

APPENDIX A

MEASUREMENT ANTENNA HEIGHT

A.1 INTRODUCTION

Section A.2 describes NTIA's Numerical Electromagnetics Code (NEC) simulation results showing the height where the peak field strength is expected in close proximity to an Access Broadband over Power Line (BPL) system operating on overhead Medium Voltage (MV) power lines. Section A.3 shows the effectiveness of the 1 meter measurement height in estimating the peak field strength at frequencies between 1.7 and 30 MHz. Section A.4 provides results from simulations performed in the 30 – 50 MHz range, using the 1 to 4 meter measurement height range defined in the compliance measurement guidelines for Access BPL systems operating above 30 MHz. In Section A.5, the optional 5-dB height correction factor for measurements at a 1 meter height is compared to the use of the 1 to 4 meter measurement height for the various power line simulations at frequencies above 30 MHz.

A.2 HEIGHT OF PEAK FIELD STRENGTH

Figures A-1 through A-18 show the heights where the peak electric field strength occurred over the frequency range of 2 to 50 MHz for the NEC power line models described in Section 2.2. The height of the modeled power lines was 12 meters. These results assume field strength values are calculated at a horizontal distance of 10 meters.

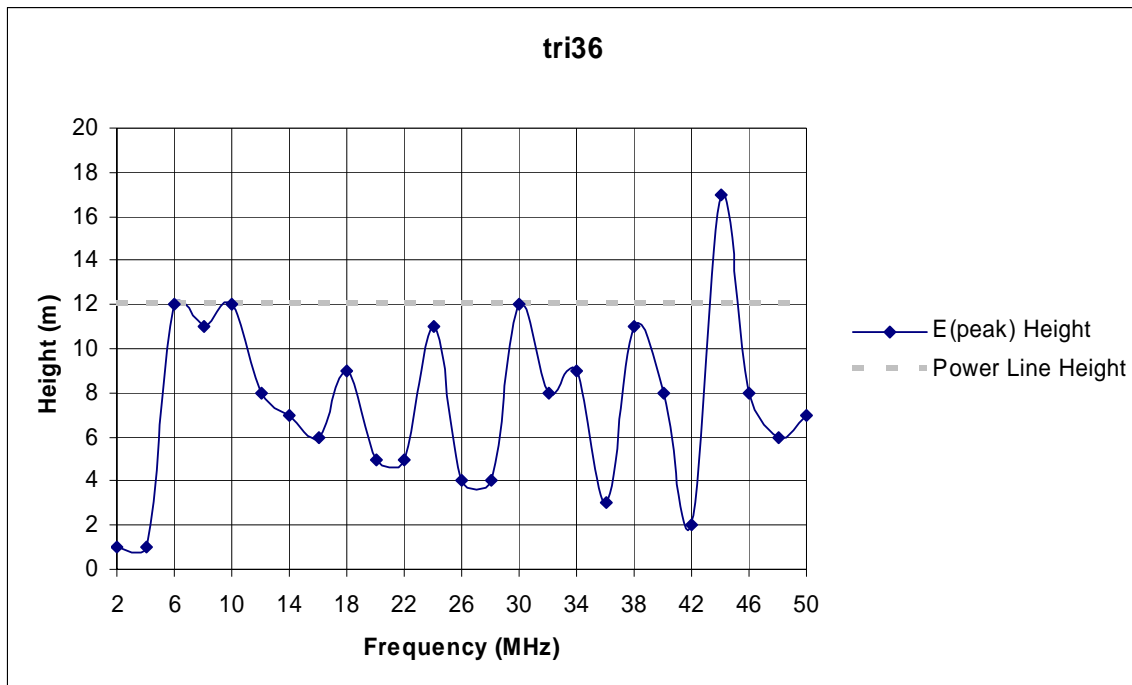


Figure A-1: Height corresponding to peak electric field strength as a function of frequency

