

ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

MITSUBISHI RF MOSFET MODULE

RA45H4452M

440-520MHz 45W 12.5V, 3 Stage Amp. For MOBILE RADIO

DESCRIPTION

The RA45H4452M is a 45-watt RF MOSFET Amplifier Module for 12.5-volt mobile radios that operate in the 440- to 520-MHz range.

The battery can be connected directly to the drain of the enhancement-mode MOSFET transistors. Without the gate voltage ($V_{GG}=0V$), only a small leakage current flows into the drain and the RF input signal attenuates up to 60 dB. 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.

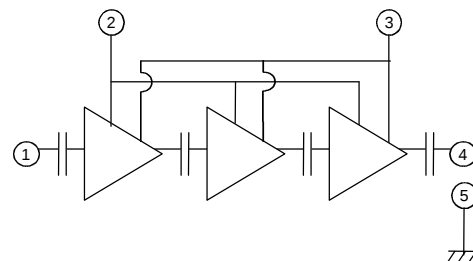
FEATURES

- Enhancement-Mode MOSFET Transistors
($I_{DD}\approx 0$ @ $V_{DD}=12.5V$, $V_{GG}=0V$)
- $P_{out}>45W$, $\eta_T>35\%$ @ $V_{DD}=12.5V$, $V_{GG}=5V$, $P_{in}=50mW$
- Broadband Frequency Range: 440-520MHz
- Low-Power Control Current $I_{GG}=1mA$ (typ) at $V_{GG}=5V$
- Module Size: 66 x 21 x 9.88 mm
- Linear operation is possible by setting the quiescent drain current with the gate voltage and controlling the output power with the input power

ORDERING INFORMATION:

ORDER NUMBER	SUPPLY FORM
RA45H4452M-01	Antistatic tray, 10 modules/tray

BLOCK DIAGRAM



- ① RF Input (P_{in})
- ② Gate Voltage (V_{GG}), Power Control
- ③ Drain Voltage (V_{DD}), Battery
- ④ RF Output (P_{out})
- ⑤ RF Ground (Case)

PACKAGE CODE: H2S



ELECTROSTATIC SENSITIVE DEVICE
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MITSUBISHI RF POWER MODULE

RA45H4452M

MAXIMUM RATINGS ($T_{\text{case}}=+25^{\circ}\text{C}$, unless otherwise specified)

SYMBOL	PARAMETER	CONDITIONS	RATING	UNIT
V_{DD}	Drain Voltage	$V_{\text{GG}} < 5\text{V}$	17	V
V_{GG}	Gate Voltage	$V_{\text{DD}} < 12.5\text{V}$, $P_{\text{in}} = 0\text{mW}$	6	V
P_{in}	Input Power	$f = 440\text{--}520\text{MHz}$, $Z_{\text{G}} = Z_{\text{L}} = 50\Omega$	100	mW
P_{out}	Output Power		55	W
$T_{\text{case(OP)}}$	Operation Case Temperature Range		-30 to +110	$^{\circ}\text{C}$
T_{stg}	Storage Temperature Range		-40 to +110	$^{\circ}\text{C}$

The above parameters are independently guaranteed.

