Design and Development of C-Band Up-Converter with Built-in-Check

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Abstract – **This paper gives design and development details of airborne C-Band up-converter for datalink application. This up-converter has built in Test (BIT) feature to verify the performance. It converts L band IF Input to C band RF Output with use of S band LO frequency. It has conversion gain of 14 dB & 0.25 dB gain-flatness over bandwidth of 120MHz with out-of-band rejection better than 70dBC.**

Keywords: Airborne Upconverter, Data link, Amplifier, Built-in-check, Microstrip design

I. INTRODUCTION

LOT of designs of up-converters are available in market now-a-days. In most of designs, Mixer is used for up/down conversion. In this customised design of up-converter open carrier double balanced mixer for up conversion is used. Double-Balanced Mixers offer broader bandwidth with increased linearity, improved suppression of spurious products (All even order products of the LO and/or the RF are suppressed) and the inherent isolation between all ports. Open carrier mixer offers flexibility of assembly at any type of housing/carrier.

Ceramic band pass filters have been used for filtering of IF and RF signals. For inbuilt functional check, Voltage controlled Oscillator (VCO) is being used in design to inject test IF signal of actual frequency. VCO injects same power to the upcoverter. Output of bandpass filter is applied to mixer through thermopad, which not only improves return loss of mixer but also compensates gain variation over the temperature as per TCR of thermopad. At the RF out port of mixer, thermopad is also being used. Two stage MMIC amplifier is being used in the design along with Ceramic BPF of 4460±60 MHz. Gain equalizer circuit is also being used in the design.

II. DESIGN APPROACH

Figure 1 shows design approach used in the development of Airborne Up converter. IF of L band of -8 dBm (typ) was estimated power level in C-Band Data Link. This signal is routed through 10 dB coupler, followed by ceramic band pass filter of desired bandwidth. Output of filter mixed with LO signal in open carrier mixer and gives upper and lower sidebands. During mixer selection Input 1 dB compression point of I/P P1 of mixer is sufficiently high. Bandpass filter at RF side allows passing desired upper side-band in C band. This is again amplified by gain blocks of required gain. Figure 1 also shows gain calculation of up converter. Chip capacitors of suitable rating have been used to protect all RF, IF, LO ports from unintended DC I/P. Ceramic BPF has been chosen to allow signals of intended Pass-band. Output of Filter is applied to Mixer. Chip thermo pad attenuator has been placed at appropriate places to improve return loss and compensate gain variation over the temperature. Microstrip coupler to monitor proper LO during operation of system has been incorporated in design. This complete Microstrip design has several advantages like manufacturability, repeatability, and low cost. Harmonics and spurious were limited using ceramic BPF. MMIC based amplifier has been chosen with High P1 O/P and such gain so that we can achieve the adequate results over the frequency and temperature.

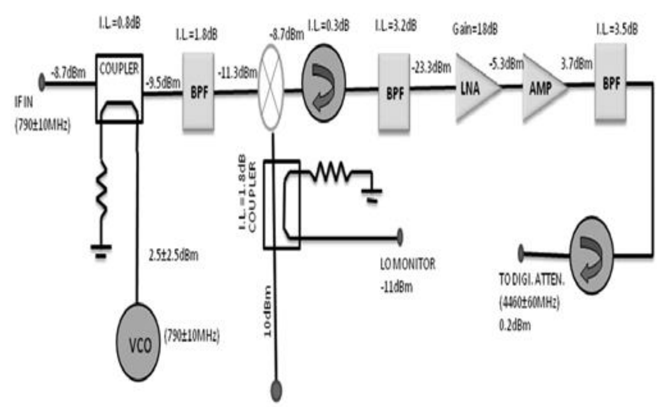

Figure 1. Block Diagram of Airborne Upconverter.

