MARK 5 MEMO #074

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To: Mark 5 Development Group

From: A.E.E. Rogers

Subject: Phase calibrator pulse distortion in UDC

1] Distortion of phase cal pulses vs peak power in pulse

If the pulses from the phase calibrator are too strong they can be distorted in the Updown converter (UDC). The 1 dB compression point of the UDC is -10 dBm (see memo #70). The phase calibration distortion for various levels was measured by offsetting the UDC first L.O. by +100 kHz so that the spurious signals produced by the UDC are now offset from the phase calibration rails by + 400 kHz. The results of the measurements are given in the table below:

UDC 1st L.O. MHz	Pcal peak power dBm	Tone freq. GHz	Distortion dB
5750.1	0	1.1	-20
5750.1	-10	1.1	-30
5750.1	-20	1.1	-40
6750.1	-10	5.1	-31
7750.1	-10	9.1	-30

Notes:

1. The peak power is measured at the input of the UDC.
2. Distortion is the relative level of the 400 kHz sidebands on the phase cal rails.

2] Phase cal power and spectral density relations

If a Gaussian pulse has a peak voltage of V and full width at half power of τ the peak power into a 50 ohm load is given by

$$peak\_power = v^2/50$$

If the pulse repeats at a rate of R pulses per second the average power is

$$average\_power = peak\_power \times \left(\sqrt{\frac{\pi}{0.6931}} \right) \times R \times \tau$$

If we assume a Gaussian pulse shape the spectrum is also Gaussian and the phase cal rails out to a frequency of $\left(0.6931/\pi\right)/\tau$ at the half power point. In practice the phase cal pulse is not Gaussian as it starts as a step which is then differentiated but we still have the approximate relationship that $peak\_power \sim 1/\left(R\tau\right) \times average\_power$ and the power in each rail is approximately given by

$$power\_in\_each\_rail \sim average\_power \times \left(R\tau\right)$$

or

$$peak\_power \sim power\_in\_each\_rail/\left(R^2\tau^2\right)$$

For the Mark 4 phase cal with 1 MHz rail spacing and 30 ps pulse $1/\left(R^2\tau^2\right) \sim +90\,dB$ so that a rail strength of about ~ -90 dBm is obtained from a peak power of about 0 dBm. If the rail spacing was changed to 5 MHz the peak power would be reduced by 14 dB for the same individual rail strengths.

3] Recommend peak pulse power

I recommend the peak pulse power at the input of the UDC be less than -10 dBm. At this level the -30 dB distortion should keep the variation of phase cal voltage with L.O. phase under 3% and a corresponding error in the extracted phase cal phase under 2 degrees.