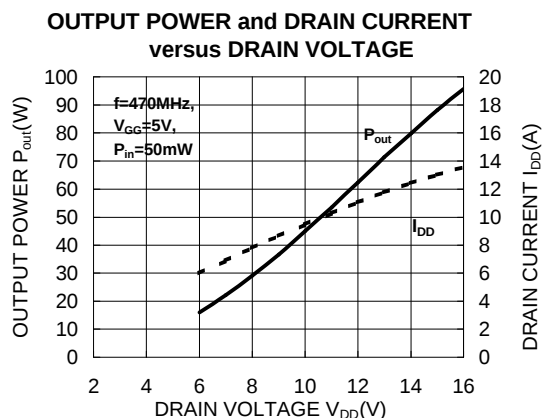
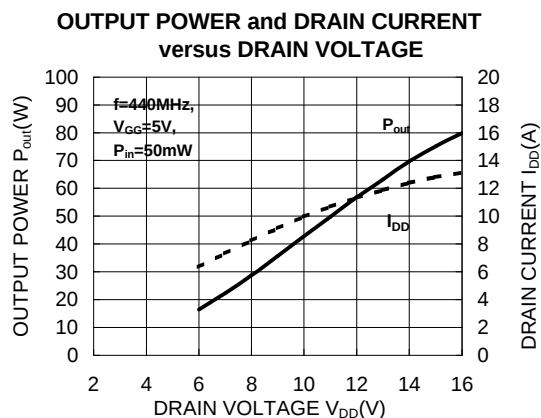
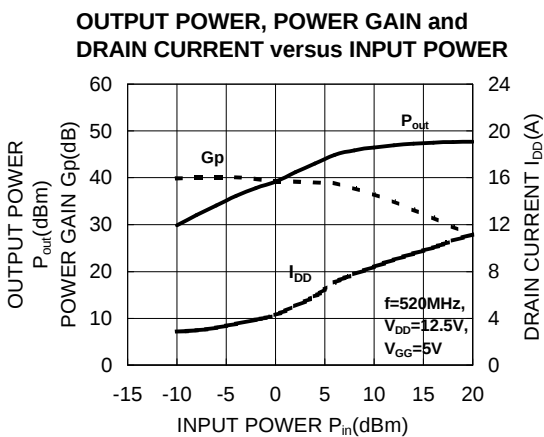
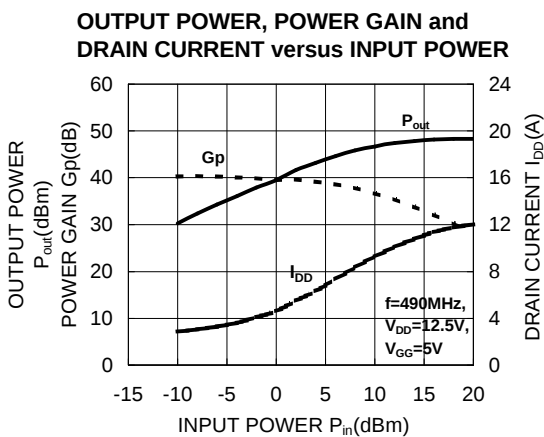
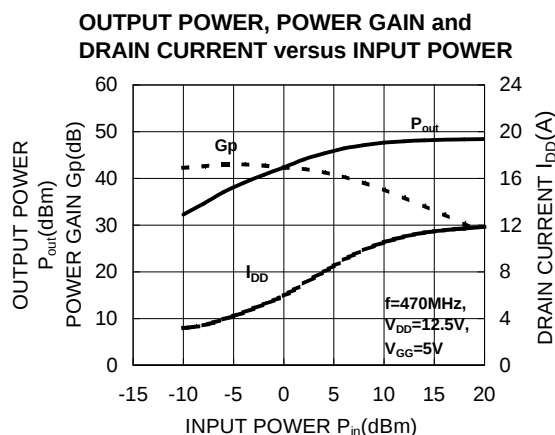
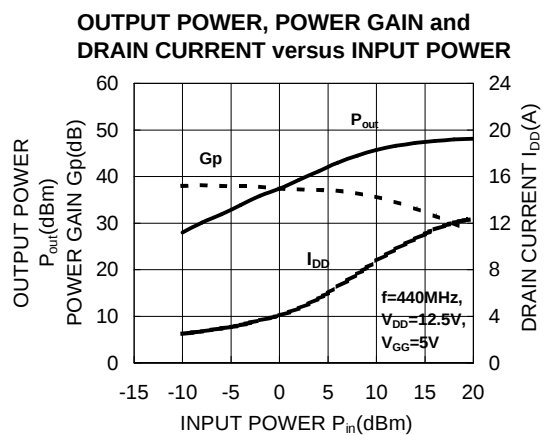
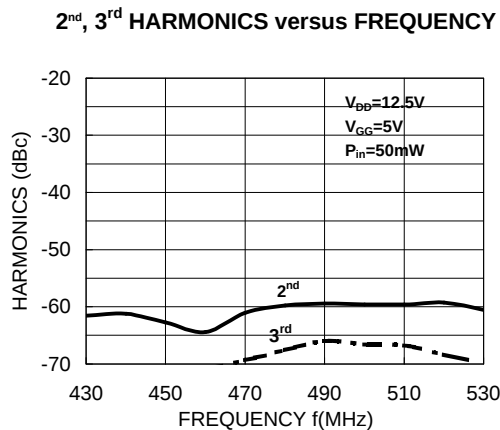
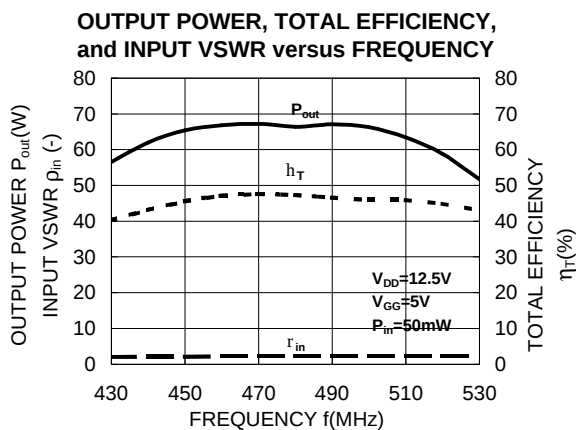
ELECTRICAL CHARACTERISTICS ($T_{\text{case}}=+25^{\circ}\text{C}$, $Z_{\text{G}}=Z_{\text{L}}=50\Omega$, unless otherwise specified)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
f	Frequency Range		440		520	MHz
P_{out}	Output Power	$V_{\text{DD}} = 12.5\text{V}$ $V_{\text{GG}} = 5\text{V}$ $P_{\text{in}} = 50\text{mW}$	45			W
η_{T}	Total Efficiency		35			%
$2f_0$	2 nd Harmonic				-25	dBc
ρ_{in}	Input VSWR				3:1	—
I_{GG}	Gate Current			1		mA
—	Stability	$V_{\text{DD}} = 10.0\text{--}15.2\text{V}$, $P_{\text{in}} = 25\text{--}70\text{mW}$, $P_{\text{out}} < 55\text{W}$ (V_{GG} control), Load VSWR=3:1	No parasitic oscillation			—
—	Load VSWR Tolerance	$V_{\text{DD}} = 15.2\text{V}$, $P_{\text{in}} = 50\text{mW}$, $P_{\text{out}} = 45\text{W}$ (V_{GG} control), Load VSWR=20:1	No degradation or destroy			—

