Evaluation of Frequency Multipliers for the ALMA Local Oscillator System

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1 Introduction

This memo describes the various evaluation procedures proposed to be used to characterize the performance, reliability and lifetime issues with the frequency multipliers intended for use in the ALMA local oscillator system.

2 Basic Performance Evaluation

The evaluation of the Band-6: 80/240 GHz frequency tripler will be carried out by driving it with a frequency tunable phase locked Gunn diode oscillator and measuring the generated output power using an appropriate power sensor and meter. The details of the arrangement are illustrated in Figure-1 and explained below.

The calibrated precision attenuator attached to the Gunn diode oscillator output may be used as a power leveling device and adjusted as required. The HP W8486A power meter sensor attached to port "B" of the waveguide switch may be used to measure/calibrate the input power level to the frequency tripler, which is connected to port "C" of the waveguide switch. The output of the frequency tripler, appearing at section identified as "D" in the figure, can be detected using an Erickson model PM1 power sensor. The input of the frequency tripler is referenced to port "C" while its output is referenced to "D". The flange-to-flange performance of the frequency tripler might be calculated by accounting for the losses of the waveguide sections between section "C" and the multiplier input flange, as well as those of the waveguide sections between the multiplier output flange and section "D".

Prior to commencing each measurement, the precision attenuator needs to be set to maximum attenuation and the waveguide switch set to connect port "A" to the Gunn source. The frequency of the Gunn diode oscillator can then be set by observing the oscillation frequency on the spectrum analyzer. The attenuation setting on the precision attenuator may lowered to raise the signal level on the spectrum analyzer, if needed, taking care not to exceed the power rating of the HP W8486A power sensor. Subsequently, the waveguide switch may be turned to connect the Gunn source to port "B" and precision attenuator setting adjusted till the HP E4419B power meter reads the desired pump power level for the frequency tripler. Finally the waveguide switch may be turned to connect the frequency tripler input (port "C") to the Gunn source. The output power detected by the Erickson PM1 power sensor connected at "D" can then be recorded as measured by the power meter.

The same setup could be used to measure the pumped large signal input return loss of the frequency tripler by comparing the coupled reflected input pump power level as measured by the Tektronix 2784 Spectrum Analyzer to the reference level obtained with the waveguide switch connected to the short on port "A".

The proposed measurements are listed below:

1. Room Temperature Measurements
   (a) Output power (efficiency) vs output frequency in 1 GHz steps (with rated input pump power).
   (b) Large signal input return loss vs input frequency (with rated input pump power).

2. Measurements at 77 K

   (a) Output power (efficiency) vs output frequency in 1 GHz steps (with rated input pump power).

   (b) Large signal input return loss vs input frequency (with rated input pump power).

3 Reliability Evaluation

To ensure the long term reliability, the following tests are proposed:

1. When cooled to 77 K, operate the multiplier with 125% (about 2 dB more) than the input pump power required to generate the specified 100 μW output power (ALMA specification) for 20 minutes and subsequently verify performance at a few frequency points with the input power level required to generate an output power of 100 μW.

2. With the pump power turned off, bring the multiplier block to room temperature then cool down back to 77 K (thermal cycling), repeat 10 times and then verify proper operation.

3. When cooled to 77 K, cycle the input RF pump power on and off 100 times while operating at the rated input power level.

4. Operate the frequency multiplier with its rated input pump power for 24 hours (at 77 K), and subsequently verify performance at a few frequency points with the input power level required to generate an output power of 100 μW.

4 Lifetime Estimation

These tests being destructive in nature are **not planned at this time** due to a lack of supply of frequency multipliers and the long turn around time for repairs. However, they could be carried out later in consultation with Virginia Diodes Inc.

- The frequency multiplier could be operated at elevated temperatures and its performance monitored to estimate the time elapsed before the performance (conversion efficiency) begins to degrade. Knowledge of the lifetime of the frequency multipler at several different values of elevated temperatures would enable an estimation of the lifetime under normal operating conditions.

- The RF burn out test could be performed to estimate the absolute maximum allowable input pump power, by slowly ramping up the input pump power with the multiplier operating at 77 K till degradation in performance is noticed.

