PEAK
COMMUNICATIONS

APPLICATION NOTE AN0025: Beacon Receiver Acquisition Time Analysis

Introduction

The **Peak** range of **Beacon receiver units**, including the **PTR50, RTR50** and **UPC7000series (**Uplink Power control units fitted with Beacon receiver options) are tracking receivers, designed specifically to track and measure CW beacons from commercial satellites. Primarily an L-Band input receiver, the units are designed to be used for telemetry and control, typically in earth stations using large antennae.

Note: the standard **PTR50** receiver circuitry is offered as an option with the **UPC7000series** (Option 2).

The **Beacon receiver units** will down convert an L-Band signal to an IF of 70MHz. The tracking function then uses a coherent detector to lock to the 'CW' beacon and measure the power of the beacon signal. The digital search facility sweeps the frequency to locate a signal in the acquisition band and if a signal is detected the frequency is locked immediately to this beacon. A secondary anti-sideband (ASB) search is then initiated to look for a more intense signal within the search band. If one is detected then the locked tracking frequency is modified. The process repeats until the largest signal is found in the search band and the ASB device is then disabled. (Note: The ASB function is outside the scope of this application note, which only deals with initial acquisition and re-acquisition timing).

A log amplifier is used to provide an output voltage representing the input power in logarithmic scale, in effect making the input power to output voltage log-conformal. The sensitivity of the logarithmic output is user selectable.

The standard **RTR50**, & **PTR50** (with option 11), are offered with a fast acquisition feature, achieving lock in <1s average (<2s max.) for combinations of lower search ranges (search bandwidths) and higher sweep rate settings (see table 2 below).

This application note will endeavor to establish the tradeoff between search range (bandwidth), sweep rate, and subsequent threshold of lock (Carrier to Noise) performance, to allow the user to select the most appropriate settings for their particular application.

Search Range (bandwidth)
User selectable swept bandwidths allow for drifts on the required signal whilst searching, it is suggested to leave on the narrower settings as this will speed up acquisition of lock. Settings available are typically ±20KHz, ±50KHz, ±100KHz, ±200KHz and ±500KHz.

Sweep Rate
User selectable sweep rates allow the user the choice to speed up the acquisition of lock. The user must be aware that the lower the signal to noise ratio the slower the sweep rate needs to be to guarantee lock detection. It is suggested 5KHz/s as a starting point. The settings available are typically 2.5KHz/s (Slowest Acquisition), 5KHz/s, 10KHz/s, 20KHz/s, 40KHz/s, 80KHz/s, 120 kHz/s and 240kHz (Fastest Acquisition).

Peak Communications Ltd., Unit 1, The Woodvale Centre, Woodvale Road, Brighouse, West Yorkshire, HD6 4AB, U.K.
Tel; +44 (0)1484 714200 Sales; +44 (0)1484 714229 Fax; +44 (0)1484 723666 Email; sales@peakcom.co.uk Web; www.peakcom.co.uk

