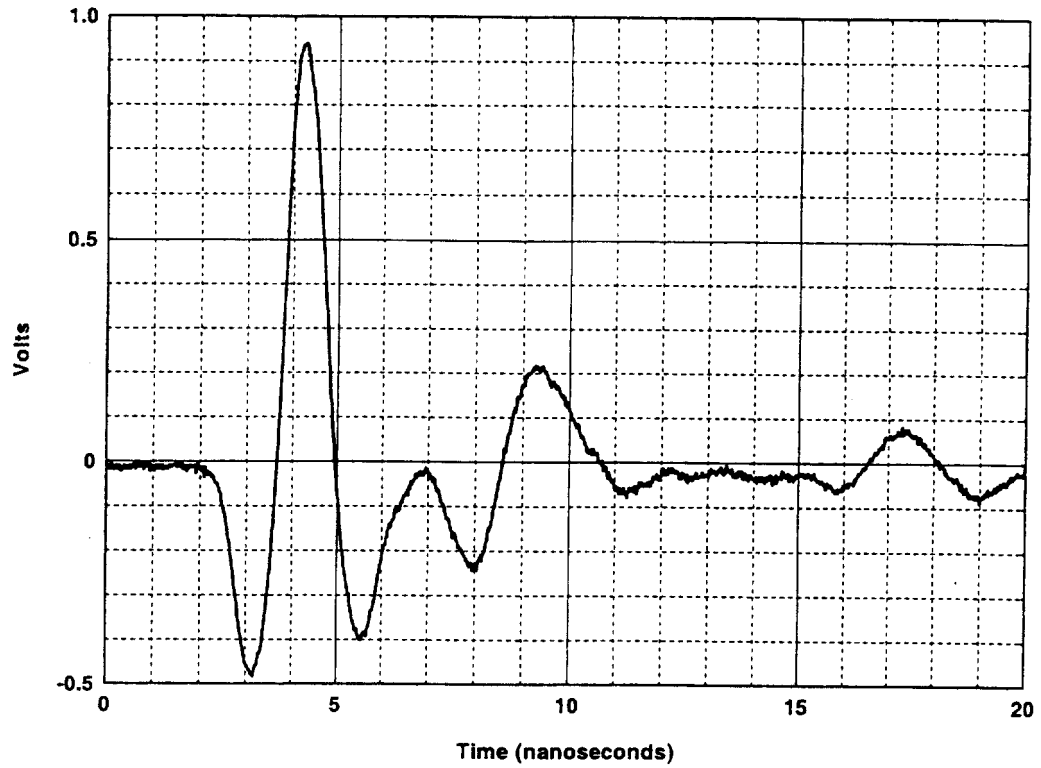

Figure D.E.1. Device E, (300 MHz) radiated time-domain waveform.

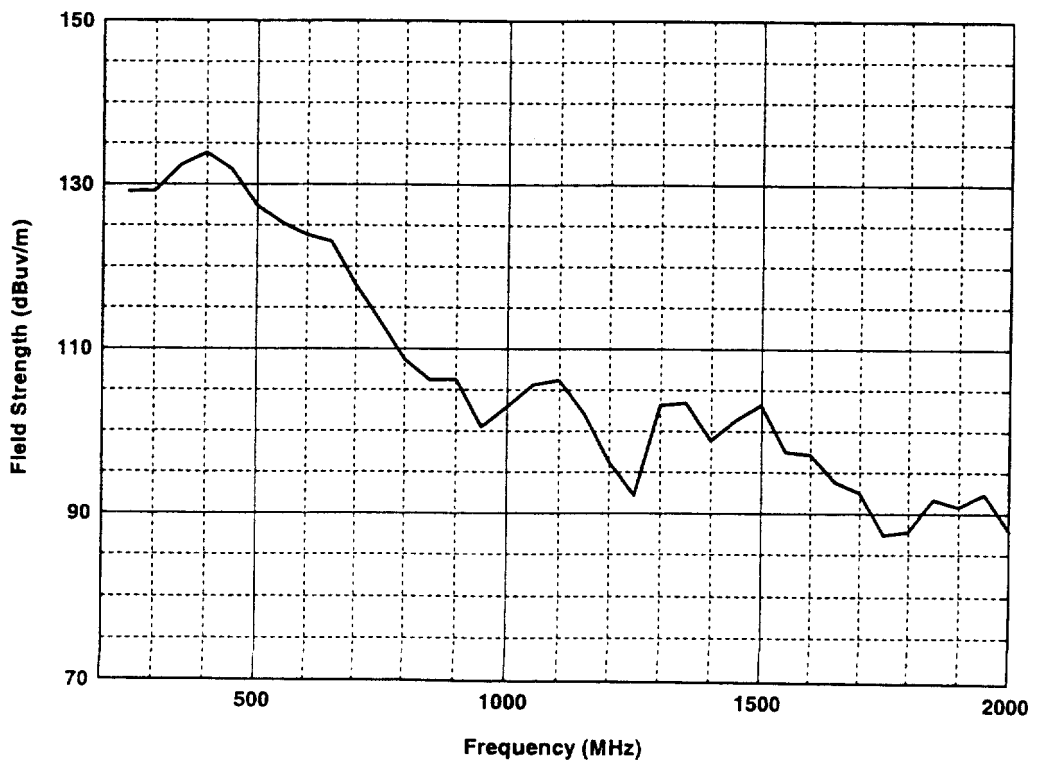

Figure D.E.2. Device E, (300 MHz) radiated peak field strength at 1 m, $\Delta f = 49.99$ MHz.

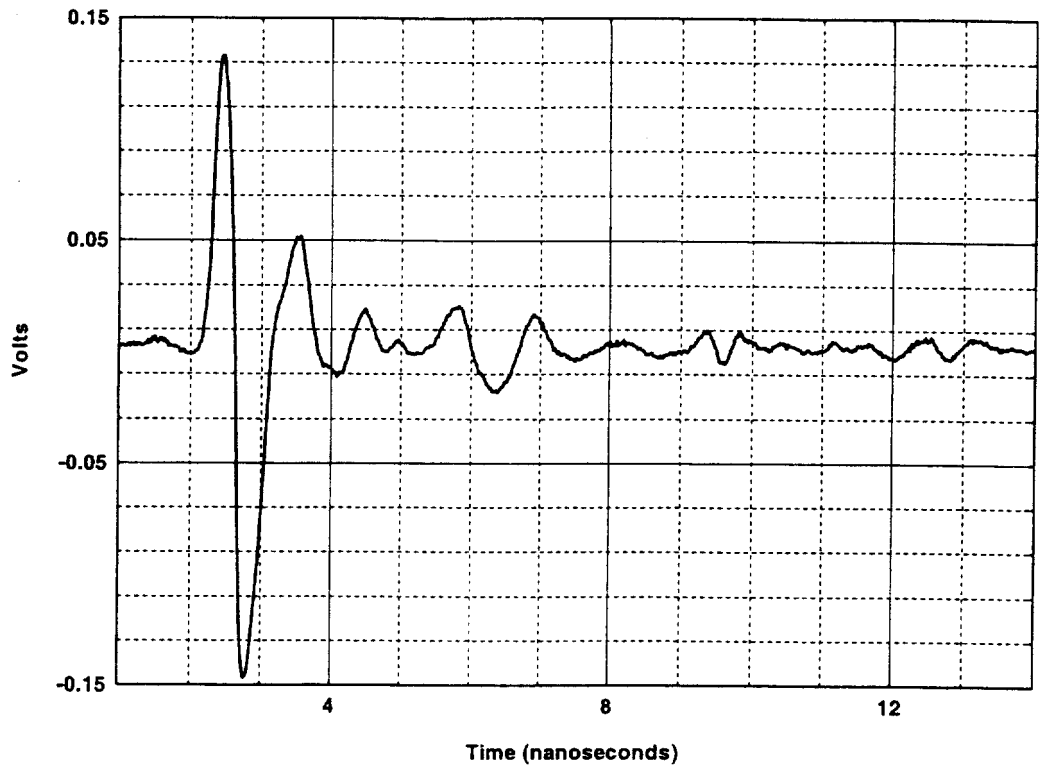

Figure D.E.3. Device E, (900 MHz) radiated time-domain waveform.

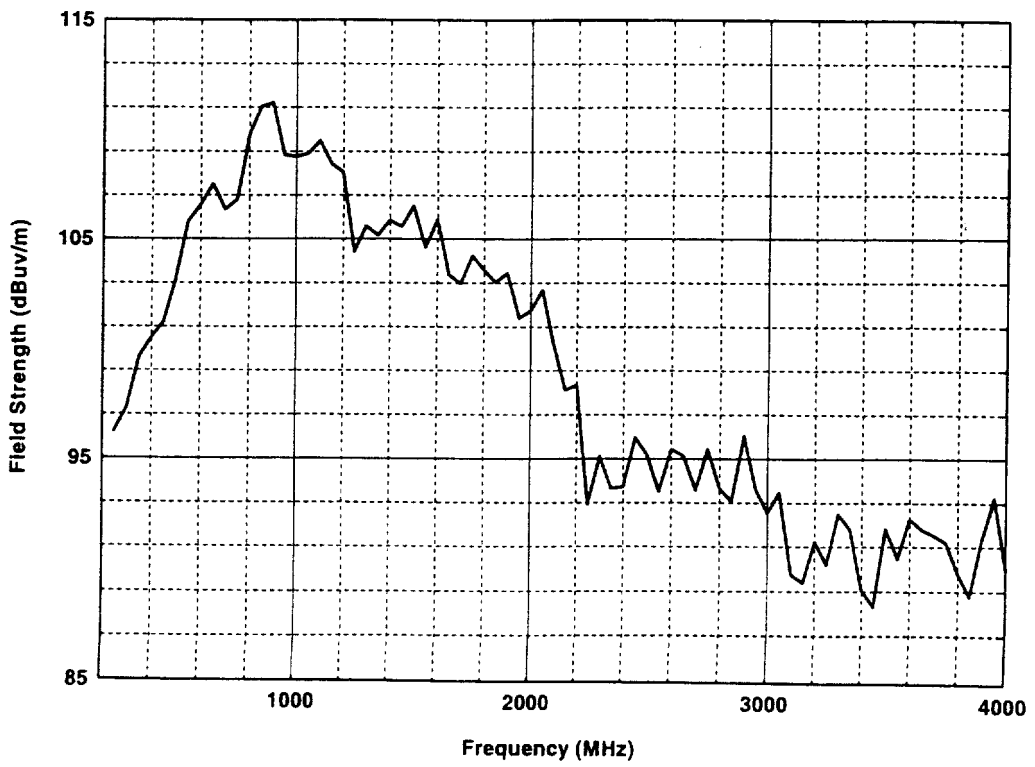

Figure D.E.4. Device E, (900 MHz) radiated peak field strength at 1 m, $\Delta f = 49.99$ MHz.

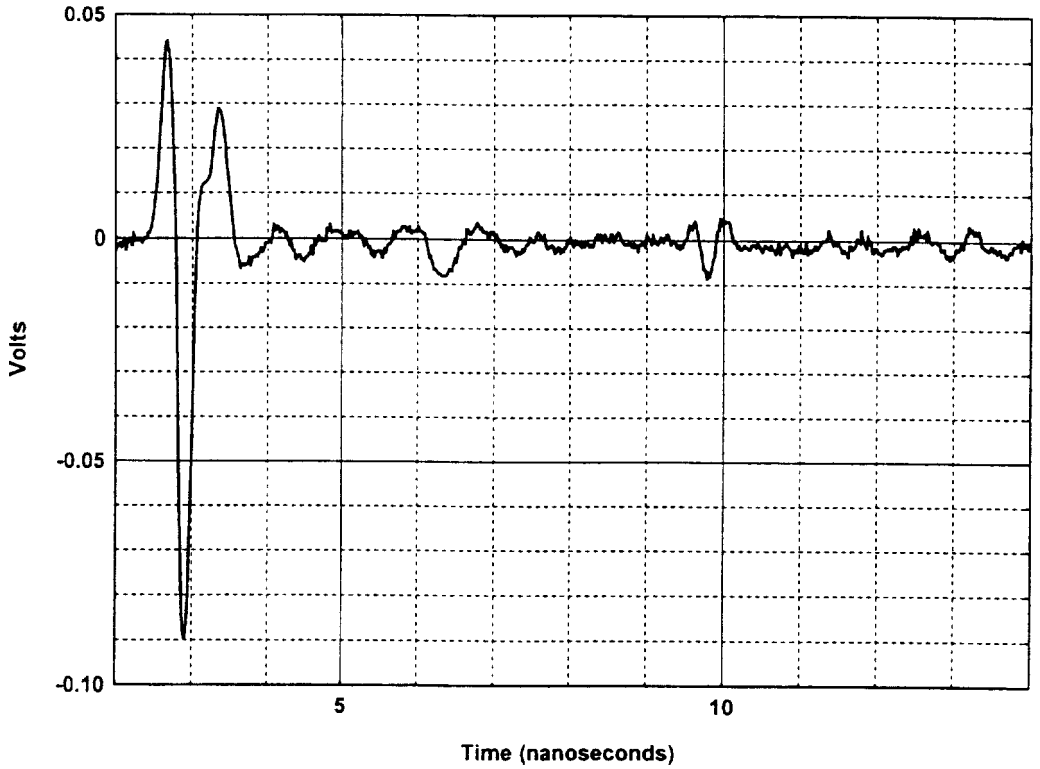

Figure D.E.5. Device E, (1500 MHz) radiated time-domain waveform.