III. DESIGN METHOD

In design, Micro strip line based PCB structure has been used. The established design equation of Micro strip has been used to draw PCB layout using ADS software on Rogers's substrate. Parallel line Coupler for monitoring of LO, RF & IF has been designed on same PCB substrate for miniaturized size. Coupler design Equation, the methods given by Bryant and Weiss [1] and Kirschning and Jansen [2] are among the first reliable and accurate methods to obtain information on coupled microstrip transmission lines. Ceramic SMD Bandpass filter was used and assembled on the same substrate.

IV. DESIGN OUTPUT AND MEASUREMENTS

Layout of designed PCB is shown in Figures 2 and 3.

Figure 2. PCB Layout of IF side.

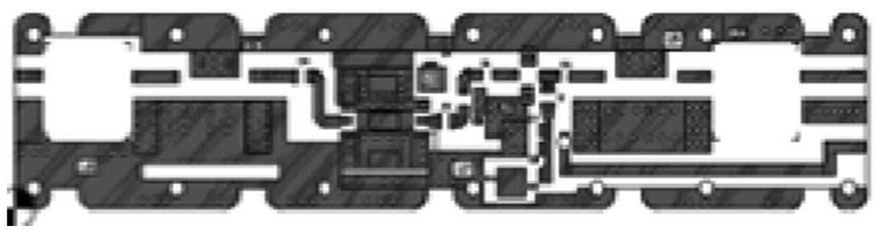

Figure 3. PCB Layout of RF side.

Figures 4 and 5 show assembled view of printed PCB.

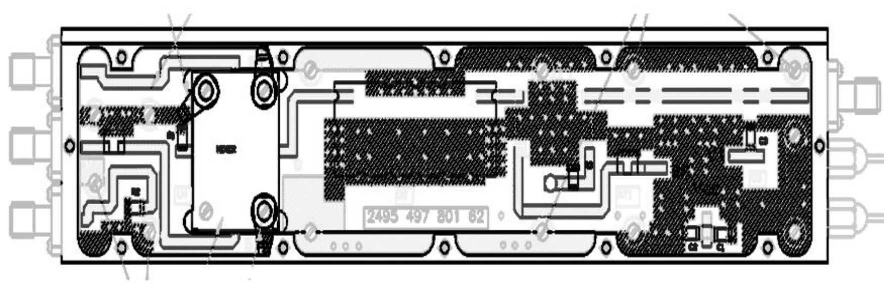

Figure 4. Assembled PCB Layout of IF side.

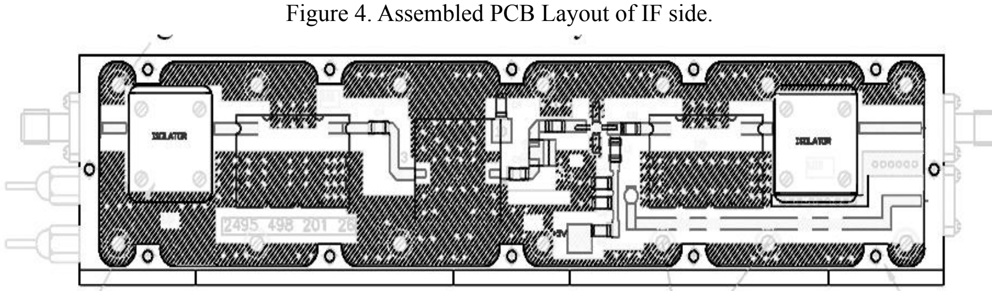

Figure 5. Assembled PCB Layout of RF side.

Mechanical View with mounting details is shown in Figure 6. Figure 7 shows actual realised hardware.

