RF Diode Detector Measurement

November 23, 2012

1 Introduction

3 RF diode detectors were purchased in order to take measurements of beam position in tandem with the downconverter electronics,as a way of testing the signal. All 3 diodes were manufactured by Krytar, these were 2 Schottky diodes: 201S and 301S, and a tunnel diode: KDT6018. The data sheets of these diodes were very brief and gave input power vs. output voltage curves in terms of different load impedance R_L to video impedance R_V ratio. However they did not state the low level video impedances of the devices, this prompted an investigation into the behaviour of the devices.

2 Setup and Procedure

The diodes were tested using a signal generator and an oscilloscope. The signal generator was capable of delivering the 15GHz we require and all the diodes operated up to 18GHz, but the oscilloscope only could operate up to 3GHz, so for this investigation the signal was set to 2.5GHz. The oscilloscope had 2 impedance settings, 50Ω, which did not deliver a satisfactory signal, and 1MΩ, which had a rise time which was too long (for a typical beam we would require less than 50ns). An appropriate load impedance was found using the following equation.

$$t_R = \frac{2.197 R_L R_V (C_b + C_L)}{R_L + R_V} \tag{1}$$

By setting the load impedance R_L to a known value (1MΩ) and measuring the rise time t_R (the time to for the signal to rise from 10% of it's maximum to 90%) one could calculate the low level video impedance of the device. The calculated impedances of the devices are shown below with the bypass capacitance C_b of each device.

Diode	C_b	R_V
201S	30pF	7.8kΩ
301S	3pF	7.7kΩ
KDT6018	10pF	3.2kΩ

These video impedances were then put back into the above equation to determine a load impedance to give an adequate rise time of 40ns. Rather than using a specific load impedance for each device a general impedance of 150Ω was used. These resulted in rise times of 40-50ns for the 2 Schottky diodes and 40ns for the tunnel diode.

3 Results

The output voltage was measured for each diode at various input powers for 3 different load impedances (1MΩ, 1500Ω, 150Ω). These were plotted as shown in figures 1 - 3.

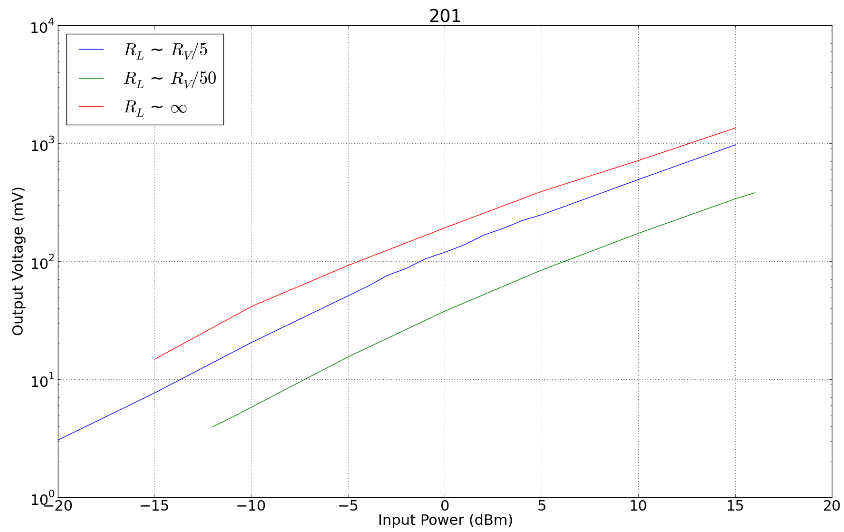

Figure 1: Output voltage vs. input power for the 201S diode.

Decreasing the load impedance decreases the rise time but it also reduces the output signal. This can be seen in the plots as the green curve which corresponds to the 150Ω load impedance (labelled in the plots as an impedance ratio to conform with the plots in the data sheet) has the lowest signal. The 2 Schottky diodes have very similar curves with the output values being almost identical for given input powers. They also seem to correspond well with the curves found in their data sheets (although the impedances expressed as ratios make it difficult to compare exactly). The tunnel diode appears to give a better signal level for a given input power level compared to the Schottky diodes as well as having a slightly better rise time for a given R_L.

