Intermodulation Product Generator

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This article describes a microwave circuit used to generate intermodulation products in a predictable manner. This circuit is used in connection with dual-carrier testing to provide a known signal to verify the correct tuning of exciters, receivers, and transmitters. An adjustable voltage probe for a waveguide system is also described.

I. Introduction

When doing dual-carrier testing, it is often desirable to generate an intermodulation product (IMP) on demand to verify receiver operation, exciter tuning, etc. IMPs are generated by nonlinear action when both carriers are present, and result from a combination of multiplication and mixing.

II. Theory

The normal operation of a crystal rectifier diode (as is often used as a microwave mixer) requires that one signal, local oscillator (LO), be much larger than the other signal, and that the diode operate at low signal level to maintain "square law" operation where only the first few terms of the Taylor series expansion are significant (Ref. 1). However, to generate intermodulation products, the crystal rectifier must be operated in the large signal region so multiplication and mixing take place with some degree of efficiency. Also, some form of reactive termination for undesired IMPs should be provided to increase the conversion efficiency at the desired frequency.

III. Implementation

Figure 1 is a block diagram of the test configuration used to determine the feasibility of this approach. Utilizing N orders of 31, a conversion loss of approximately 100 dB was desired with input powers of +20 dBm. The crystal is operated "saturated" with approximately 50 mA of crystal current. Removal of one carrier (equivalent to a 3-dB decrease in incident power) will result in only a small change (<5 mA) in crystal current. The bandpass filters used provide reactive termination to lower sideband

IMPs and those far removed from the frequency of interest. However, due to the non-zero line lengths between the crystal rectifier and the filters, the output IMP level is dependent on the choice of input frequencies.

IV. Installation

In order to utilize this IMP generator in a waveguide system, some form of coupling is required. To meet the needs of our system, a 50-dB voltage probe was constructed (Fig. 2). Due to the power level involved, care must be taken to prevent voltage breakdown in the vicinity of the probe tip. Another approach would be to use a current probe (loop). Since the expected IMP would be -130 dBm, an adjustable attenuator was installed in the output line. Figure 3 is a block diagram of the system as installed on the Venus (DSS 13) 26-m-diameter antenna.

V. Results

With this IMP generator installed as shown in Fig. 3, performance was as predicted. With dual 10-kW carriers, the received IMP level was adjustable from below receiver threshold (< -170 dBm) to -130 dBm. With the unit switched out, IMPs are not detectable, regardless of the attenuator setting.

VI. Future Activities

Time and manpower restrictions precluded thorough testing of this unit, but investigation of conversion efficiency as a function of input frequency and power would be desirable. Also, some effort could be expended in making the line lengths between the filters and the diode as short as possible.

Reference

1. Torrey, H. C., and Whitman, C. C., *Crystal Rectifiers*, MIT Radiation Laboratory Series, Vol. 15, pp. 2–5. McGraw-Hill Book Co., Inc., New York, 1948.

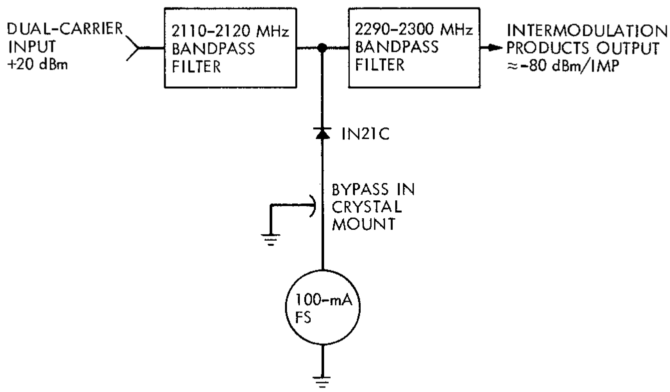

Fig. 1. Basic intermodulation product generator

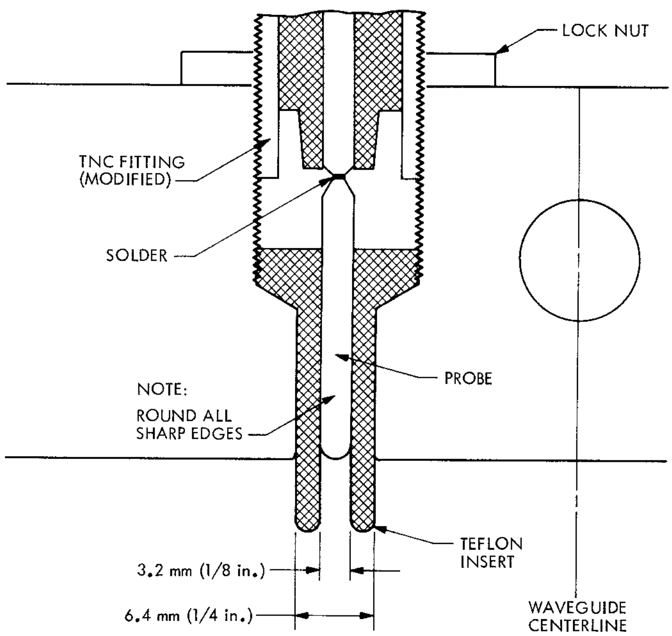

Fig. 2. WR-430 voltage probe

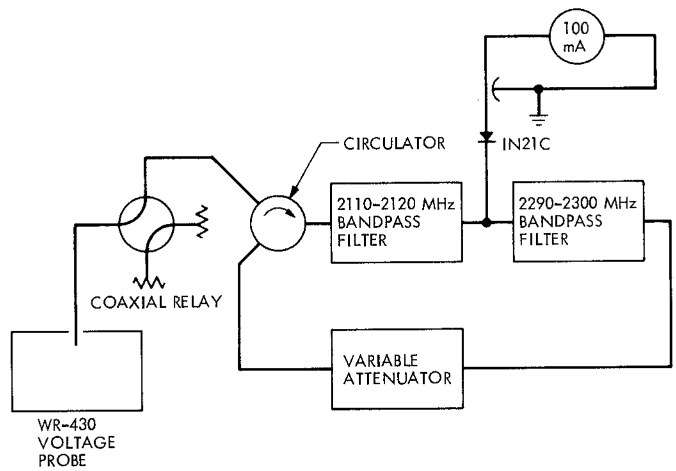

Fig. 3. Intermodulation product generator operational model