FREQUENCY MULTIPLICATION BY A PRIME NUMBER USING MULTIPLIER CHAINS

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ABSTRACT

This paper describes the design of varactor frequency multiplier chains for frequency multiplication by a prime number. The design and performance of a times-eleven and times-nineteen frequency multiplier is presented. The use of this configuration for a times-fourteen multiplier is also presented.

INTRODUCTION

The use of frequency multiplier chains to generate crystal controlled signals at microwave frequencies is well known. In fig.1 for example a 100 Mhz. crystal controlled oscillator is used to generate a 2.7 Ghz. signal. In this example, two frequency triplers driven by a 100 Mhz. signal produce a 900 Mhz. signal which drives a transistor amplifier. The output of this amplifier then drives the final tripler. The major contributions to the D.C. to R.F. efficiency of this chain are the efficiencies of the transistor amplifier and the final tripler. This configuration is more efficient than that of a power amplifier at 100 Mhz. followed by a times-twenty seven multiplier. In the latter case the major contributions to the D.C. to R.F. efficiency are the efficiencies of the power amplifier and the times-twenty-seven multiplier, which is inherently less efficient than a frequency tripler. The multiplier chain can also generate more power than a single times-twenty-seven high order multiplier, since the power handling capability of a high order multiplier is in general inversely proportional to the order of the multiplication. It is therefore desireable, when efficiency and high output power are important to use a multiplier chain.

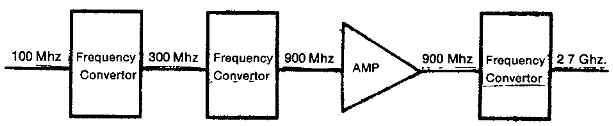

Figure 1. Times-Twenty-Seven Multiplier Chain

In the past, the generation of a signal where the order of multiplication was a prime number, required either a single high order multiplier or a locked oscillator. In this paper we will describe multiplier chains which produce prime number multipliction*. Two chains will be described, the first a times-eleven multiplier with an output frequency of 1.1 Ghz. and the second a times-nineteen multiplier with an output frequency of 1.9 Ghz.
This technique can also be a used advantageously to non-prime number multiplications and such a chain will also be described.

DESCRIPTION

The configuration for the times-eleven multiplier chain is shown in fig.2. The first frequency convertor when driven by a 2 mw. signal at 100 Mhz. produces an output signal with power at both 300 and 400 Mhz. The total output power produced is 0.7 mw. with the power at 300 Mhz. 7db above the power level at 400 Mhz. A standard comb generator design was used for this frequency convertor with the output circuit tuned to the third and fourth harmonics. This signal was amplified in a TRW CA2820 amplifier to produce a power of 500 mw. The final frequency convertor has an input bandwidth which includes both 300 and 400 Mhz. and an output which is tuned to 1.1 Ghz. The frequency convertor was initially designed to operate as a frequency tripler with an output frequency band centered at 1.1 Ghz. and a bandwidth of about 20%. An interdigital filter with 10% bandwidth was then connected to the output and the matching networks retuned to optimize the performance of the chain as a times-eleven multiplier. The output power at 1.1 Ghz. is 150 mw. and the 3db input bandwidth is 101 to 109 Mhz.A plot of output power vs. frequency is given in fig.3.

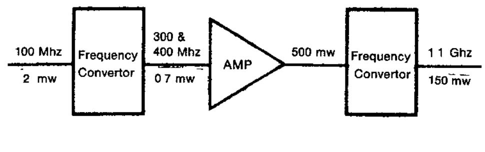

Figure 2. Times-Eleven Multiplier Chain

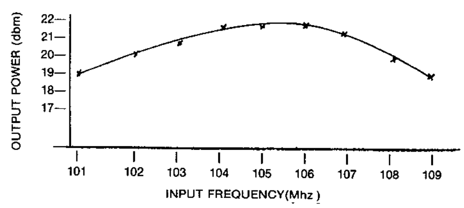

Figure 3. Output Power vs. Frequency

The configuration for the times-nineteen multiplier chain is shown in fig. 4. The first frequency convertor is driven by a 10 mw. signal at 100 Mhz. and produces an output signal with power at both 400 and 500 Mhz. The total output power produced is 3 mw. with the power at the fourth harmonic 10db above the power level of the fifth harmonic. A standard comb generator design was used for this frequency convertor with the output circuit tuned to the fourth and fifth harmonics. This output signal drives a second frequency convertor which was initially designed as a 30% bandwidth frequency doubler. The input and output matching networks were then tuned to accept the input signal and produce an output signal with power at 900 Mhz. and 1.0 Ghz. The total output power level at the output port of this frequency convertor was 1.2 mw. with the power at 900 Mhz. about 8db above the power level at 1.0 Ghz. This signal is then amplified to a 100 mw.

