Technical Note:
AKELA VNA Sweep Speed and Resolution Bandwidth Calculation

Background

The AKELA 6a and 2a VNAs have a single receiver and a single transmitter. There are five unique paths that must be measured to generate a calibrated 2-port S-parameter matrix: T1R1, T1R2, T2R1, T2R2, and the reference path. These paths are measured one at a time, so the total sweep time is 5 times that of a single sweep. For uncalibrated data, the API allows the user to measure a minimum of two sweeps: the reference path plus one of the other paths.

For the remainder of this document, we will be discussing how to calculate the duration of a single sweep.

There are two factors that affect the time it takes to perform a frequency sweep: the time spent per frequency, and the delay required when changing bands.

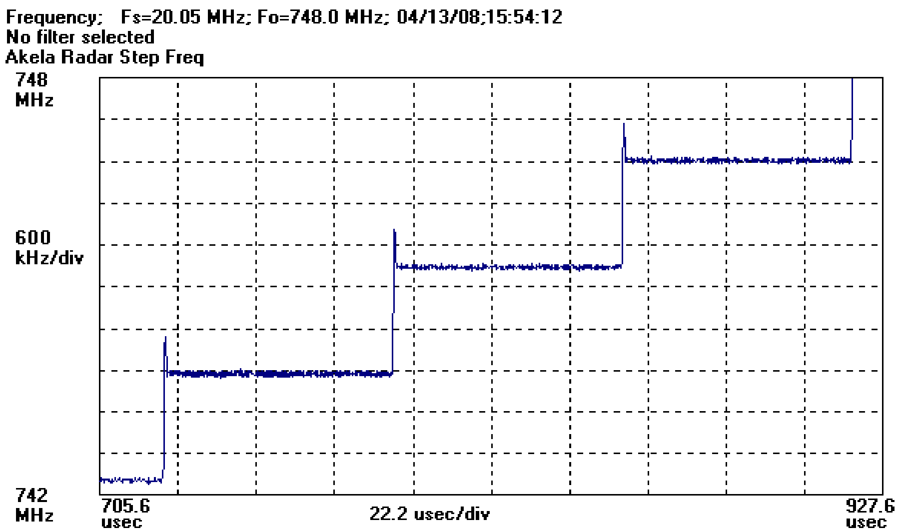
Time Spent Per Frequency

The AKELA VNA uses a stepped-frequency waveform, meaning that the synthesizer dwells on a frequency for a user-specified duration before changing to the next frequency. This duration is controlled by the frequency step rate parameter. The API supports 13 user selectable rates:

Step rate (frequencies/second)	Dwell time (us)
45,000	22.2
30,000	33.3
15,300	65.4
7,000	142.9
3,500	285.7
2,000	500
1,000	1,000
550	1,818
312	3,205
156	6,410
78	12,820
39	25,641
20	50,000

The dwell time is simply the reciprocal of the frequency stepping rate.

The chart below shows a portion of a frequency stepping sequence for a step rate of 15,300 frequencies per second. Note that the settling time is less than 1 us.



Band Change Delay

All models of the AKELA VNA have 4 bands:

VNA 6a	VNA 2a
375 MHz – 700 MHz	125 MHz – 233 MHz
700 MHz – 1400 MHz	233 MHz – 466 MHz
1400 MHz – 2800 MHz	466 MHz – 933 MHz
2800 MHz – 6050 MHz	933 MHz – 2000 MHz

These values are available through the C/Python API via the **getHardwareDetails()** method. Future models may have different or additional bands, so it is best to use the API to query their ranges rather than use the numbers quoted here.

Changing bands adds a fixed delay to allow the internal phase-locked loop to settle. Stepping around randomly within the VNA's bandwidth, for example, could add significant overhead due to the many band changes that would take place.

One band change delay is always present at the start of a sweep, even for frequency ranges that do not cross a band boundary. This is typically called the "retrace delay", and accounts for the fact that the synthesizer is jumping a large distance, causing the phase-locked loop to take longer to settle. If there is a large jump in your frequency table (in the same band), you might try measuring the frequency after the jump twice, and see if the second measurement is less noisy.

Internally, the band change delay is implemented by waiting an integer number of dwell times. Below is a table of the band change delay at each step rate.

Step Rrate (frequencies/second)	Delay (dwell times)	Delay (us)
45,000K points/second	4	(1 / 45,000) * 4 = 88.8 uS
30,000K points/second	3	(1 / 30,000) * 3 = 100 uS
15,300K points/second	2	(1 / 15,0300) * 2 = 1330.73 uS
7,000K points/second	1	(1 / 7,000) * 1 = 142.8 uS
3,500K points/second	1	(1 / 3,0500) * 1 = 333.3285.7 uS
2,000K points/second	1	(1 / 2,000) * 1 = 500 uS
1,000K points/second	1	(1 / 1,000) * 1 = 1000 mS
550 points/second	0	0
312 points/second	0	0
156 points/second	0	0
78 points/second	0	0
39 points/second	0	0
20 points/second	0	0

Example

- Full 2-port calibrated data (5 sweeps)
- 1024 frequencies
- 1 GHz to 6 GHz
- Step rate = 45,000 frequencies/second

Time spent measuring: (1024 points) * (1/45,000 points/sec) * (5 sweeps) = 113.78 ms
Retrace delays: (4 points) * (1/45,000 points/sec) * (5 sweeps) = 0.44 ms
Band change delays: (2 crossings) * (4 points) * (1/45,000 points/sec) * (5 sweeps) = 0.89 ms
Total time = 113.78 + 0.44 + 0.89 = 115.11 ms

Resolution Bandwidth

Resolution bandwidth is determined by the frequency stepping rate selected. AKELA uses a digital filter clocked synchronously with the A/D sampling clock to recover the information for each frequency point. To obey the Nyquist rate relationship, the resulting bandwidth of the digital filter (and therefore the resolution bandwidth) is half of the frequency stepping rate. For the VNA's highest frequency stepping rate of 45kHz, the resolution bandwidth is 22.5 kHz.