High Power RF/Microwave Transistors, Pallets and Amplifiers from Integra Technologies, Inc.

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ABSTRACT

Integra Technologies, Inc. is engaged in design and manufacturing of High Power RF/Microwave transistors, 50-ohm matched pallet amplifiers, miniaturized power amplifiers (MPA) and High Power Amplifiers (HPA) based on silicon Bipolar and FET technologies, including LDMOS, operating from VHF to S-band frequencies. Currently, extensive development work is being done on Gallium Nitride technology, which will enable operations for X-band and higher frequencies.

Incorporated in the state of California in 1997, Integra has become a leading supplier of RF transmitter modules for Radar and Avionics equipment and system manufacturers. Today Integra is a multi-million dollar, ISO9001 certified company with a broad customer base spanning the globe including Armenia.

The purpose of this paper is to familiarize the audience with the company and how its products can be used in Armenia.

The 50 Ohm pallets are essentially building blocks combined in parallel to achieve any required system level power for a conventional high power transmitter or can be used individually as radiating elements for a Phased Array Radar (PAR) system.

Institutions in Armenia have been utilizing such products to build RF transmitters. This knowledge base which appears to be growing over the years can be extended to cover other types of RF transmitters used in Avionics, Broadcast, Cell phone infrastructure, SATCOM and miscellaneous wireless communication systems.

The photo below illustrates an S-band 3.1-3.5GHz, 2-stage, 650 Watt HPA, where Integra transistors and pallets are employed on both stages of amplification. The unit also includes digital circuitry to monitor output Voltage Standing Wave Ratio (VSWR) and flange temperature of transistors. Systems designers use several such HPA's combined in parallel to achieve desired system level power.

