EMPOWER RF SYSTEMS, INC.

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 use 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.

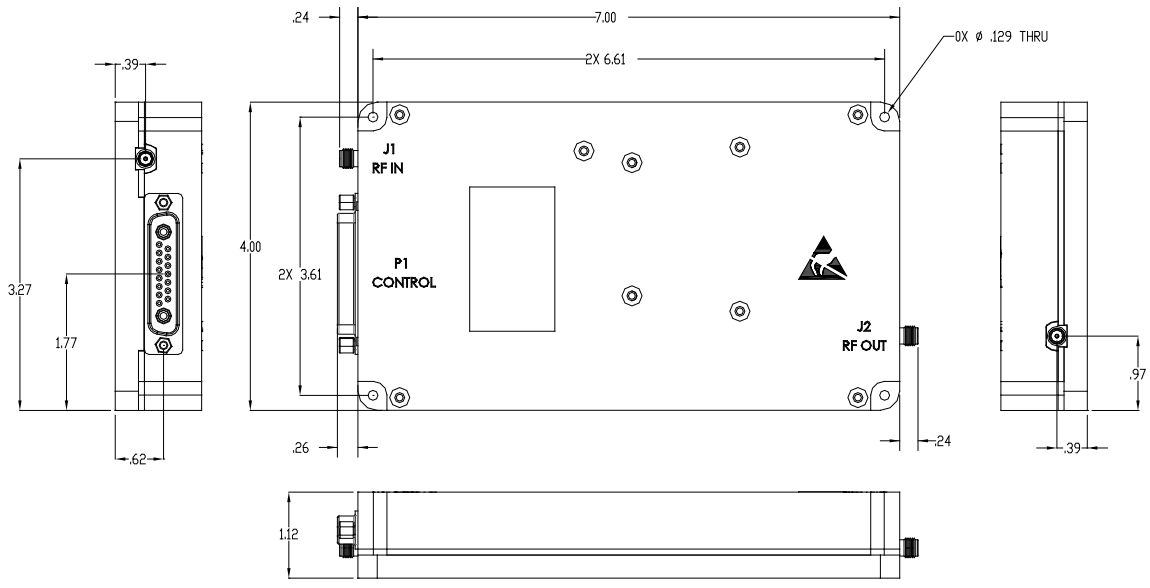
ENVIRONMENTAL SPECIFICATIONS

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



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 – *(Temperature Monitor Reporting is currently available only from RS485)*
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). (*Internally Pulled-High 3.3V*) 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 – *(Current Monitor Reporting is currently available only from RS485)*
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.

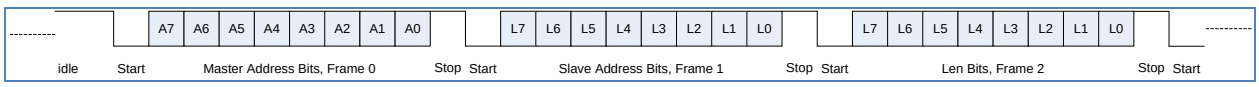


Figure 1: Serial interface frame structure

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.

Message structure

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

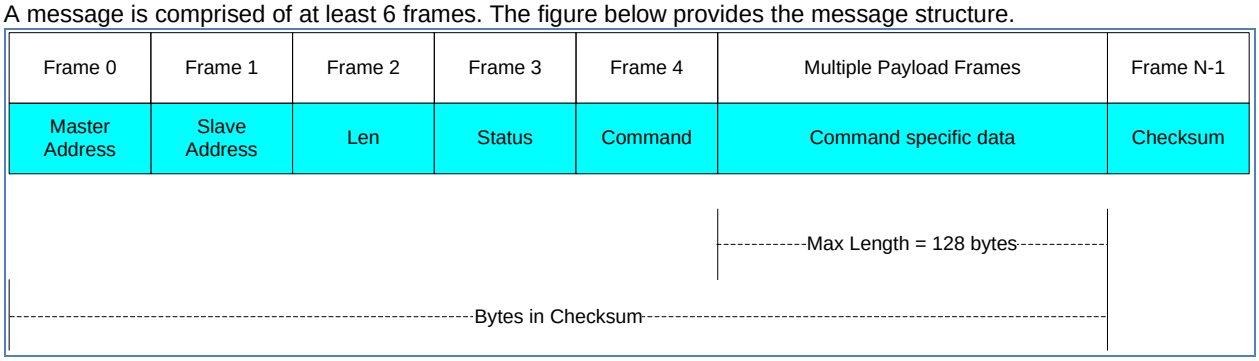


Figure 2: Serial interface message structure

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 .....

[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 .....

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. D7 D6 D5 D4 D3 D2 D1 D0 0 0 16 8 4 2 1 1/2 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 (*see Alarm state bit map table*)[1] (*see threshold alarm and warning state bit map table*)[2]	IQ1 current (2 bytes) IQ2 current (2 bytes) IQ3 current (2 bytes) Total Current (2 Bytes) 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

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.