

Solid State Broadband High Power Amplifier

1193 – BBM2E4AKO
20 – 1000 MHz / 100 Watts

The BBM2E4AKO (SKU 1193) is a 20 to 1000 MHz amplifier which is guaranteed to deliver 100W minimum output power and related RF performance under all specified temperature and environmental conditions. Typical power output is 120W and other typical performance parameters are also listed as a guide for consideration, but not guaranteed. This amplifier is suitable as a broadband PA building block in target markets and related end applications for electronic attack, digital communications, and test and measurement in the UHF / VHF frequency bands. This compact module utilizes the latest high power RF LDMOS transistors and also features built in control and monitoring, with protection functions to insure high availability.



- Solid-state Class AB linear design
- Instantaneous ultra broadband
- Suitable for CW, AM, and FM (Consult factory for other modulation types)
- 50 ohm input/output impedance
- Small, lightweight, high reliability and ruggedness
- Built-in control, monitoring and protection circuits
- RS485 serial interface for monitoring and control

Product can be factory configured for use with up to 48V_{DC} yielding up to 200W output. Consult factory for operation and limitations of this feature.

ELECTRICAL SPECIFICATIONS @ 28.0V_{DC}, Over Temperature and Environmental Conditions, as specified.

| Parameter | Symbol | Units | Test Conditions | Min | Typ | Max |
|------------------------------------|----------------------|-------|--|-----|-----|------|
| Operating frequency | BW | MHz | | 20 | | 1000 |
| Peak output power | P _{SAT} | W | Measured with an IS-95, 9 channel forward link waveform without clipping. Channel bandwidth ~1.25MHz and PAR 10dB at 0.01% probability. | 100 | 120 | |
| Gain, small signal | G _{SS} | dB | Measured with VNA in swept frequency mode at -10dBm CW. Input power calibrated / measured at the amplifier input port. Variable attenuator set to nominal attenuation. | 50 | 53 | 56 |
| Gain flatness small signal | ΔG _{SS} | dB | Test conditions the same as G _{SS} | | | ±2.5 |
| Gain adjustment range | G _{ADJ} | dB | Test conditions the same as G _{SS} | 15 | | |
| Gain adjustment step size | G _{STEP} | dB | Test conditions the same as G _{SS} | 0.5 | | |
| Maximum input power without damage | P _{IN, Max} | dBm | CW input signal for unlimited duration. | | | 20 |
| Input return loss | IRL | dB | Measured with VNA in swept frequency mode at -10dBm and 0dBm CW. Input power calibrated / measured at the PA input port. Variable attenuator set to nominal attenuation. | | | -10 |
| Noise figure | NF | dB | Variable attenuator set to nominal attenuation. | | | 15 |
| Harmonics | 2 ND | dBc | Variable attenuator set to nominal attenuation. CW signal source at an output power of 100W. | | | -15 |
| | 3 RD | | | | | -9 |
| Spurious | Spur | dBc | Variable attenuator set to nominal attenuation. CW signal source of 0dBm at the input of the PA. Spurious defined as any non-harmonic amplifier output. Spurious measured in a 1kHz resolution bandwidth, 10kHz video bandwidth. Specifications apply at offsets of greater than or equal to +/- 10kHz from the RF carrier. Maximum measurement frequency is 3GHz. | | | -60 |
| Operating voltage | V _{DC} | V | Note: Output power capabilities and gain will vary with voltage. (Factory configurable for up to 48V_{DC} operation) | 26 | 28 | 30 |
| Current consumption | I _{DC} | A | Variable attenuator set to nominal attenuation. Measurement at an output power of 100W with a CW source. | | | 15 |
| PA enable / disable time | T _{ON/OFF} | uSec | Variable attenuator set to nominal attenuation. Measurement with 0dBm CW signal presented to the input of the amplifier. Rise and fall times of amplifier output envelope recorded. Rise and fall times at 10% / 90% of the output power in linear scale. PA Enable / Disable signal set to 10kHz repetition rate and 50% duty cycle. | | | 1 |

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PA PROTECTION / RUGGEDNESS

The PA includes protection circuits for:

- Over temperature
- Over voltage
- Reverse polarity
- Over current
- PA will withstand full reflection at the RF output port at any angle for up to 1 minute at 100W CW.