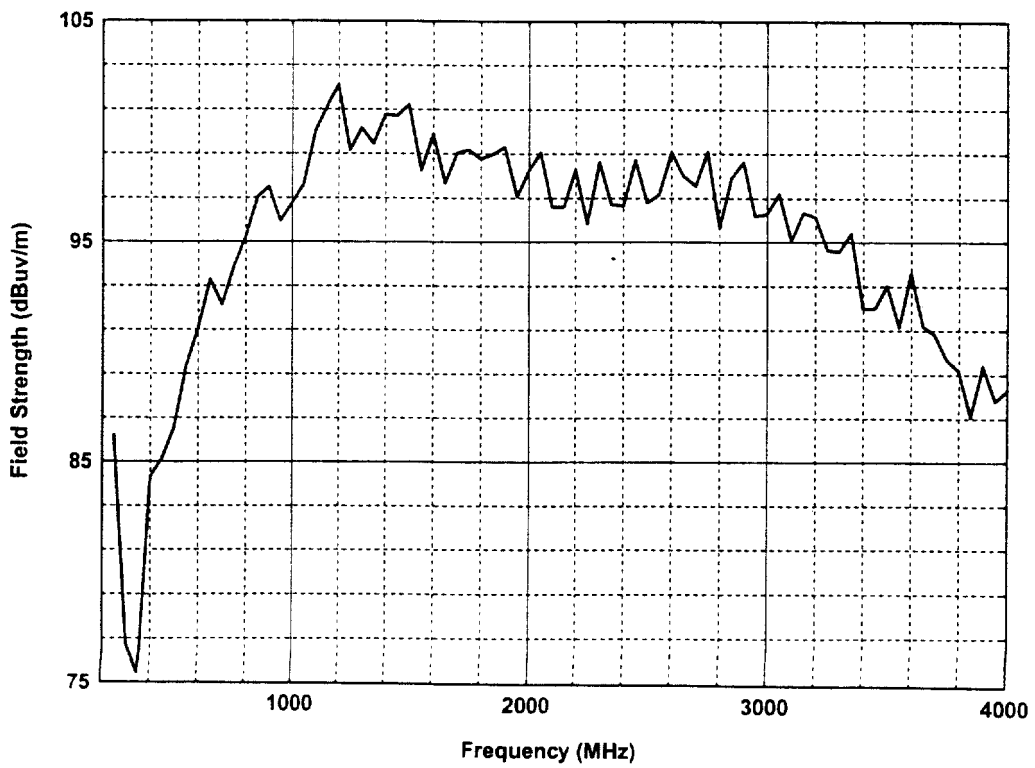

Figure D.E.6. Device E, (1500 MHz) radiated peak field strength at 1 m, $\Delta f = 49.99$ MHz.

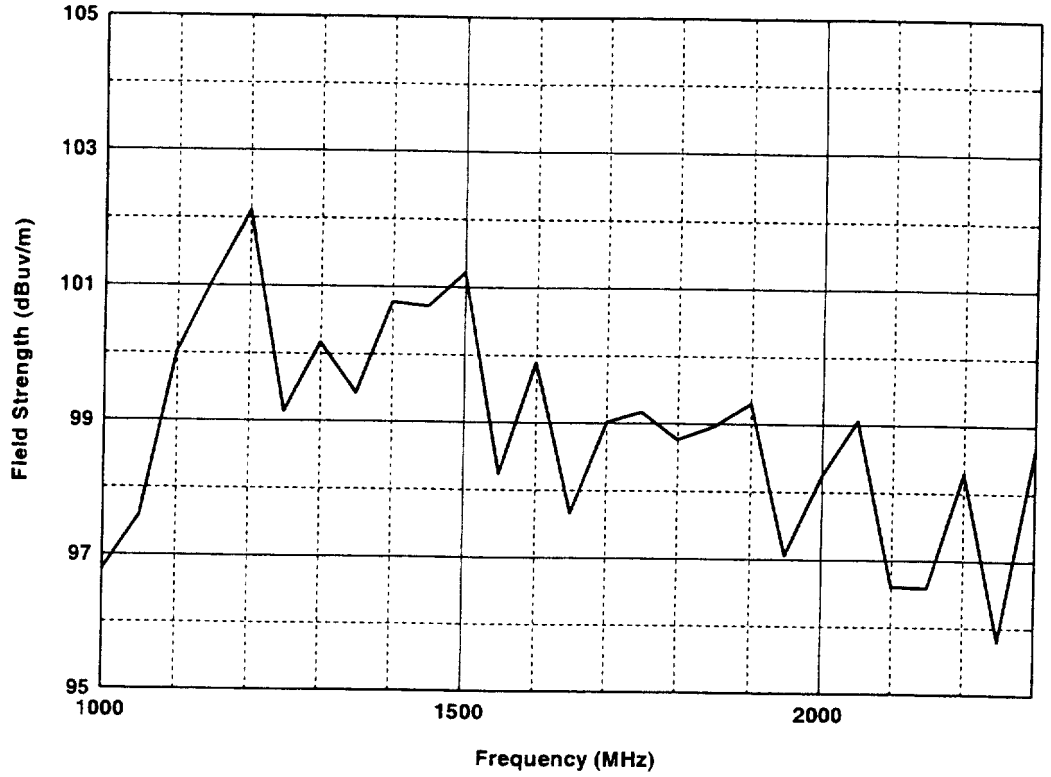

Figure D.E.7. Device E, (1500 MHz) radiated peak field strength at 1 m, $\Delta f = 49.99$ MHz.

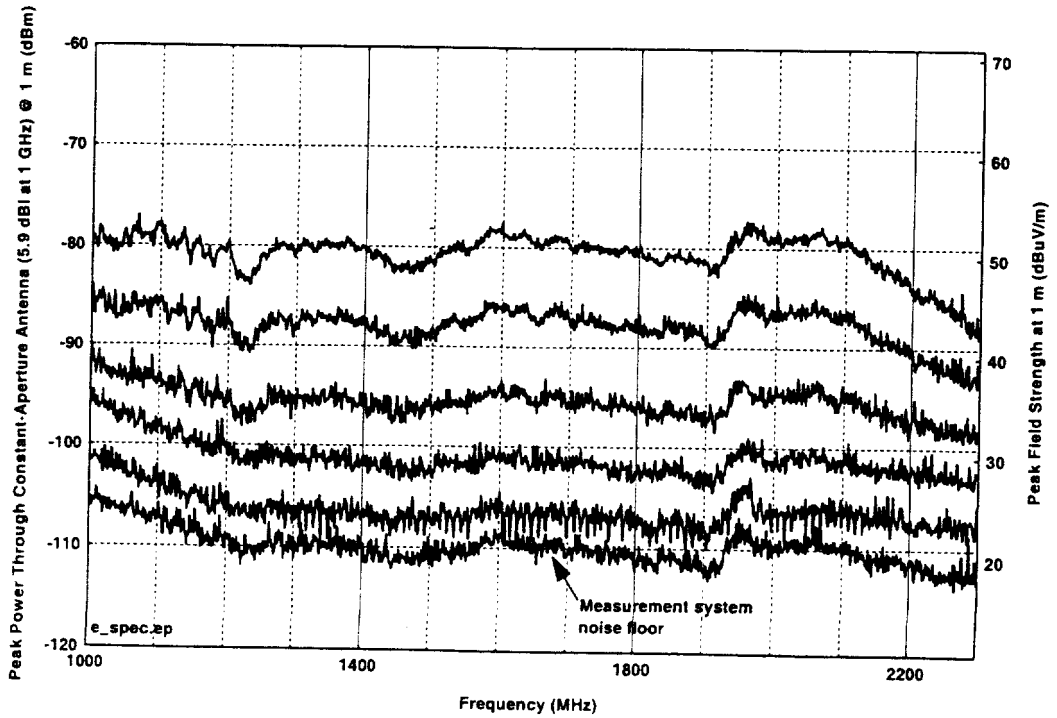

Figure D.E.8. Device E, (1500 MHz head) spectra as a function of measurement bandwidth.

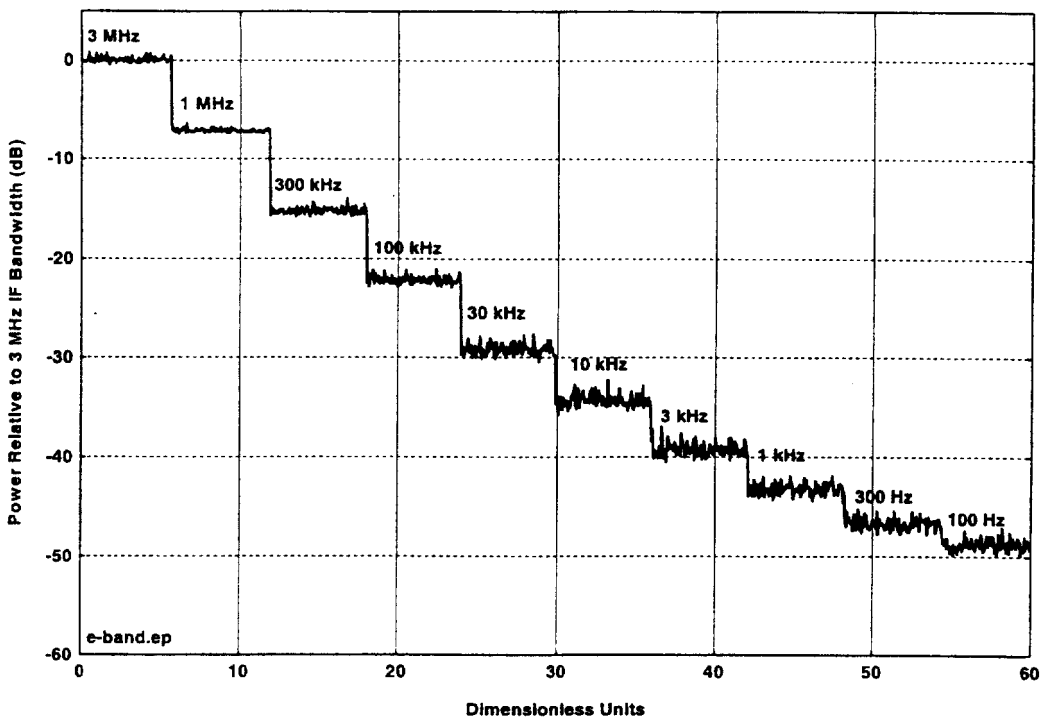

Figure D.E.9. Device E, power as a function of measurement bandwidth stairstep.

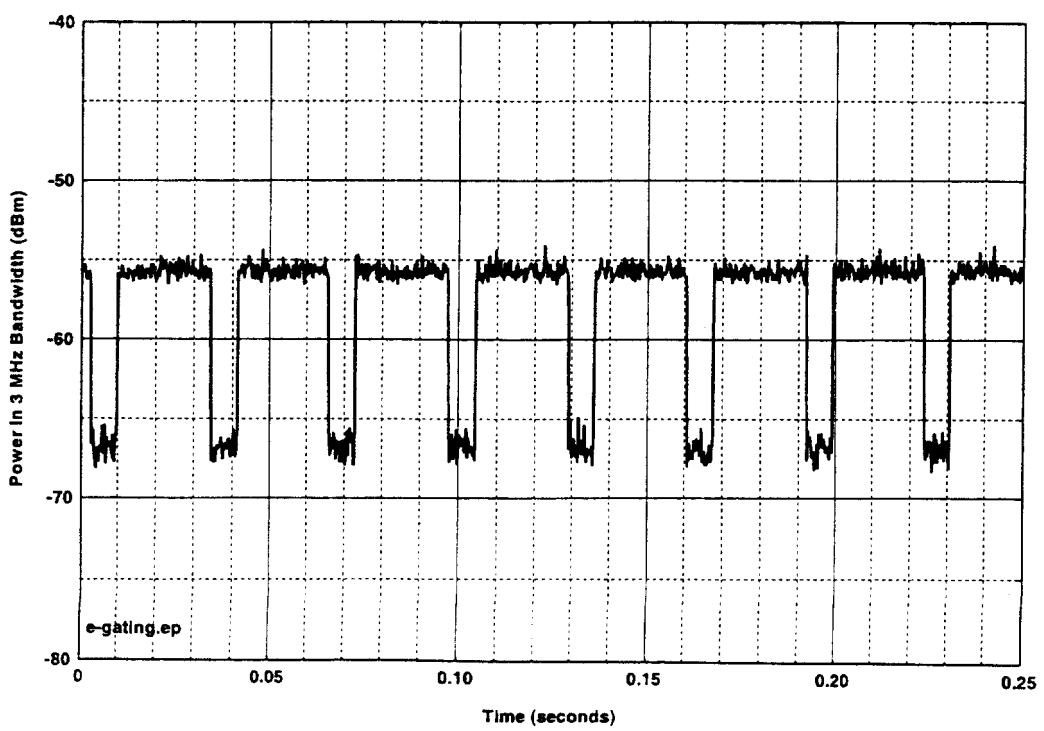

Figure D.E.10. Device E, gating behavior.

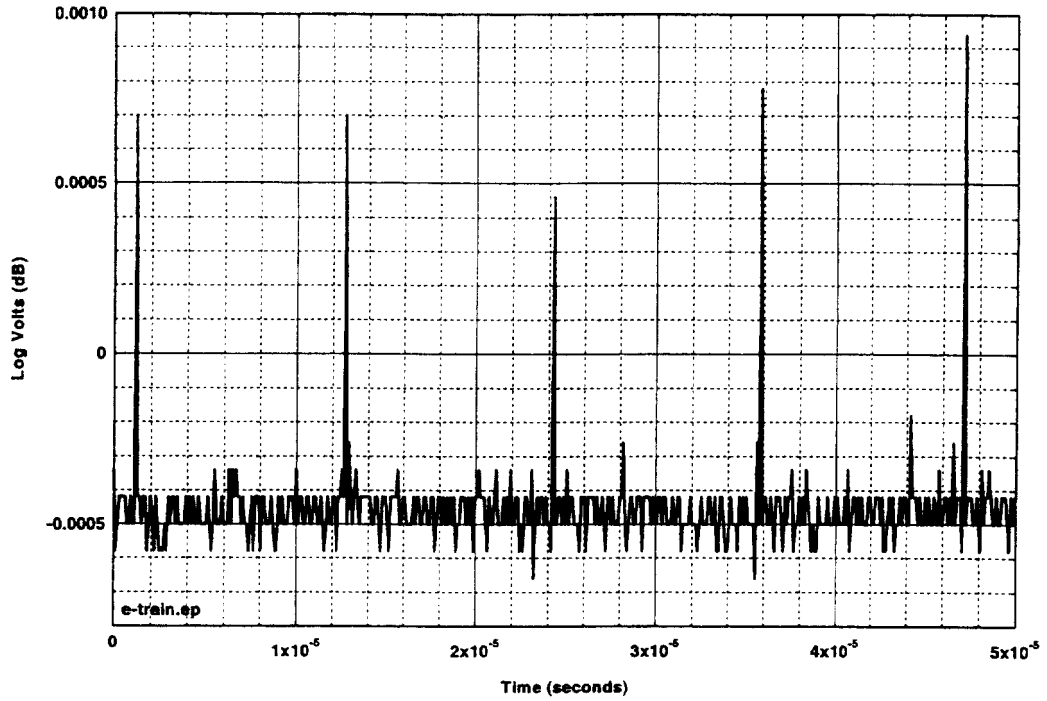

Figure D.E.11. Device E, pulse train.