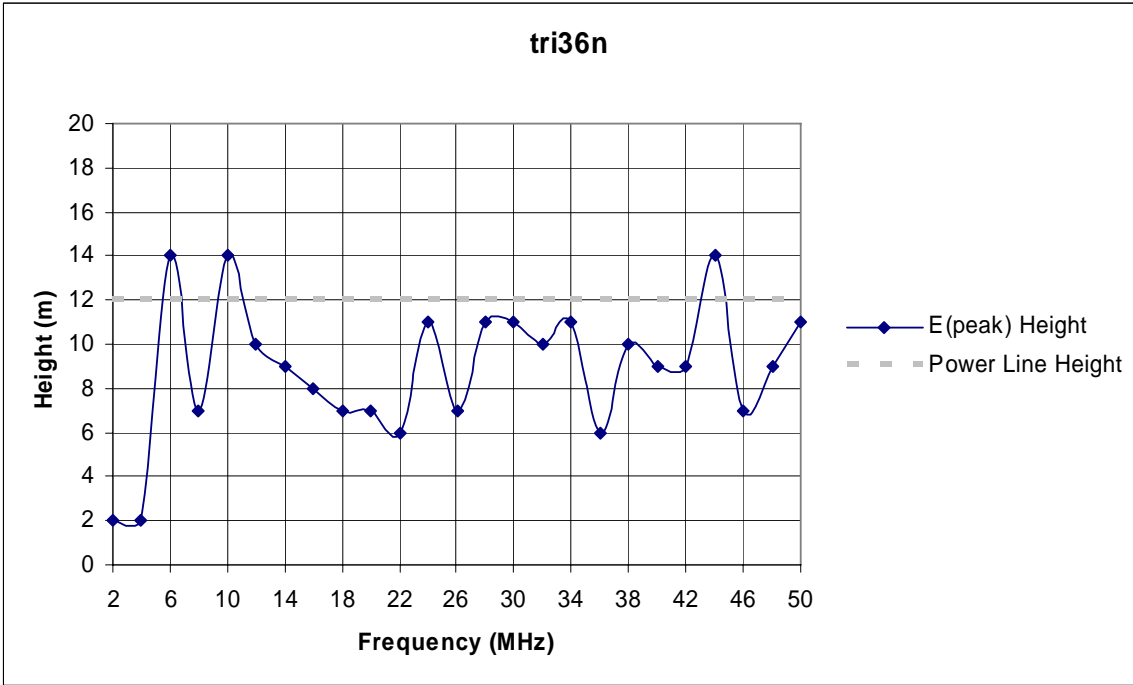


Figure A-2: Height corresponding to peak electric field strength as a function of frequency

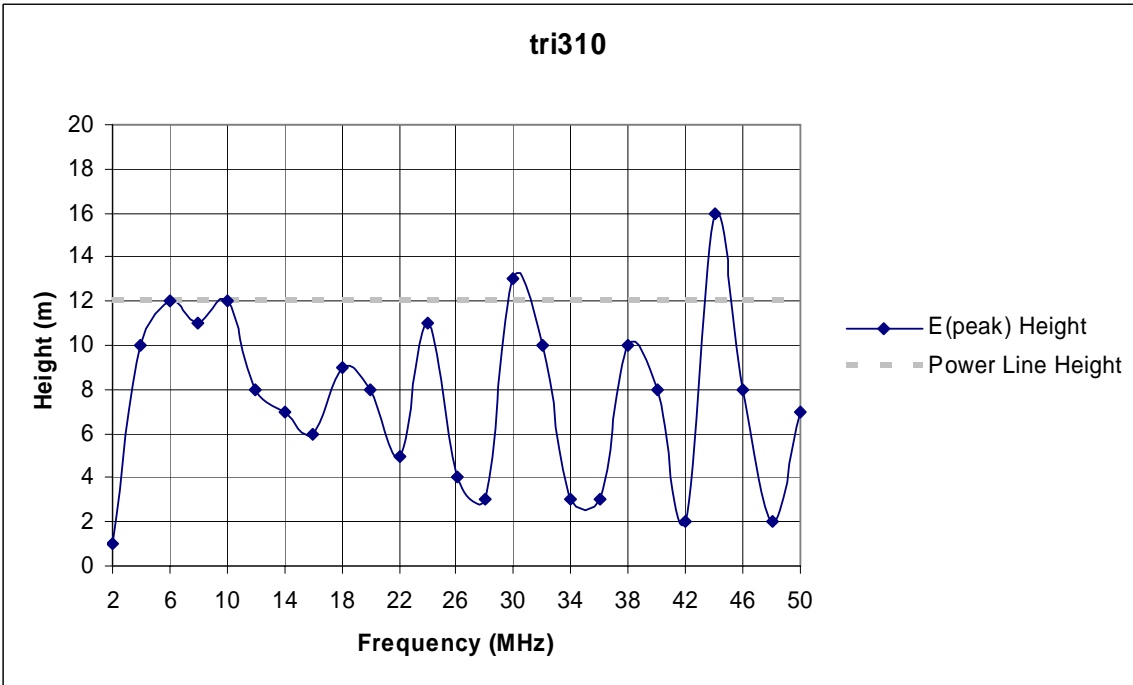


Figure A-3: Height corresponding to peak electric field strength as a function of frequency

