Compact High Power IFF Transmitter for Secondary Surveillance Radar Application

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Abstract - **A solid state light weight highly reliable and Compact High Power Transmitter for IFF (Identification, Friend or Foe) application is developed and presented in paper. It can give variable output power in 12 dB range (250 W to 4 KW) in 4 steps with a maximum output power of 4 KW+/-10%. This variable power suits it to long range, medium range and short range interrogator for Secondary Surveillance Radar Applications. Module supports DPSK and PAM modulation which makes it suitable for ICAO Mode S application as well as for Mode 1, 2, 3/A, C. The module generates a fault for High Pulse Width, High VSWR and High Duty Cycle and protects itself by getting OFF. The module has protection against thermal burnt out. This paper gives complete design and measurement results of 4 KW amplifier.**

Keywords: Identification, Friend or Foe (IFF), Secondary Surveillance Radar, Transmitter, ICAO, STANAG, Interrogator

I. INTRODUCTION

NOW-A-DAYS High power transmitters with GaN Amplifers are available in market but use of the same in production is very difficult because of price & technological design barriers. Systems using Mode S capabilities are generally used for air traffic control surveillance systems. In addition, certain ATC applications may use Mode S transmitters, *e.g.* for vehicle surface surveillance or for fixed target detection on Surveillance system. Authors of [1] discussed design of 4 KW transmitter using amplifiers in class-C Mode which possess higher collector efficiency [2,3] and better harmonic rejection is being offered by Cavity diplexers.

RF power transistors dissipate a significant amount of power. Thus provision of heat sink or cold plate is required as per the availability of cooling technique in system. It is desirable to maintain low junction temperature for high reliability [4]. Maximum temperature inside the housing is maintained below 80ºC in developed module.

II. DESIGN APPROACH

Design approach is shown in figure 1 for realization of compact high power transmitter. In this approach PAM, DPSK and power supply signals are given through monitor and protection card. This card not only protects transmitter from high pulse width, high duty cycle, high temperature and high duty cycle but also generates fault on RS232 along with respective TTL signal for system level application. TTL mode pulse (PAM signal) applied to Gated crystal oscillator generates 1030 MHz signal. DPSK modulator works with TTL DPSK control signal from monitor and protection card. This modulator drives 200 W driver amplifier, which in turn drives 1KW FET (Microsemi MDS-1100). Output of 1 KW is divided in four ways to drive four 1 KW amplifiers whose outputs are combined to get 4 KW RF Output. To monitor forward power, a high power coupler with detector diode has been used in design.

At final output, Circulator has been used to provide protections to high power transistors from reflected power in case of high VSWR. At third port of Circulator, detector diode is being used to cater VSWR fault and protection. This forward and reflected detected output is compared w.r.t threshold and fault is generated by monitor protection card. The module works on voltage +12V, +5V & +50V DC.

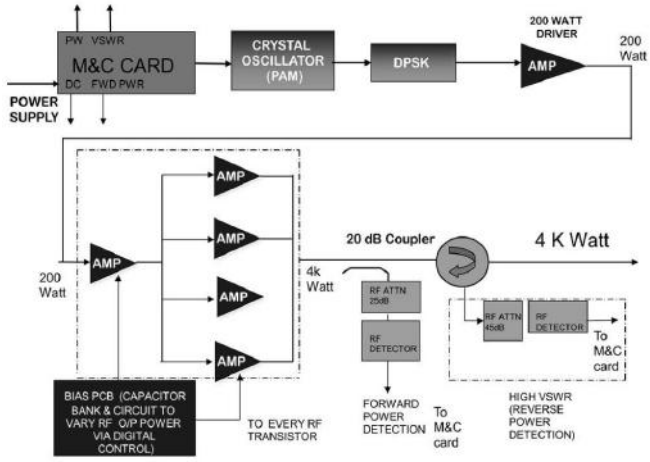


Figure 1. Design approach of compact 4KW IFF Interrogator Transmitter.

III. DESIGN METHOD

Compact SSPA's RF PCB's are designed with RT Duroid 6010 substrate. Supplier's suggested land-pattern was modified as

per substrate data. High Power divider (1:4) and Combiner (4:1) are also designed using same substrate with high power matched termination.

Bias card is designed using FR-4 substrate, to provide power supply sequencing & filtering. It includes capacitor bank required by all five FET devices for faster charging and discharging. Schematic is shown in Figure 2.