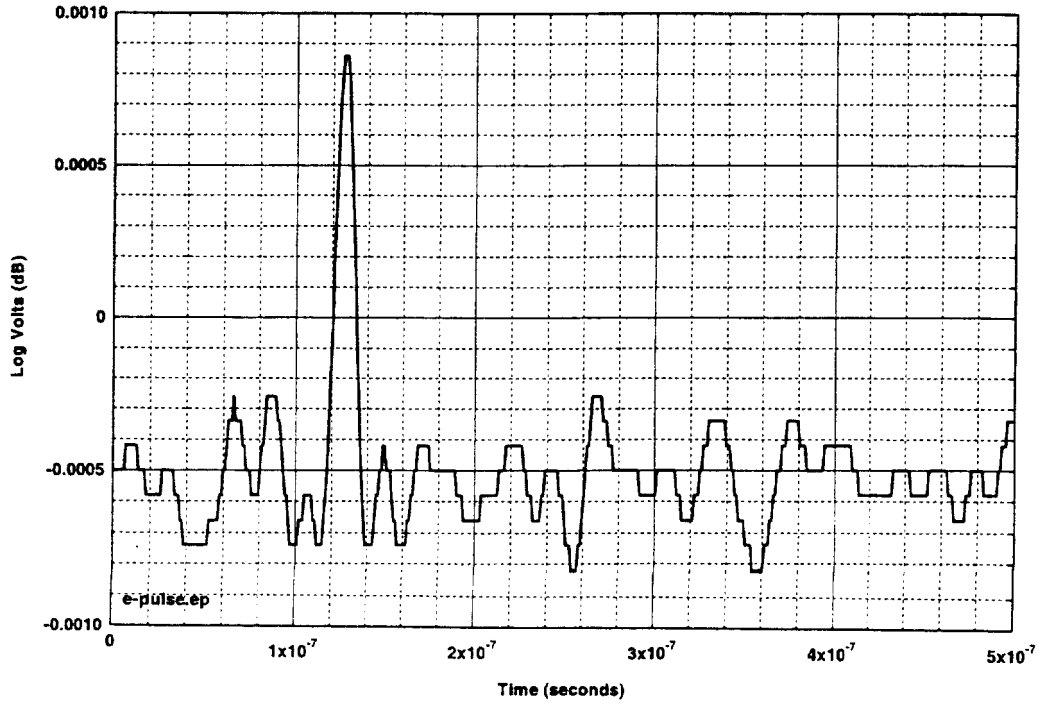

Figure D.E.12. Device E, individual pulse (bandwidth-limited at 50 MHz).

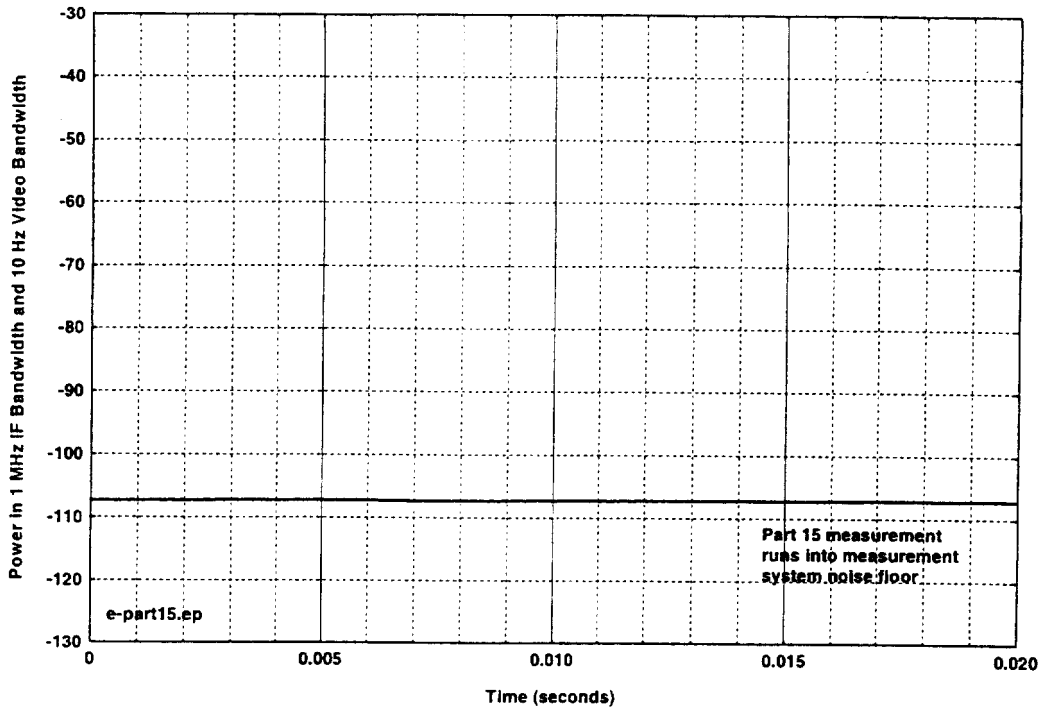

Figure D.E.13. Device E, Part 15 measurement.

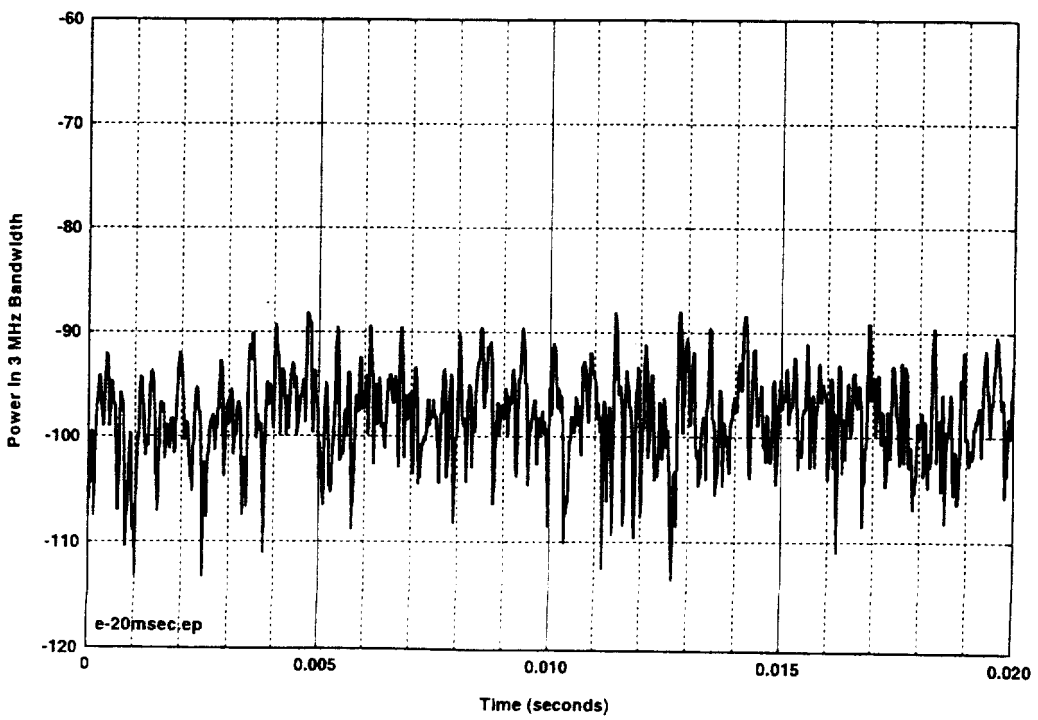

Figure D.E.14. Device E, 20-msec time waveform.

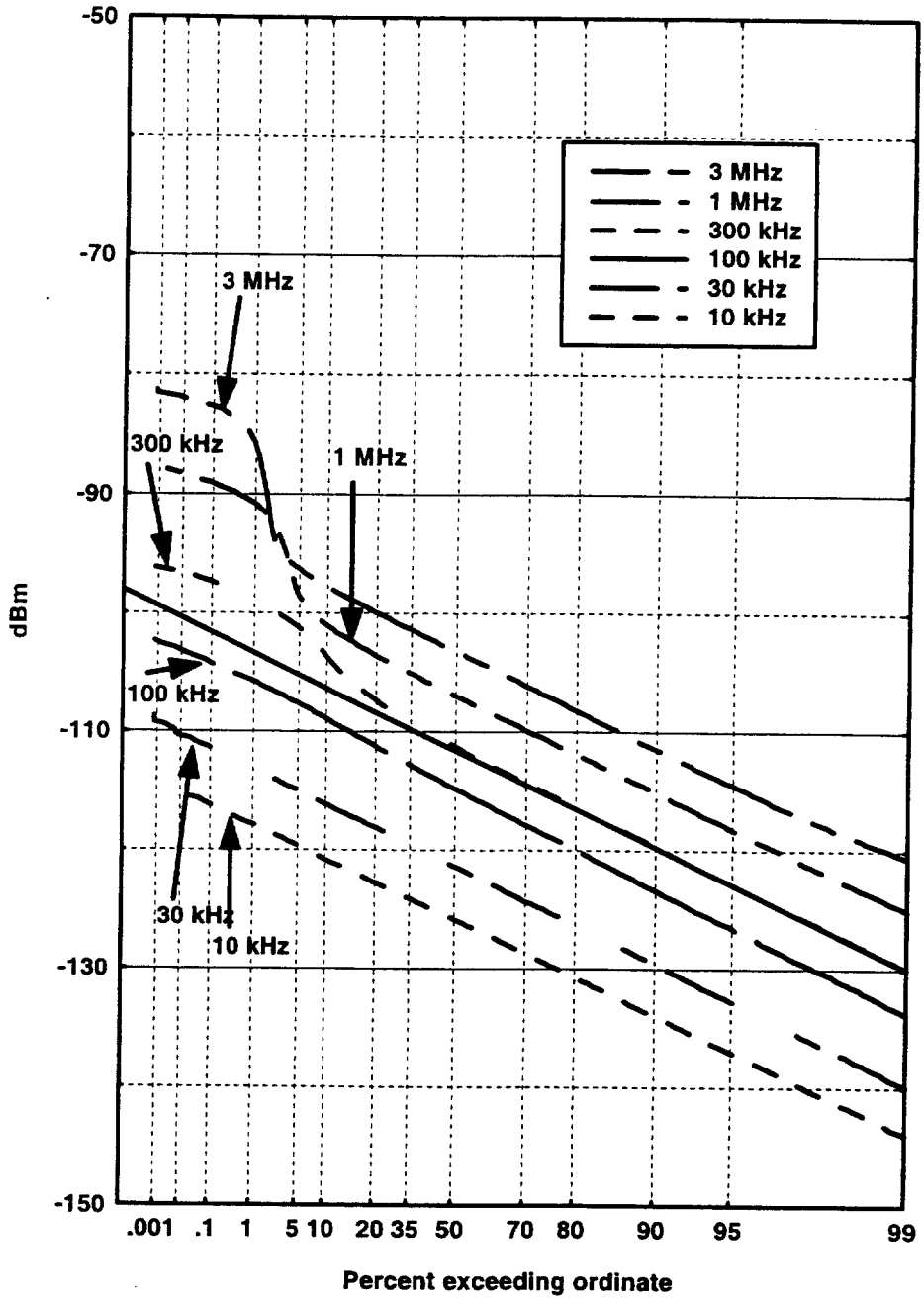

Figure D.E.15. Device E, APDs.

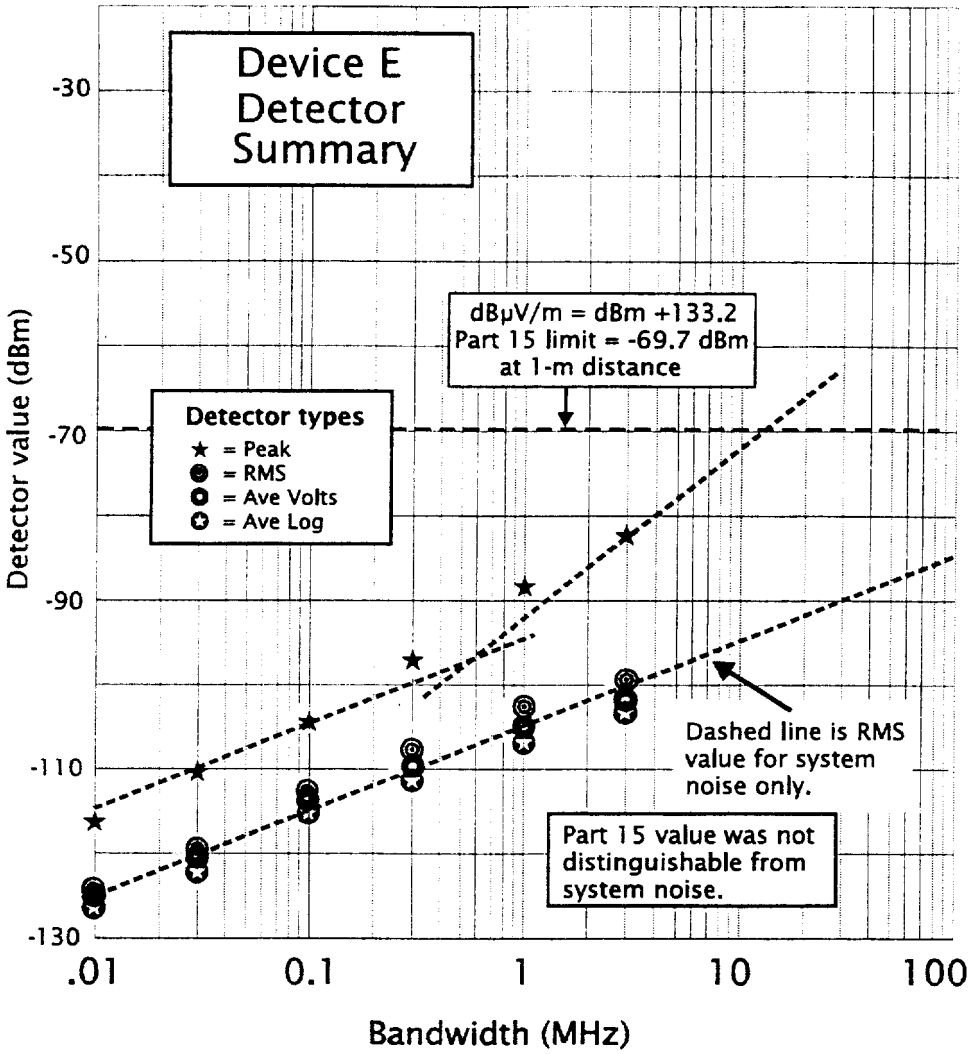

Figure D.E.16. Device E, detector summary.