4 Expected Signals

After the output levels of the diodes were measured, they needed to be evaluated for the signals expected from the pickup. The signal levels from both the position and reference cavity

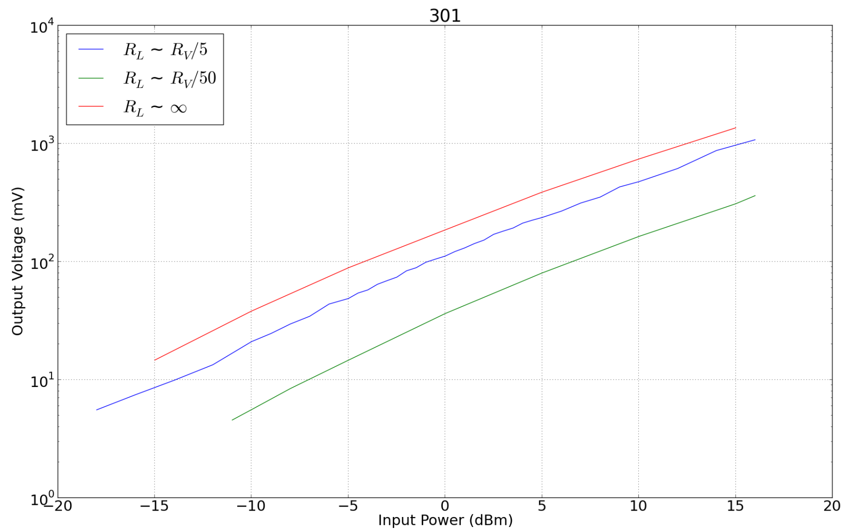

Figure 2: Output voltage vs. input power for the 301S diode.

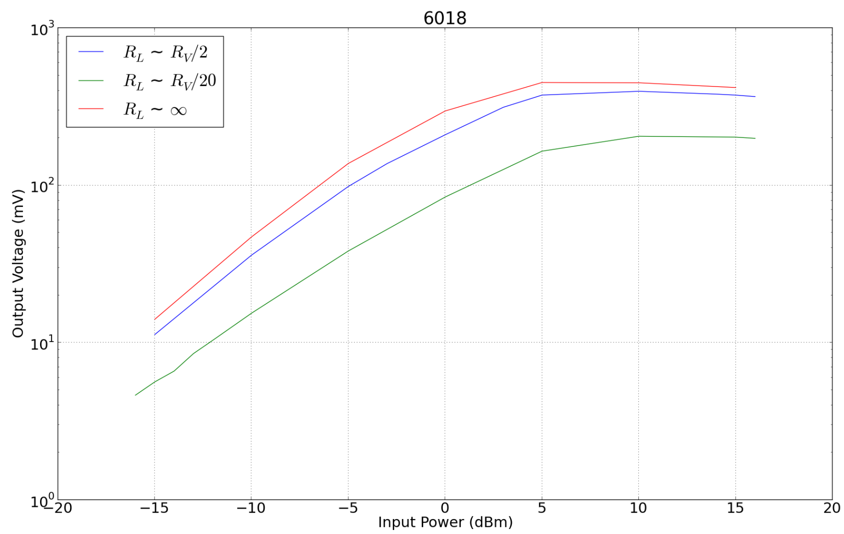

Figure 3: Output voltage vs. input power for the KDT6018 diode.

were calculated for a beam consisting of 100 bunches of 100pC charge separated by 0.667ns. The beam was offset by 1mm which was considered as the maximum displacement, and therefore maximum signal in the position cavity, which would be achieved. The calculated signals for both cavities are shown in the figures below.