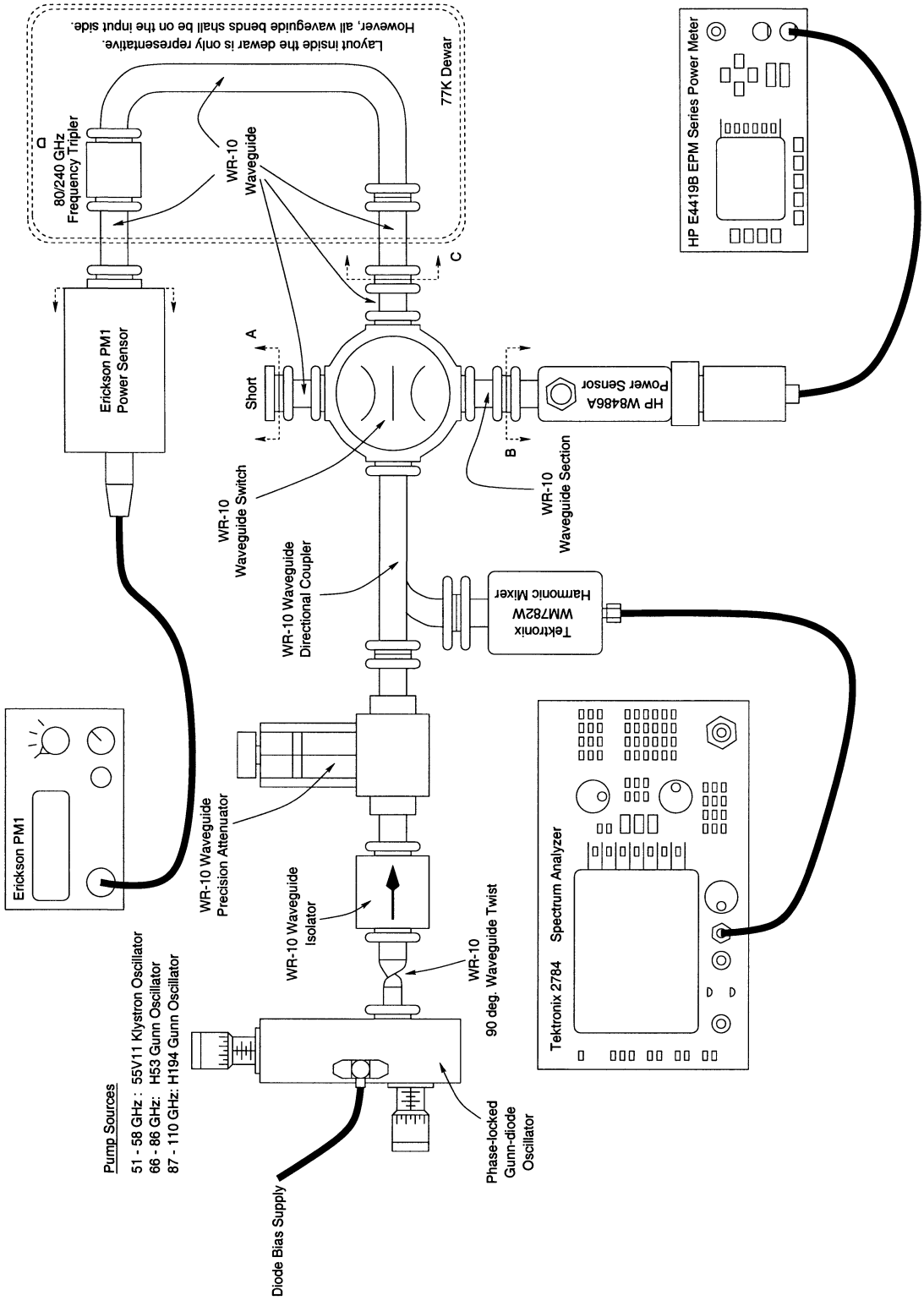

Figure 1: Experimental setup for evaluation of the 80/240 GHz frequency tripler.