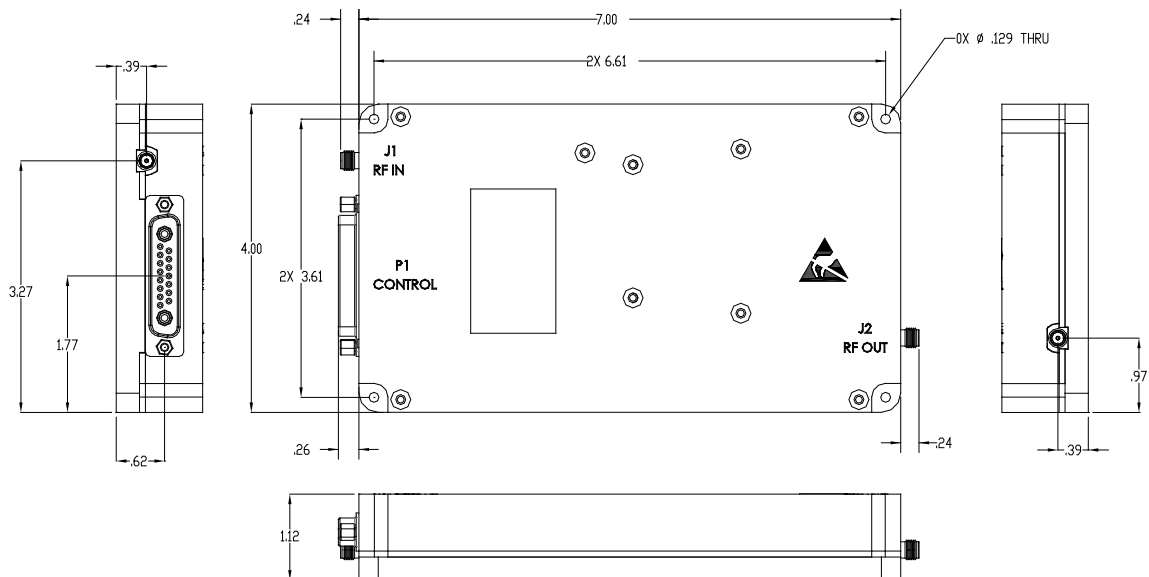
ENVIRONMENTAL SPECIFICATIONS

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|------------------|-----|----------|--------|------|
| Operating Case Temperature | T _C | -40 | | +85 | °C |
| Storage Temperature | T _{STG} | -40 | | +85 | °C |
| Relative Humidity (non-condensing) | RH | | | 95 | % |
| Altitude (MIL-STD-810F Method 500.4) | ALT | | | 30,000 | Feet |
| Vibration / Shock MIL-STD-810F Method 514.5/516.5 – Proc 1 | VI/SH | | Airborne | | |

MECHANICAL SPECIFICATIONS

| Parameter | Value | Unit |
|------------------------|--|-------|
| Dimensions | 7.0 x 4.0 x 1.2 | Inch |
| Weight | 2.0 Typ. | Pound |
| RF Connectors | Input: Type-SMA, Female Output: Type-SMA, Female | |
| DC Interface Connector | Hybrid – D-Sub 17-Pin, Male (17W2) | |
| Cooling | External Heatsink Required (not supplied) ➤ Heatsink Recommendations: • Thermal resistance of ≤0.2DegC/W. • Mounting surface flatness of 0.003 in. max. across the longest contact surface with either thermal compound or "phase change material" (Liard Technologies: TPCM-585) applied to the surface contact. | |

