12-46 GHz GaAs Surface Mount LO Driver Amplifier AMM-7200SM

1. Device Overview

1.1 General Description
The AMM-7200SM is a surface-mount amplifier suitable for use as a single tone driver or general-purpose gain block. It can drive an L or H diode mixer from 12 to 46 GHz, or S diode mixer from 14 to 40 GHz when supplied with 0-10dBm input power. This amplifier also has exceptionally low input and output reflections, and excellent gain flatness in-band. The AMM-7200SM is packaged in a compact 3mm QFN for surface mount integration onto printed circuit boards.

1.2 Features
- +20 dB Small Signal Gain
- Can drive H, L, or S diode mixer
- +20 dBm saturated output power
- Excellent return losses
- Compact 3mm QFN package
- .s2p S-Parameters: EVAL-AMM-7200SM.s2p

1.3 Applications
- Mobile test and measurement equipment
- Radar and satellite communications
- 5G transceivers
- LO driver for Marki L-, H-, and S-diode mixers

1.4 Functional Block Diagram

1.5 Part Ordering Options

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Package</th>
<th>Green Status</th>
<th>Product Lifecycle</th>
<th>Export Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMM-7200SM</td>
<td>3x3 mm Surface Mount</td>
<td>QFN</td>
<td>RoHS</td>
<td>Pre-Release</td>
<td>3A001.b.2.d</td>
</tr>
<tr>
<td>EVAL-AMM-7200SM</td>
<td>Connectorized Evaluation Fixture</td>
<td>EVAL</td>
<td>RoHS</td>
<td>Pre-Release</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

1 Refer to our website for a list of definitions for terminology presented in this table.
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Revision History

<table>
<thead>
<tr>
<th>Revision Code</th>
<th>Revision Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE</td>
<td>February 2021</td>
<td>Pre-Release</td>
</tr>
</tbody>
</table>
2. Port Configurations and Functions

2.1 Port Diagram

A port diagram of the AMM-7200SM’s QFN package is shown below. The pin functions are detailed in section 2.2 of this datasheet.
## 2.2 Port Functions

<table>
<thead>
<tr>
<th>Port</th>
<th>Function</th>
<th>Description</th>
<th>Equivalent Circuit for Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 14</td>
<td>Positive DC Supply $V_d$</td>
<td>Pins 14 provides +2V to +4V DC voltage to the amplifier’s third stage. <strong>Negative voltage must be supplied to Pin 6 before turning on the positive supply voltage.</strong></td>
<td><img src="image1" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>Pin 15</td>
<td>Positive DC Supply $V_d$</td>
<td>Pins 15 provides +2V to +4V DC voltage to the amplifier’s second stage. <strong>Negative voltage must be supplied to Pin 6 before turning on the positive supply voltage.</strong></td>
<td><img src="image2" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>Pin 16</td>
<td>Positive DC Supply $V_d$</td>
<td>Pins 16 provides +2V to +4V DC voltage to the amplifier’s first stage. <strong>Negative voltage must be supplied to Pin 6 before turning on the positive supply voltage.</strong></td>
<td><img src="image3" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>Pin 2</td>
<td>RF Input</td>
<td>Pin 2 is the RF input of the amplifier, and is matched to 50 ohms. It is internally DC blocked.</td>
<td><img src="image4" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>Pin 11</td>
<td>RF Output</td>
<td>Pin 11 is the RF output of the amplifier, and is matched to 50 ohms. It is internally DC blocked.</td>
<td><img src="image5" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>Pin 6</td>
<td>Negative DC Supply $V_g$</td>
<td>Pin 6 provides -0.2V to -0.7V of DC voltage. This must be turned on before turning on the positive supply voltage to Pin 1.</td>
<td><img src="image6" alt="Equivalent Circuit" /></td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>Ground paddle and non-connected pins must be connected to a DC/RF ground potential with high thermal and electrical conductivity, and low inductance.</td>
<td><img src="image7" alt="Equivalent Circuit" /></td>
</tr>
</tbody>
</table>

2 Pins 14, 15, and 16 may be biased together for ease of use, or individually to adjust overall performance.

3 Pin 6 may be biased with constant DC voltage, or actively biased to produce a fixed $I_d$ for consistent performance.
3. Specifications

3.1 Absolute Maximum Ratings
The Absolute Maximum Ratings indicate limits beyond which damage may occur to the device. If these limits are exceeded, the device may be inoperable or have a reduced lifetime.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Rating</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage (Pin 14, 15, 16)</td>
<td>4.5</td>
<td>V</td>
</tr>
<tr>
<td>Negative Bias Voltage (Pin 6)</td>
<td>-2</td>
<td>V</td>
</tr>
<tr>
<td>RF Input Power</td>
<td>+15</td>
<td>dBm</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 to +85</td>
<td>ºC</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65 to +150</td>
<td>ºC</td>
</tr>
<tr>
<td>Max Junction Temperature for MTTF &gt; 1E6 Hours</td>
<td>175</td>
<td>ºC</td>
</tr>
</tbody>
</table>

