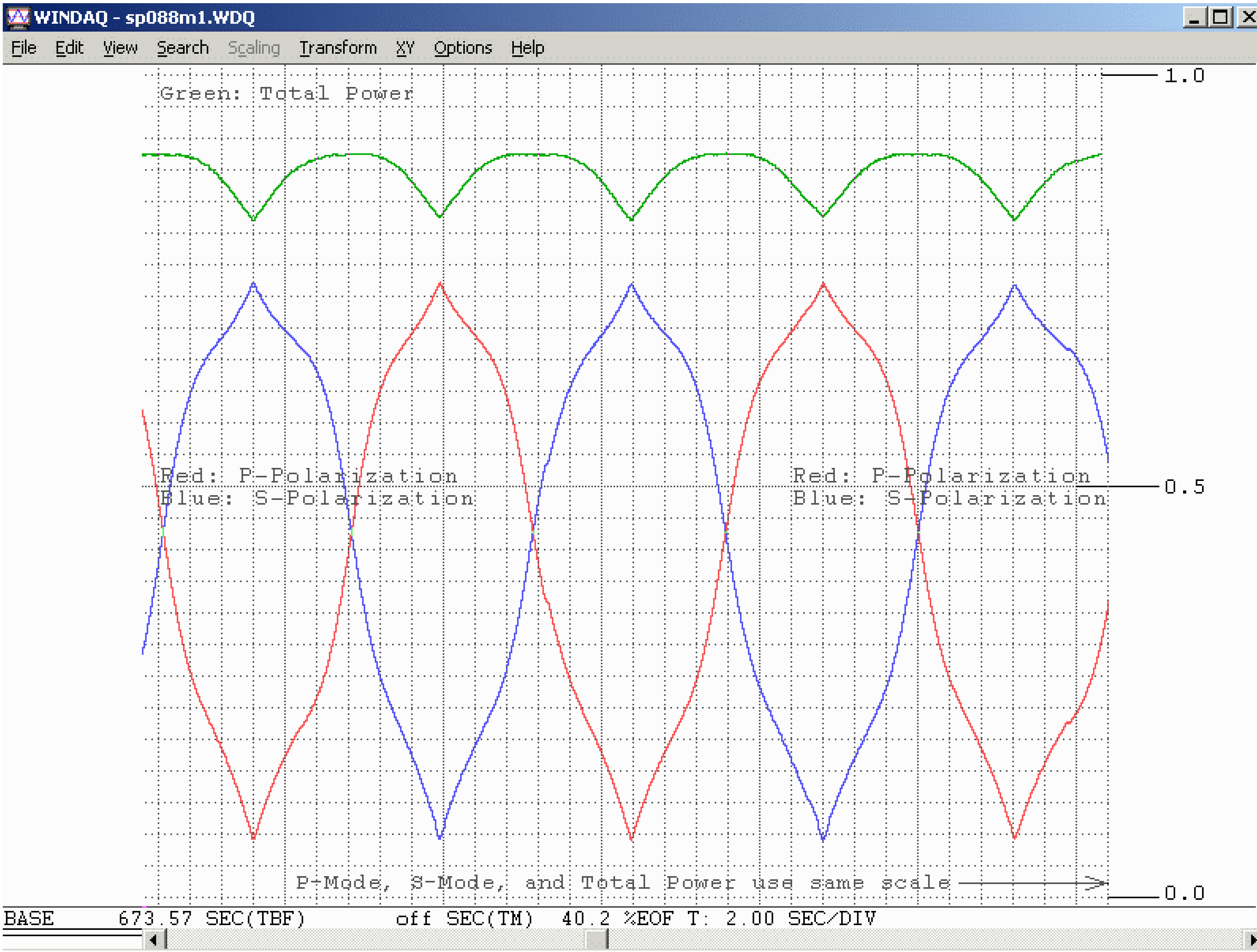

Figure 0 – No Magnetic Field

This is the normal mode sweep for the Spectra-Physics 088 HeNe laser tube. The red waveform (P-Polarization) is the horizontally polarized mode while the blue waveform (S-Polarization) is the vertically polarized mode. Note that the modes change smoothly from maximum to minimum and back again with no discontinuities. For this length tube (about 233 mm between mirrors), there is a small contribution from modes on the tails of the Doppler broadened neon gain curve so they don't go to zero at the valleys.

The approximate total power is also shown. It maximum when the modes are situated equally on either side of the gain curve and minimum when a mode is at the center of the gain curve.

For the following figures, the magnetic field increases monotonically, though the strength numbering shares little else with reality. ☺