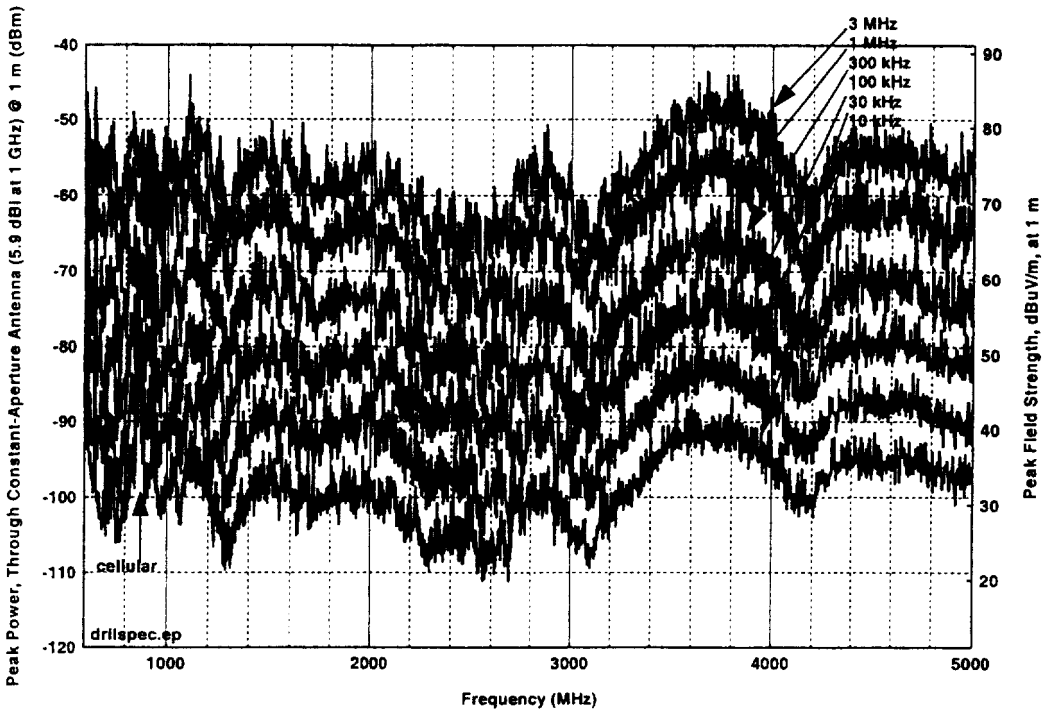

Figure D.F.1. Electric drill, emission spectrum as a function of bandwidth.

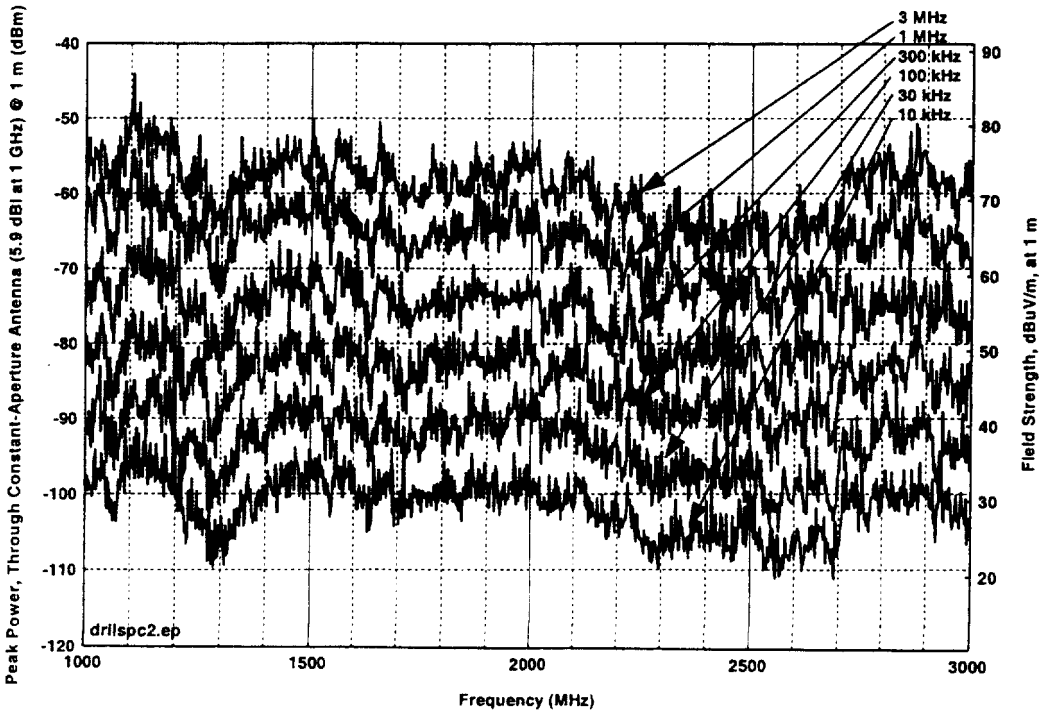

Figure D.F.2. Electric drill, emission spectrum from 1-3 GHz as a function of bandwidth.

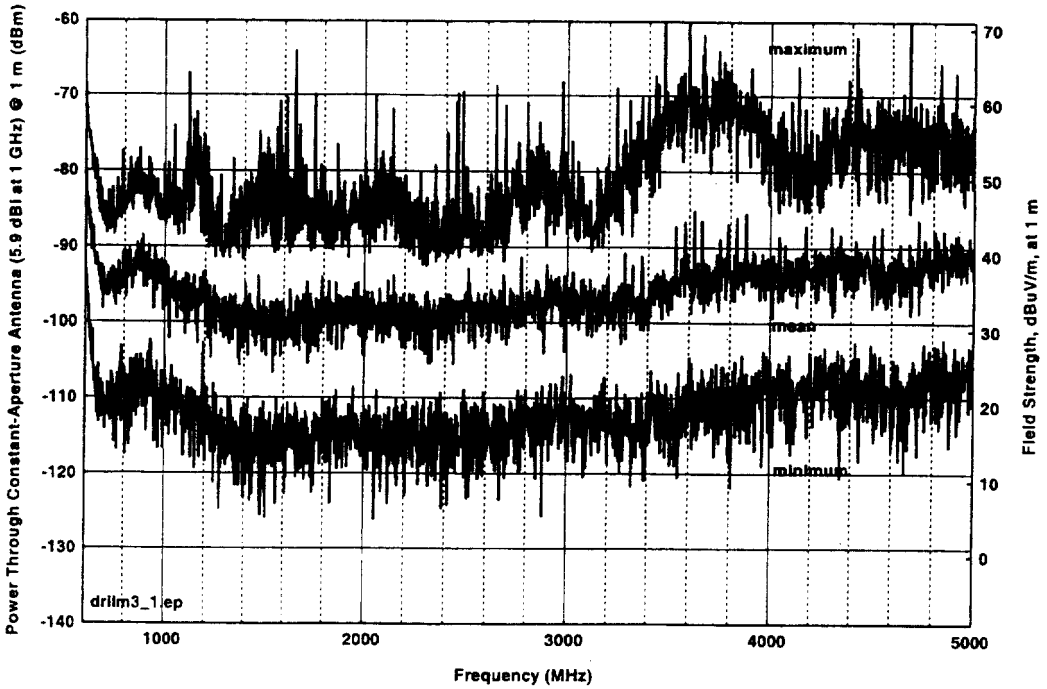

Figure D.F.3. Electric drill, sample-detected electric drill spectrum, 3 MHz bandwidth, max, mean, and min curves.

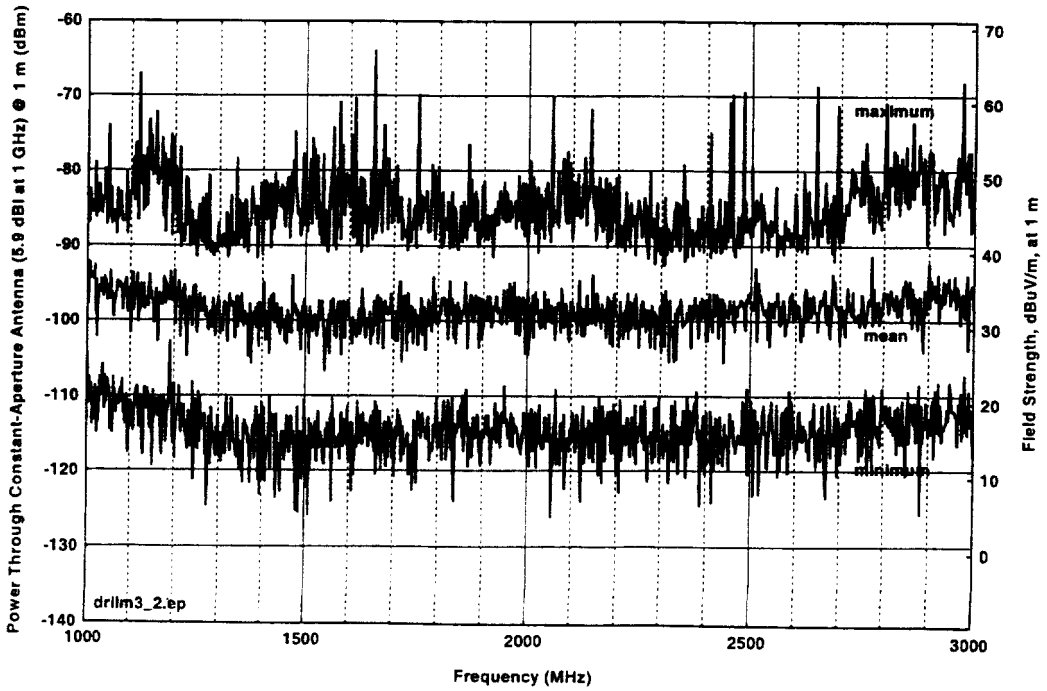

Figure D.F.4. Electric drill, sample-detected electric drill spectrum, 3 MHz bandwidth, max, mean, and min curves.

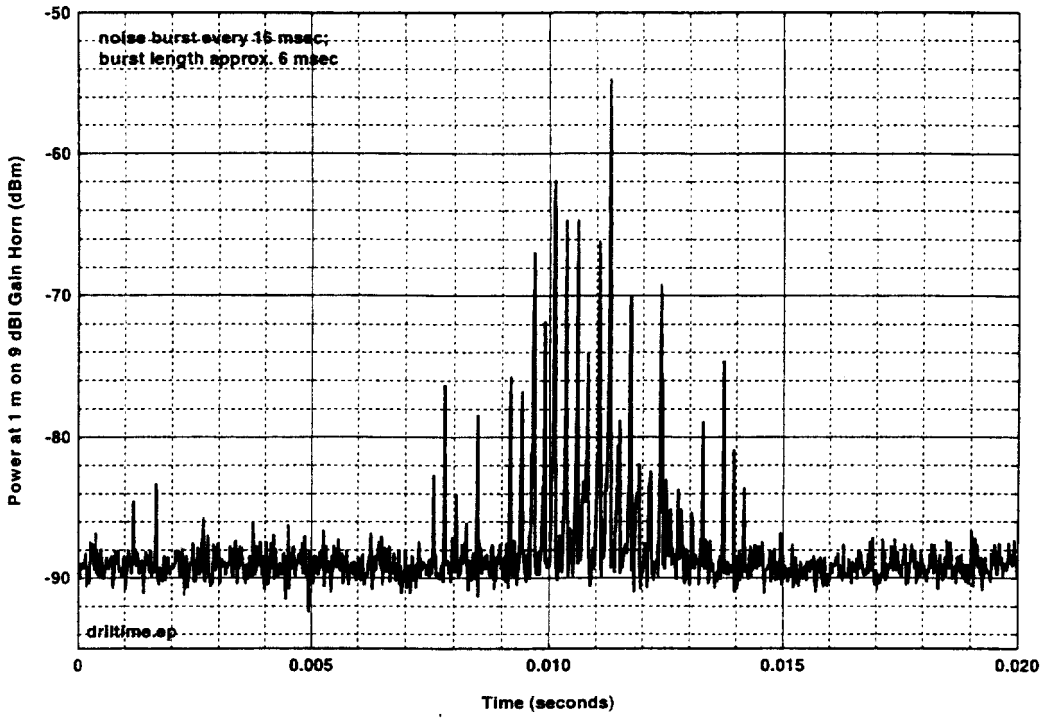

Figure D.F.5. Electric drill, time waveform in 3 MHz bandwidth, sample detected, for 20 msec.