3.2 Package Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>EVAL Package</td>
<td>31.2g</td>
</tr>
</tbody>
</table>
3.3 Recommended Operating Conditions

The Recommended Operating Conditions indicate the limits, inside which the device should be operated, to guarantee the performance given in Electrical Specifications (3.5). Operating outside these limits may not necessarily cause damage to the device, but the performance may degrade outside the limits of the Electrical Specifications. For limits, above which damage may occur, see Absolute Maximum Ratings (3.1).

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Nominal</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_A$, Ambient Temperature</td>
<td>-55</td>
<td>+25</td>
<td>+85</td>
<td>°C</td>
</tr>
<tr>
<td>Power Supply DC Voltage</td>
<td>+2</td>
<td>+3</td>
<td>+4</td>
<td>V</td>
</tr>
<tr>
<td>Power Supply DC Current</td>
<td>100</td>
<td>180</td>
<td>350</td>
<td>mA</td>
</tr>
<tr>
<td>Gate Bias DC Voltage</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.2</td>
<td>V</td>
</tr>
<tr>
<td>Input Power for Saturation</td>
<td>+5</td>
<td>+10</td>
<td>+15</td>
<td>dBm</td>
</tr>
</tbody>
</table>

3.4 Sequencing Requirements

Turn-on Procedure:

1) Apply $<-0.2$V to $V_g$ (Pin 6)
2) Apply $V_d$ (Pin 14, 15, 16)

Turn-off Procedure:

1) Turn off $V_d$ (Pin 14, 15, 16)
2) Turn off $V_g$ (Pin 6)

---

4 Power Supply DC current is specified as $I_{d1} + I_{d2} + I_{d3}$
3.5 Electrical Specifications
The electrical specifications apply at $T_A = +25^\circ C$ in a 50Ω system.

QFNs are 100% RF tested.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Frequency</th>
<th>Min</th>
<th>Typical</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated Output Power&lt;sup&gt;5&lt;/sup&gt;</td>
<td>3V/-0.5V bias</td>
<td>12 GHz – 22 GHz</td>
<td></td>
<td>+19 dBm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 GHz – 38 GHz</td>
<td></td>
<td>+18 dBm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 GHz – 46 GHz</td>
<td></td>
<td>+17 dBm</td>
<td></td>
</tr>
<tr>
<td>Small Signal Gain</td>
<td>3V/-0.5V bias, -25 dBm</td>
<td>12 GHz – 22 GHz</td>
<td></td>
<td>16 dB</td>
<td></td>
</tr>
<tr>
<td>Input Return Loss</td>
<td></td>
<td>22 GHz – 38 GHz</td>
<td></td>
<td>13 dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 GHz – 46 GHz</td>
<td></td>
<td>12 dB</td>
<td></td>
</tr>
<tr>
<td>Output Return Loss</td>
<td></td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>18 dB</td>
<td></td>
</tr>
<tr>
<td>Reverse Isolation</td>
<td></td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>14 dB</td>
<td></td>
</tr>
<tr>
<td>Noise Figure</td>
<td>3V/-0.5V Bias</td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>6.9 dB</td>
<td></td>
</tr>
<tr>
<td>Drain Current&lt;sup&gt;6&lt;/sup&gt;, Id</td>
<td>3V/-0.4V</td>
<td></td>
<td></td>
<td>-</td>
<td>230 mA</td>
</tr>
<tr>
<td></td>
<td>3V/-0.5V</td>
<td></td>
<td></td>
<td>-</td>
<td>180 mA</td>
</tr>
<tr>
<td></td>
<td>3V/-0.6V</td>
<td></td>
<td></td>
<td>-</td>
<td>130 mA</td>
</tr>
<tr>
<td>Input IP3 (IIP3)</td>
<td>3V/-0.5V bias, -20 dBm</td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>+14 dBm</td>
<td></td>
</tr>
<tr>
<td>Output IP3 (OIP3)</td>
<td></td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>+29 dBm</td>
<td></td>
</tr>
<tr>
<td>Output $P_{1dB}$</td>
<td>3V/-0.5V bias</td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>+18 dBm</td>
<td></td>
</tr>
<tr>
<td>Input Power for Saturation</td>
<td>3V/-0.5V bias</td>
<td>12 GHz – 46 GHz</td>
<td></td>
<td>+15 dBm</td>
<td></td>
</tr>
</tbody>
</table>

<sup>5</sup> Saturated output power specification defined using the EVAL-APM-7200SM $P_{5dB}$ compression curve shown in section 3.6