OUTLINE DRAWING



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DC INTERFACE CONNECTOR

| Pin # | Description | Specifications |
|-------|-----------------------|---|
| A1 | GND | Ground Return |
| A2 | VDD | Supply Voltage: +26.0-30.0V _{DC} , 28.0V _{DC} Nominal |
| 1 | RS485 (-) | Serial Communication Bus |
| 2 | Temperature Reporting | N/A – <i>(Temperature Monitor Reporting is currently available only from RS485)</i> |
| 3 | Address 1 | Hardware Address 1 |
| 4 | Address 3 | Hardware Address 3 |
| 5 | Attenuator Setting | Voltage input in the range of 0.5-3.0V _{DC} , 0.5V _{DC} corresponds with minimum attenuation, 3.0V _{DC} is maximum attenuation. Leave pin open or grounded to utilize RS-485 interface. (See RS-485 details below) |
| 6 | PA Enable | 0/3.3V logic levels: Power Amplifier disable is a TTL Logic Low (0V). <i>(Internally Pulled-High 3.3V)</i> Leave pin open or pulled high to utilize RS-485 interface. (See RS-485 details below) |
| 7 | Alarm | Amplifier Alarm indicator: Normally TTL Low A logic High indicates a fault condition, 0/3.3V Logic Levels |
| 8 | RS485 (+) | Serial Communication Bus |
| 9 | Current Reporting | N/A – <i>(Current Monitor Reporting is currently available only from RS485)</i> |
| 10 | Address 0 | Hardware Address 0 – Least significant bit |
| 11 | Address 2 | Hardware Address 2 |
| 12 | Address 4 | Hardware Address 4 – Most significant bit |
| 13 | Not Used | No Connection |
| 14 | Not Used | No Connection |
| 15 | Reset | Hardware reset: Logic 0 to resets PA and clears latched faults |

RS-485 User Interface

The following settings are used for serial communications:

- Baud rate: 115,200
- Start bits: 1
- Data bits: 8
- Stop bits: 1
- Parity: None
- Handshake: None

Frame and Message Structures

Frame structure

The serial link will be asynchronous, and follows a typical RS485 frame structure. The frame structure is defined in the figure below.

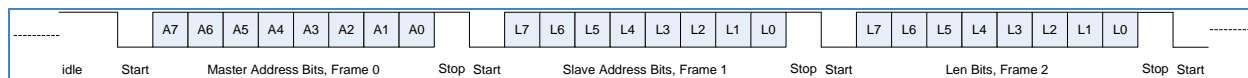


Figure 1: Serial interface frame structure

Each frame is 10 bits in length and will begin with a start bit, followed by 8 data bits and finally a single stop bit.

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Message structure

A message is comprised of at least 6 frames. The figure below provides the message structure.

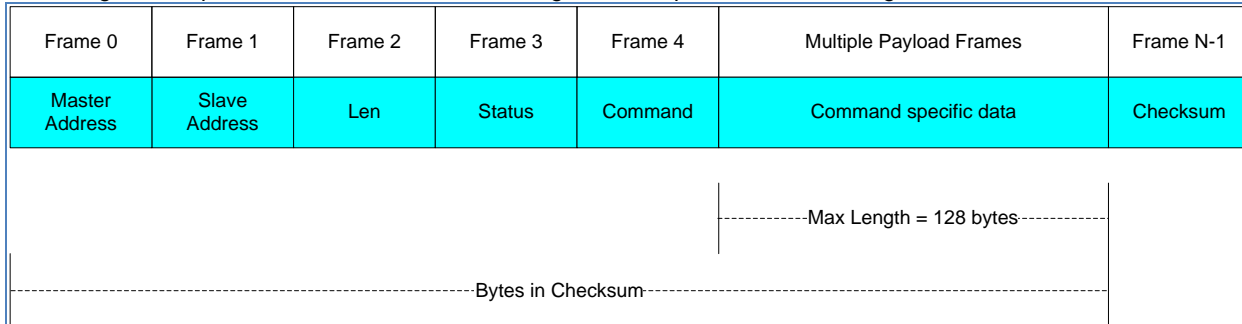


Figure 2: Serial interface message structure

Master Address

A7 A6 A5 A4 A3 A2 A1 A0
 X X X X X X X X

Master Address is not evaluated

Slave Address

A7 A6 A5 A4 A3 A2 A1 A0
 0 0 0 16 8 4 2 1

32 Slave addresses are possible (If no address lines are strapped on hardware, unit defaults to address 0)

Len

Len contains the number of bytes that follow, from Status to Checksum.