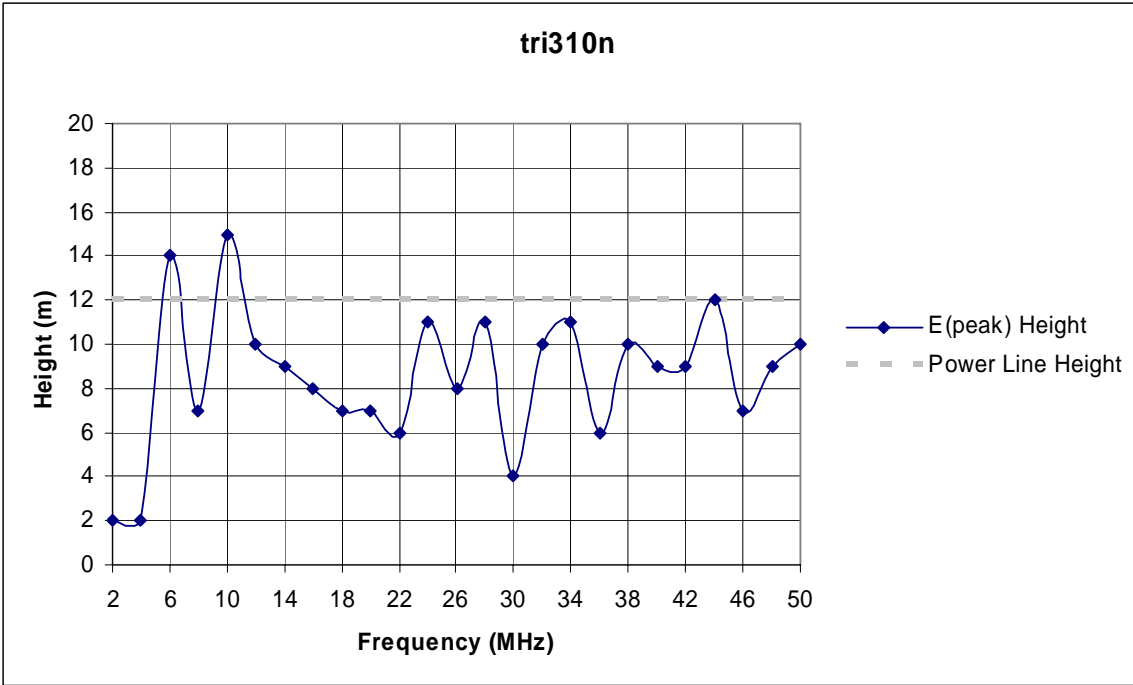


Figure A-4: Height corresponding to peak electric field strength as a function of frequency

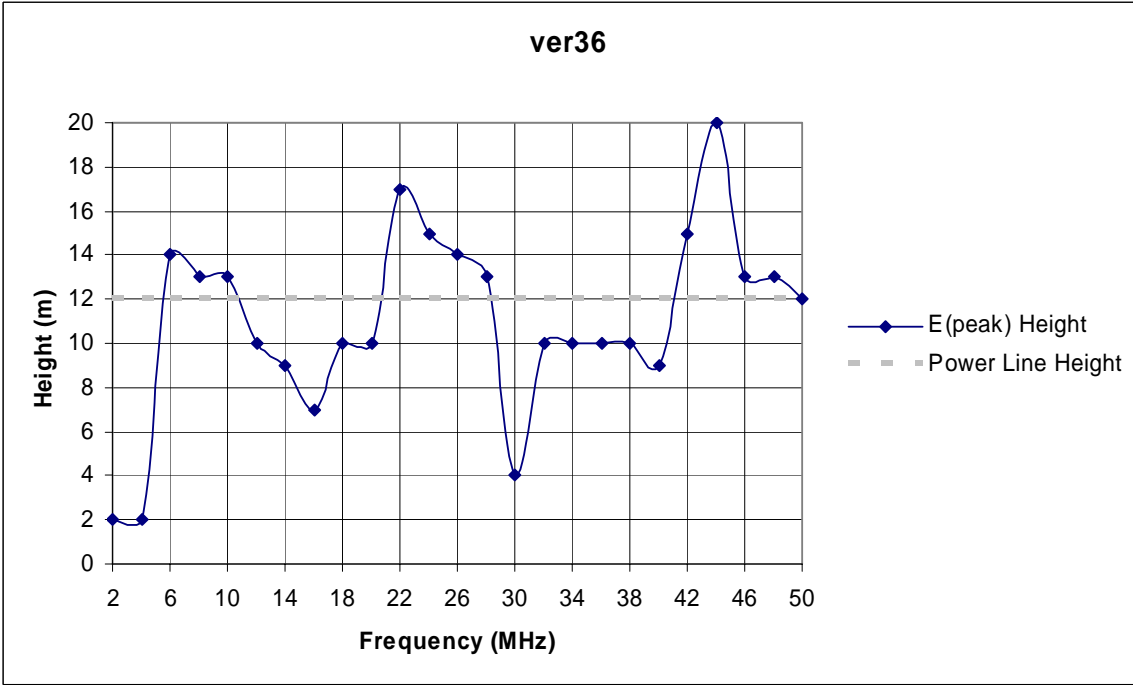


Figure A-5: Height corresponding to peak electric field strength as a function of frequency