All parameters, conditions, ratings, and limits are subject to change without notice.



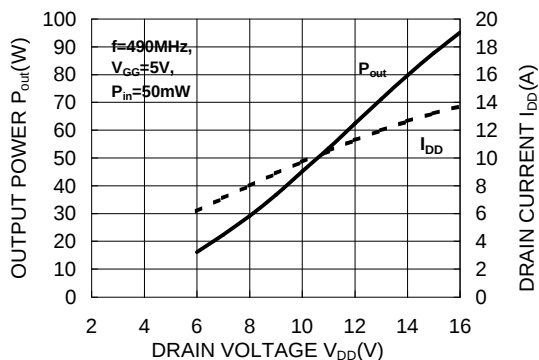
TYPICAL PERFORMANCE ($T_{\text{case}}=+25^{\circ}\text{C}$, $Z_G=Z_L=50\Omega$, unless otherwise specified)



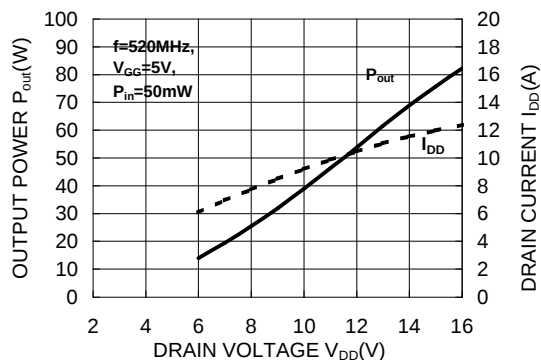


TYPICAL PERFORMANCE ($T_{\text{case}}=+25^{\circ}\text{C}$, $Z_G=Z_L=50\Omega$, unless otherwise specified)

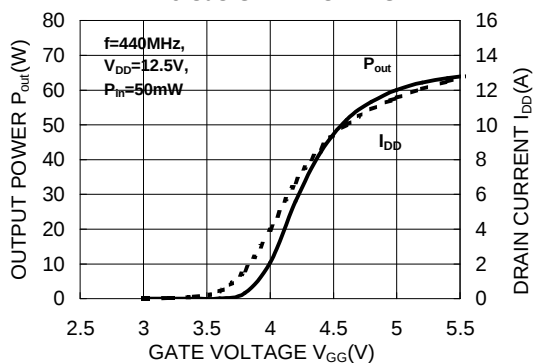
OUTPUT POWER and DRAIN CURRENT
versus DRAIN VOLTAGE



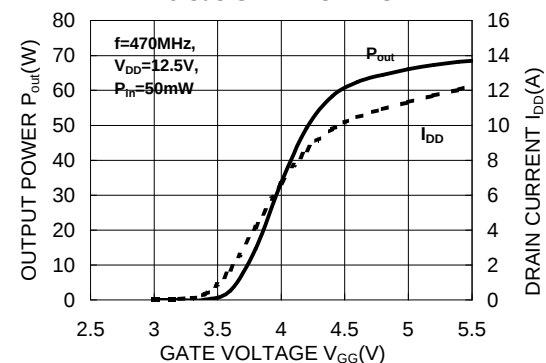
OUTPUT POWER and DRAIN CURRENT
versus DRAIN VOLTAGE