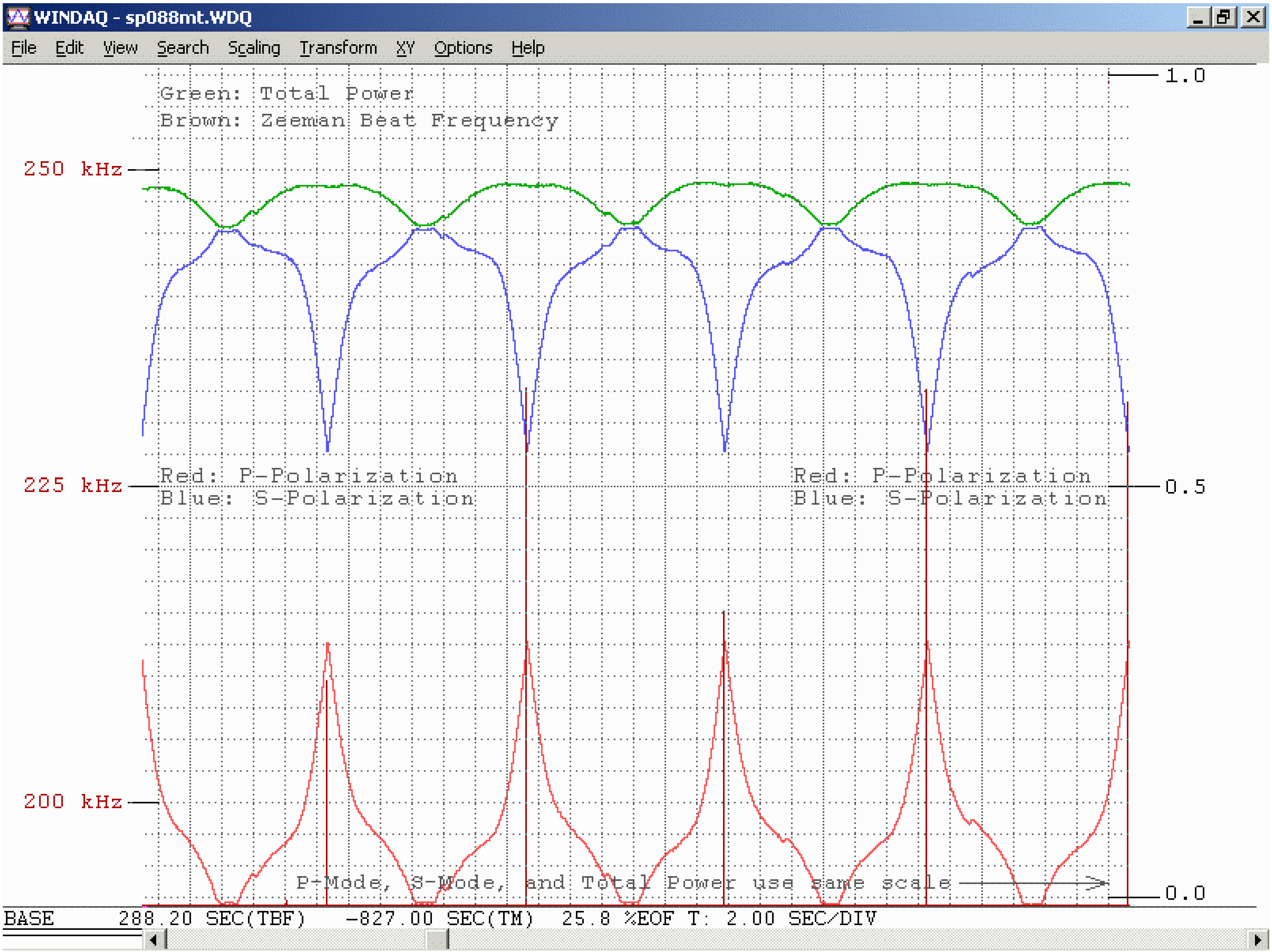

Figure 1 – Transverse Magnetic Field Strength 1

A (horizontal) transverse magnetic field has now been applied to the tube. This is just about the minimum field strength to have any effect. The tube is now operating in the Zeeman split single mode regime. Although the shape of the mode "envelope" hasn't changed very much, the modes no longer vary over the entire range as they did with no field but remain with the same polarization. Where the switchover point would have been is where the modes would have been equally spaced on either side of the gain curve. Now, what must happen is that the single mode jumps from one side to the other.

A very brief burst of beat frequency activity can be seen at the switchover point. But it is too short to really determine its actual frequency. The random nature of the frequency spikes is probably due to the averaging of the data acquisition system.

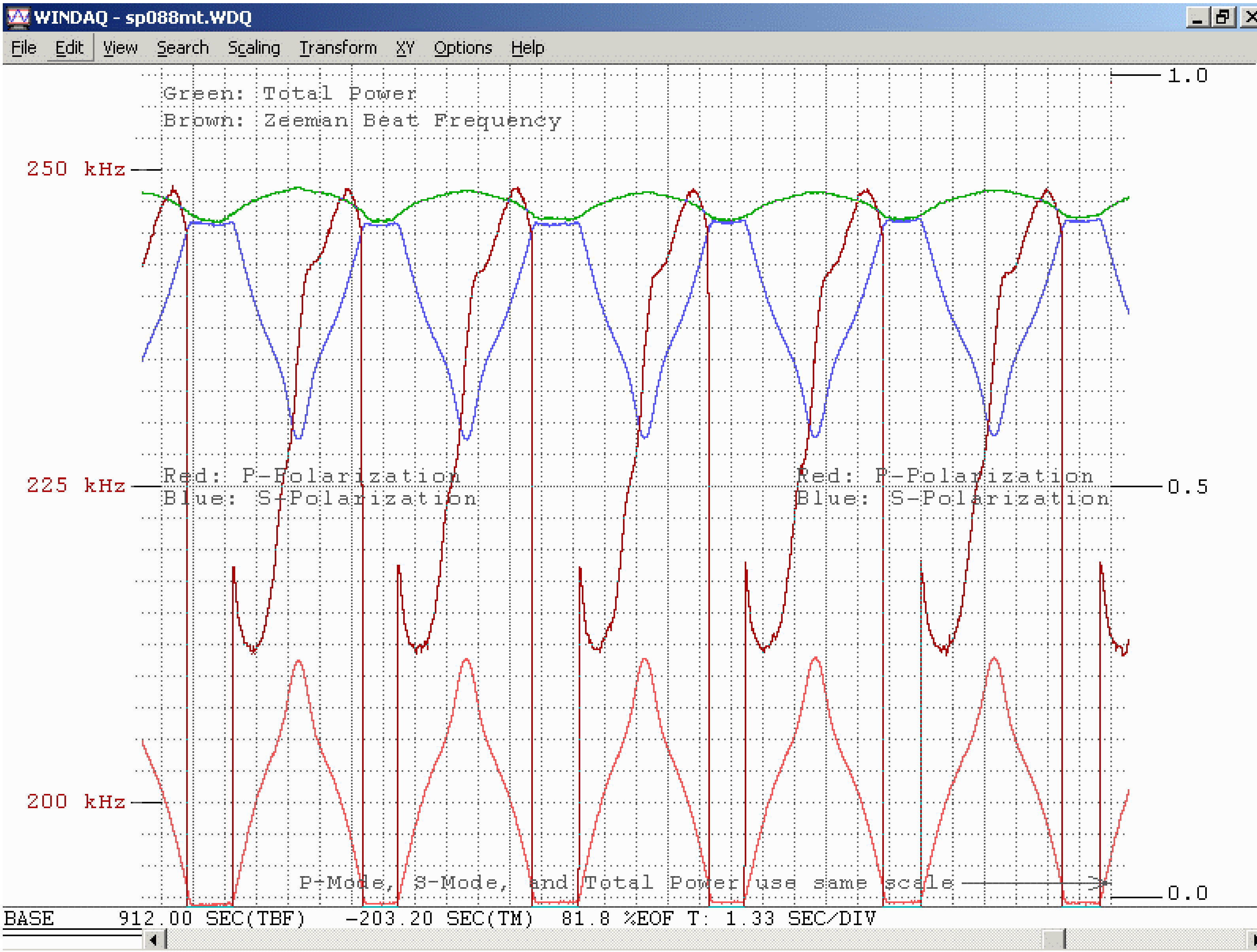

Figure 2 – Transverse Magnetic Field Strength 2

With a slightly stronger magnetic field, the modes have begun to move toward each-other and there is now a well defined beat over more than half the mode sweep cycle. At other times it is exactly zero frequency with no beat signal at all - not just a weak one.