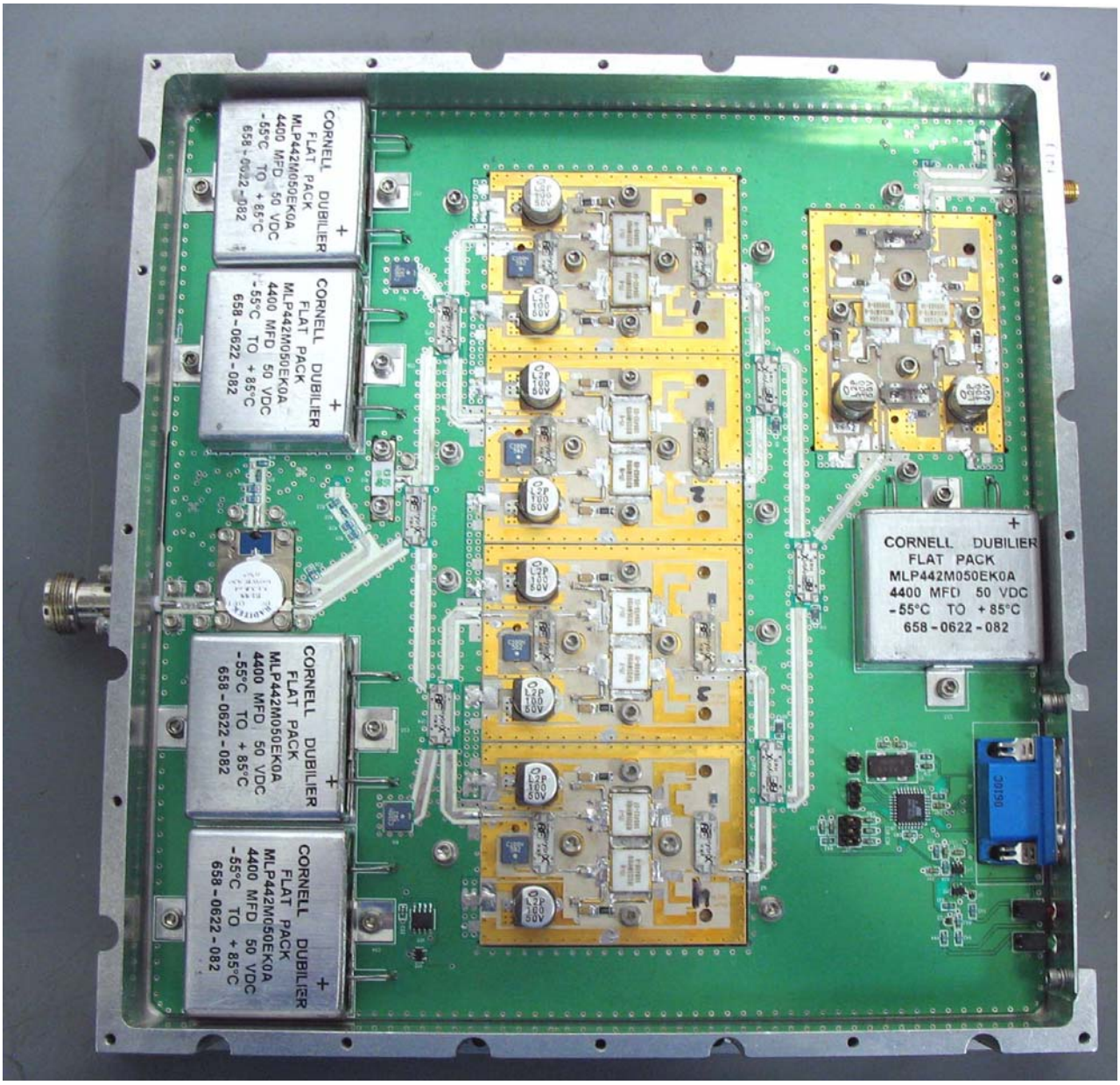

Figure 1. 3.1-3.5GHz, 2-stage, 650 Watt Pulsed Power Amplifier

1.1 IBA3135M650 Amplifier

The IBA3135M650 is a solid state, base plate cooled, pulsed RF amplifier operating in the 3.1-3.5GHz frequency range. Its operating voltage is 36.0 ± 0.2VDC and operating temperature is -25 to +65ºC. The amplifier has an optional internal circuitry to monitor temperature and operating power levels (input, output, and reflected). RF input to the amplifier is through a female SMA connector and output is via a female N connector.

This amplifier is intended for use in military radar systems and is capable of a wide variety of pulse formats and duty cycles. Its output is protected against high VSWR by an internal circulator. The nominal output power at 25ºC is 650W with 25W input power.

1. **Specifications @ 25 degree Celsius**
   - Operating frequency range – 3.1 to 3.5GHz
   - Instantaneous Bandwidth – 400MHz
   - Output Power - > 650W peak
   - Input Power – 25W peak
   - Input Return Loss - > 10dB
   - Pulse Width – up to 150us
   - Duty Cycle – 10% max
   - Pulse Amplitude Droop – 1dB max
   - Insertion Phase – 0 ± 20º
   - Peak DC Current – 80A max
   - RF Envelope Rise time – 130ns max
   - RF Envelope Fall time – 110ns max
   - Spurious Outputs – 50dBc min
   - Harmonics (2^{nd} through 4^{th}) – 30dBc
   - Note: Amplifier can operate at higher duty cycles with reduced power output

1.2 Amplifier Architecture

The IBA3135M650 is a solid state two-stage pulsed power amplifier. The RF amplifier assembly consists of a hybrid coupled first stage driver module followed by a 4-way hybrid power splitter. The four outputs from the power splitter are fed to 4 identical hybrid coupled power modules whose outputs are combined and routed to the internal output circulator, protecting the module from high VSWR load conditions.

The first stage of amplification is realized via Integra IBP3255 pallet. This driver module consists of two IB3135M70 transistors combined in parallel and amplifies the 25W input signal to minimum of 130 Watt level.
The output of IBP3255 pallet is then split via a 2 stage, 4-way hybrid splitter into four equal signals used to drive the second stage power module IBP3249.

IBP3249 pallet is based on the Integra IB3135MH100 power transistor – 2 combined in parallel and has typical Power Output of 200 Watts and Power Gain of 8dB . It operates under 36Volt collector bias. The outputs from the 4 power modules are combined via a 2- stage, 4-way hybrid combiner and routed to the output power coupler and circulator.

The output of the amplifier is protected against high VSWR conditions by a Raditek RI-SS-3.1-3.5-CD-100WR-A30 circulator.