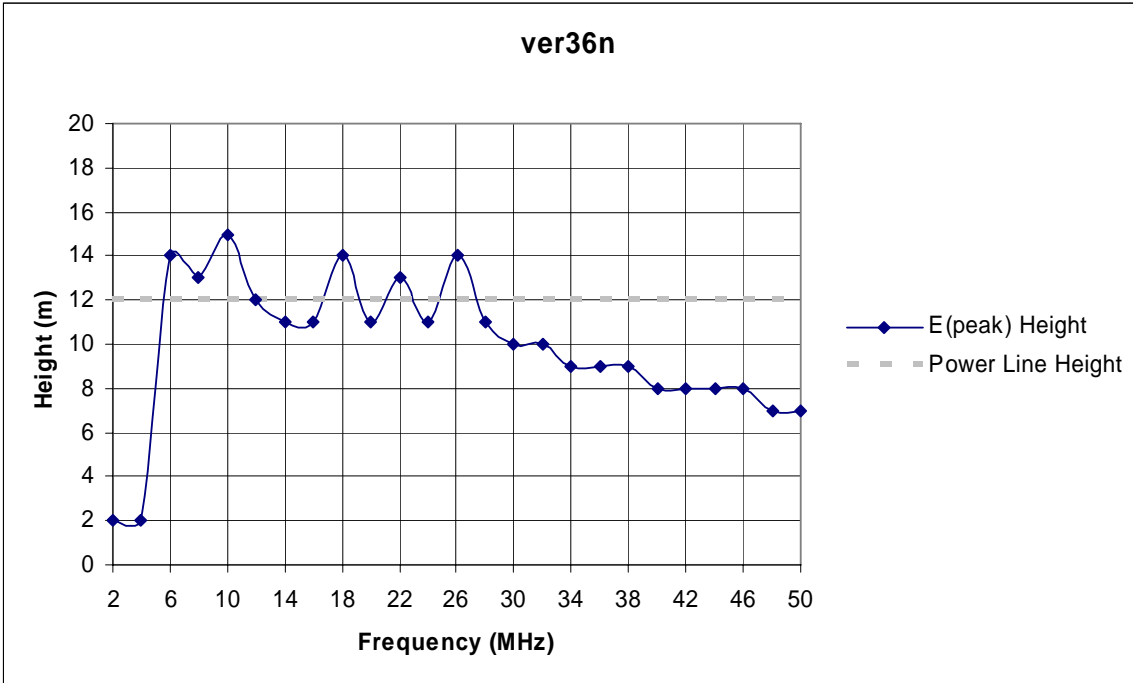


Figure A-6: Height corresponding to peak electric field strength as a function of frequency

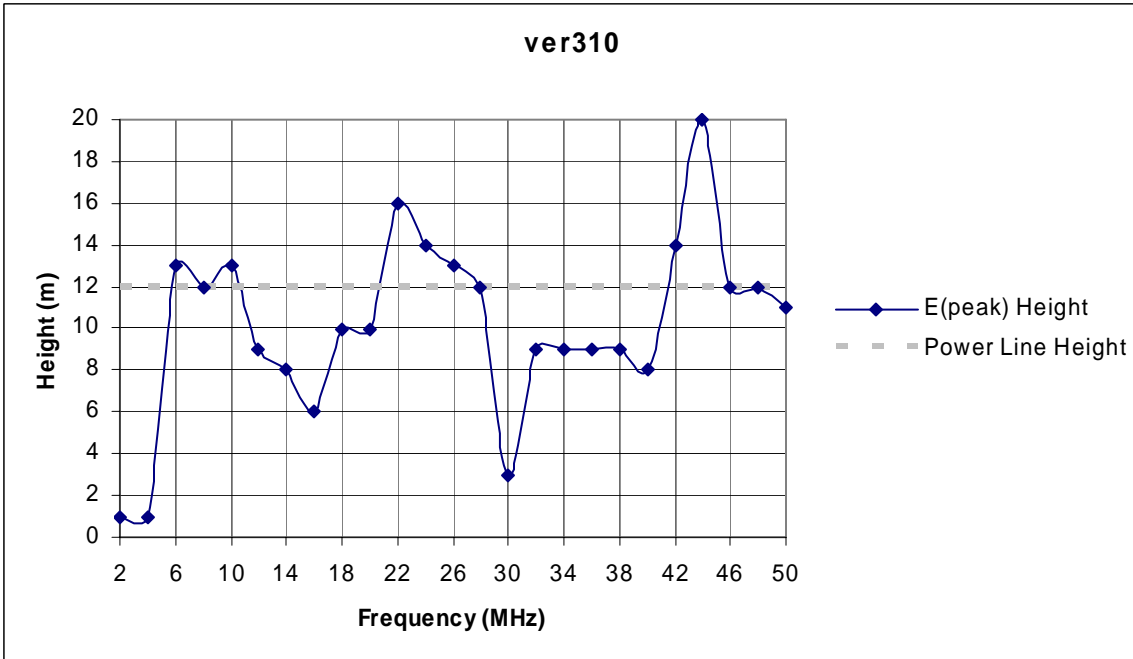


Figure A-7: Height corresponding to peak electric field strength as a function of frequency