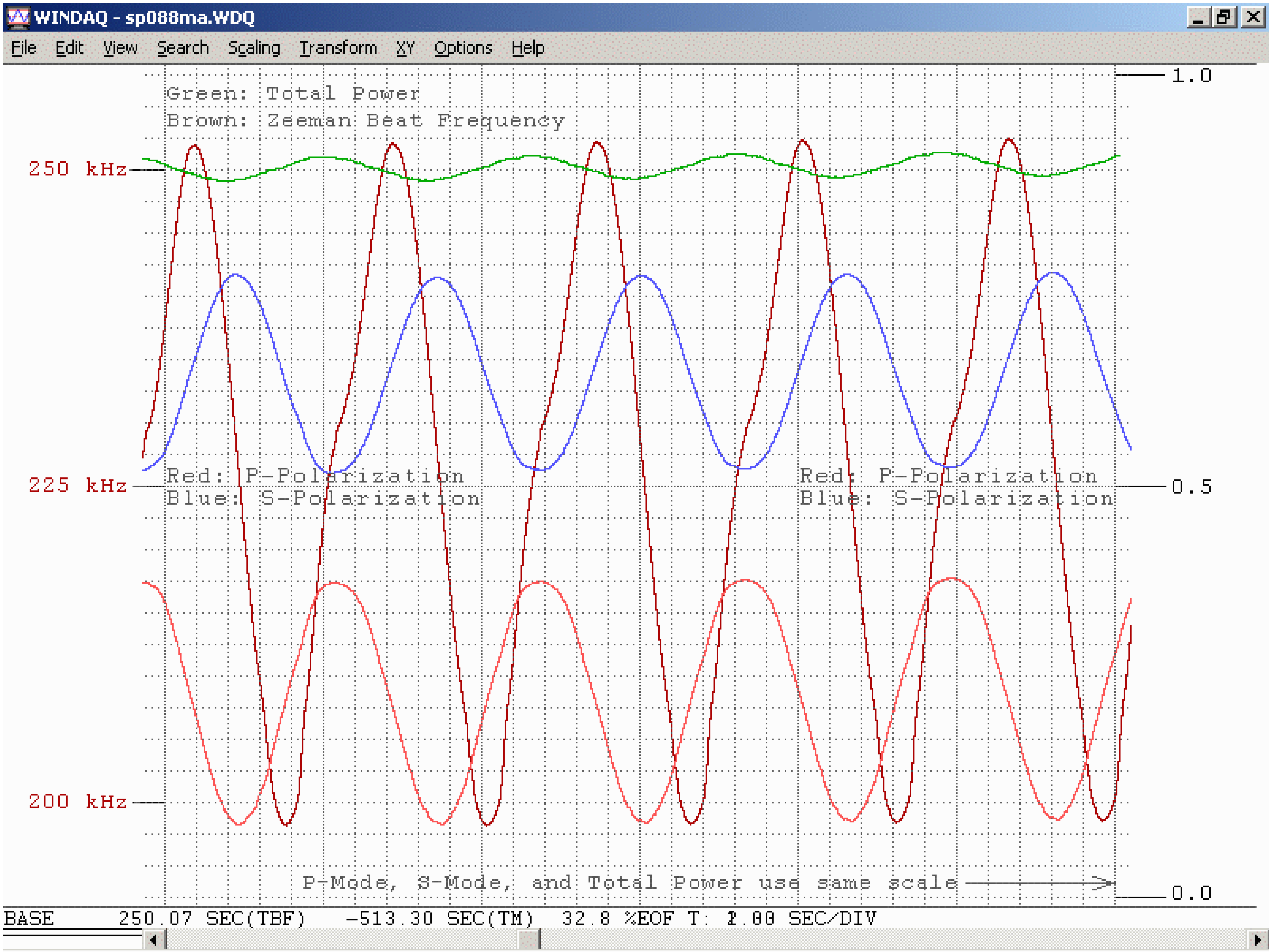

Figure 3 – Transverse Magnetic Field Strength 3

Now the beat is present with decent signal strength throughout the mode sweep cycle. The modes are changing with close to a sinusoidal shape though there still must be the mode switchover point at the same place as before – the peak of the P-Mode. The beat frequency also varies with a nearly sinusoidal shape except for the slight change in slope at that same location.

The fluctuations in total power have also become smaller.

With the very nicely behaved signals, this magnetic field strength may be a good place to operate a stabilized transverse Zeeman HeNe laser. Locking near the center of the negative slope of the beat frequency (voltage) signal would place the single split mode near the center of the gain curve.