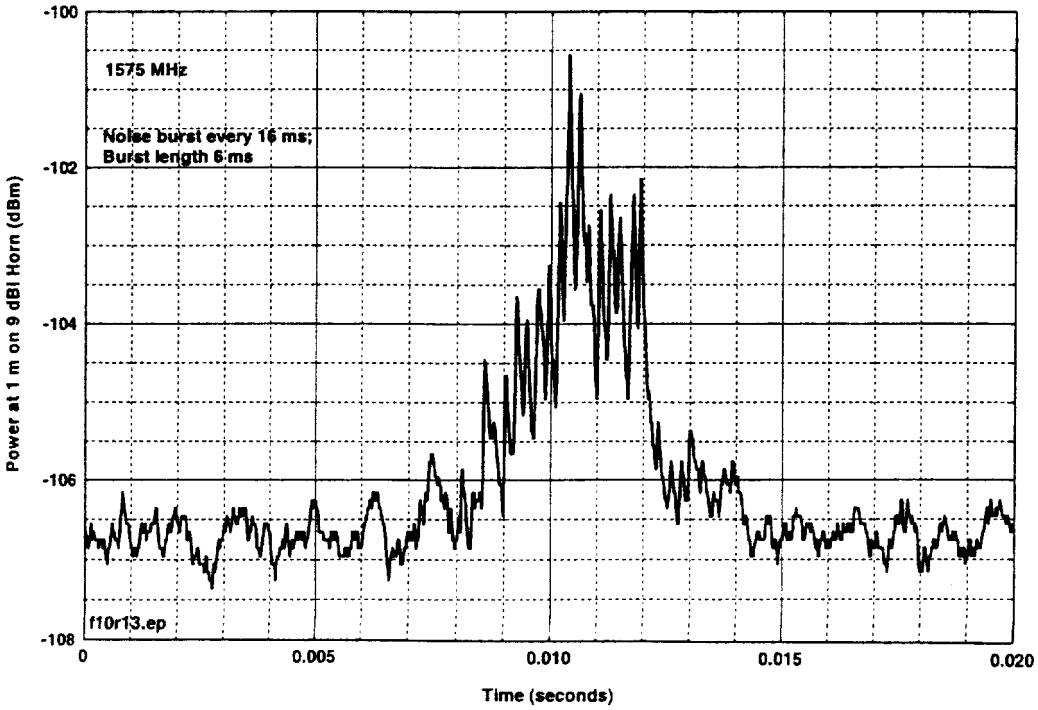

Figure D.F.6. Electric drill, Part 15 measurement, 1-MHz IF bandwidth, 1-kHz video bandwidth.

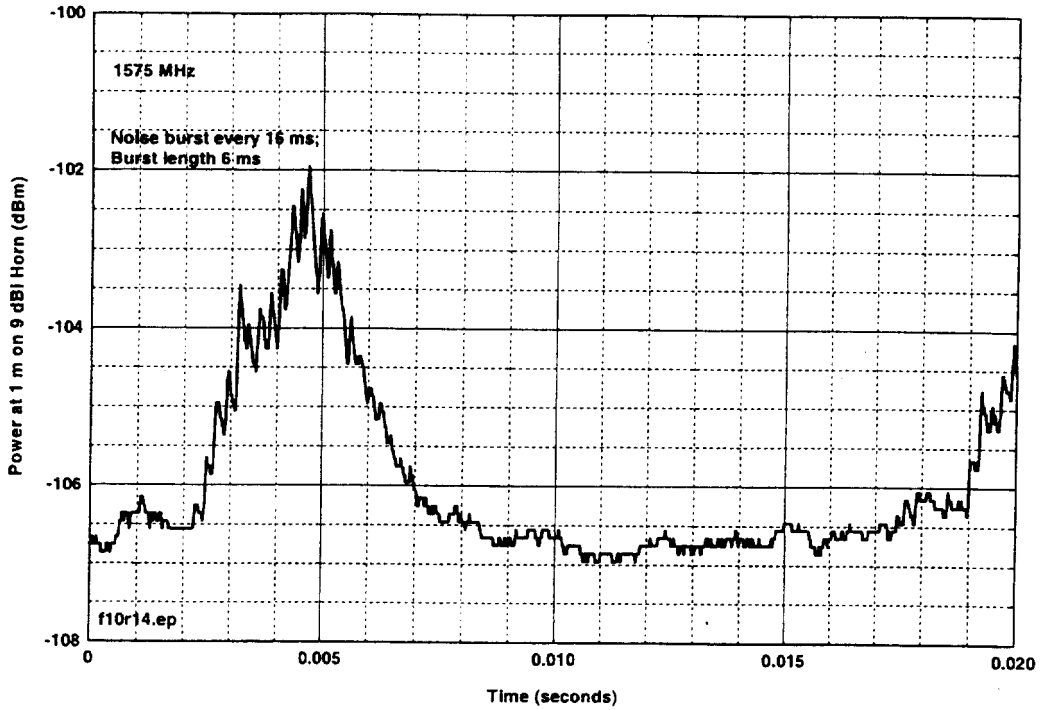

Figure D.F.7. Electric drill, Part 15 measurement, 1-MHz IF bandwidth, 300-Hz video bandwidth.

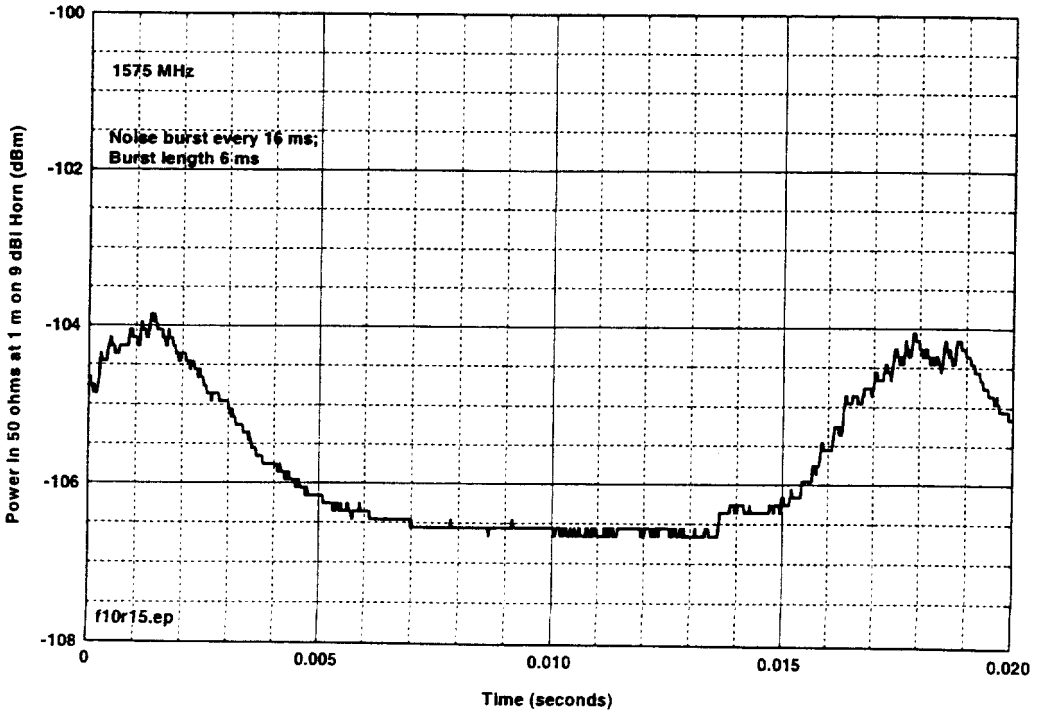

Figure D.F.8. Electric drill, Part 15 measurement, 1-MHz IF bandwidth, 100-Hz video bandwidth.

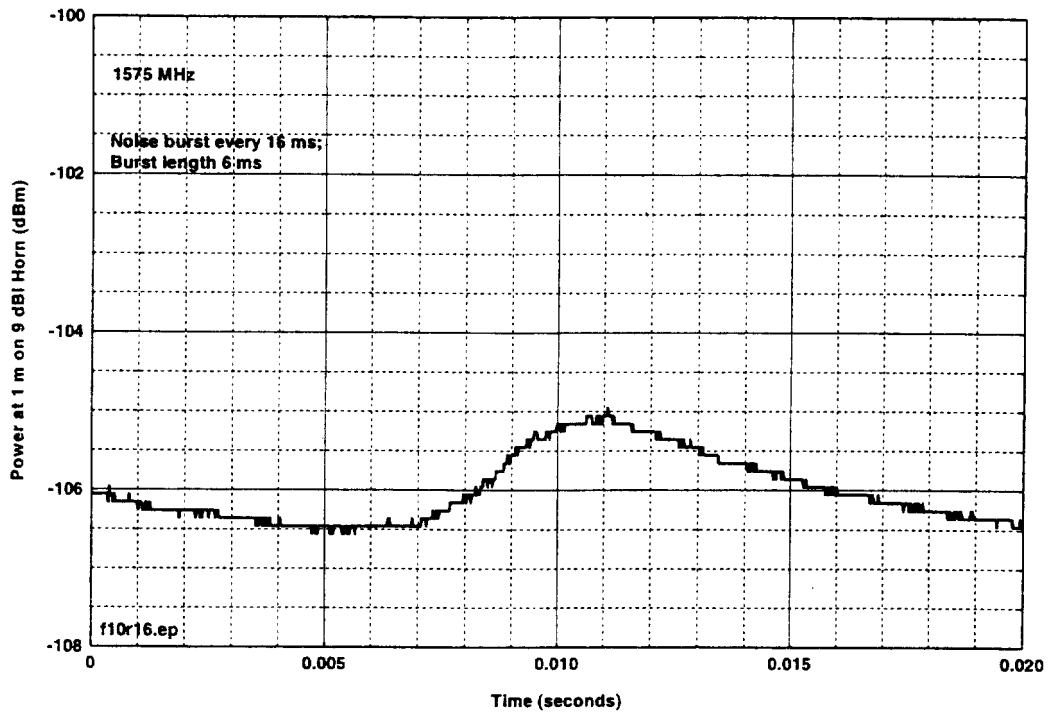

Figure D.F.9. Electric drill, Part 15 measurement, 1-MHz IF bandwidth, 30-Hz video bandwidth.

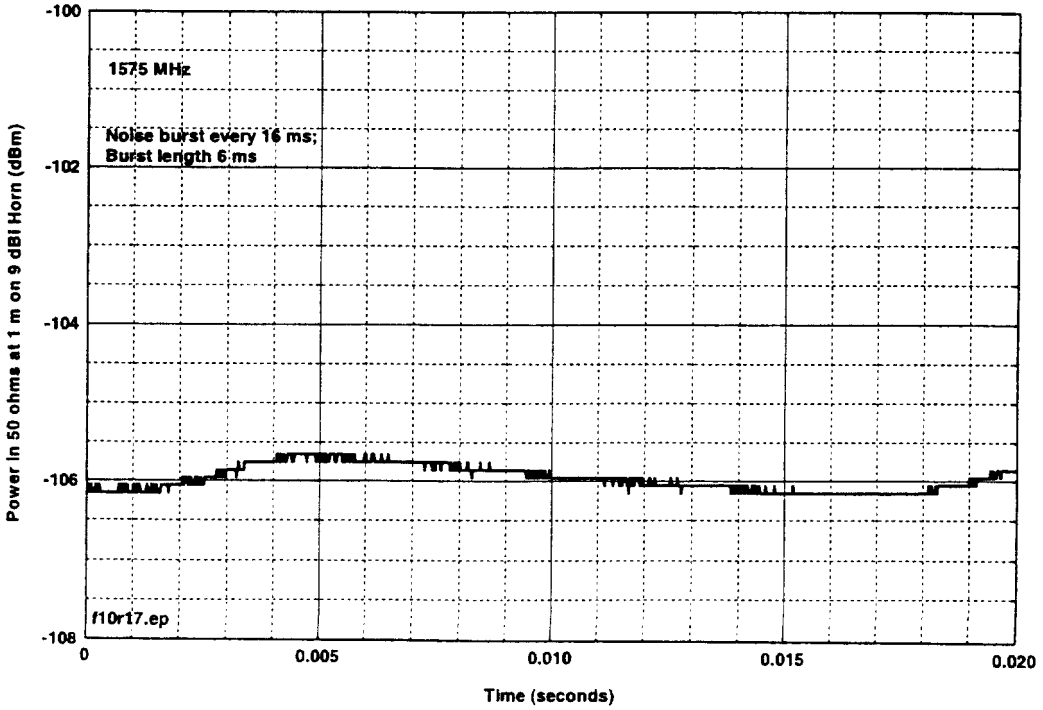

Figure D.F.10. Electric drill, Part 15 measurement, 1-MHz IF bandwidth, 10-Hz video bandwidth.