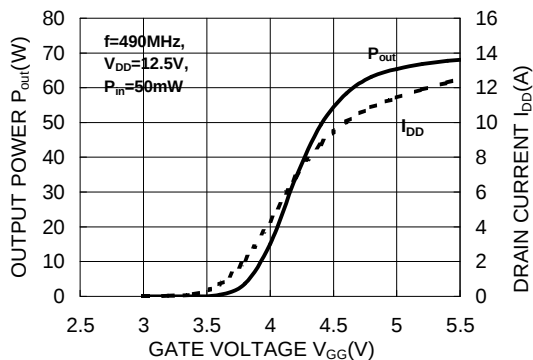
OUTPUT POWER and DRAIN CURRENT
versus GATE VOLTAGE



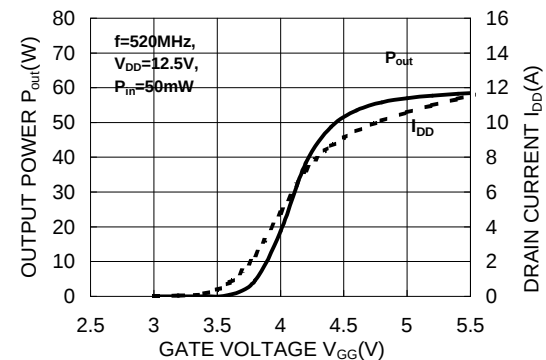
OUTPUT POWER and DRAIN CURRENT
versus GATE VOLTAGE



OUTPUT POWER and DRAIN CURRENT
versus GATE VOLTAGE



OUTPUT POWER and DRAIN CURRENT
versus GATE VOLTAGE





Technical drawing of a mechanical part, showing a top view and a side view. The top view includes dimensions for overall length (66.0 ± 0.5), width (21.0 ± 0.5), and various internal features. The side view shows the profile of the part, including a base dimension of 50.4 and a height of 7.5 ± 0.5 (9.88). The drawing includes callouts for specific features, such as 2-R2 ± 0.5 and Ø0.45 ± 0.15.

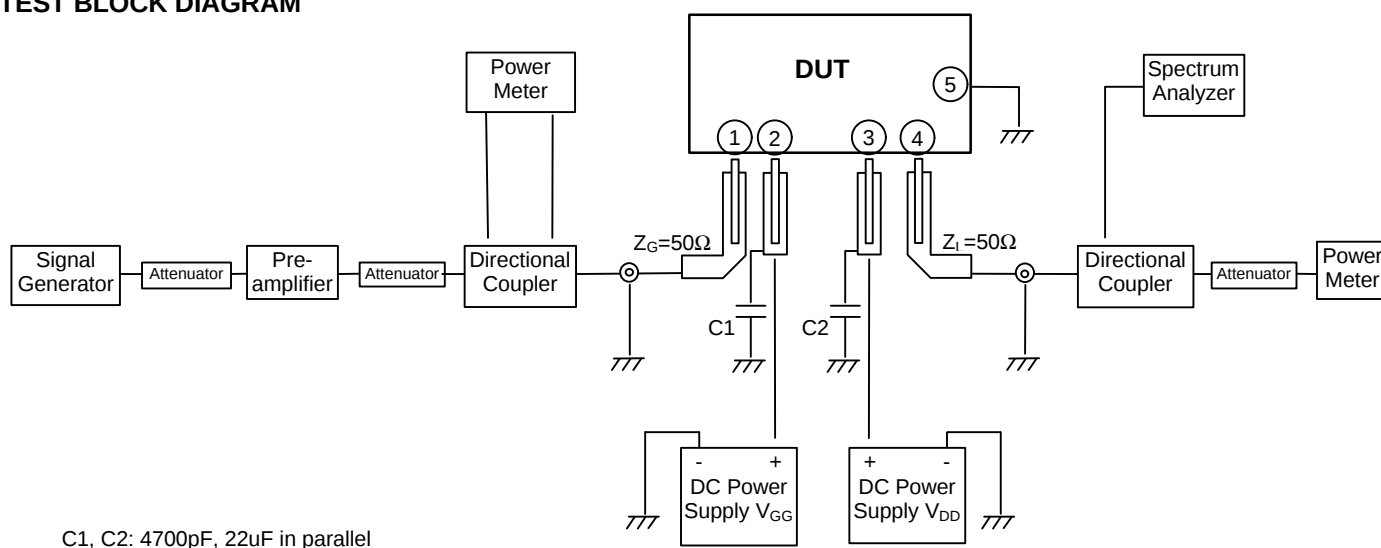
Dimensions and Callouts:

- Overall Length: 66.0 ± 0.5
- Overall Width: 21.0 ± 0.5
- Internal Length 1: 60.0 ± 0.5
- Internal Length 2: 51.5 ± 0.5
- Internal Width 1: 3.0 ± 0.3
- Internal Width 2: 7.25 ± 0.8
- Internal Width 3: 9.5 ± 0.5
- Internal Width 4: 2.0 ± 0.5
- Internal Width 5: 14.0 ± 1
- Internal Width 6: 12.0 ± 1
- Internal Width 7: 16.5 ± 1
- Internal Width 8: 43.5 ± 1
- Internal Width 9: 55.5 ± 1
- Internal Width 10: 4.0 ± 0.3
- Internal Width 11: 17.0 ± 0.5
- Internal Width 12: 2.3 ± 0.3
- Internal Width 13: 7.5 ± 0.5 (9.88)
- Internal Width 14: 3.1 + 0.6/-0.4
- Internal Width 15: 0.09 ± 0.02
- Internal Width 16: 50.4
- Internal Width 17: 2.0 ± 0.5
- Internal Width 18: 12.0 ± 1
- Internal Width 19: 16.5 ± 1
- Internal Width 20: 43.5 ± 1
- Internal Width 21: 55.5 ± 1
- Internal Width 22: 4.0 ± 0.3
- Internal Width 23: 17.0 ± 0.5
- Internal Width 24: 2.3 ± 0.3
- Internal Width 25: 7.5 ± 0.5 (9.88)
- Internal Width 26: 3.1 + 0.6/-0.4
- Internal Width 27: 0.09 ± 0.02
- Internal Width 28: 50.4
- Internal Width 29: 2.0 ± 0.5
- Internal Width 30: 12.0 ± 1
- Internal Width 31: 16.5 ± 1
- Internal Width 32: 43.5 ± 1
- Internal Width 33: 55.5 ± 1
- Internal Width 34: 4.0 ± 0.3
- Internal Width 35: 17.0 ± 0.5
- Internal Width 36: 2.3 ± 0.3
- Internal Width 37: 7.5 ± 0.5 (9.88)
- Internal Width 38: 3.1 + 0.6/-0.4
- Internal Width 39: 0.09 ± 0.02
- Internal Width 40: 50.4
- Internal Width 41: 2.0 ± 0.5
- Internal Width 42: 12.0 ± 1
- Internal Width 43: 16.5 ± 1
- Internal Width 44: 43.5 ± 1
- Internal Width 45: 55.5 ± 1
- Internal Width 46: 4.0 ± 0.3
- Internal Width 47: 17.0 ± 0.5
- Internal Width 48: 2.3 ± 0.3
- Internal Width 49: 7.5 ± 0.5 (9.88)
- Internal Width 50: 3.1 + 0.6/-0.4
- Internal Width 51: 0.09 ± 0.02
- Internal Width 52: 50.4
- Internal Width 53: 2.0 ± 0.5
- Internal Width 54: 12.0 ± 1
- Internal Width 55: 16.5 ± 1
- Internal Width 56: 43.5 ± 1
- Internal Width 57: 55.5 ± 1
- Internal Width 58: 4.0 ± 0.3
- Internal Width 59: 17.0 ± 0.5
- Internal Width 60: 2.3 ± 0.3
- Internal Width 61: 7.5 ± 0.5 (9.88)
- Internal Width 62: 3.1 + 0.6/-0.4
- Internal Width 63: 0.09 ± 0.02
- Internal Width 64: 50.4
- Internal Width 65: 2.0 ± 0.5
- Internal Width 66: 12.0 ± 1
- Internal Width 67: 16.5 ± 1
- Internal Width 68: 43.5 ± 1
- Internal Width 69: 55.5 ± 1
- Internal Width 70: 4.0 ± 0.3
- Internal Width 71: 17.0 ± 0.5
- Internal Width 72: 2.3 ± 0.3
- Internal Width 73: 7.5 ± 0.5 (9.88)
- Internal Width 74: 3.1 + 0.6/-0.4
- Internal Width 75: 0.09 ± 0.02
- Internal Width 76: 50.4
- Internal Width 77: 2.0 ± 0.5
- Internal Width 78: 12.0 ± 1
- Internal Width 79: 16.5 ± 1
- Internal Width 80: 43.5 ± 1
- Internal Width 81: 55.5 ± 1
- Internal Width 82: 4.0 ± 0.3
- Internal Width 83: 17.0 ± 0.5
- Internal Width 84: 2.3 ± 0.3
- Internal Width 85: 7.5 ± 0.5 (9.88)
- Internal Width 86: 3.1 + 0.6/-0.4
- Internal Width 87: 0.09 ± 0.02
- Internal Width 88: 50.4