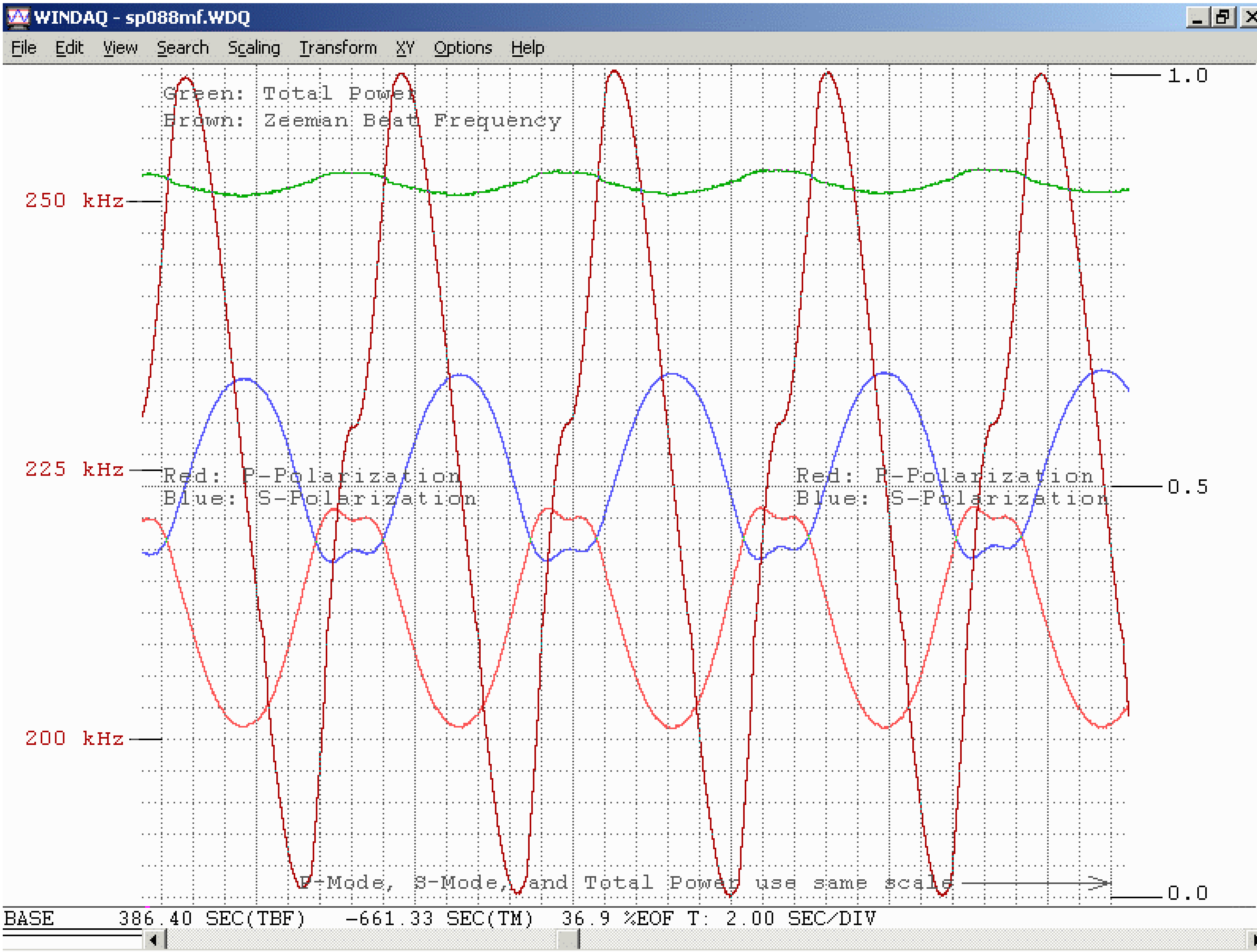

Figure 4 – Transverse Magnetic Field Strength 4

Here the modes are continuing to move together and the beat frequency excursion has increased. (Note the scale change on the frequency axis.) A pair of bumps in the modes is beginning to appear around the switchover point as well as the increased change in slope of the beat frequency waveform.

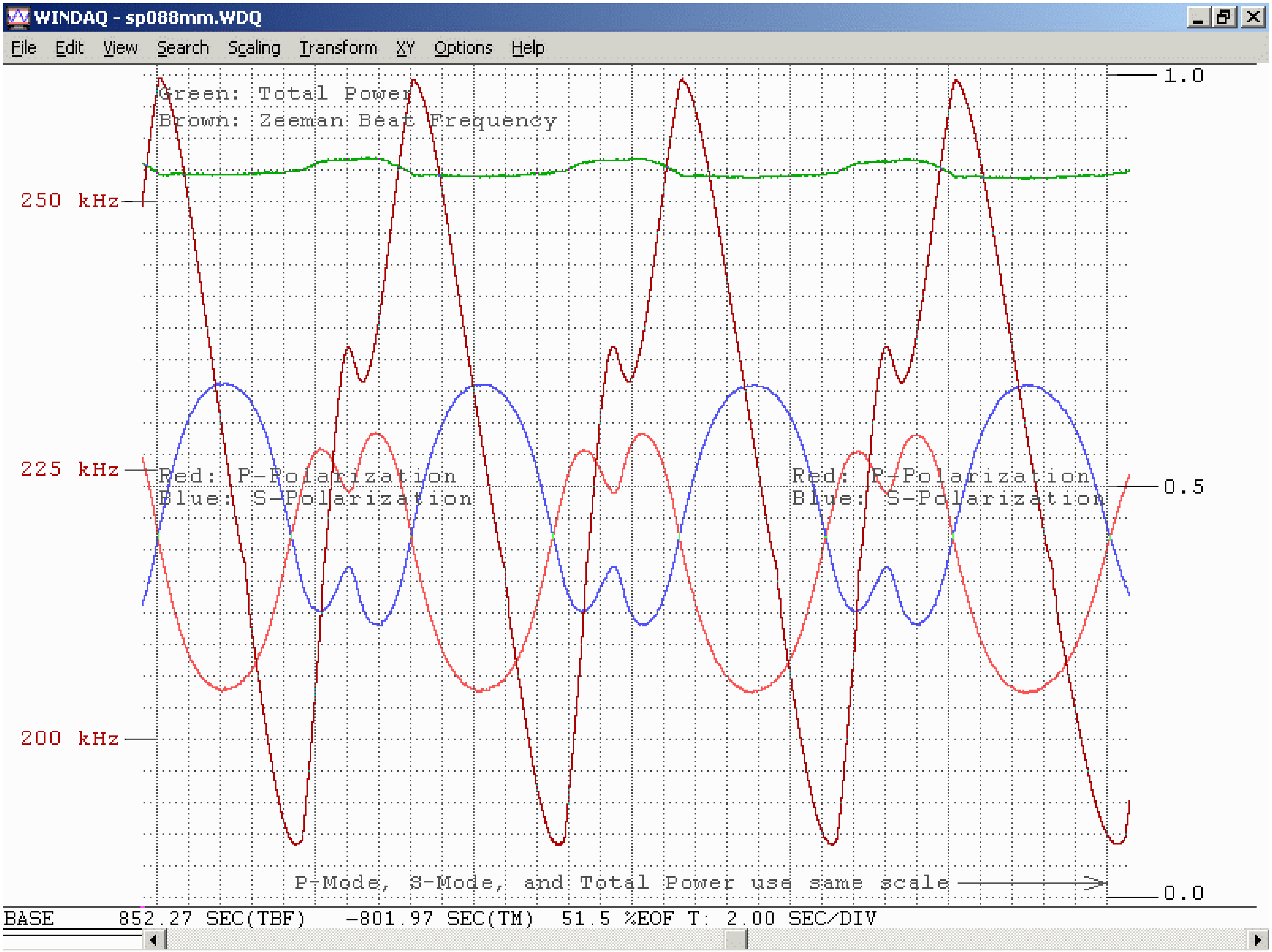

Figure 5 – Transverse Magnetic Field Strength 5

Now the modes are almost overlapping. The change in slope of the beat frequency waveform has now become a distinct dip.