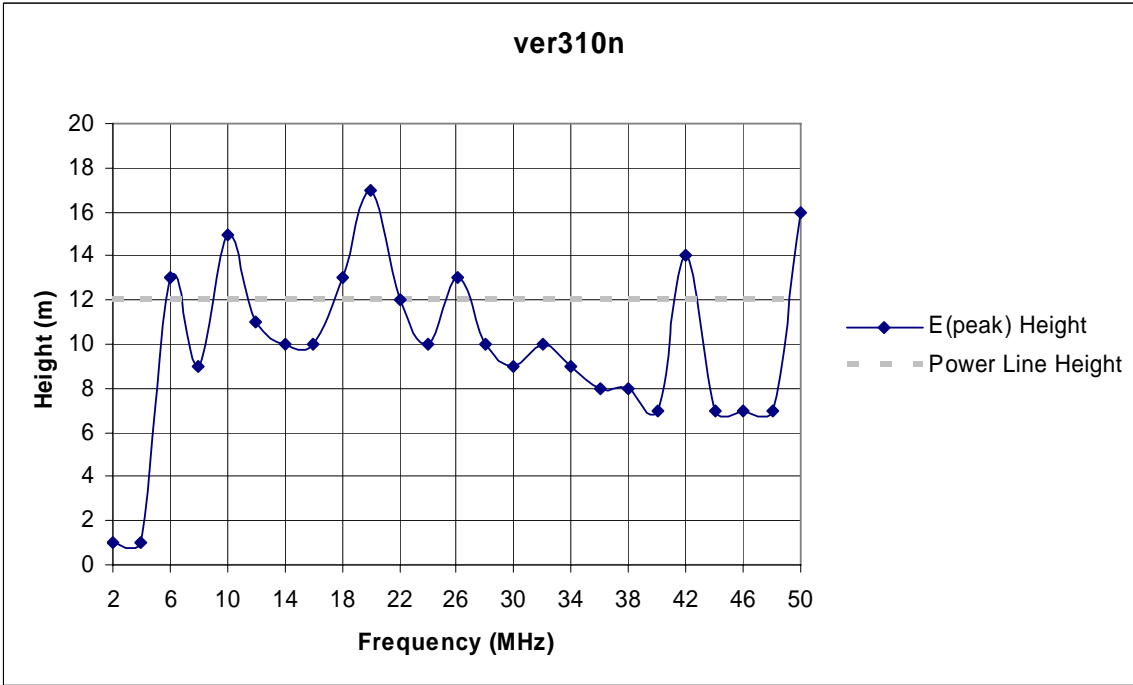


Figure A-8: Height corresponding to peak electric field strength as a function of frequency