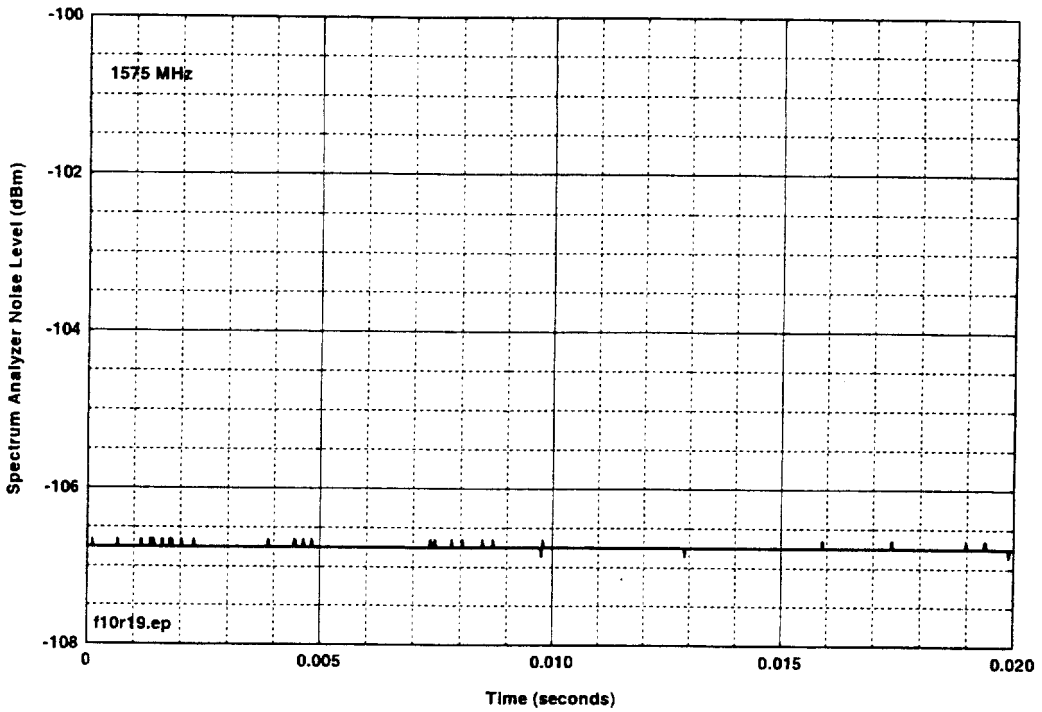

Figure D.F.11. Electric drill, terminated spectrum analyzer input with 1-MHz IF bandwidth, 10-Hz video bandwidth.

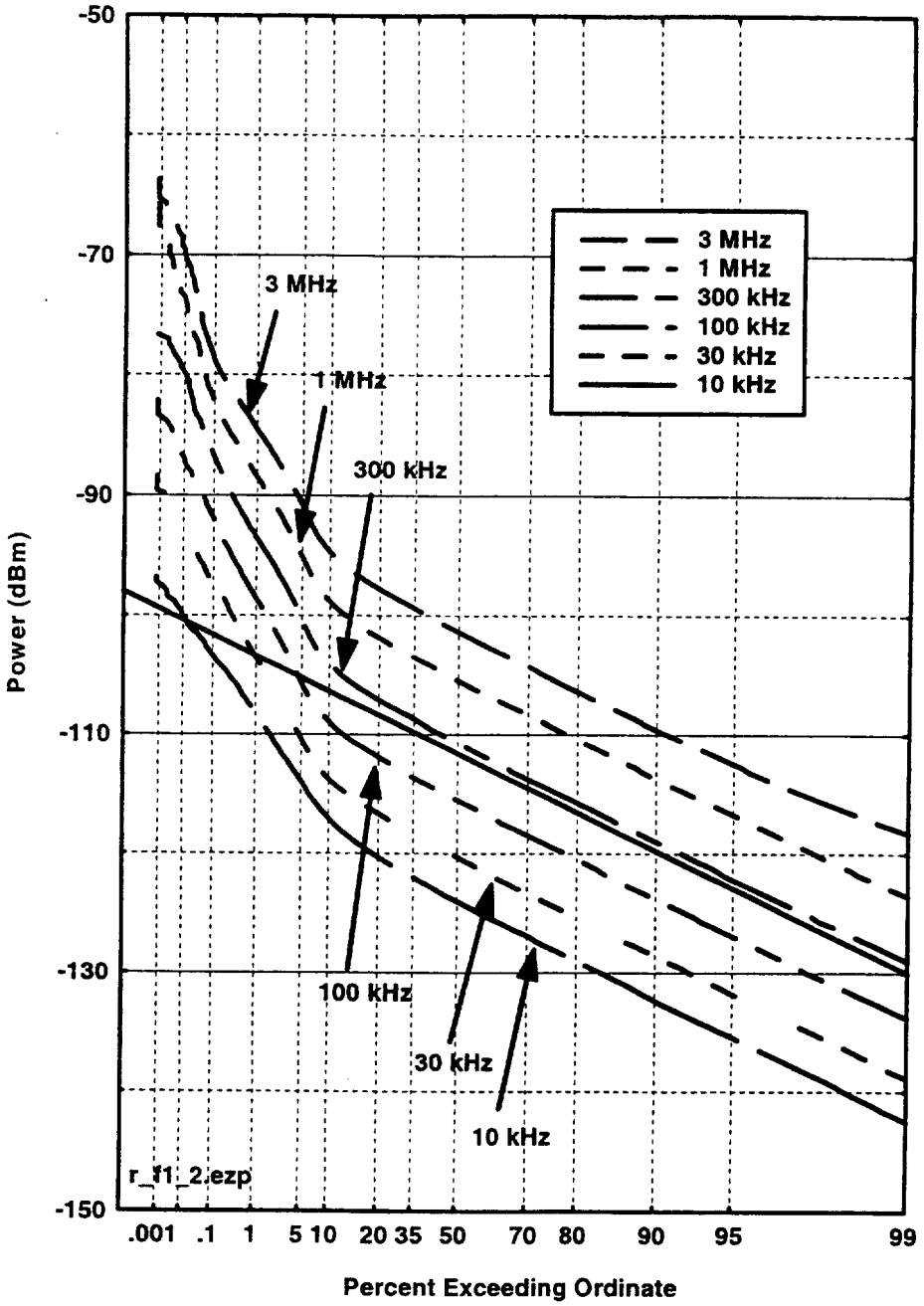

Figure D.F.12. Electric Drill, APDs.

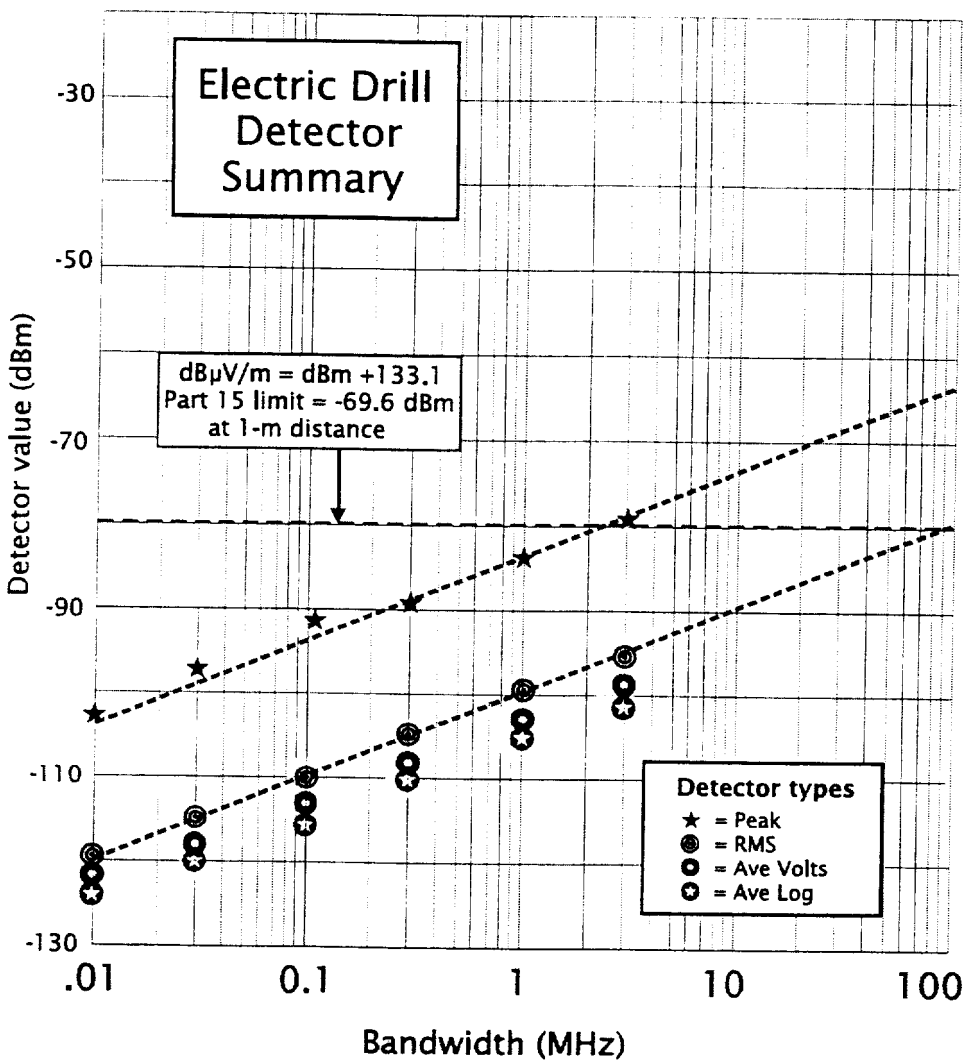

Figure D.F.13. Electric Drill, detector summary.

APPENDIX E. SUMMARY OF AGGREGATE MEASUREMENTS

Frank Sanders[1]

Device description. A pair of UWB pulsers were procured by ITS and operated for the purpose of assessing the emission levels in various IF bandwidths as a function of nominal pulse repetition rate (PRR), dither, and the number of pulsers in an aggregate. These pulsers produce UWB impulses at times precisely controlled by signals from an arbitrary waveform generator. Therefore, these pulsers can be controlled to provide a wide range of PRR, dither, and gating combinations, depending on the programming of the arbitrary waveform generators. An independent (and non-synchronized) generator was used to control each pulser.

Figure E.1 shows the measurement system used for the aggregate measurements.

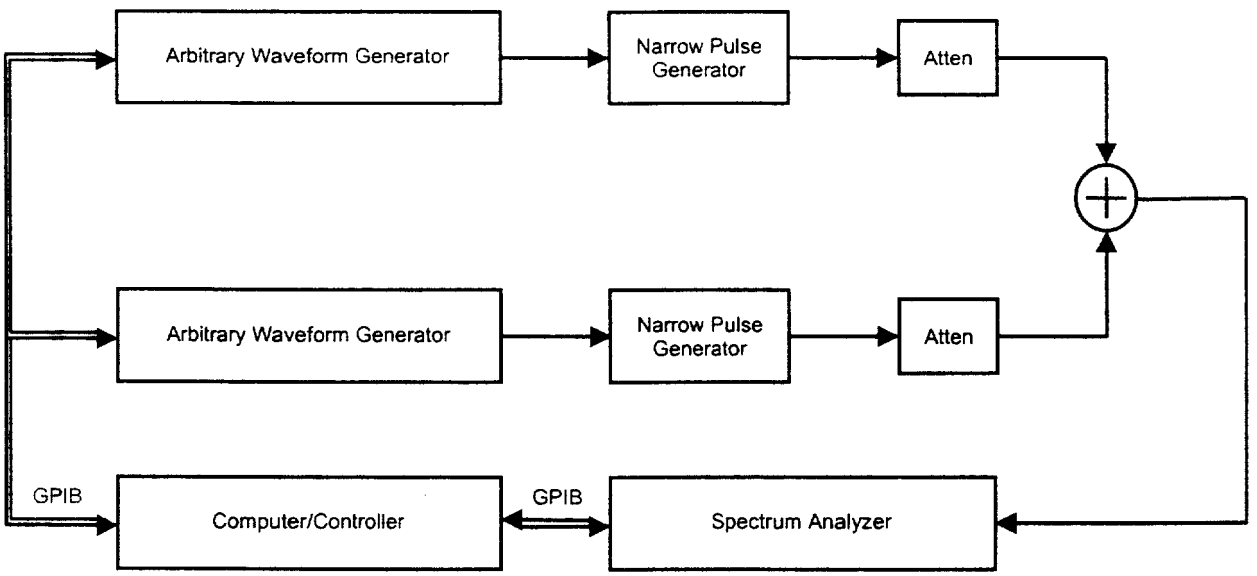

Figure E.1. Aggregate measurements block diagram.

Arbitrary waveform generators were programmed to give average PRRs of 100 kHz and 10 MHz, 50% dithered or non-dithered. This dithering is based on delay relative to a fixed time base. When both pulsers were in use, their respective wideband peak amplitudes were matched to within 0.2 dB.

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Measurement comments. The general technique for investigating aggregate UWB signals was to independently measure APDs from each of two UWB sources, then combine the UWB sources and measure an APD from the combined sources. This technique was followed for all of the aggregate measurements, with the only variable being the modulation parameters of two UWB signals.

Figures E.2 and E.3 show the wide range peak emission spectra of single pulsers using a 100-kHz PRR and 50% dithering, and a 10-MHz PRR and 50% dithering, respectively. Figure E.4 shows the peak bandwidth progression for a pulser with 10 MHz PRR and 50% dithering.

Figure E.5 shows video-averaged measurements for a single dithered pulser (10 MHz PRR, 50% dither) and for two such pulsers. The measured signal for two pulsers increased 2.6 dB over the level for a single pulser. This falls within the precision of the measurement for the expected 3-dB increase.

Figure E.6 shows APDs measured in a 1-MHz bandwidth for a single pulser and two pulsers. Each pulser produced a signal with10-MHz PRR and 50% dither. The APDs for the individual pulsers appeared Gaussian. The APD for the two pulsers also appeared Gaussian, but was raised about 3 dB from the individual pulser APD, as theory predicts.

Figure E.7 shows APDs measured in a 1-MHz bandwidth for a single pulser and two pulsers. Each pulser produced a non-dithered signal with 100-kHz PRR. The two-pulser APD shows a stepped high-amplitude plateau, where the lower step is equal in amplitude to the single pulser APD, but with about 1.5-2 times the percentage duration (depending on what amplitude is used to compare the duration). In addition, there is a very-small-percentage step that is about 6 dB higher than the single pulser maximum amplitude, which is consistent with impulses from the two pulsers occasionally overlapping and combining coherently.

Figure E.8 shows a 1-MHz APD that was derived from the combination of one pulser with 10-MHz PRR (dithered) and one pulser with 100-kHz PRR (non-dithered). The APD shows an approximately Gaussian character, which should be expected considering that the non-dithered 100-kHz pulser produced only 1% as many impulses as the 10-MHz dithered pulser.

Figure E.9 shows APDs measured in a 1-MHz bandwidth for a single pulser and two pulsers. Each pulser produced a signal with 100-kHz PRR and 50% dithering. Since the UWB pulses remain non-overlapping in the 1-MHz bandwidth, the resulting APDs are identical to the APDs measured in Figure E.7.

