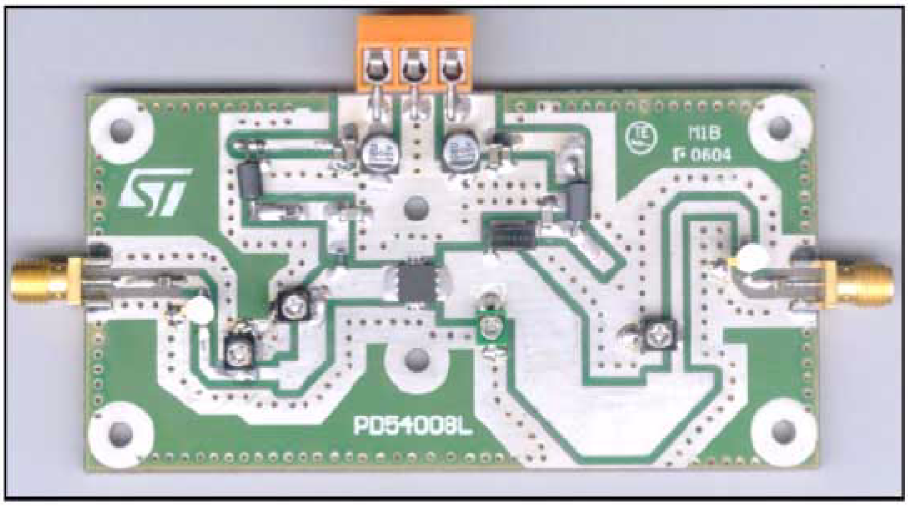



Figure 16. PD54008L-E amplifier



# 7 Characterization results

As we can see from *Figure 9*, *10* and *11*, we can achieve a minimum gain of 12 dB with an input return loss better than 5 dB and a drain efficiency between 55% and 65% over the frequency band 445 ÷ 475 MHz.

Even so the output power can be controlled through Vgs, a minimum of 15 dB dynamic range can be achieved by varying $V_{dd}$ (*Figure 13*). This allows better control of the transmitted power out and may extend the transmission range capability to more than 3 miles (depending on environment) as requested in some commercial products.

# 8 Feature characteristics

Other optional functions in which this application may be used are:

- Equipment monitoring
- CO/Methane/Fire detection
- Security/Alarm services
- Data logging
- All VHF and UHF PMR portables

# 9 References

1. "RF power amplifiers for wireless communications", Artech House
2. "RF transistors meet wireless challenges" - Technical Editor - EDN magazine pag. 53 - 61, May 3, 2001 - www.ednmag.com.
3. "PowerSO-10RF - The first true RF power SMD Package" - Application Note 1294 - STMicroelectronics.
4. "Understanding LDMOS device fundamentals" Application Note 1226 - STMicroelectronics.

# 10 Revision history

**Table 4. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 14-Oct-2004 | 1 | Initial release |
| 06-Feb-2008 | 2 | Document reformatted no content change<br>PD54008L replaced by PD54008L-E |