Monitor-and-Control card doesn't allow pulses > 33µs pulse-width and greater than 2% duty cycle.

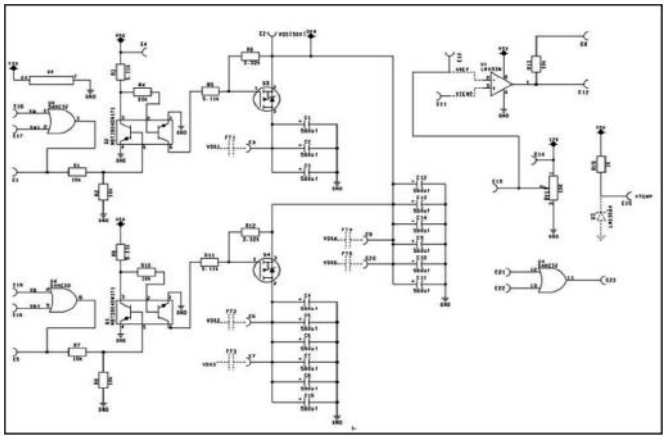


Figure 2. Bias Card schematic used in developed 4KW IFF Interrogator Transmitter.

IV. DESIGN OUTPUT

Designed SSPA is shown in Figures 3 and 4. The module has one 25 pin Mini D connector and one SMA connector. Mini D connector has all the DC supplies, Mode pulse, BPSK pulse, GND connections, faults indication (in form of TTL High logic) and control signals on it, while the SMA connector has RF Output power. Fault and power are displayed on PC via RS232 Communication. The module can work up to 32 µs and 1% duty cycle (2% short term) pulse-width. Entire Transmitter is encapsulated in a single housing of size 216 mm x 170 mm x 35 mm.

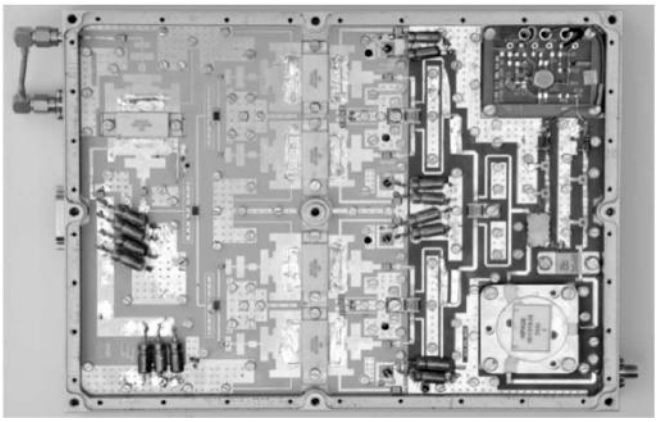


Figure 3. Developed 4KW IFF Interrogator Transmitter.

The transmitter housing can be screwed on to the liquid cooled cold plate, which provides the best cooling efficiency by cooling underneath each of the power devices of the transmit chain. The same module can work with forced airflow cooling application by using external heat sink.

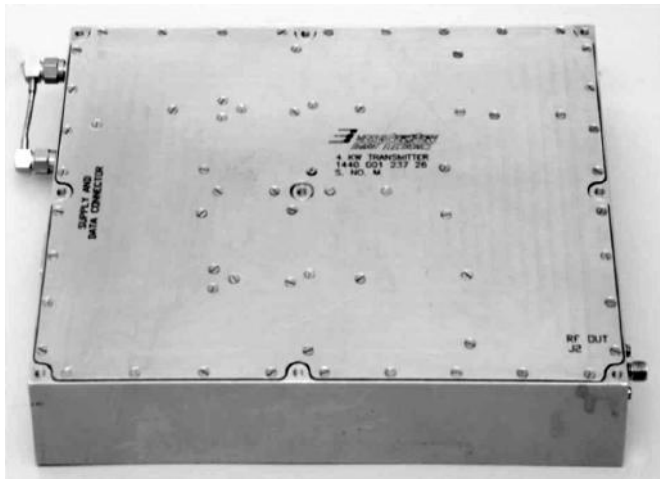


Figure 4. Developed 4KW IFF Interrogator Transmitter with cover.