- Internal Width 89: 2.0 ± 0.5
- Internal Width 90: 12.0 ± 1
- Internal Width 91: 16.5 ± 1
- Internal Width 92: 43.5 ± 1
- Internal Width 93: 55.5 ± 1
- Internal Width 94: 4.0 ± 0.3
- Internal Width 95: 17.0 ± 0.5
- Internal Width 96: 2.3 ± 0.3
- Internal Width 97: 7.5 ± 0.5 (9.88)
- Internal Width 98: 3.1 + 0.6/-0.4
- Internal Width 99: 0.09 ± 0.02
- Internal Width 100: 50.4
- Internal Width 101: 2.0 ± 0.5
- Internal Width 102: 12.0 ± 1
- Internal Width 103: 16.5 ± 1
- Internal Width 104: 43.5 ± 1
- Internal Width 105: 55.5 ± 1
- Internal Width 106: 4.0 ± 0.3
- Internal Width 107: 17.0 ± 0.5
- Internal Width 108: 2.3 ± 0.3
- Internal Width 109: 7.5 ± 0.5 (9.88)
- Internal Width 110: 3.1 + 0.6/-0.4
- Internal Width 111: 0.09 ± 0.02
- Internal Width 112: 50.4
- Internal Width 113: 2.0 ± 0.5
- Internal Width 114: 12.0 ± 1
- Internal Width 115: 16.5 ± 1
- Internal Width 116: 43.5 ± 1
- Internal Width 117: 55.5 ± 1
- Internal Width 118: 4.0 ± 0.3
- Internal Width 119: 17.0 ± 0.5
- Internal Width 120: 2.3 ± 0.3
- Internal Width 121: 7.5 ± 0.5 (9.88)
- Internal Width 122: 3.1 + 0.6/-0.4
- Internal Width 123: 0.09 ± 0.02
- Internal Width 124: 50.4
- Internal Width 125: 2.0 ± 0.5
- Internal Width 126: 12.0 ± 1
- Internal Width 127: 16.5 ± 1
- Internal Width 128: 43.5 ± 1
- Internal Width 129: 55.5 ± 1
- Internal Width 130: 4.0 ± 0.3
- Internal Width 131: 17.0 ± 0.5
- Internal Width 132: 2.3 ± 0.3
- Internal Width 133: 7.5 ± 0.5 (9.88)
- Internal Width 134: 3.1 + 0.6/-0.4
- Internal Width 135: 0.09 ± 0.02
- Internal Width 136: 50.4
- Internal Width 137: 2.0 ± 0.5
- Internal Width 138: 12.0 ± 1
- Internal Width 139: 16.5 ± 1
- Internal Width 140: 43.5 ± 1
- Internal Width 141: 55.5 ± 1
- Internal Width 142: 4.0 ± 0.3
- Internal Width 143: 17.0 ± 0.5
- Internal Width 144: 2.3 ± 0.3
- Internal Width 145: 7.5 ± 0.5 (9.88)
- Internal Width 146: 3.1 + 0.6/-0.4
- Internal Width 147: 0.09 ± 0.02
- Internal Width 148: 50.4
- Internal Width 149: 2.0 ± 0.5
- Internal Width 150: 12.0 ± 1
- Internal Width 151: 16.5 ± 1
- Internal Width 152: 43.5 ± 1
- Internal Width 153: 55.5 ± 1
- Internal Width 154: 4.0 ± 0.3
- Internal Width 155: 17.0 ± 0.5
- Internal Width 156: 2.3 ± 0.3
- Internal Width 157: 7.5 ± 0.5 (9.88)
- Internal Width 158: 3.1 + 0.6/-0.4
- Internal Width 159: 0.09 ± 0.02
- Internal Width 160: 50.4
- Internal Width 161: 2.0 ± 0.5
- Internal Width 162: 12.0 ± 1
- Internal Width 163: 16.5 ± 1
- Internal Width 164: 43.5 ± 1
- Internal Width 165: 55.5 ± 1
- Internal Width 166: 4.0 ± 0.3
- Internal Width 167: 17.0 ± 0.5
- Internal Width 168: 2.3 ± 0.3
- Internal Width 169: 7.5 ± 0.5 (9.88)
- Internal Width 170: 3.1 + 0.6/-0.4
- Internal Width 171: 0.09 ± 0.02
- Internal Width 172: 50.4
- Internal Width 173: 2.0 ± 0.5
- Internal Width 174: 12.0 ± 1
- Internal Width 175: 16.5 ± 1
- Internal Width 176: 43.5 ± 1
- Internal Width 177: 55.5 ± 1
- Internal Width 178: 4.0 ± 0.3</