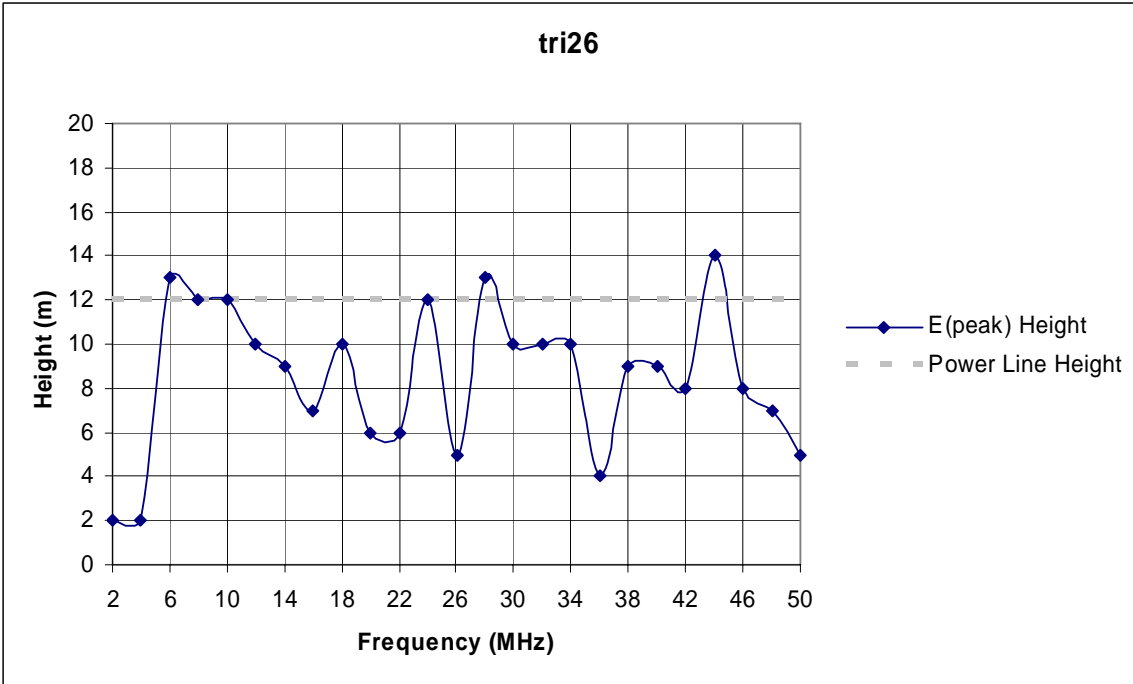


Figure A-9: Height corresponding to peak electric field strength as a function of frequency

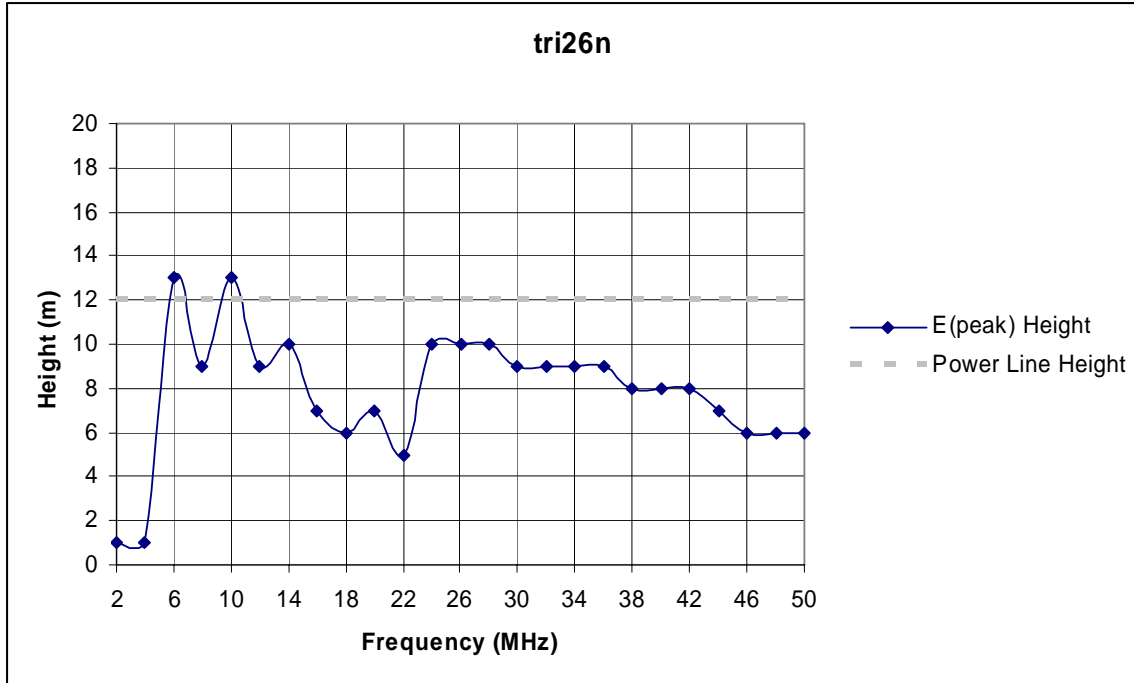


Figure A-10: Height corresponding to peak electric field strength as a function of frequency