V. MEASUREMENTS

Developed system has been evaluated at high temperatures as well. At 55°C after 4-hour operation with fan of CFM 90 the currents are as follows: 3.00 Amp (32 µs, 1.0% duty cycle), current @12V: 40 mA, current @5V: 20 mA. Measured power was 65.341 dBm with droop of 0.734 dBm (shown in figure 2). Pulse characteristics are measured as Power 65.34 dBm pulse droop of 0.74dB, harmonics -33 dBc rise time <100 ns and fall time <200 ns.

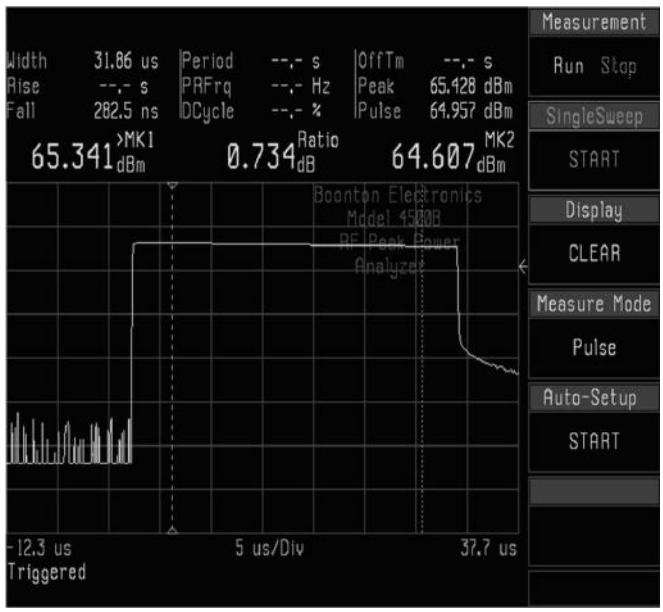
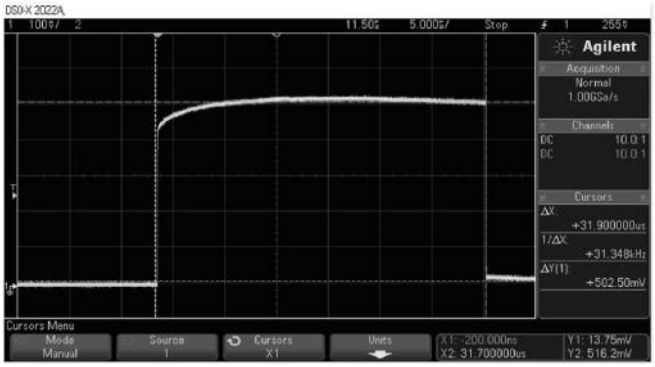
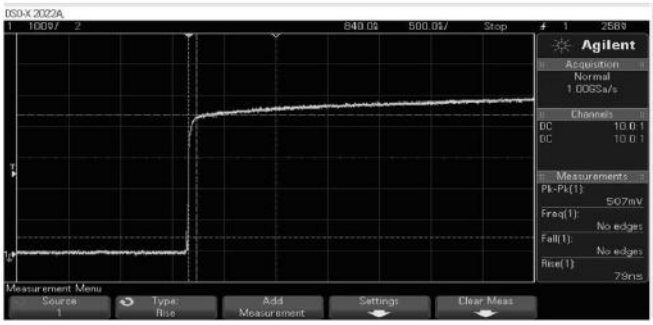


Figure 5. Measured output power and droop.



(*a*)



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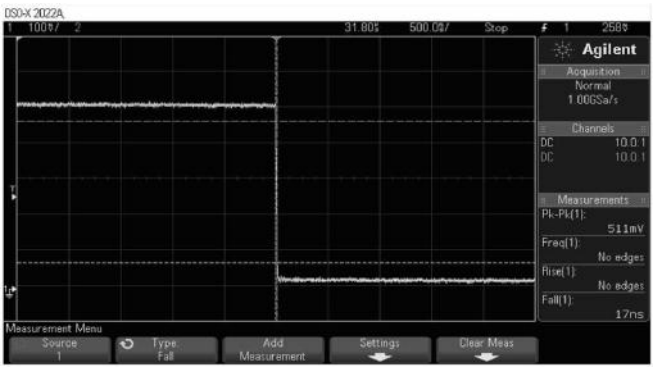
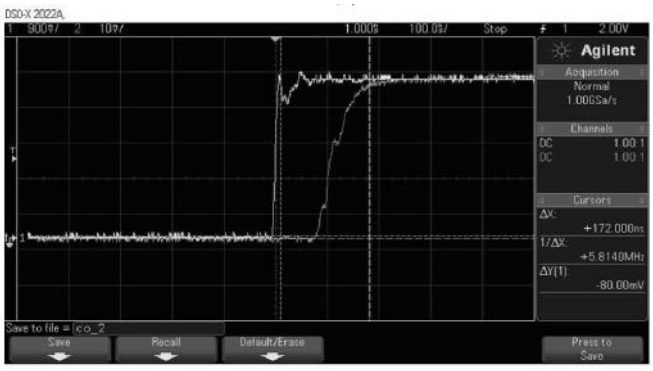