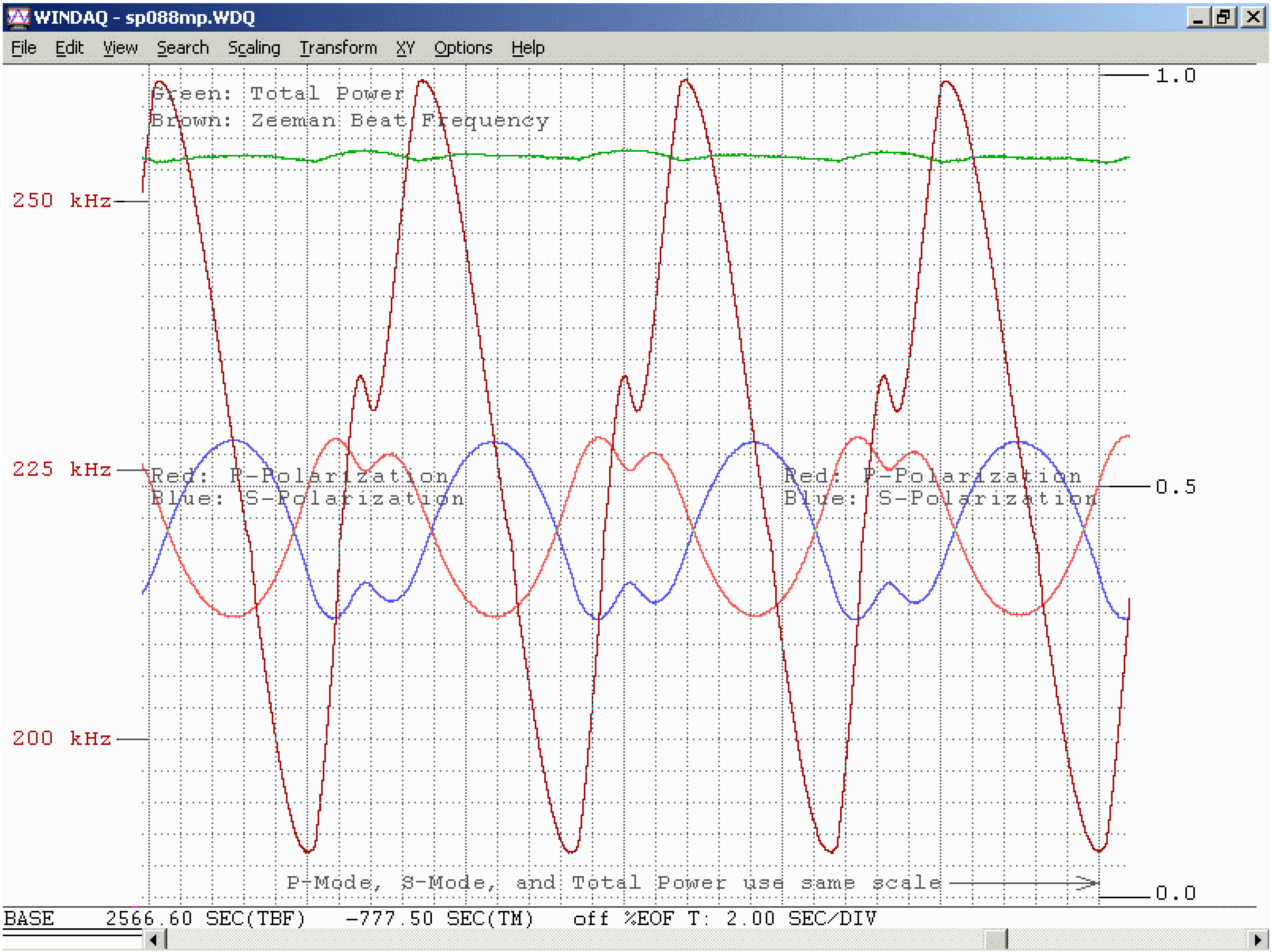

Figure 6 – Transverse Magnetic Field Strength 6

Now the modes are almost precisely overlapping. This should result in a clean strong beat signal over the entire mode sweep cycle

The amplitude of the total power ripple has also decreased.