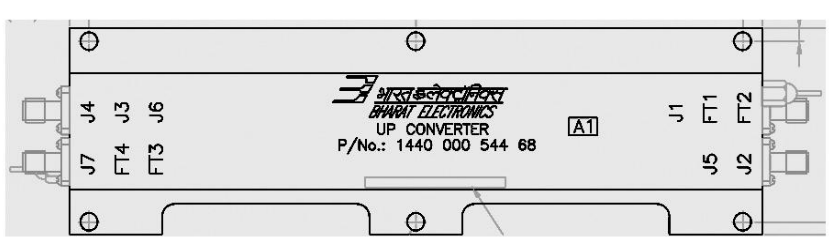

Figure 6. Mechanical Housing of Upconverter.

Figure 7. Integrated Up Converter Module

Figure 8 shows Frequency versus Gain variation of Up Converter. Gain Variation of 0.3 dB was achieved at room temperature over 120MHz bandwidth and thermo pad has been used to maintain almost same variation over the temperature. Module operates in Class A with current consumption of 210mA@ 5V.

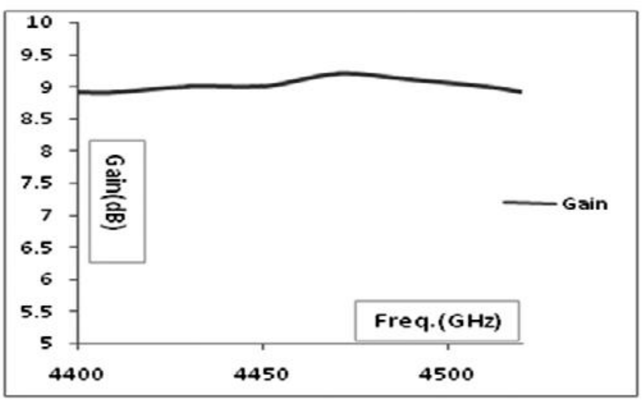

Figure 8. Frequency vs Gain of Up-Converter.

V. CONCLUSION

In developed Airborne Up-converter module, compact customised size, light weight, gain of 9±1 dB and gain flatness of ±0.25dB over 120 MHz band width was achieved. The developed airborne up-converter module has built in test option to check the health of up converter module and multiple IF, RF & LO monitor port to monitor all signals during application. Separate digital attenuator module can be attached in system with up converter which makes it suitable to realise reconfigurable system.

As developed module is enclosed in conductive enclosure with proper gaskets, it can meet EMI/EMC-461E standard as well. Results were meeting simulated results not only at room temperature but also at -20°C and +55°C. Gain flatness over the frequency and temperature of the module was excellent (0.25dB). Input and Output Return Loss of better than 16 dB was achieved at all RF, IF & LO Ports.

REFERENCES

[1] T.G. Bryant and J.A. Weiss, "Parameters of Microstrip Transmission Line and Coupled pair Microstrip line", *IEEE Trans. Microwave Theory and Techniques,* vol MTT-16, no 12, pp 1021-1027, Dec 1969.

[2] M. Kirschning and R.H. Jansen, "Accurate wide range design for the frequency dependent characteristic of parallel coupled microstrip lines , *ibid*, vol. MTT 32, no 1, pp 83-90, Jan 1984.

[3] Data sheet of M/A-COM MC4520, Open Carrier Double Balanced Mixer.

[4] Datasheet of Wattkins Johnson SMT-86, AG203-86 Transistors.

Amit Tiwari FIETE obtained Bachelor degree in Engineering in Electronics and Communication and Master of Technology in Microwave Engineering from IT-BHU. He has 18 years of R&D experience. He served MITS and Institute of Engineering, Jiwaji University Gwalior as an assistant professor. He is currently working as Manager, in Development & Engineering-Microwave Components of Bharat Electronics Limited, Ghaziabad. He has designed and developed C-Band Airborne RF Transceivers, IFF Tx-Rx Unit for AEW&CS, IFF Transmitters for Radars, SSPA, Receivers and its components etc for Data link and Radar applications. He has published various research papers and articles in international journals and conference proceedings.

He has been honoured as IETE Sh. Devi Singh Tyagi Award 2018. He has received various awards for innovative efforts, six sigma, technical symposia etc.