DESCRIPTION
The RA60H1317M1A is a 60-watt RF MOSFET Amplifier Module for 12.5-volt mobile radios that operate in the 136- to 174-MHz range. The battery can be connected directly to the drain of the enhancement-mode MOSFET transistors. The output power and drain current increase as the gate voltage increases. With a gate voltage around 4V (minimum), output power and drain current increases substantially. The nominal output power becomes available at 4.5V (typical) and 5V (maximum). At V_{GG}=5V, the typical gate current is 1 mA. This module is designed for non-linear FM modulation, but may also be used for linear modulation by setting the drain quiescent current with the gate voltage and controlling the output power with the input power.

FEATURES
- Enhancement-Mode MOSFET Transistors (I_{DSS}=0 @ V_{DD}=12.5V, V_{GG}=0V)
- P_{out}>60W, \eta>45% @ V_{DD}=12.5V, V_{GG}=5V, P_{in}=50mW
- Broadband Frequency Range: 136-174MHz
- Low-Power Control Current I_{GG}=1mA (typ) at V_{GG}=5V
- Module Size: 67 x 19.4 x 9.9 mm

RoHS COMPLIANCE
- RA60H1317M1A-201 is a RoHS compliant product.
- RoHS compliance is indicate by the letter “G” after the Lot Marking.
- This product include the lead in the Glass of electronic parts and the lead in electronic Ceramic parts.

However, it is applicable to the following exceptions of RoHS Directions.
1. Lead in the Glass of a cathode-ray tube, electronic parts, and fluorescent tubes.
2. Lead in electronic Ceramic parts.

ORDERING INFORMATION:

<table>
<thead>
<tr>
<th>ORDER NUMBER</th>
<th>SUPPLY FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA60H1317M1A-201</td>
<td>Antistatic tray, 10 modules/tray</td>
</tr>
</tbody>
</table>
**MAXIMUM RATINGS** *(T\text{case}=+25^\circ C, unless otherwise specified)*

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>RATING</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>V\text{DD}</td>
<td>Drain Voltage</td>
<td>V\text{GG}&lt;5V</td>
<td>17</td>
<td>V</td>
</tr>
<tr>
<td>V\text{GG}</td>
<td>Gate Voltage</td>
<td>V\text{DD}&lt;12.5V, P\text{in}=0mW</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>P\text{in}</td>
<td>Input Power</td>
<td>f=136-174MHz, Z_G=Z_L=50\Omega</td>
<td>100</td>
<td>mW</td>
</tr>
<tr>
<td>P\text{out}</td>
<td>Output Power</td>
<td></td>
<td>80</td>
<td>W</td>
</tr>
<tr>
<td>T_{\text{case(OP)}}</td>
<td>Operation Case Temperature Range</td>
<td></td>
<td>-30 to +100</td>
<td>°C</td>
</tr>
<tr>
<td>T_{\text{stg}}</td>
<td>Storage Temperature Range</td>
<td></td>
<td>-40 to +110</td>
<td>°C</td>
</tr>
</tbody>
</table>

The above parameters are independently guaranteed.

**ELECTRICAL CHARACTERISTICS** *(T\text{case}=+25^\circ C, Z_G=Z_L=50\Omega, unless otherwise specified)*

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f</td>
<td>Frequency Range</td>
<td></td>
<td>136</td>
<td>-</td>
<td>174</td>
<td>MHz</td>
</tr>
<tr>
<td>P\text{out}</td>
<td>Output Power</td>
<td></td>
<td>60</td>
<td>-</td>
<td>-</td>
<td>W</td>
</tr>
<tr>
<td>\eta_T</td>
<td>Total Efficiency</td>
<td>V\text{DD}=12.5V</td>
<td>45</td>
<td>-</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>2f_o</td>
<td>2\textsuperscript{nd} Harmonic</td>
<td>V\text{GG}=5V</td>
<td>-</td>
<td>-</td>
<td>-50</td>
<td>dBC</td>
</tr>
<tr>
<td>3f_o</td>
<td>3\textsuperscript{rd} Harmonic</td>
<td>P\text{in}=50mW</td>
<td>-</td>
<td>-</td>
<td>-50</td>
<td>dBC</td>
</tr>
<tr>
<td>P\text{in}</td>
<td>Input VSWR</td>
<td></td>
<td>-</td>
<td>-</td>
<td>3:1</td>
<td>—</td>
</tr>
<tr>
<td>I\text{GG}</td>
<td>Gate Current</td>
<td></td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>—</td>
<td>Stability</td>
<td>V\text{DD}=10.0-15.2V, P\text{in}=25-70mW, P\text{out}&lt;70W (V\text{GG control}), Load VSWR=3:1</td>
<td>No parasitic oscillation More than –60dBC</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>—</td>
<td>Load VSWR Tolerance</td>
<td>V\text{DD}=15.2V, P\text{in}=50mW, P\text{out}=60W (V\text{GG control}), Load VSWR=20:1</td>
<td>No degradation or destroy</td>
<td>—</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All parameters, conditions, ratings, and limits are subject to change without notice.
TYPICAL PERFORMANCE (\(T_{case}=+25^\circ C, \ Z_G=Z_L=50\Omega\), unless otherwise specified)