Table E.1 shows the detector values for the various APDs.

Table E.1 - Detector Values for Aggregate Tests

Figure	Source	PRR	Dither	Avg Log	Avg volt	RMS	Peak
Figure E.6	#1	10 MHz	50%	-49.2	-47.9	-46.9	-39
	#2	10 MHz	50%	-49.2	-47.9	-46.9	-39
	#1 & #2	- - -	- - -	-46.5	-45.1	-44.1	-36.5
Figure E.7	#1	100 kHz	none	-87.2	-76.6	-67.9	-54
	#2	100 kHz	none	-87.2	-76.6	-67.9	-54
	#1 & #2	- - -	- - -	-84.1	-72.1	-65.2	-49
Figure E.8	#1	10 MHz	50%	-49.2	-47.9	-46.9	-39
	#2	100 kHz	none	-87.2	-76.6	-67.9	-54
	#1 & #2	- - -	- - -	-49.2	-47.9	-46.9	-39
Figure E.9	#1	100 kHz	50%	-86.9	-76.6	-67.9	-54
	#2	100 kHz	50%	-86.9	-76.6	-67.9	-54
	#1 & #2	- - -	- - -	-84.0	-72.1	-65.2	-49

The measurement results can be summarized as follows:

1. Noise-like signals with Gaussian APD characteristics (10-MHz PRR, 50% dither) add together to give noise-like signals with Gaussian APD characteristics (Figure E.6). All detector values increased by approximately 3 dB when two equal UWB Gaussian signals were added.

2. A noise-like signal with Gaussian APD characteristics added to a weaker (20 dB weaker) impulsive signal produced a signal with a Gaussian APD characteristic (Figure E.8). The difference in detector values was not apparent, though this may have been caused by limited measurement system resolution.

3. Impulsive signals added to impulsive signals (Figures E.7 and E.8) produced APDs that were less impulsive that the original signals. Dithering of signals in an impulse environment (i.e., measurement bandwidth greater than the combined PRR) produced similar results to non-dithered signals. The combined signals produced APDs with approximately twice the total percentage pulse duration as the original pulses at the same amplitude, as well as a small percentage of pulses with amplitudes as much as 6 dB higher than the original pulses. The detector values were generally about 3 dB higher for the combined signals (except 6 dB increase for peak).

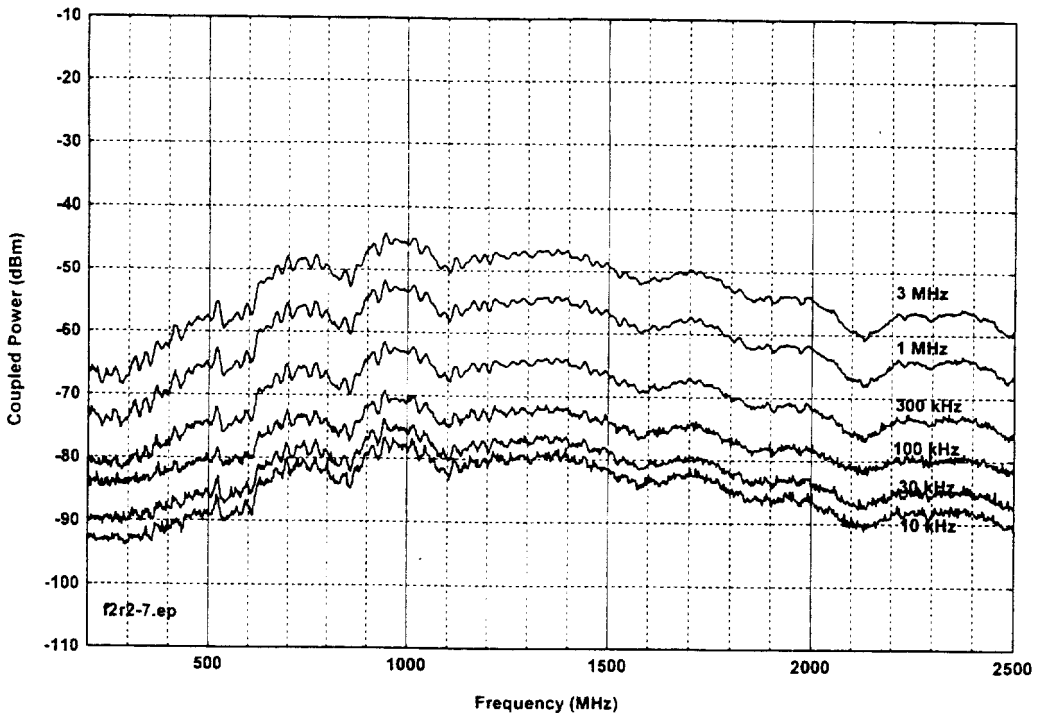

Figure E.2. Spectrum analyzer emissions spectra from 100-kHz PRR, 50% dither pulser.

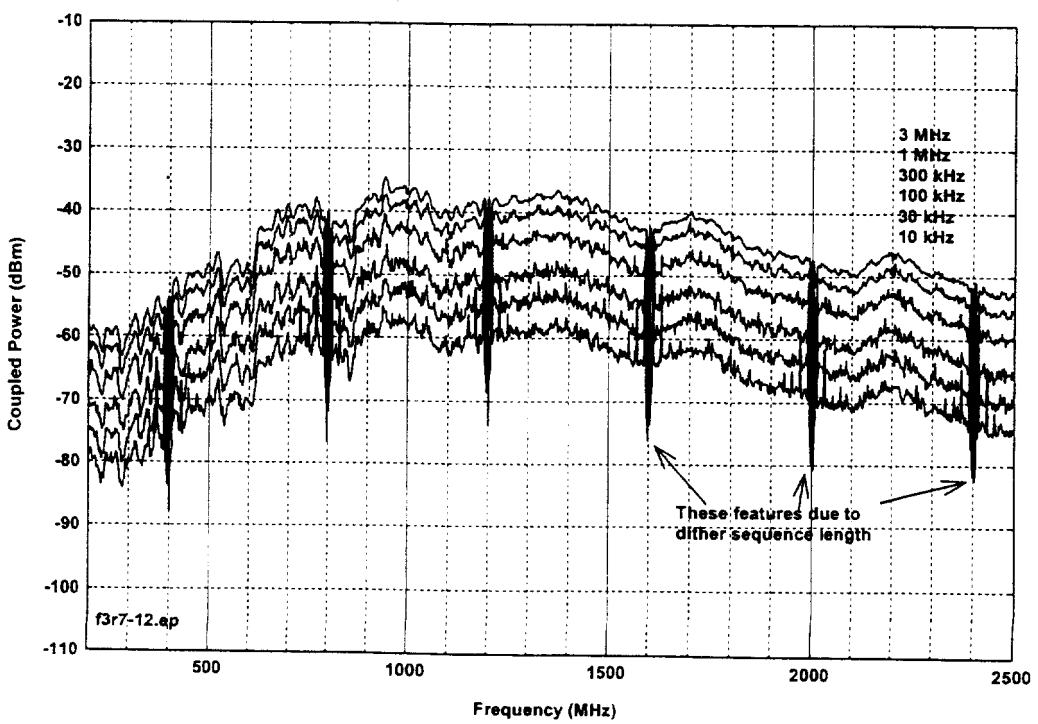

Figure E.3. Spectrum analyzer emission spectra from 10-MHz PRR, 50% dither pulser.

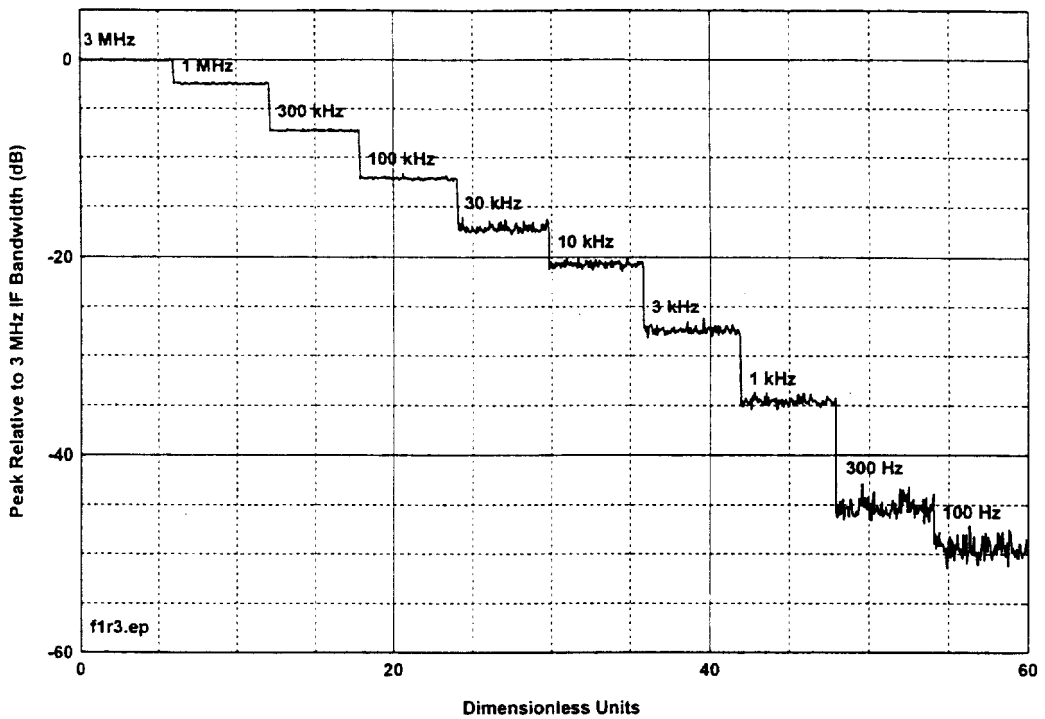

Figure E.4. Peak bandwidth progression stairstep for 10-MHz PRR, 50% dither pulser.

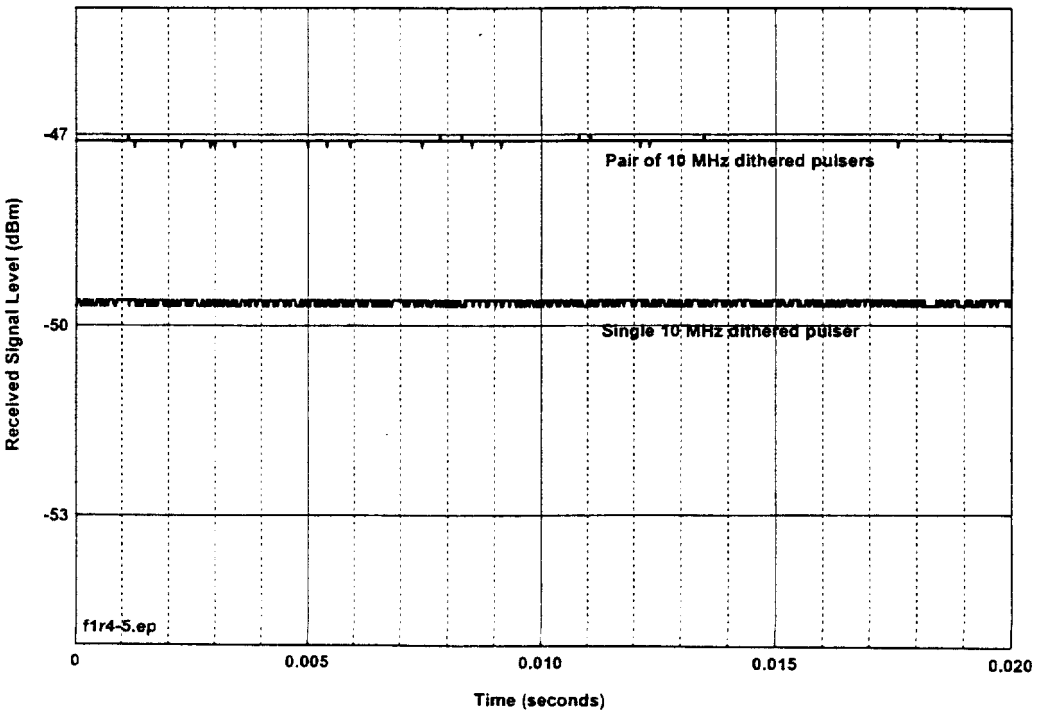

Figure E.5. Video signal from single and double pulsers, each at 10 MHz PRR, 50% dither.