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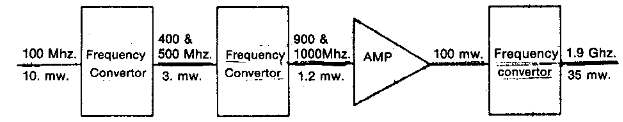

Figure 4. Times-Nineteen Multiplier Chain

level and drives a third frequency convertor. The third frequency convertor was initially designed as a 15% bandwidth frequency doubler with an output frequency band centered at 1.9 Ghz. An interdigital filter was connected to the output and the matching networks retuned to optimize the performance of the chain as a times-nineteen multiplier. The output power at 1.9 Ghz. is 35 mw. and the 3db input bandwidth is 102 to 104 Mhz. No attempt was made to achieve wider bandwidth and the bandwidth limitations of this circuit are not yet known.

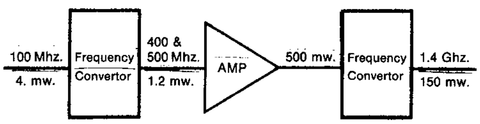

Figure 5. Times-Fourteen Multiplier Chain

The configuration for a times-fourteen multiplier chain is shown in fig. 5. A comb generator generates 400 and 500 Mhz. which is amplified by a TRW CA2820 amplifier. This signal then drives a frequency convertor which is terminated in a 1.5% bandwidth interdigital filter to produce a times-fourteen multiplication. The output power vs. input power is plotted in fig. 6. The saturation effect seen in this plot is due to the amplifier. Fig. 7 shows a picture of the final unit. This multiplier chain was also built as a passive unit by deleting the amplifier and retuning the matching network. An output power of 5 mw. was obtained for an input power of 30 mw. and 55 mw. for an input power of 300 mw.

The times-fourteen multiplier could have been built as a times-seven multiplier followed by a frequency doubler. The efficiency would not however, have been as high nor could the 500 Mhz. amplifier been used.

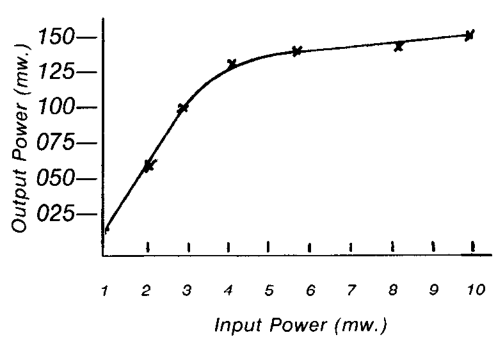

Figure 6. Output Power vs. Input Power

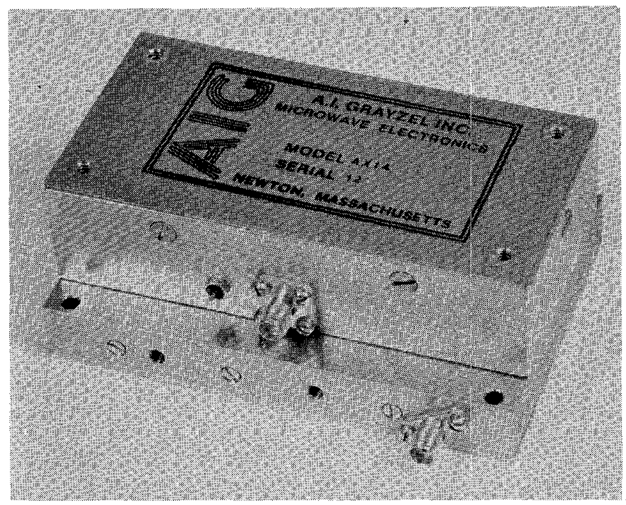

Figure 7. Times-Fourteen Multiplier Chain

CONCLUSION

A new configuration has been presented for prime number multiplication in the form of a multiplier chain. This configuration has advantages over high order multipliers.

*Patent applied for.