(*c*)



(*d*)

Figure 6. (*a*) Measured pulse-width (*b*) Measured rise time (c) Measured Fall time (*d*) Measured pulse delay of Developed 4 KW IFF transmitter.

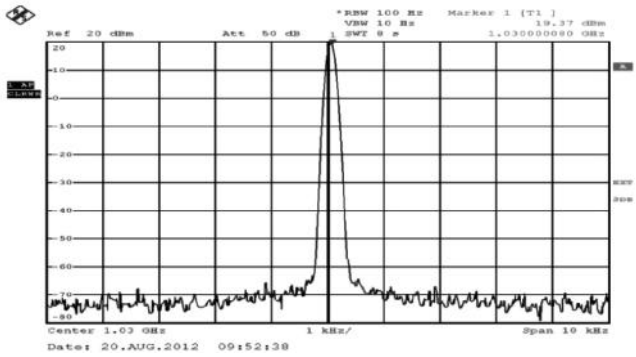


Fig 7: Measured Carrier Frequency.

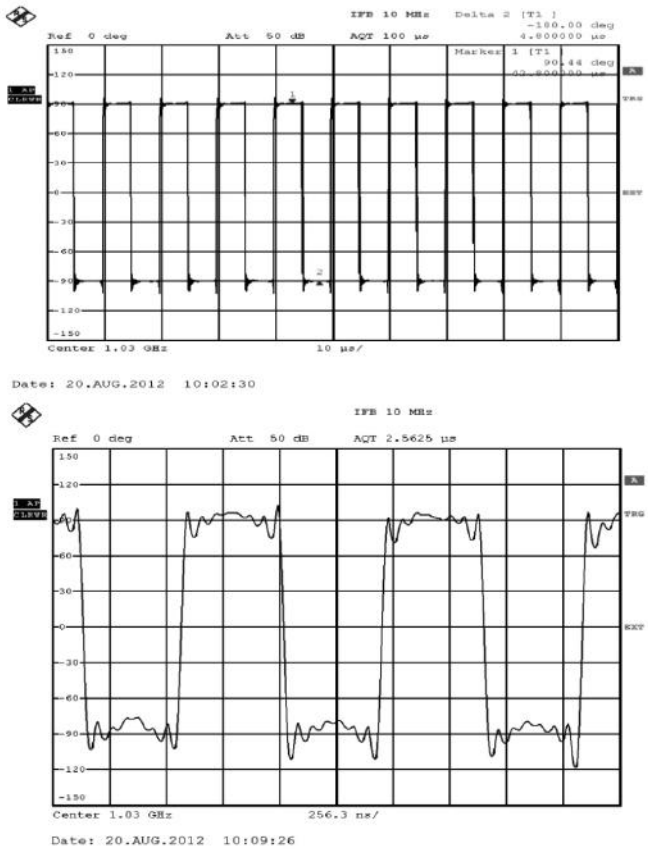


Fig 8: BPSK modulation.

VI. RESULTS

Compact SSPA meets all pulse characteristic requirement of ICAO & STANAG standards Like frequency stability, rise time <100 ns and fall time < 200ns [1,5]. It meets environmental MIL standards 810E and EMI/EMC MIL STD of 461 E (with EMI filter at supply). Compact size, light weight, variable power features make it suitable for short range, medium range, long range IFF interrogator transmitter. MTBF analysis has been carried out on this transmitter and MTBF value at room temperature is 4, 55,126 Hrs.

VII. ACKNOWLEDGEMENT

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VIII. REFERENCES

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