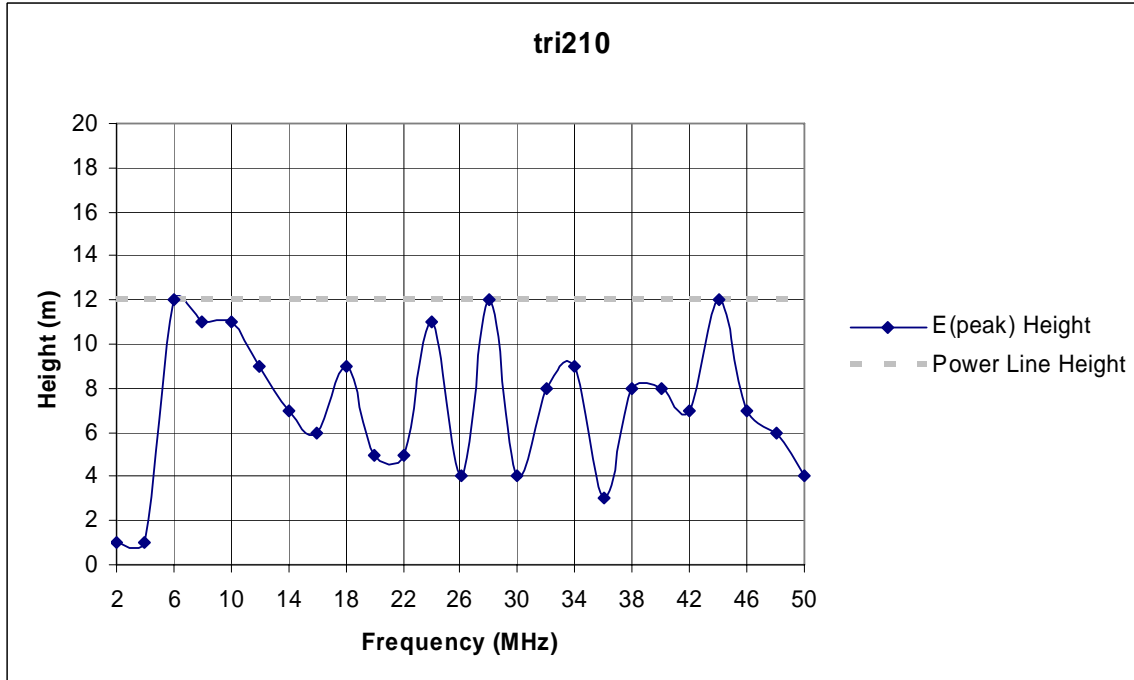


Figure A-11: Height corresponding to peak electric field strength as a function of frequency

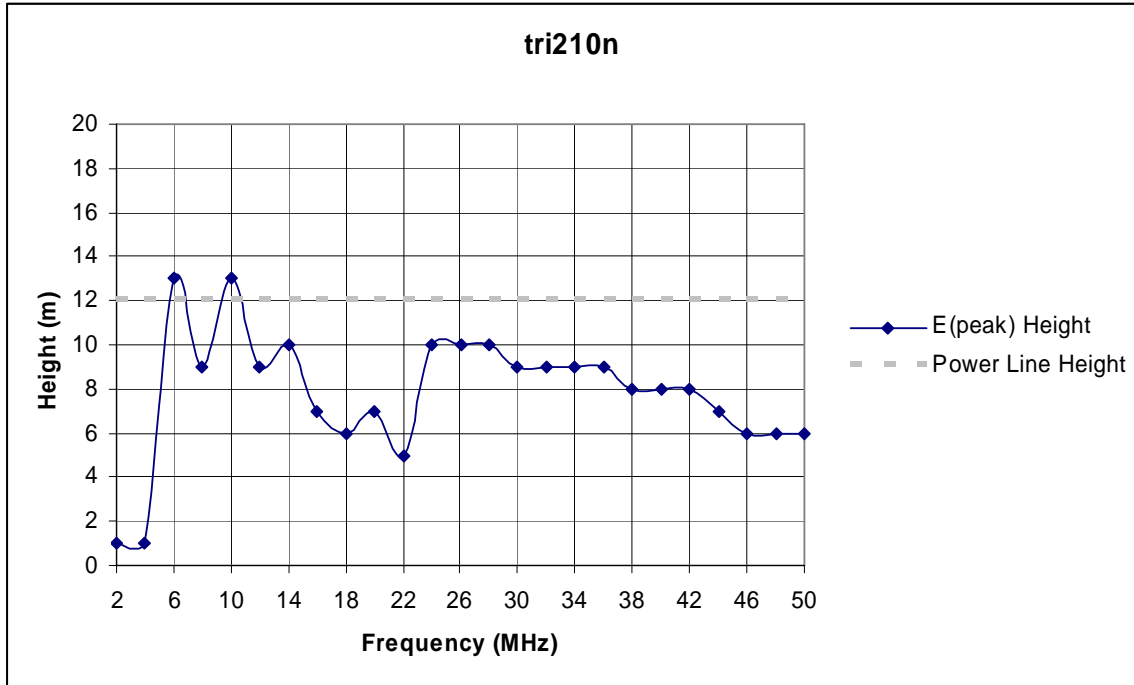


Figure A-12: Height corresponding to peak electric field strength as a function of frequency

