Design and Verification of Specialized Test Equipment (STE) to support production of Linearized Block Up-Converters (L-BUCs)

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***Abstract*—This research project report includes the design, analysis and experimental verification of Specialized Test Equipment developed to support the production of Linearized Block Up-Converters (L-BUCs). L-BUCs are devices used to take base-band signals (typically in the 1 to 2 GHz range) and up-convert them to microwave and millimeter-wave frequencies (30 to 31 GHz in this application), and also linearize the converted signals to compensate for distortion introduced by post L-BUC power amplification. In order to test an L-BUC with a network analyzer where the port 1 and 2 frequencies are at the same, a down converter is necessary. The goal of this work was to optimize an initial down converter design and to develop test equipment to support L-BUC production.**

***Index Terms*—block up converter, heterodyne principle, linearizer, monolithic microwave integrated circuit (MMIC), sub-harmonic mixer.**

I. Introduction

SPECAIL Test Equipment (STE) was needed for the production of Ka-band linearized block up-converters (L-BUCs). A linearizer corrects the gain and phase distortion of power amplifiers. A vector network analyzer (VNA) is normally used to evaluate the phase correction produced by a linearizer. However, when a linearizer is combined with an up-converter, the input and output frequencies of the assembly are not at the same frequency. VNAs require that input and output signals be at the same. A down-converter was required to move the L-BUC's signal back to its input frequency to enable the use of a VNA. In addition the output frequency of the converter must be phase locked to the L-BUC's frequency to preserve the phase information. The development of this STE down-converter is the focus of this report.

A high performance mixer was selected to provide required frequency translation. When a mixer is used to move a signal (or signals) from a higher frequency to a lower frequency, this process is known as down-conversion. This process uses the heterodyne principle, where an incoming signal is mixed with a local oscillator (LO) to produce sum and difference frequency components; these new frequencies are called heterodynes. Traditionally a filter is necessary to eliminate the many undesired frequencies created during the mixing process. For this application, a down-conversion from the 30 to 31 GHz to 1 to 2 GHz, a 29 GHz LO signal can be used. A reference signal at 7.25 GHz was available from the L-BUC; therefore, a frequency doubler was designed to create a 14.5 GHz frequency.

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This signal can be used directly with a sub-harmonically pumped mixer, which internally doubles this frequency to the desired 29 GHz LO frequency. 10 dB of attenuation at the mixer's input was used to minimize the effects of mismatch on the mixer's performance. A block diagram of the mixer is shown in Figure 1.

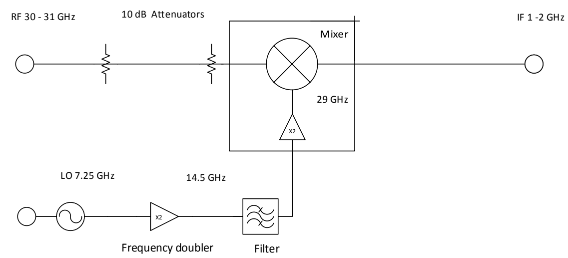

Fig. 1 General RF down conversion topology

II. Design Process

In order to assemble and test the STE a New Drawing Request (NDR) form was created and approved. The design had to be configured in order to fit into the pre-existing housing that was readily available.

One significant problem with mixers is that in addition to the desired products there are also numerous unwanted spurious products. According to the data sheet, we can expect excellent spurious harmonic suppression. A spectrum analyzer was used to evaluate the down-converter. The output spectrum of a 1.5 GHz test signal is shown in Figure 2. It can be observed that the signal at 1.5 GHz is about 20 dBc below LO signal leakage. This signal is rejected by the VNA.

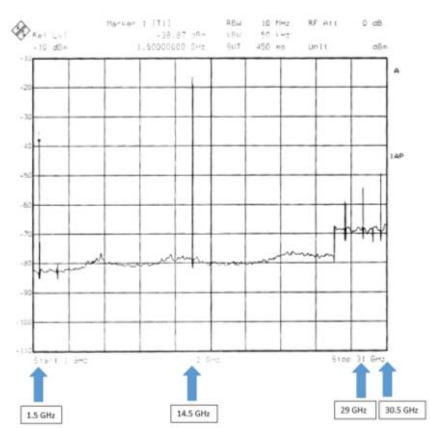

Fig. 2 The measured results from a spectrum analyzer

In order to double the LO, an HMC 205 GaAs MMIC passive frequency doubler was selected. It has a conversion loss about 12 to 17 dB and requires no bias. When the LO frequency is located close to the signal band, it is necessary to use a sharp and more expensive filter structures. For the mixing process, the HMC338 GaAs MMIC sub-harmonically pumped mixer was chosen. This mixer can be used as an up-converter or down-converter in the 26 to 33 GHz frequency range. The high 2 LO to RF Isolation eliminates the need for additional filtering since it removes the undesirable inter-modulated terms. This IC requires no external balun circuitry, which makes possible its direct insertion into small commercial packages for MIC modules. It only needs a +3 V to +4 V single bias. Two HMC656 wideband fixed attenuator chips, which require no additional ground connections, were used to achieve the 10 dB attenuation level needed by this design.

III. Assembly Methods

The housing used was made from nickel plated machined aluminum. Substrates and MMIC devices were mounted in the housing using an electrically conductive epoxy. This epoxy cures in an oven at 125 C˚(257 F). Interconnections to the MMIC devices, substrates and DC feedthroughs were made with 0.008 mm gold wire and 0.010 gold ribbon.

The output and LO connectors were Gilbert push-on (GPO) style. The 30 GHz input required a special 2.92 mm air dielectric connector to maintain a satisfactory match. Figure 3 shows the final assembled STE.

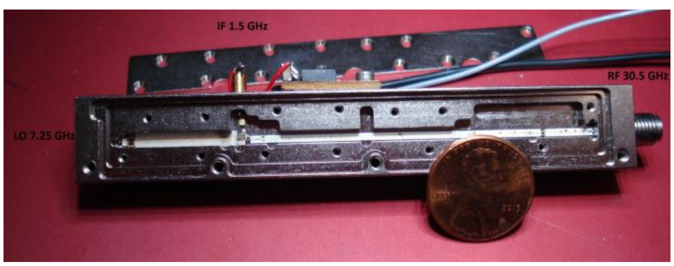

Fig. 3 The assembled down-converter STE

IV. Test Results

Signals in the 30 to 31 GHz frequency range were successfully down-converted to the 1.5 GHz with the 7.25 GHz LO signal. The down-conversion STE had a conversion loss of about 20 dB. The down converted signal was free of unwanted spurious signals.

V. Conclusion

Down-conversion is important not just for testing purposes, but in many communications systems. In these systems, signals at the transmission frequency need to be converted to a lower frequency, where they are usually further processed or detected. The STE design performed as expected and successfully met all requirements.

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