The amplifier has a built in RF power detectors and a microprocessor which monitors a sample of the input, output and reflected output power in addition to the amplifier temperature. There is a green and a red LED near the D-subminiature power connector that provide indication of DC power and over-temperature respectively. BIT features to include:

- Input power fault – over range
- Output VSWR fault – over range
- Over temperature fault – over range

Typical RF performance data is given in the table below:

Part No.	Freq(GHz)	P_o(W)	RL(dB)	Gain (dB)	Nc (%)	Droop
	3.10	**779**	**18.0**	**14.93**	**25.24**	**-0.38**
IBA3135M650	**3.30**	**709**	**24.0**	**14.53**	**27.77**	**-0.44**
	3.50	**670**	**21.0**	**14.28**	**28.32**	**-0.31**

The rated 650 Watt minimum power is achieved by combining four IBP3249 pallets in parallel. The insertion losses associated with power combining and output isolator are about 0.8dB at the high end of the band.

Output Power/Gain Flatness of the amplifier is less than 1dB maximum and typical number is about 0.7dB. This is achieved by implementation of Gain Equalizing Networks employed on both stages of amplification. Both IBP3255 and IBP3249 pallets include the Gain Equalizing Networks on the input of the matching networks.

1.3 IBP3249 and IBP3255 pallet amplifiers

As we mentioned above, IBP3255 pallet consists of two IB3135M70 transistors combined in parallel. It operates under 36Volt collector bias and has typical Power Gain of 7.5dB. Typical RF data is given in the table below:

Part No.	Freq(GHz)	P_o (W)	RL (dB)	Gain (dB)	Nc (%)	Pulse Droop (dB)
	3.10	**157**	**17.8**	**7.98**	**41.34**	**-0.25**
IBP3255	3.30	**175**	**17.4**	**8.46**	**43.29**	**-0.20**
	3.50	**143**	**14.0**	**7.57**	**40.35**	**-0.19**

IBP3249 pallet is based on the Integra IB3135MH100 power transistor, operates under 36Volt collector bias and has typical Power Output of 200 Watts and Power Gain of 8dB. Typical RF data is given in the table below:

Part No.	Freq (GHz)	P_o (W)	RL (dB)	Gain (dB)	Nc (%)	Pulse Droop (dB)
	3.10	**225**	**13.2**	**8.34**	**44.46**	**-0.18**
IBP3249	3.30	**221**	**14.4**	**8.25**	**41.48**	**-0.20**
	3.50	**197**	**18.4**	**7.75**	**40.88**	**-0.22**

1.4 IB3135M70 and IB3135MH100 transistors

The primary building block of a reliable High Power RF amplifier is the RF circuit and the High Power RF transistor itself. It is in the design of this transistor that reliability related factors, such as metallization and ballasting, must be taken into account. Integra's transistors utilize high f_t process, interdigitated geometry and gold metallization for the highest possible functional performance and reliability. Emitter ballast resistors assure devices are less susceptible to thermal runaway and prevent hot spotting across the transistor chip.

Integra's IB3135M70 transistor is used for the 1st stage of the amplifier. The second stage of amplification is realized via IB3135MH100 transistor. Both transistors are Common Base, Class C, hybrid bipolar junction transistors, are gold metallized and use gold bonding wires for electrical connections to enhance device reliability.

IB3135MH100 device is specified at 100 Watt minimum output power over the given frequency with 7.90 dB minimal gain. The device has internal input and output matching networks and operates from a single 36V power supply. It is rated at 2:1 VSWR for survivability. IB3135M70 device is specified at 70 Watt minimum output power over the given frequency with 7.65 dB minimal gain. The device has internally matched input and output networks and operates from a single 36V power supply. The device is also rated at 2:1 VSWR for survivability.

Conclusion

Integra Technologies, Inc is a vertically integrated company with unique ability to provide high power RF solutions from basic transistors to pallet and amplifier levels, covering operations from VHF to S-band frequencies. Over the past several years Integra has proven many times its ability to design and mass produce state of the art transistors, pallets and amplifiers in very short time intervals. Integra products are used in critical systems such as Air Traffic Control, Phased Array, Shipboard and other military and civilian use radars. Therefore, regardless of your needs in RF High Power industry – transistors, pallets or amplifiers, Integra Technologies, Inc is able and willing to help you to find and produce solutions. If you have a system level requirement, for example, transmitter box or complete radar system, Integra team can help you to select right component from the existing reach portfolio or if necessary, will develop one that will work for you. We will work with you to create component specifications based on the given system level requirement and support your needs through production cycle.