Status

Master should load this with zero.

Slave will echo back status of the command after it is evaluated.

Possible Slave responses

| Value | Description |
|-------|---|
| 0x00h | Message received and decoded successfully |
| 0x13h | Checksum error |
| 0x2Bh | Command not available |

There are 7 supported RS-485 commands, detailed below.

1. Null

The null command responds with message status. It is used for a basic test of the communications link.

| | |
|---------------------------|----------------------|
| Command frame value (hex) | 0x00 |
| Length frame value (hex) | 0x03 |
| Command data | none |
| Slave response | Echo with status set |

Example:

[8/30 17:58:15.3]SEND: 00 00 03 00 00 03

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[8/30 17:58:15.4]RECV: 00 00 03 00 00 03

2. Soft reset

Performs a re-start of the system

| | |
|---------------------------|----------------------|
| Command frame value (hex) | 0x04 |
| Length frame value (hex) | 0x03 |
| Command data | None |
| Slave response | Echo with status set |

Example:

[8/30 18:09:39.0]SEND: 00 00 03 00 04 07

[8/30 18:09:39.1]RECV: 00 00 03 00 00 03

3. Set power-up condition

Sets the state of the amplifier bias upon application of DC or hardware reset

| | |
|---------------------------|---|
| Command frame value (hex) | 0x05 |
| Length frame value (hex) | 0x03 |
| Command data | 2 bytes: 0x0001 sets power up condition to bias enabled. 0x0000 sets power up condition to bias disabled. |
| Slave response | Echo with status set |

Example:

[8/30 18:13:08.5]SEND: 00 00 05 00 05 00 01 01

[8/30 18:13:12.3]RECV: 00 00 03 00 05 06

4. Disable

Disables amplifier bias

| | |
|---------------------------|----------------------|
| Command frame value (hex) | 0x06 |
| Length frame value (hex) | 0x03 |
| Command data | None |
| Slave response | Echo with status set |

Example:

[8/30 18:14:36.7]SEND: 00 00 03 00 06 05

[8/30 18:14:36.8]RECV: 00 00 03 00 06 05

5. Enable

Enables amplifier bias

| | |
|---------------------------|----------------------|
| Command frame value (hex) | 0x07 |
| Length frame value (hex) | 0x03 |
| Command data | None |
| Slave response | Echo with status set |

Example:

[8/30 18:15:35.4]SEND: 00 00 03 00 07 04

[8/30 18:15:35.5]RECV: 00 00 03 00 07 04

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6. Set input attenuation

Sets the attenuation level

Notes:

- The RS-485 attenuation value overrides voltage control on pin 5.
- The value of the attenuation can only be increased from the factory value.
- The gain of the amplifier is also a function of temperature compensation.
- Variations in gain versus temperature are expected, independent of the user attenuation setting.

| | |
|---------------------------|---|
| Command frame value (hex) | 0x11 |
| Length frame value (hex) | 0x05 |
| Command data | 2 bytes. The first byte is 0 and the second byte is the mixed number attenuation value. $\begin{array}{cccccccc} \text{D7} & \text{D6} & \text{D5} & \text{D4} & \text{D3} & \text{D2} & \text{D1} & \text{D0} \\ \hline 0 & 0 & 16 & 8 & 4 & 2 & 1 & 1/2 \end{array}$ Examples: 30dB is 0x00 0x3C 8.5dB is 0x00 0x11 |
| Slave response | Echo with status set |