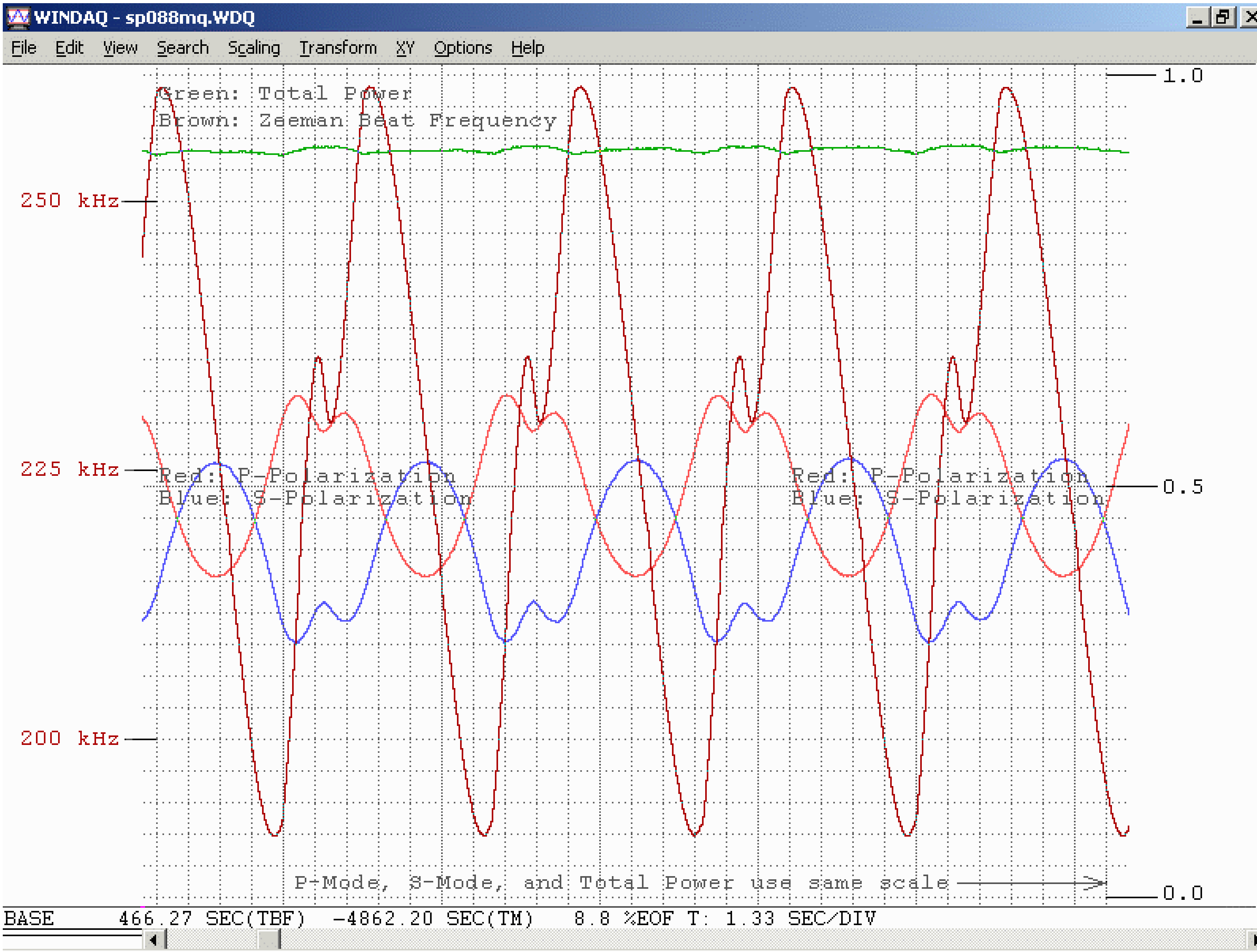

Figure 7 – Transverse Magnetic Field Strength 7

The P-Mode in parallel with the magnetic field continues to increase and the S-Mode perpendicular to the magnetic field continues to decrease. The dip and bumps are getting larger.

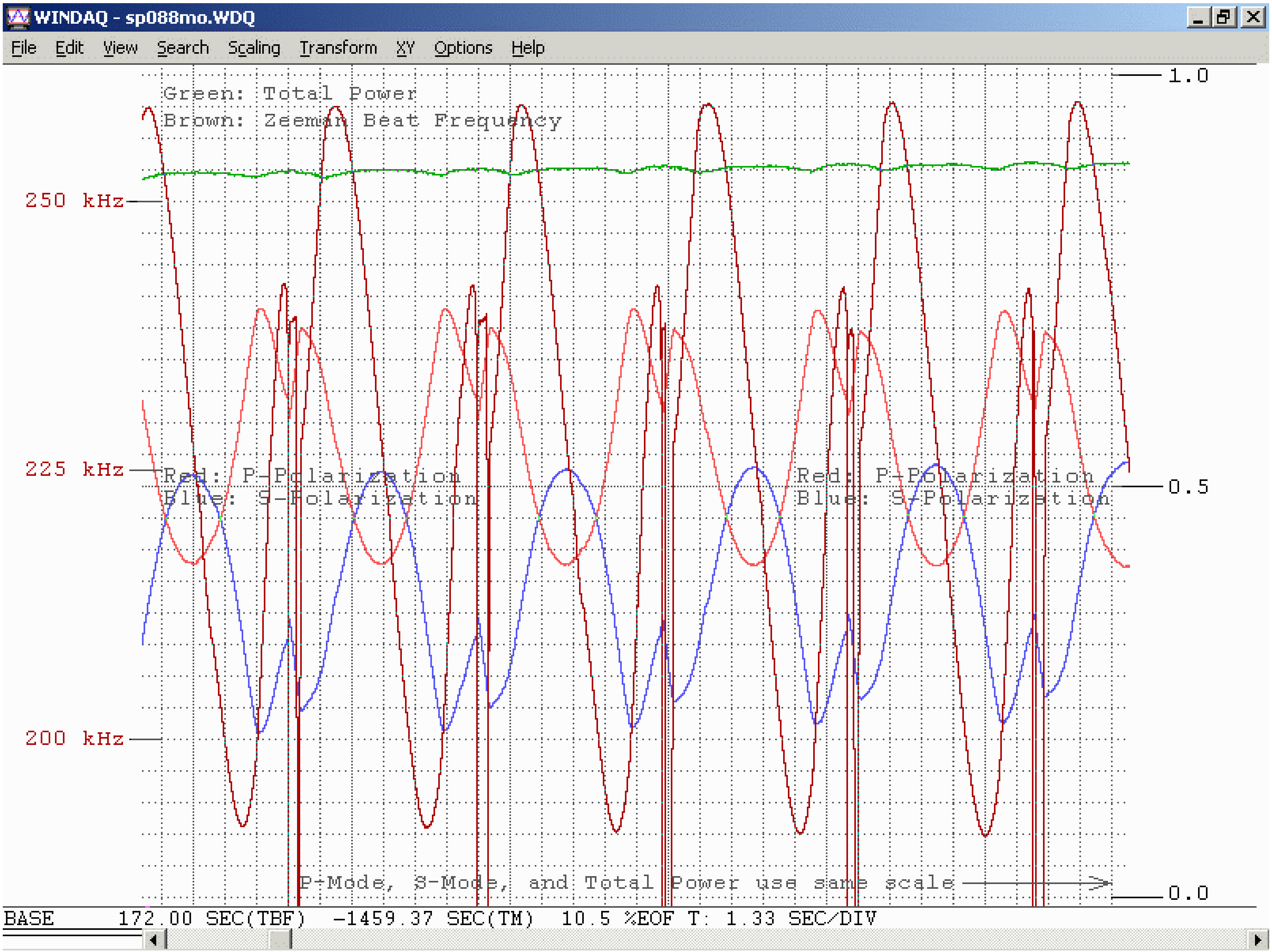

Figure 8 – Transverse Magnetic Field Strength 8

Here, the beat disappears for an instant or two around the transition point. The mode bumps there are much larger, and the dip is now HUGE.