### OUTPUT POWER, TOTAL EFFICIENCY, and INPUT VSWR versus FREQUENCY

- **Frequency f (MHz)**
- **Output Power \(P_{out}\) (W)**
- **Input VSWR \(\rho_{in}\)**
- **Total Efficiency \(\eta_T\)**

### 2nd, 3rd HARMONICS versus FREQUENCY

- **Harmonics (dB)**

### OUTPUT POWER, POWER GAIN and DRAIN CURRENT versus INPUT POWER

- **Frequency f (MHz)**
- **Power Gain \(G_{p}\) (dB)**
- **Drain Current \(I_{D}\) (A)**

### OUTPUT POWER, TOTAL EFFICIENCY, and INPUT VSWR versus FREQUENCY

- **Frequency f (MHz)**
- **Output Power \(P_{out}\) (dBm)**
- **Power Gain \(G_{p}\) (dB)**
- **Drain Current \(I_{D}\) (A)**

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TYPICAL PERFORMANCE (T_{case}=+25^\circ\text{C}, Z_G=Z_L=50\Omega, unless otherwise specified)

OUTPUT POWER and DRAIN CURRENT versus DRAIN VOLTAGE

- f=136MHz
- V_{GG}=5V
- P_{in}=50mW

- f=155MHz
- V_{GG}=5V
- P_{in}=50mW

- f=174MHz
- V_{GG}=5V
- P_{in}=50mW
TYPICAL PERFORMANCE  \( (T_{\text{case}}=+25^\circ \text{C}, \, Z_G=Z_L=50\Omega, \, \text{unless otherwise specified}) \)

- **OUTPUT POWER and DRAIN CURRENT versus GATE VOLTAGE**
  - Frequency: 136MHz
  - Gate Voltage \( V_{\text{GS}} \): 2.0 to 5.5 V
  - Output Power \( P_{\text{out}} \): 0 to 100 W
  - Drain Current \( I_{\text{D}} \): 0 to 20 A

- **OUTPUT POWER and DRAIN CURRENT versus GATE VOLTAGE**
  - Frequency: 155MHz
  - Gate Voltage \( V_{\text{GS}} \): 2.0 to 5.5 V
  - Output Power \( P_{\text{out}} \): 0 to 100 W
  - Drain Current \( I_{\text{D}} \): 0 to 20 A

- **OUTPUT POWER and DRAIN CURRENT versus GATE VOLTAGE**
  - Frequency: 174MHz
  - Gate Voltage \( V_{\text{GS}} \): 2.0 to 5.5 V
  - Output Power \( P_{\text{out}} \): 0 to 100 W
  - Drain Current \( I_{\text{D}} \): 0 to 20 A
RA60H1317M1A
RoHS Compliance, 136-174MHz 60W 12.5V, 2 Stage Amp. For MOBILE RADIO

OUTLINE DRAWING (mm)

1. INPUT TERMINAL (P_{in})
2. GATE BIAS DC SUPPLY TERMINAL (V_{GG})
3. DRAIN BIAS DC SUPPLY TERMINAL (V_{DD})
4. OUTPUT TERMINAL (P_{out})
5. Fin (GND)
RA60H1317M1A
RoHS Compliance, 136-174MHz 60W 12.5V, 2 Stage Amp. For MOBILE RADIO

TEST BLOCK DIAGRAM

C1, C2: 4700pF, 22μF in parallel

1. INPUT TERMINAL (P_in)
2. GATE BIAS DC SUPPLY TERMINAL (V_GG)
3. DRAIN BIAS DC SUPPLY TERMINAL (V_DD)
4. OUTPUT TERMINAL (P_out)
5. Fin (GND)

EQUIVALENT CIRCUIT

Publication Date: Apr. 2011
RECOMMENDATIONS and APPLICATION INFORMATION:

Construction:
This module consists of a glass-epoxy substrate soldered onto a copper flange. For mechanical protection, a metal cap is attached (which makes the improvement of RF radiation easy). The MOSFET transistor chips are die bonded onto metal, wire bonded to the substrate, and coated with resin. Lines on the substrate (eventually inductors), chip capacitors, and resistors form the bias and matching circuits. Wire leads soldered onto the glass-epoxy substrate provide the DC and RF connection.

Following conditions must be avoided:

a) Bending forces on the glass-epoxy substrate (for example, by driving screws or from fast thermal changes)
b) Mechanical stress on the wire leads (for example, by first soldering then driving screws or by thermal expansion)
c) Defluxing solvents reacting with the resin coating on the MOSFET chips (for example, Trichloroethylene)
d) ESD, surge, overvoltage in combination with load VSWR, and oscillation

ESD:
This MOSFET module is sensitive to ESD voltages down to 1000V. Appropriate ESD precautions are required.