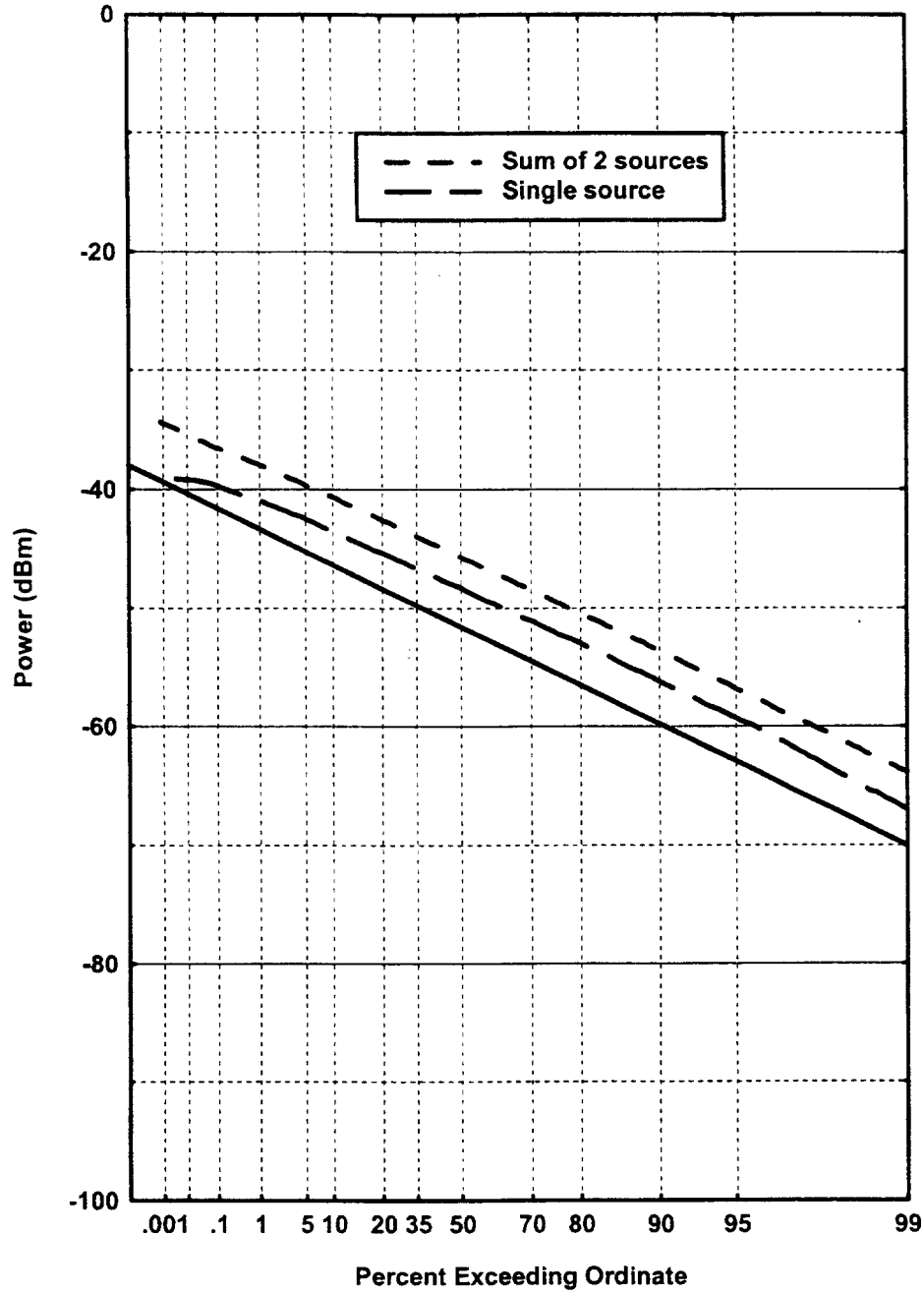

Figure E.6. 1-MHz APD for single and double 10-MHz, 50% dither pulser.

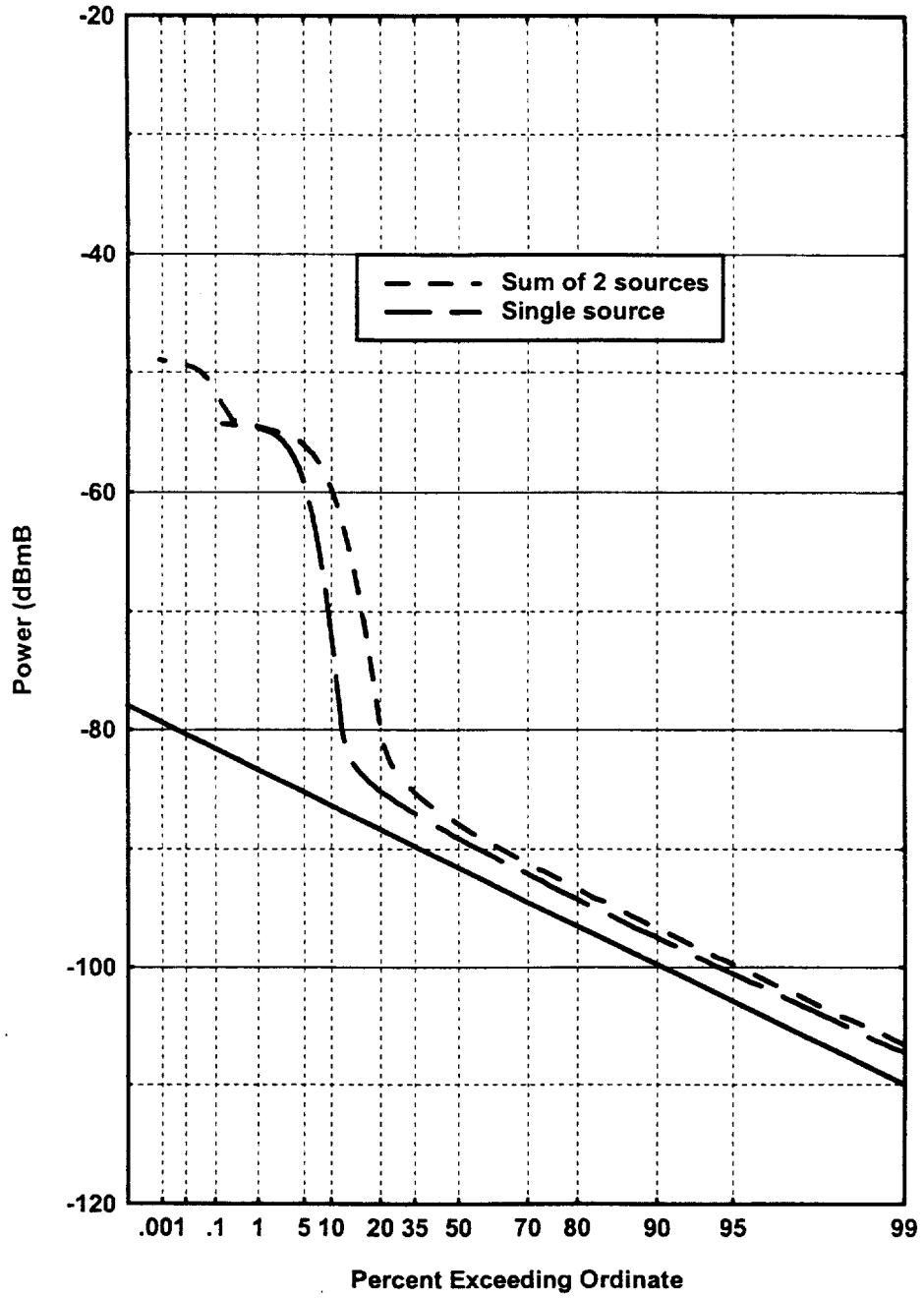

Figure E.7. 1-MHz APD for single and double 100-kHz PRR, non-dither pulsers.

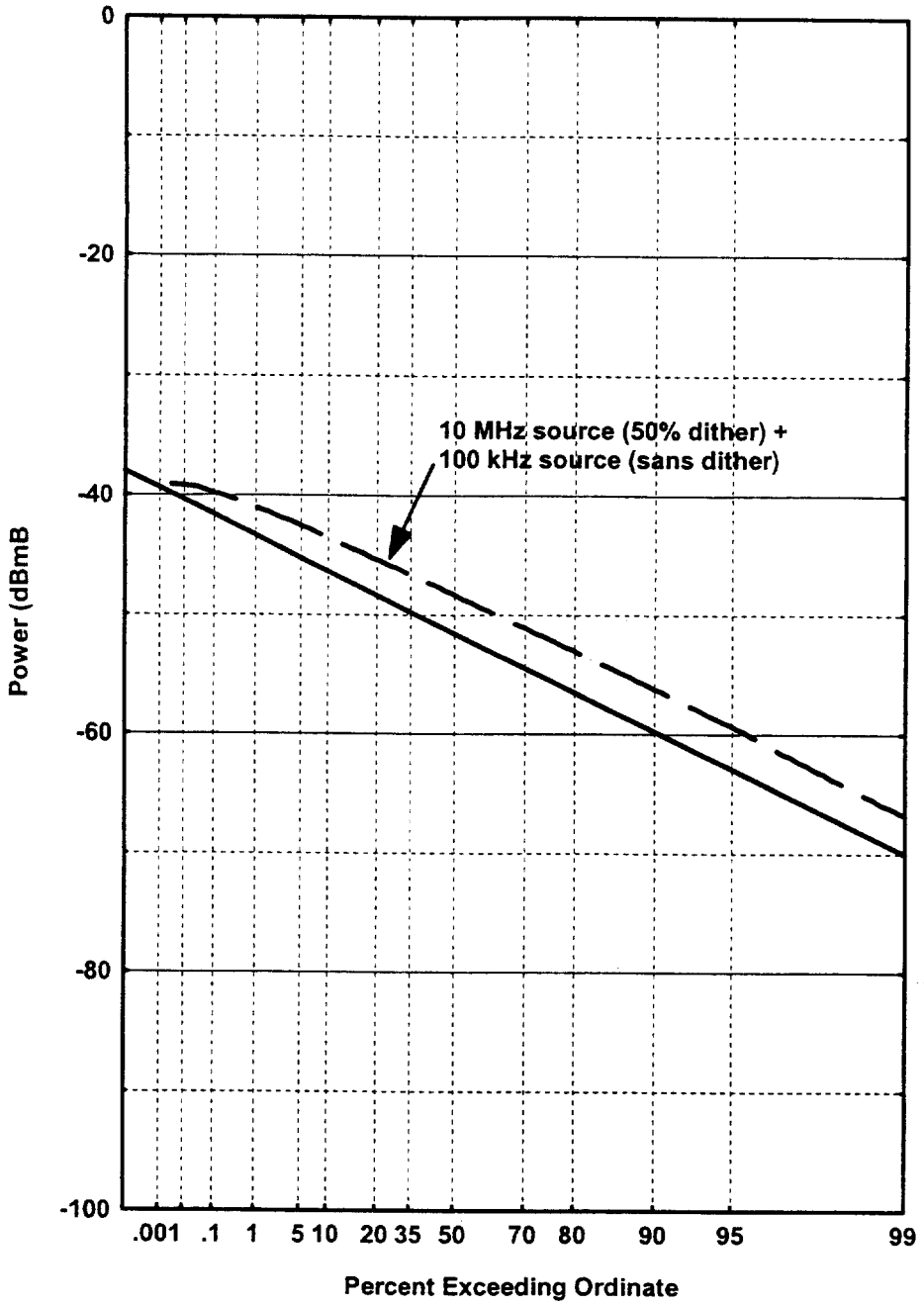

Figure E.8. 1-MHz APD for a 10-MHz PRR, 50% dither pulser and a 100-kHz, non-dithered pulser.

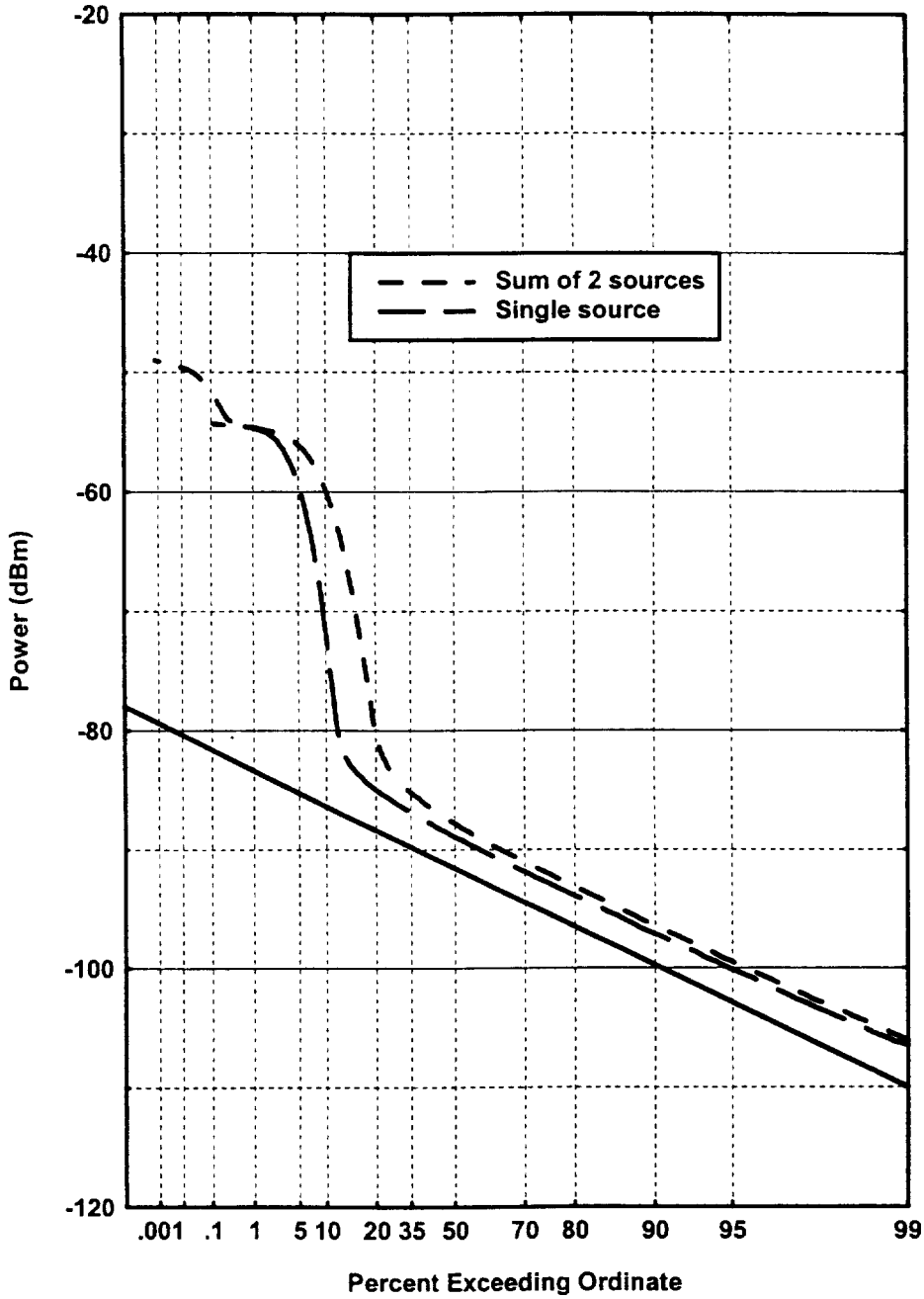

Figure E.9. 1-MHz APDs for single and double 100-kHz PRR 50% dithered pulsers.