Analysis Set-up

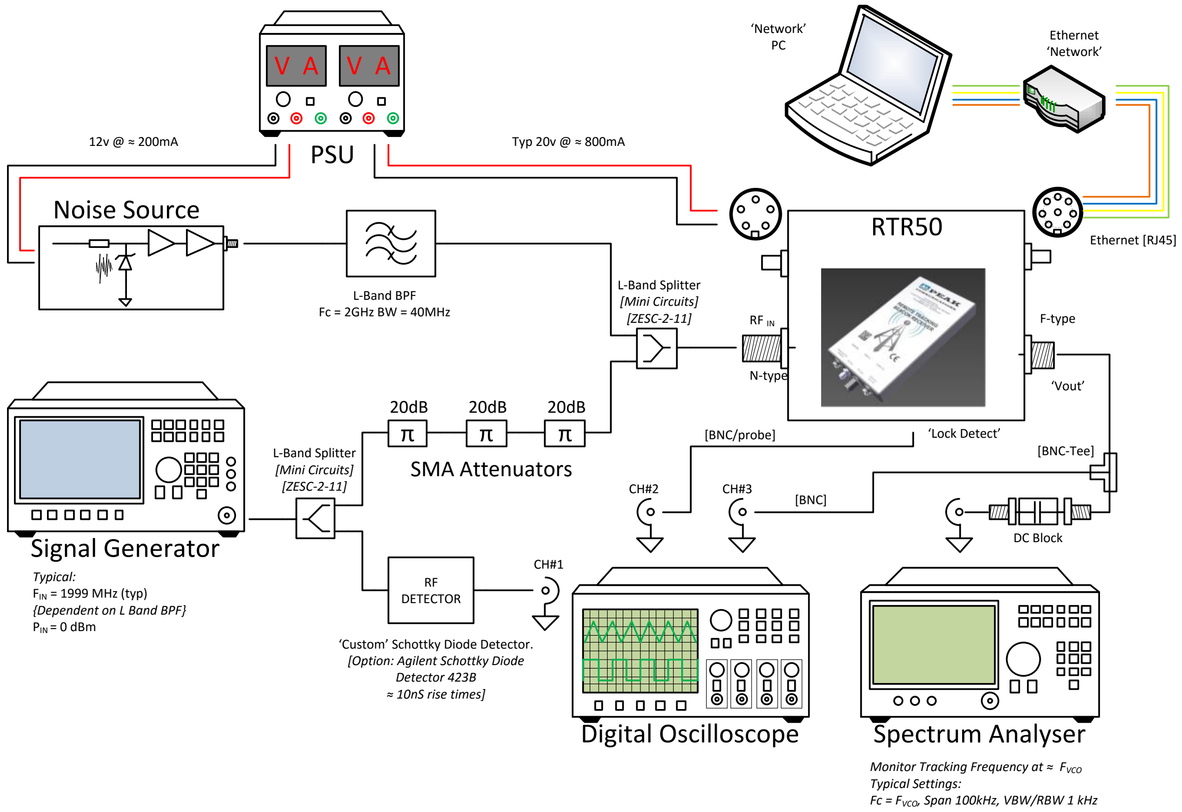
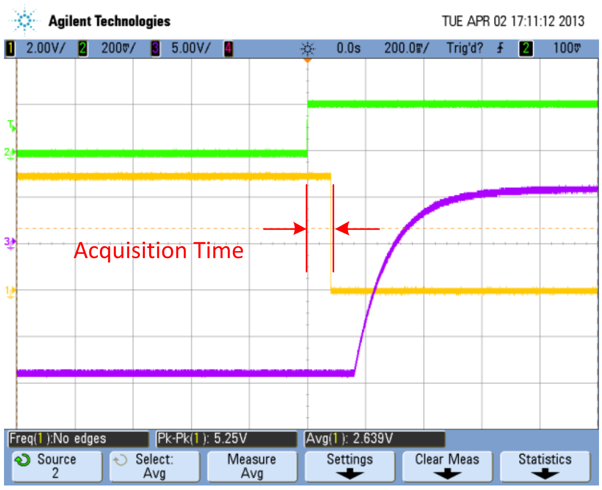


Figure 1 : Equipment Set-up.



Typical 'Fast' Acquisition Response
RTR50 Settings:
Sweep Rate : 240 KHz/s
Bandwidth: ± 20kHz
CH1 [Yellow] : RTR50 'Lock Detect'
CH2 [Green] : RF Detector Output (Trigger)
CH3 [Purple] : RTR50 'Vout'

Figure 2 : Oscilloscope Plot (typical).

Peak Communications Ltd., Unit 1, The Woodvale Centre, Woodvale Road, Brighouse, West Yorkshire, HD6 4AB, U.K.
Tel; +44 (0)1484 714200 Sales; +44 (0)1484 714229 Fax; +44 (0)1484 723666 Email; sales@peakcom.co.uk Web; www.peakcom.co.uk

The test set-up for the acquisition time analysis for the RTR50 is shown in Figure 2 (configuration identical for other products). A signal generator is used to simulate an incoming 'CW' beacon signal. This signal is split to allow a fast (nS) RF detector to be used to trigger the acquisition time measurement (rising edge of RF detector is the T=0s as measured on the oscilloscope, CH2 trace on Figure 2). The second path is heavily attenuated to replicate a low level beacon signal. This is then combined with a broadband noise source (used to effectively reproduce a noisy channel so C/No performance can be measured). Beacon signal and noise are then applied to the device under test. The acquisition lock time and Vout can be measured on an oscilloscope. Triggering the measurement between the RF detector rising edge and falling edge of lock detect (lock detect is active low) will give an accurate measurement for the acquisition time for any given device setting.