Example for setting 8.5dB user attenuation:

```
[9/4 15:45:49.9]SEND: 00 00 05 00 11 08 05 19 .....
[9/4 15:45:49.9]RECV: 00 00 03 00 11 12 .....
```

7. Get status

Returns status message that may be used for “heartbeat” polling of slave.

| | |
|---------------------------|---|
| Command frame value (hex) | 0x02 |
| Length frame value (hex) | 0x03 |
| Command data | None |
| Slave response | IQ1 current (2 bytes) IQ2 current (2 bytes) IQ3 current (2 bytes) Total Current (2 Bytes) <i>(see Alarm state bit map table)¹</i> <i>(see threshold alarm and warning state bit map table)²</i> V _{SUPPLY_SNS} (2 Bytes) Temperature (2 Bytes) Alarm State (1 Byte) ¹ Hi_Thresh_Alarm_state (2 Bytes) ² Hi_Thresh_warning_state (2 Bytes) ² Lo_Thresh_Alarm_state (2 Bytes) ² Lo_Thresh_Warning_state (2 Bytes) ² |

Alarm state bit map: ⁽¹⁾

Bit 0 is current limit alarm

Bit 1 is PA enable. (PA enable is not truly an alarm, but is routed to the microcontroller for monitoring purposes and future use.)

Bit 5 is negative supply shutdown alarm (applied to PA with GaN devices)

| | N/A | N/A | Negative Supply S/D | N/A | N/A | N/A | PA ENABLE | I _{LIM} (Current Limit) |
|-----------|-----|-----|---------------------|-----|-----|-----|-----------|----------------------------------|
| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Alarm ON | x | x | 1 | x | x | x | 1 | 1 |
| Alarm OFF | x | x | 0 | x | x | x | 0 | 0 |

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Threshold alarm and warning state bit map: ⁽²⁾

| Bits 0 through 11 maps to ADC 0 through 11 | | | | | | | | | | | | | |
|--|------|--------|--------|------|------|------|------|------|------|------|------|------|------|
| Bit 12 maps to temperature | | | | | | | | | | | | | |
| | Temp | ADC 11 | ADC 10 | ADC9 | ADC8 | ADC7 | ADC6 | ADC5 | ADC4 | ADC3 | ADC2 | ADC1 | ADC0 |
| BIT | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Alarm/Warn ON | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Alarm/Warn OFF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

- All current/voltage readings will be in hundredths of Amps/Volts.

Below are results in hexadecimal using "FoxTerm" terminal emulator program;

```
[5/20 13:42:10.3]SEND: 00 00 03 00 02 01 .....
[5/20 13:42:10.4]RECV: 00 00 18 00 02 00 0A 00 .....
0008: 0A 00 55 00 7E 09 8C 00 ..U.~...
0010: 22 02 00 00 00 00 00 00 ".....
0018: 00 00 94 FF .....

```

Therefore;

- IQ1 current (2 bytes): 00 0A = 10/100 = 0.100A
- IQ2 current (2 bytes): 00 0A = 10/100 = 0.100A
- IQ3 current (2 bytes): 00 55 = 85/100 = 0.850A
- Total Current (2 Bytes): 00 7E = 126/100 = 1.26A
- V_{SUPPLY_SNS} (2 Bytes): 09 8C = 2444/100 = 24.44V
- Temperature (2 Bytes): 00 22 = 34DegC
- Alarm State (1 Byte): 02 = bit 1 is set; so only PA enable = 1, No other alarm is active; I_{LIMIT}, V and 8V Shutdown alarm.
- Threshold bytes x4 (2 Bytes each): The remaining bytes are all zeros; therefore, no other ADC channel alarm or warning is active.

Notes on Alarms

- Any alarm condition will pull the Alarm line TTL logic high (3.3V) on Pin 7.
- For latched alarms; Current, Voltage or Temperature, the unit will disable.
- A Software or Hardware reset is required to clear Latched Alarm.