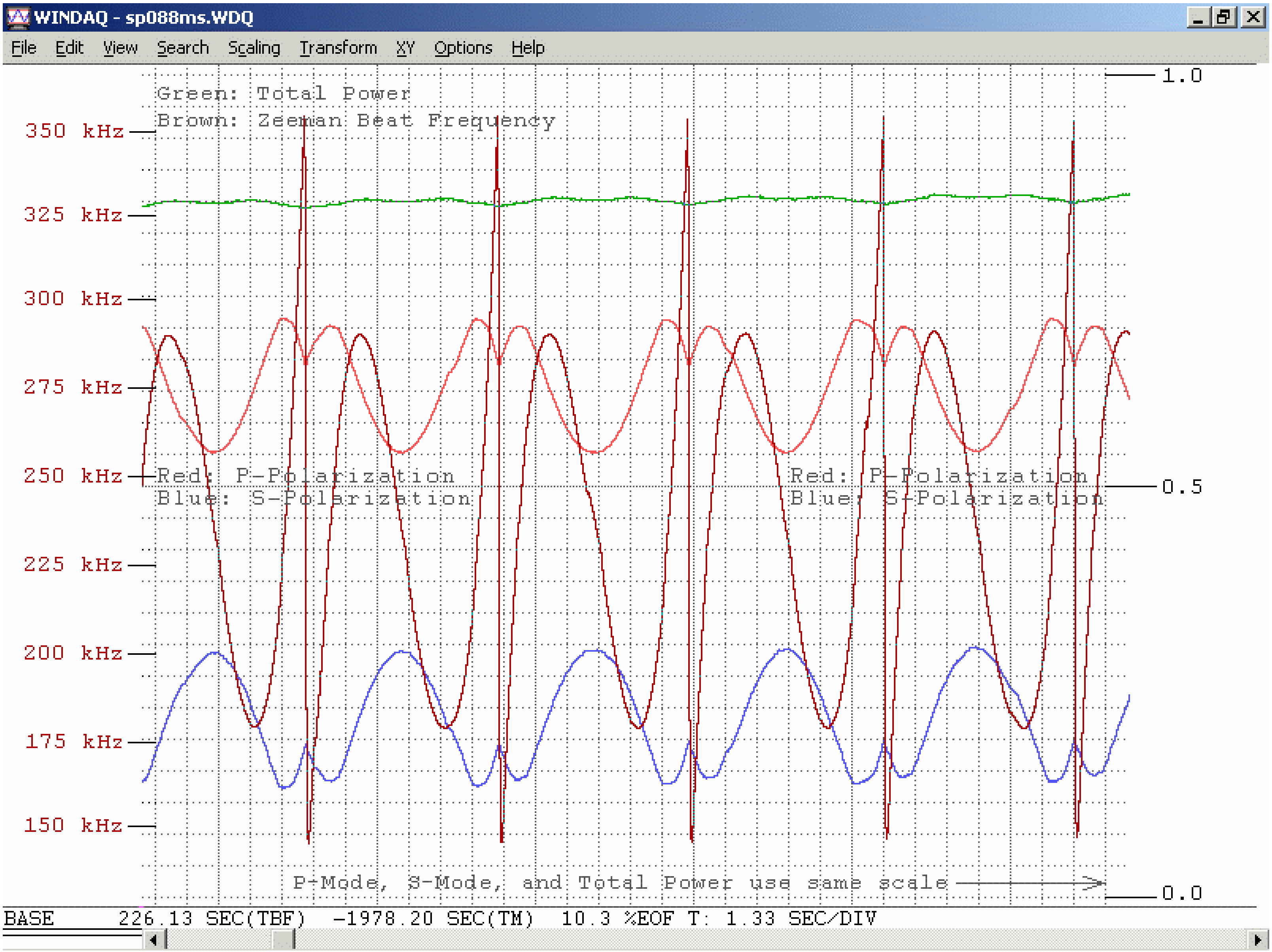

Figure 9 – Transverse Magnetic Field Strength 9

With an even stronger field, the modes have pulled apart more but their ripple is lower. And, the frequency in the transition region would appear to be changing continuously over a very wide range. (Note the scale change once again on the beat frequency axis.) However, looks can be deceiving as the actual waveform of the beat within this period is not a pure tone but a mixture that perhaps results from two completing split modes mixing their respective beats in the F-V converter and outputting the result shown.