Mounting:
A thermal compound between module and heat sink is recommended for low thermal contact resistance. The module must first be screwed to the heat sink, then the leads can be soldered to the printed circuit board. M3 screws are recommended with a tightening torque of 4.0 to 6.0 kgf-cm.

Soldering and Defluxing:
This module is designed for manual soldering.

The leads must be soldered after the module is screwed onto the heat sink.

Ethyl Alcohol is recommend for removing flux. Trichloroethylene solvents must not be used (they may cause bubbles in the coating of the transistor chips which can lift off the bond wires).

Thermal Design of the Heat Sink:
At P_out=60W, V_DD=12.5V and P_in=50mW each stage transistor operating conditions are:

<table>
<thead>
<tr>
<th>Stage</th>
<th>P_in (W)</th>
<th>P_out (W)</th>
<th>R_th(ch-case) (°C/W)</th>
<th>I_DD @ η_T=45% (A)</th>
<th>V_DD (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>0.05</td>
<td>5.0</td>
<td>2.1</td>
<td>0.8</td>
<td>12.5</td>
</tr>
<tr>
<td>2nd</td>
<td>5.0</td>
<td>60.0</td>
<td>0.5</td>
<td>9.8</td>
<td></td>
</tr>
</tbody>
</table>

The channel temperatures of each stage transistor T_ch = T_case + (V_DD x I_DD - P_out + P_in) x R_th(ch-case) are:

T_ch1 = T_case + (12.5V x 0.8A - 5.0W + 0.05W) x 2.1°C/W = T_case + 10.6 °C
T_ch2 = T_case + (12.5V x 9.8A - 60W + 5.0W) x 0.5°C/W = T_case + 33.8 °C

For long-term reliability, it is best to keep the module case temperature (T_case) below 90°C. For an ambient temperature T_air=60°C and P_out=60W, the required thermal resistance R_th(case-air) = (T_case - T_air) / (P_out / η_T) - P_out + P_in of the heat sink, including the contact resistance, is:

R_th(case-air) = (90°C - 60°C) / (60W/45% - 60W + 0.05W) = 0.41 °C/W

When mounting the module with the thermal resistance of 0.41 °C/W, the channel temperature of each stage transistor is:

T_ch1 = T_air + 40.6 °C
T_ch2 = T_air + 63.8 °C

The 175°C maximum rating for the channel temperature ensures application under derated conditions.
PRECAUTION FOR THE USE OF MITSUBISHI SILICON RF POWER AMPLIFIER DEVICES:

1. The specifications of mention are not guarantee values in this data sheet. Please confirm additional details regarding operation of these products from the formal specification sheet. For copies of the formal specification sheets, please contact one of our sales offices.

2. RA series products (RF power amplifier modules) and RD series products (RF power transistors) are designed for consumer mobile communication terminals and were not specifically designed for use in other applications. In particular, while these products are highly reliable for their designed purpose, they are not manufactured under a quality assurance testing protocol that is sufficient to guarantee the level of reliability typically deemed necessary for critical communications elements. In the application, which is base station applications and fixed station applications that operate with long term continuous transmission and a higher on-off frequency during transmitting, please consider the derating, the redundancy system, appropriate setting of the maintain period and others as needed. For the reliability report which is described about predicted operating life time of Mitsubishi Silicon RF Products, please contact Mitsubishi Electric Corporation or an authorized Mitsubishi Semiconductor product distributor.

3. RA series products and RD series Products use MOSFET semiconductor technology. They are sensitive to ESD voltage therefore appropriate ESD precautions are required.

4. In order to maximize reliability of the equipment, it is better to keep the devices temperature low. It is recommended to utilize a sufficient sized heat-sink in conjunction with other cooling methods as needed (fan, etc.) to keep the case temperature for RA series products lower than 60deg/C under standard conditions, and less than 90deg/C under extreme conditions.

5. RA series products are designed to operate into a nominal load impedance of 50Ω. Under the condition of operating into a severe high load VSWR approaching an open or short, an over load condition could occur. In the worst case there is risk for burn out of the transistors and burning of other parts including the substrate in the module.

6. The formal specification includes a guarantee against parasitic oscillation under a specified maximum load mismatch condition. The inspection for parasitic oscillation is performed on a sample basis on our manufacturing line. It is recommended that verification of no parasitic oscillation be performed at the completed equipment level also.

7. For specific precautions regarding assembly of these products into the equipment, please refer to the supplementary items in the specification sheet.

8. Warranty for the product is void if the products protective cap (lid) is removed or if the product is modified in any way from it's original form.

9. For additional “Safety first” in your circuit design and notes regarding the materials, please refer the last page of this data sheet.

10. Please refer to the additional precautions in the formal specification sheet.

ADDITIONAL "SAFETY first" in your circuit design and notes regarding the materials, please refer the last page of this data sheet.
Keep safety first in your circuit designs!

Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of non-flammable material or (iii) prevention against any malfunction or mishap.

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