Device setting control is achieved either by Ethernet or front panel selection, depending upon the product type and options selected.

Measured maximum acquisition times for all valid sweep rates and swept bandwidths are shown in **Table 1 & 2.** Variability contributing to general measurement uncertainties includes slight variance in actual sweep rates and search ranges (bandwidths).

Sweep Rate \ Swept BW	± 20 kHz	± 50 kHz	± 100 kHz	± 200 kHz	± 500 kHz	Typical C/N
2.5 kHz/s	≈ 16.00 s (max)	≈ 40.00 s (max)	≈ 80.00 s (max)	≈ 160.00 s (max)	≈ 400.00 s (max)	-34.0 dB/Hz
5 kHz/s	≈ 8.00 s (max)	≈ 20.00 s (max)	≈ 40.00 s (max)	≈ 80.00 s (max)	≈ 200.00 s (max)	-34.0 dB/Hz

<4s Average aquistion times. (<8s max)

Table 1 : 'Standard Acquisition' (standard PTR50 & UPC7000series fitted with Option 2) Acquisition Times.

Sweep Rate \ Swept BW	± 20 kHz	± 50 kHz	± 100 kHz	± 200 kHz	± 500 kHz	Typical C/N
2.5 kHz/s	22.70 s (max)	55.00 s (max)	101.00 s (max)	187.00 s (max)	480.00 s (max)	-34.0 dB/Hz
5 kHz/s	11.00 s (max)	26.00 s (max)	49.00 s (max)	97.00 s (max)	243.00 s (max)	-34.0 dB/Hz
10 kHz/s	3.70 s (max)	13.00 s (max)	24.90 s (max)	47.00 s (max)	120.00 s (max)	-34.0 dB/Hz
20 kHz/s	1.85 s (max)	6.80 s (max)	12.46 s (max)	23.40 s (max)	60.00 s (max)	-34.5 dB/Hz
40 kHz/s	1.42 s (max)	3.30 s (max)	6.20 s (max)	11.60 s (max)	30.00 s (max)	-35.0 dB/Hz
80 kHz/s	0.65 s (max)	1.60 s (max)	2.98 s (max)	5.57 s (max)	14.00 s (max)	-36.0 dB/Hz
120 kHz/s	0.32 s (max)	0.84 s (max)	1.57 s (max)	2.99 s (max)	7.60 s (max)	-39.0 dB/Hz
240 kHz/s	0.18 s (max)	0.44 s (max)	0.79 s (max)	1.52 s (max)	3.80 s (max)	-44.0 dB/Hz

<1s Average aquistion times. (<2s max)

Table 2 : 'Fast Acquisition' (standard RTR50 & PTR50 fitted with Option 11) Acquisition Times.

Peak Communications Ltd., Unit 1, The Woodvale Centre, Woodvale Road, Brighouse, West Yorkshire, HD6 4AB, U.K.
Tel; +44 (0)1484 714200 Sales; +44 (0)1484 714229 Fax; +44 (0)1484 723666 Email; sales@peakcom.co.uk Web; www.peakcom.co.uk