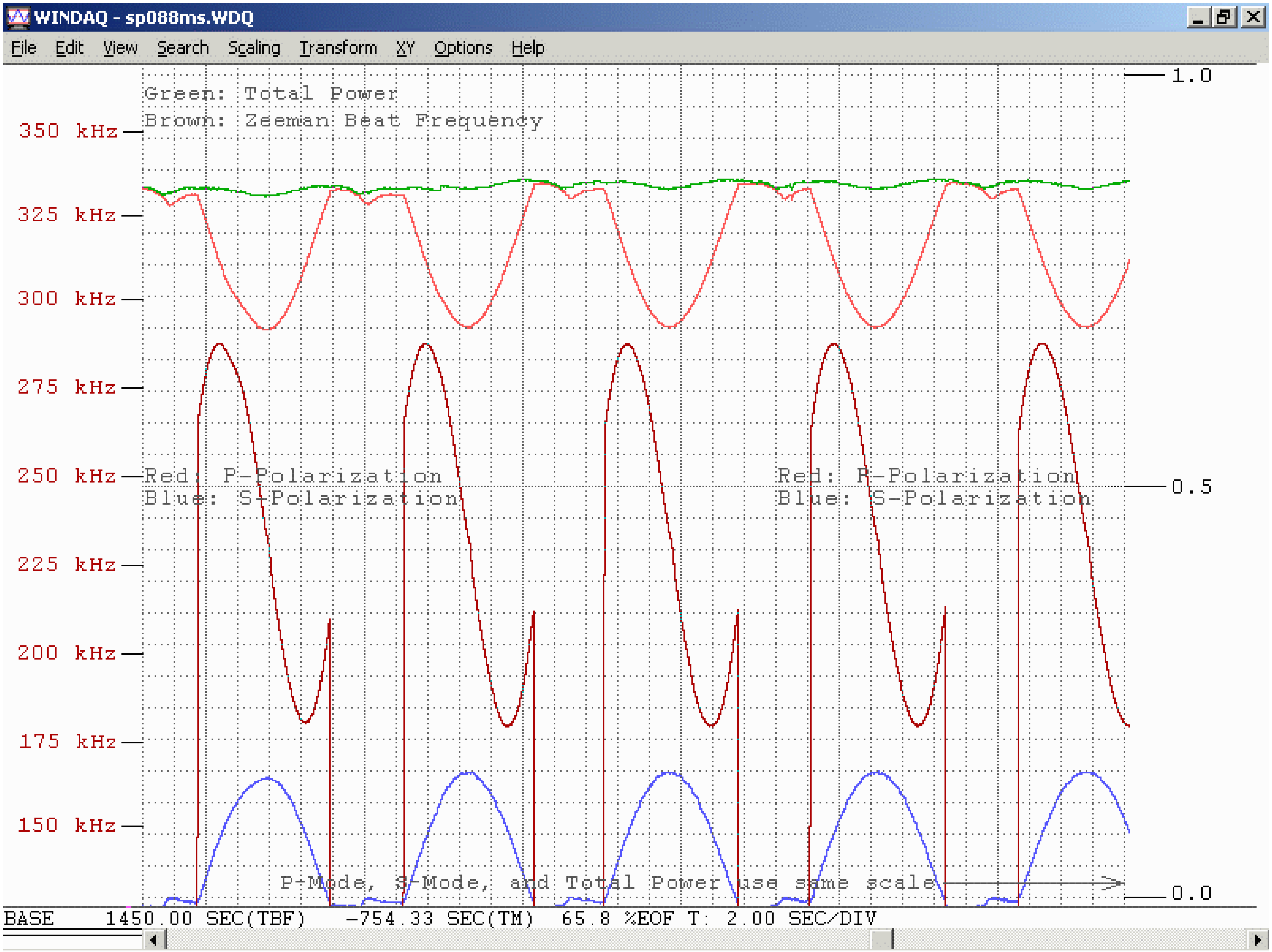

Figure 10 – Transverse Magnetic Field Strength 10

With the largest of the moderate magnetic fields, the modes have almost completely moved to the far ends of the field ☺ and the beat is only present for a portion of the mode sweep cycle, disappearing entirely for much of the transition region.

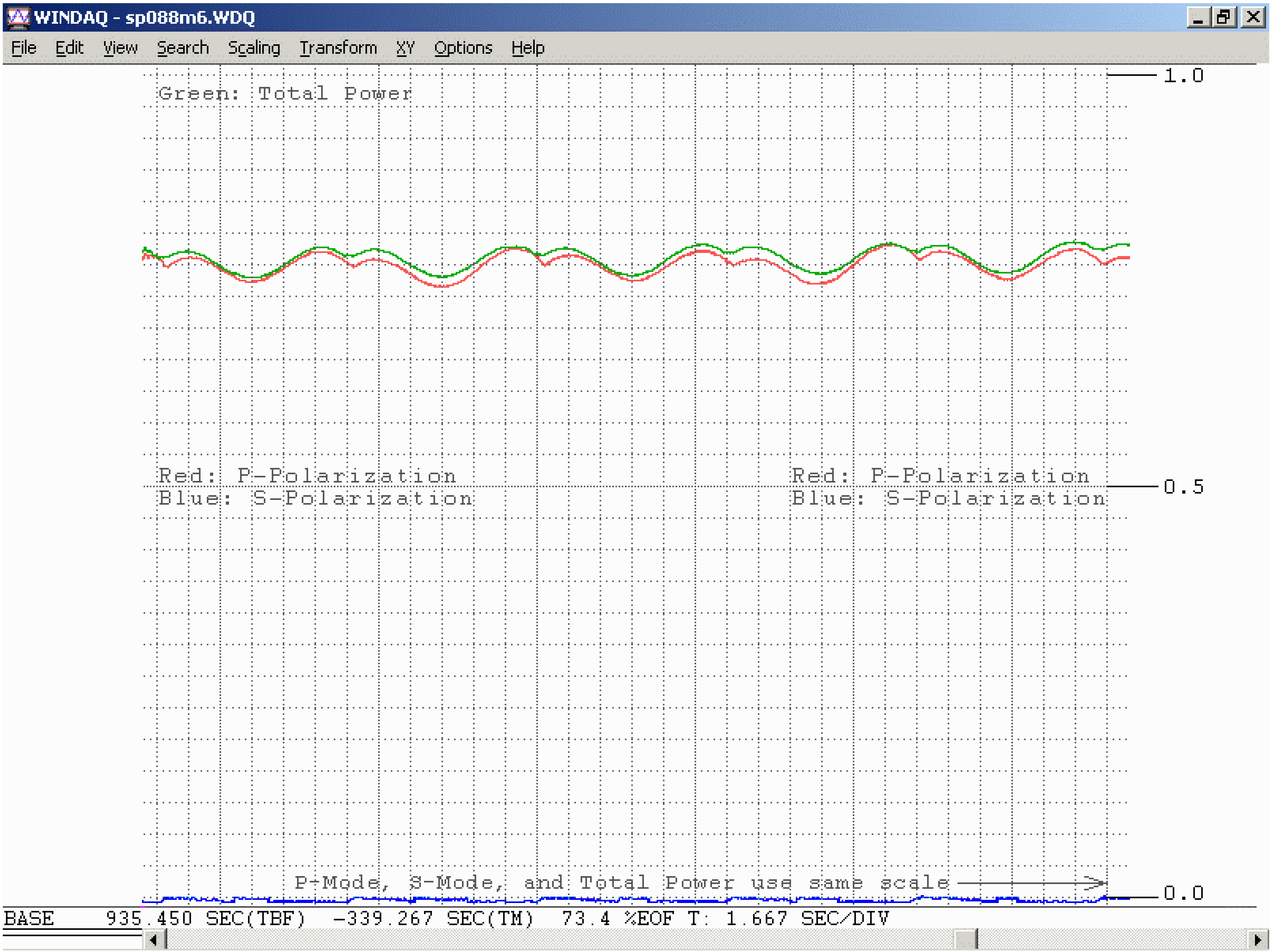

Figure 11 – Transverse Magnetic Field Strength Super

Finally, using the pair of super strength rare earth magnets, the output is almost perfectly linearly polarized with no beat. However, the polarization ratio is not nearly as good as with an intracavity Brewster window or plate, and the output power has relatively large fluctuations. These had mostly disappeared with the more moderate magnetic fields.