<sup>6</sup> Bias conditions for Id tested with no RF input power. See section 3.6 for DC current vs. RF power. Bias conditions presented as Vd/Vg. Drain current is specified as $I_d = I_d + I_d + I_d$.
3.6 Typical Performance Plots

Measurement data taken using the EVAL-AMM-7200SM module.
Drain current is specified as \( I_{d1} + I_{d2} + I_{d3} \)
3.7 Typical Performance Plot of Marki MM1-1140H Using AMM-7200SM as LO Driver

Plots taken using EVAL-AMM-7200SM as LO driver for connectorized MM1-1140H module in configuration A with a 91MHz IF. Power specified is input power to EVAL-AMM-7200SM driver.
3.8 Typical Performance Plot of Marki MM1-1240S Using AMM-7200SM as LO Driver

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11 Plots taken using EVAL-AMM-7200SM as LO driver for connectorized MM1-1240S module in configuration A with a 91MHz IF. Power specified is input power to EVAL-AMM-7200SM driver.
4. Application Information

4.1 Best Practices to Prevent Oscillations

Millimeter-wave amplifiers such as the AMM-7200SM are susceptible to oscillation due to positive feedback either from the bias lines or radiation in metal cavities. To prevent bias line feedback, 0.1µF bypass capacitors should be placed on all DC biasing lines close to the QFN. Additionally, a series resistor should be placed on the gate biasing pin close to the QFN with a value between 10 and 100 ohms (see application circuit in 4.2). Higher resistor values than 100 ohms will lead to excessive drain current draw and possible performance degradation. Radiative feedback can be minimized by placing RF absorbing material in the space between the QFN and the metal cavity.

4.2 Example Application Circuit

Below is the recommended application circuit for the AMM-7200SM:

```
    Vd
  /     \
A      A
 /     \
Vd     Vd
 /     \
50Ω Line
/     \\ 50Ω Line
RF In  AMM 7200 YYWW  RF Out
\     /    \    /     \
A     A     B
\     /     \\     \
Vg

Designator | Description          | Sample Part Number
------------|----------------------|---------------------
A            | 0.1µF 16V 0402 Capacitor | AVX 0402YD104KAT2A  
B            | 10Ω 0402 Resistor      | TE CPF0402B10RE1     
```

The three Vd lines are separated to minimize feedback between the transistor’s stages. The passive devices should be 0402 or 0201 surface mount. Examples of suitable passive devices would be the AVX 0402YD104KAT2A capacitor and TE CPF0402B10RE1 resistor. In addition to the resistor and capacitor on the gate pin, the layout of the board should be designed to minimize stray coupling between the drain and gate biasing traces on the board. Additionally, the gate biasing pin AMM-7200SM can draw up to 0.5mA at certain combinations of frequency and input power.
4.3 Constant Current and Constant Voltage Operation
As with most amplifiers utilizing HEMT technology, the AMM-7200SM can be biased with a constant gate and drain voltage, or with a constant drain current by regulating the gate voltage. Using a constant gate and drain voltage for biasing reduces complexity, but has variable current consumption during operation. On the other hand, biasing the gate using a feedback network that samples the drain current minimizes unit-to-unit variation in gain and other parameters.

Under small signal excitation at a fixed temperature, these two approaches are equivalent. However, they will diverge in large signal conditions, where the drain current is affected by the frequency and power of the input signal. In these conditions P1dB, P3dB, and P5dB will be somewhat different, but based on tests with similar parts, they will be within a few dBm of the constant voltage curves.
4.3 Header Pinouts

On the EVAL-AMM-7200SM, there are two headers for biasing the drains and gates of the transistors. The pinout of the headers is given with their location on the evaluation board below:
5. Mechanical Data

5.1 SMT Package Outline Drawing

Notes:

1) QFN material is plastic
2) I/O Leads and Die Paddle are 0.05 microns Au over 0.02 microns Pd over 0.5 microns Ni
3) All unconnected pins should be connected to PCB RF ground.

5.2 AMM-7200SM Recommended PCB Footprint

Dashed line indicates flooded ground plane

Ø0.010 Plated thru via. Recommended conductive or non-conductive fill, 23 PL. Vias can be added or reduced at PCB designer discretion, except the 9 underneath the QFN ground paddle.

Material Rogers 4003 008" ½ Oz Cu.

Landing pattern .dxf drawing: Landing Pattern AMM7200SM.dxf
5.3 EVAL Package Outline Drawing

RF In
1.000 [25.40]
2.000 [50.80]
1.000 [25.40]
RF Out
microwave
InOut
Eval-AMM-07200SM
Backside Label

Vd

0.617 [15.67]

Vg

2.23 [56.7]

Edge Mount Connector
1.85mm Female, 2PL