One can see that the peak voltage level from the reference cavity, 13V, is much larger than the 4.2V from the position cavity. Both of these voltages are larger than maximum

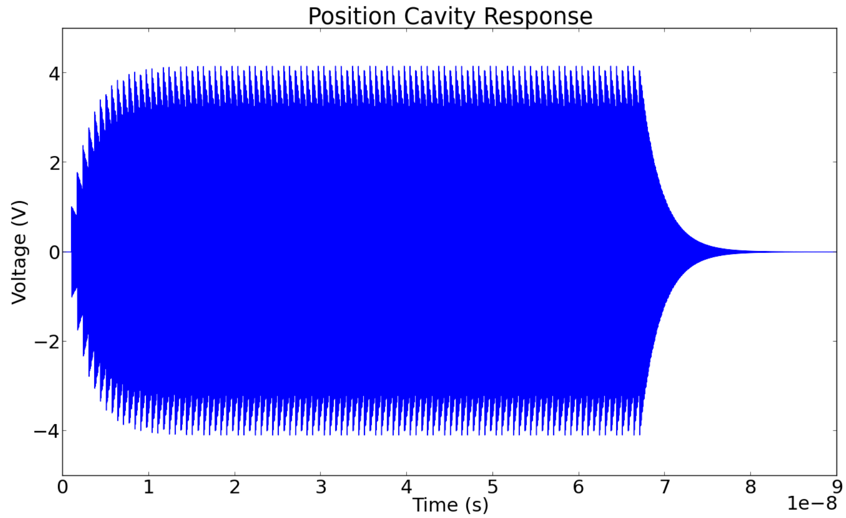

Figure 4: Expected signal from the position cavity.

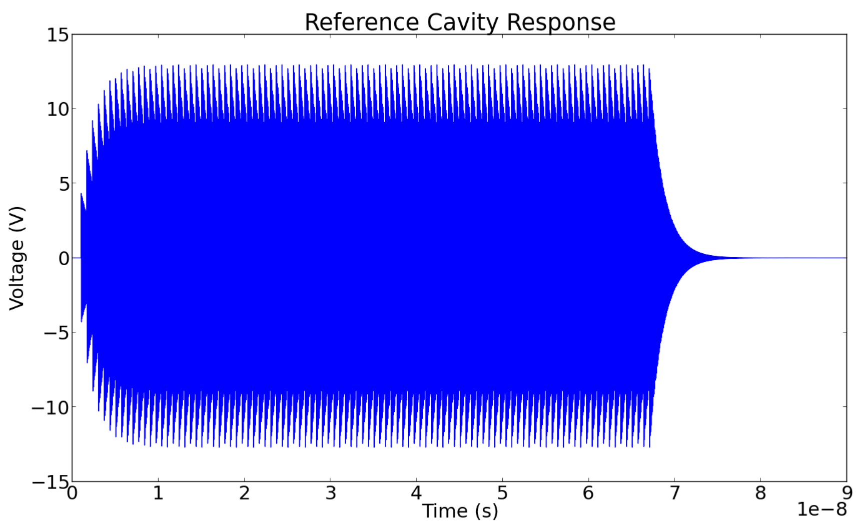

Figure 5: Expected signal from the reference cavity.

input powers of the the diodes (2.24V for the Schottky diodes and 1.58V for the tunnel). As such, if these diodes are to be used to detect these signals, some attenuation needs to be applied beforehand to bring the input levels below the maximum. For the reference cavity the Schottky diodes require at least -13dBm attenuation to be under the limit and the tunnel needs -16dBm. The position cavity needs -3dBm and -6dBm for the Schottky diodes and tunnel diodes respectively. In addition to this attenuation before the detectors, amplification of the diodes' output signal is required to reasonable level to be able to resolve smaller offsets.

The rise time of the diodes are not a problem here as the signal from the beam train is at it's maximum from about 10ns to 67ns meaning the Schottky diodes' rise time of about 50ns will acquire the full signal level and the tunnel diode's 40ns rise time will comfortably measure the full voltage.