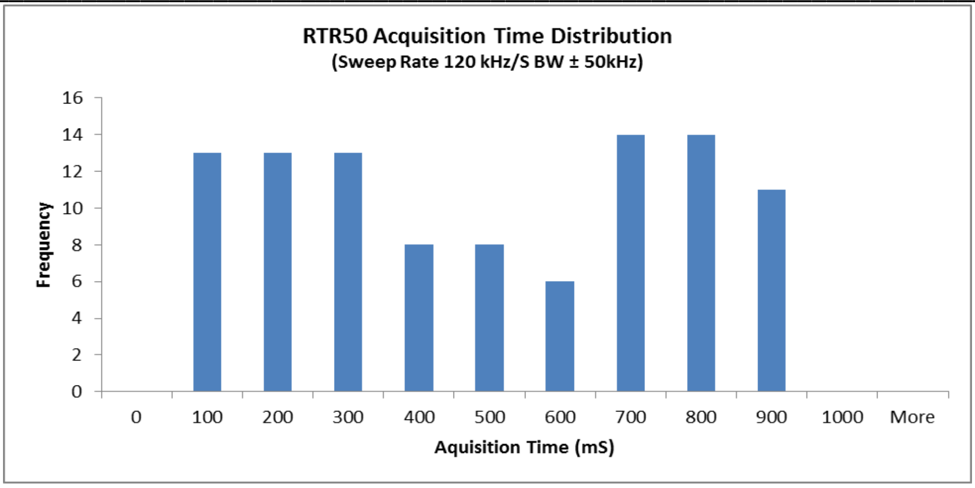


Figure 3 : Statistical Distribution of Acquisition Times for Sweep Rate of 120kHz/s and Swept BW of ±50kHz.

It is worth mentioning the statistical nature of the measurement being performed and this is graphically shown in the distribution of acquisition times shown in Figure 3.

It can be seen that this is a purely random distribution with a minimum acquisition time being just as likely as the maximum. This is not unexpected as the tracking VCO can never be coherently linked to the beacon receiver and there is no prior knowledge of the VCO frequency position at the point when the beacon signal is presented. The tracking VCO operation is shown in Figure 4 and demonstrates why the worst case (maximum) acquisition times have been presented in **Table 1 & 2**. As the lock time distribution is purely random, then the 'average' acquisition time will be half the maximum times indicated in the tables for any given sweep rate and search range (Bandwidth).

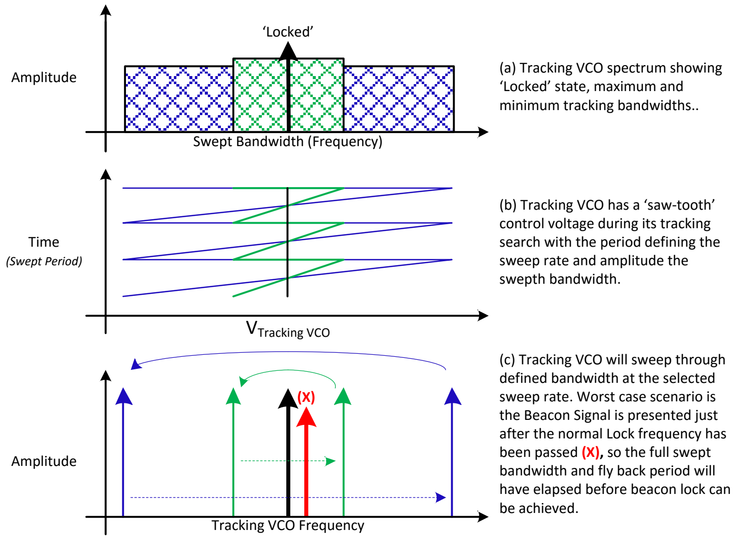


Figure 4 : Tracking VCO operation

Peak Communications Ltd., Unit 1, The Woodvale Centre, Woodvale Road, Brighouse, West Yorkshire, HD6 4AB, U.K.
Tel; +44 (0)1484 714200 Sales; +44 (0)1484 714229 Fax; +44 (0)1484 723666 Email; sales@peakcom.co.uk Web; www.peakcom.co.uk

Summary

The results shown in **Table 1 & 2** demonstrate the acquisition times for various beacon receiver settings. They relate search range (bandwidth), sweep rate & resulting maximum acquisition time to the respective carrier to noise thresholds. These tables allow the user to make an informed judgment on the correct Beacon receiver settings for any given application. Basically the lower input carrier to noise (C/No) ratio you have, the longer you will need to wait to reacquire the signal once lost.

Peak Communications Ltd., Unit 1, The Woodvale Centre, Woodvale Road, Brighouse, West Yorkshire, HD6 4AB, U.K.
Tel; +44 (0)1484 714200 Sales; +44 (0)1484 714229 Fax; +44 (0)1484 723666 Email; sales@peakcom.co.uk Web; www.peakcom.co.uk