Development of High-power MOSFET Device for Professional Radio Applications

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With the progress of digitization, miniaturization, lower power consumption and cost reduction, professional radios require a power amplification device in a surface mount package with a higher performance.

In response to these requirements, a 12.5-V operation high-power MOSFET, the RD70HUF2, has been developed.

The newly developed device has achieved industry-leading high-frequency performance: typical output power of 75 W and drain efficiency of 65% at a frequency of 530 MHz.

1. Introduction

Recent professional radio technologies are making significant progress toward a digital transmission system such as terrestrial trunked radio (TETRA) as well as for lower power consumption and smaller radios. Therefore, electric power amplification devices for the transmitting stage are required to further reduce distortion and enhance efficiency.

Meanwhile, the package of electronic components used for professional radios is shifting to the surface mount type to facilitate production automation. The electric power amplification devices for the transmitting stage are also required to shift from manual- to surface-mounting type to permit automation.

To meet these requirements, Mitsubishi Electric has developed the RD70HUF2, a surface mountable, 12.5-V operation high-power discrete MOSFET device for use in professional radios for mobile vehicles, and mass production started this year.

We have developed a device package that enables a high-power device to be surface-mounted on the circuit board to dissipate the generated heat through the heat sink of the radio chassis, and a transistor that can be used in professional digital radios in both the VHF and UHF bands.

2. Structure of the Device Package

The device package for conventional high-power MOSFET is formed with a metal flange and ceramic cap, whereas the RD70HUF2 uses a surface mountable plastic molded package to enable automated production of radio sets. Figure 1 is a photograph of the external package and Fig. 2 shows its internal structure.

Even if the device is surface-mounted on the circuit board, the newly developed package frame can dissipate the heat being generated by the MOSFET chip through the heat sink on the radio chassis.

![Fig. 1 External view of RD70HUF2](image1)

![Fig. 2 Structure of package frame](image2)

The base frame of this package consists of thin-plate source electrodes and a thick-plate heat dissipating electrode formed into a single piece, and thus the base frame varies in thickness and is difficult to be made by general press forming. This time, we have achieved single-piece forming by using a method of sintering metallic powder.

3. Structure of Transistor

Mitsubishi Electric has been working on the development of MOSFET structures using a silicon wafer to achieve high power output, high efficiency, ruggedness to VSWR mismatch, and low distortion(1)(2)(3). By integrating these technologies, we have developed a new MOSFET chip. The cross-sectional structure of the new MOSFET is shown in Fig. 3.
For this MOSFET, a thinner wafer and improved wafer back metallization are used to reduce the thermal resistance and ground resistance, and thus higher power output and enhanced efficiency have been achieved. In addition, low distortion has also been achieved by taking advantage of the impurity concentrations in the channel P+/P and N-offset regions and the filed plate, which reduce drain conductance, output capacitance, and feedback capacitance, as these are the causes of degrading distortion.

For the wideband operation, the device must also provide a high gain in the UHF band and high load mismatch tolerance in the VHF band. For this chip, the gain has been improved by reducing the gate length, and the high load mismatch tolerance has also been enhanced by using the drain N region and the P− region of the silicon wafer as a diode to release the reflected power to the back side of the chip.

Figure 4 is an external view of the MOSFET chip. With these improvements in the MOSFET structure, high-frequency characteristics exceeding those of conventional products have been achieved.

4. Device Evaluation Board

The circuit design and its implementation are essential for fully utilizing the MOSFET performance in the power amplifier for the radio transmitting stage.

To support the design and implementation of the circuit using RD70HUF2, evaluation boards corresponding to various radio applications have been developed. Figure 5 shows one of those device evaluation boards.

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition</th>
<th>Conventional</th>
<th>Newly developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency for VHF evaluation</td>
<td>175 MHz</td>
<td>RD70HV1F1</td>
<td>RD70HUF2</td>
</tr>
<tr>
<td>Saturation power</td>
<td>at 4 W input</td>
<td>83W</td>
<td>93W</td>
</tr>
<tr>
<td>Drain efficiency</td>
<td>at 4 W input</td>
<td>58%</td>
<td>67%</td>
</tr>
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Table 2 Comparison in UHF band with conventional Mitsubishi Electric product

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition</th>
<th>Conventional</th>
<th>Newly developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency for UHF evaluation</td>
<td>520 MHz</td>
<td>RD60HUF1</td>
<td>RD70HUF2</td>
</tr>
<tr>
<td>Power gain at 70 W output</td>
<td></td>
<td>8dB</td>
<td>12dB</td>
</tr>
<tr>
<td>Drain efficiency at 70 W output</td>
<td></td>
<td>58%</td>
<td>63%</td>
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</tbody>
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Figure 6 shows the frequency dependence in the UHF band. In the UHF band, under the band matching condition between 450 and 520 MHz with an input power of 5.5 W, an output power equal to or more than 75 W and a drain efficiency equal to or more than 63% have been achieved. It should be noted, in particular, that the high-frequency characteristics with a power output of 75 W (typ) and a drain efficiency of 65% (typ) at a frequency of 530 MHz is the best performance in the industry.

Figure 7 shows the output power dependence of the power gain and adjacent channel leakage ratio (ACLR) when a digital modulation signal for UHF professional radios is used. In the range from linear operation to 3 dB gain compression point with an output power of 40 dBm, a high performance with a power gain of 15 dB and ACLR of $-50$ dBc has been achieved. These high performances can significantly help to improve the characteristics of professional digital radios.

We will continue to develop high-performance MOSFET devices in response to the evolution of professional radio and other mobile communications, thus improving the performance and reducing the cost of the radio equipment.

References