- ① RF Input (P_{in})
- ② Gate Voltage (V_{GG})
- ③ Drain Voltage (V_{DD})
- ④ RF Output (P_{out})
- ⑤ RF Ground (Case)



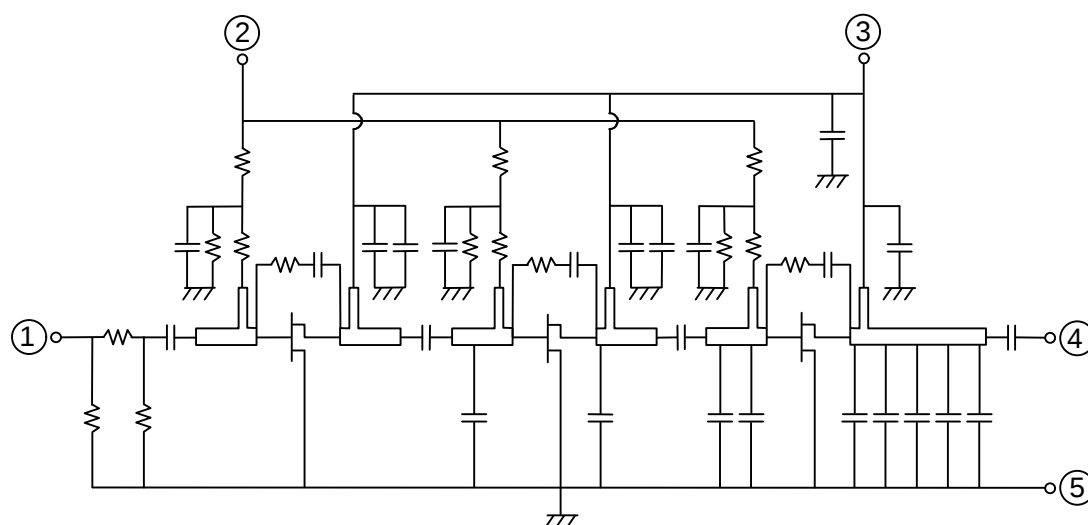
TEST BLOCK DIAGRAM



C1, C2: 4700pF, 22uF in parallel

- ① RF Input (P_{in})
- ② Gate Voltage (V_{GG})
- ③ Drain Voltage (V_{DD})
- ④ RF Output (P_{out})
- ⑤ RF Ground (Case)

EQUIVALENT CIRCUIT





PRECAUTIONS, RECOMMENDATIONS, and APPLICATION INFORMATION:

Construction:

This module consists of an alumina substrate soldered onto a copper flange. For mechanical protection, a plastic cap is attached with silicone. 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 alumina substrate provide the DC and RF connection.

Following conditions must be avoided:

- Bending forces on the alumina substrate (for example, by driving screws or from fast thermal changes)
- Mechanical stress on the wire leads (for example, by first soldering then driving screws or by thermal expansion)
- Defluxing solvents reacting with the resin coating on the MOSFET chips (for example, Trichlorethylene)
- Frequent on/off switching that causes thermal expansion of the resin
- 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:

Heat sink flatness must be less than 50 μm (a heat sink that is not flat or particles between module and heat sink may cause the ceramic substrate in the module to crack by bending forces, either immediately when driving screws or later when thermal expansion forces are added).

A thermal compound between module and heat sink is recommended for low thermal contact resistance and to reduce the bending stress on the ceramic substrate caused by the temperature difference to the heat sink.

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 0.4 to 0.6 Nm.

Soldering and Defluxing:

This module is designed for manual soldering.

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

The soldering temperature must be lower than 260°C for a maximum of 10 seconds, or lower than 350°C for a maximum of three seconds.

Ethyl Alcohol is recommended for removing flux. Trichlorethylene 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 $P_{\text{out}}=45\text{W}$, $V_{\text{DD}}=12.5\text{V}$ and $P_{\text{in}}=50\text{mW}$ each stage transistor operating conditions are:

Stage	P_{in} (W)	P_{out} (W)	$R_{\text{th(ch-case)}}$ (°C/W)	$I_{\text{DD}} @ \eta_T=35\%$ (A)	V_{DD} (V)
1 st	0.05	2.0	4.5	0.45	12.5
2 nd	2.0	12.0	2.4	2.80	
3 rd	12.0	45.0	1.2	6.80	

The channel temperatures of each stage transistor $T_{\text{ch}} = T_{\text{case}} + (V_{\text{DD}} \times I_{\text{DD}} - P_{\text{out}} + P_{\text{in}}) \times R_{\text{th(ch-case)}}$ are:

$$T_{\text{ch1}} = T_{\text{case}} + (12.5\text{V} \times 0.45\text{A} - 2.0\text{W} + 0.05\text{W}) \times 4.5^\circ\text{C/W} = T_{\text{case}} + 16.5^\circ\text{C}$$

$$T_{\text{ch2}} = T_{\text{case}} + (12.5\text{V} \times 2.80\text{A} - 12.0\text{W} + 2.0\text{W}) \times 2.4^\circ\text{C/W} = T_{\text{case}} + 60.0^\circ\text{C}$$

$$T_{\text{ch3}} = T_{\text{case}} + (12.5\text{V} \times 6.80\text{A} - 45.0\text{W} + 12.0\text{W}) \times 1.2^\circ\text{C/W} = T_{\text{case}} + 62.4^\circ\text{C}$$

For long-term reliability, it is best to keep the module case temperature (T_{case}) below 90°C. For an ambient temperature $T_{\text{air}}=60^\circ\text{C}$ and $P_{\text{out}}=45\text{W}$, the required thermal resistance $R_{\text{th(case-air)}} = (T_{\text{case}} - T_{\text{air}}) / ((P_{\text{out}} / \eta_T) - P_{\text{out}} + P_{\text{in}})$ of the heat sink, including the contact resistance, is:

$$R_{\text{th(case-air)}} = (90^\circ\text{C} - 60^\circ\text{C}) / (45\text{W}/35\% - 45\text{W} + 0.05\text{W}) = 0.36^\circ\text{C/W}$$

When mounting the module with the thermal resistance of 0.36 °C/W, the channel temperature of each stage transistor is:

$$T_{\text{ch1}} = T_{\text{air}} + 46.5^\circ\text{C}$$

$$T_{\text{ch2}} = T_{\text{air}} + 90.0^\circ\text{C}$$

$$T_{\text{ch3}} = T_{\text{air}} + 92.4^\circ\text{C}$$

The 175°C maximum rating for the channel temperature ensures application under derated conditions.



Output Power Control:

Depending on linearity, the following two methods are recommended to control the output power:

a) Non-linear FM modulation:

By the gate voltage (V_{GG}).

When the gate voltage is close to zero, the RF input signal is attenuated up to 60 dB and only a small leakage current flows from the battery into the drain.

Around $V_{GG}=4V$, the output power and drain current increases substantially.

Around $V_{GG}=4.5V$ (typical) to $V_{GG}=5V$ (maximum), the nominal output power becomes available.

b) Linear AM modulation:

By RF input power P_{in} .

The gate voltage is used to set the drain's quiescent current for the required linearity.

Oscillation:

To test RF characteristics, this module is put on a fixture with two bias decoupling capacitors each on gate and drain, a 4,700 pF chip capacitor, located close to the module, and a 22 μF (or more) electrolytic capacitor.

When an amplifier circuit around this module shows oscillation, the following may be checked:

a) Do the bias decoupling capacitors have a low inductance pass to the case of the module?

b) Is the load impedance $Z_L=50\Omega$?

c) Is the source impedance $Z_G=50\Omega$?

Frequent on/off switching:

In base stations, frequent on/off switching can cause thermal expansion of the resin that coats the transistor chips and can result in reduced or no output power. The bond wires in the resin will break after long-term thermally induced mechanical stress.

Quality:

Mitsubishi Electric is not liable for failures resulting from base station operation time or operating conditions exceeding those of mobile radios.

This module technology results from more than 20 years of experience, field proven in tens of millions of mobile radios. Currently, most returned modules show failures such as ESD, substrate crack, and transistor burnout, which are caused by improper handling or exceeding recommended operating conditions. Few degradation failures are found.

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. 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.

SALES CONTACT

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