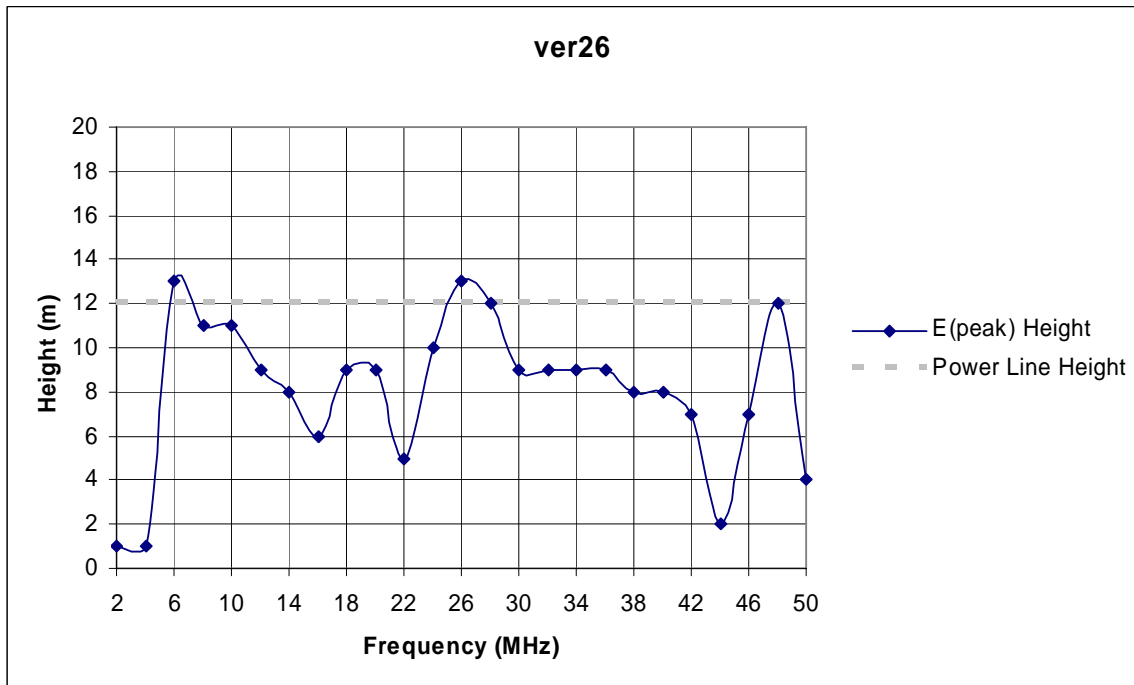


Figure A-13: Height corresponding to peak electric field strength as a function of frequency

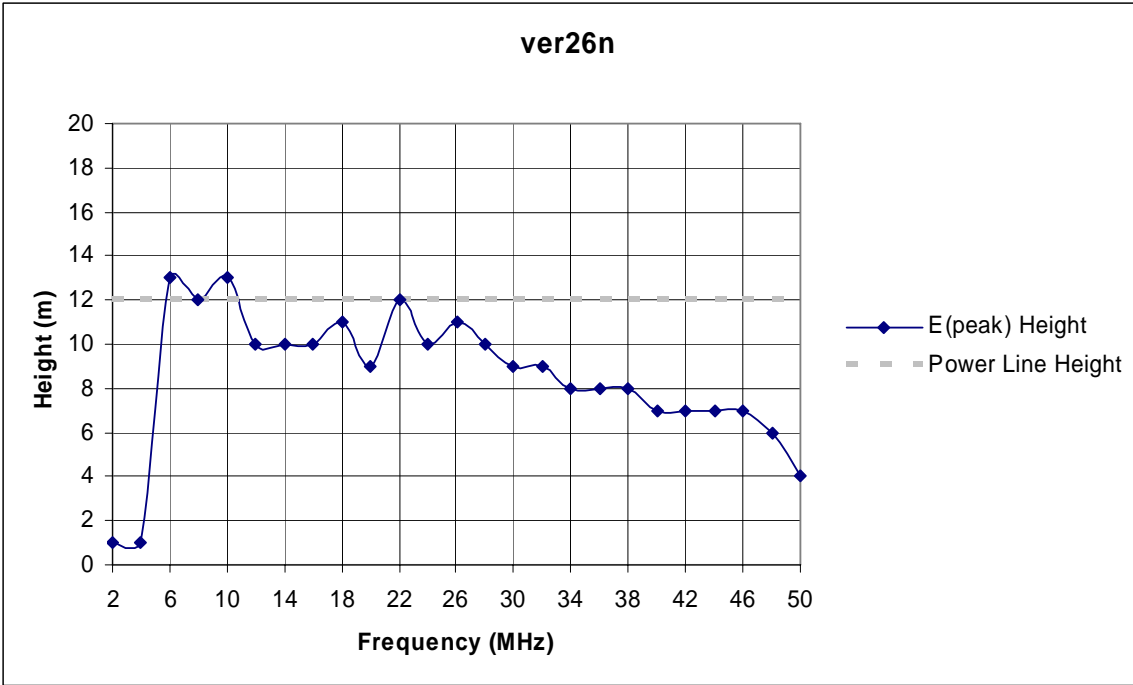


Figure A-14: Height corresponding to peak electric field strength as a function of frequency

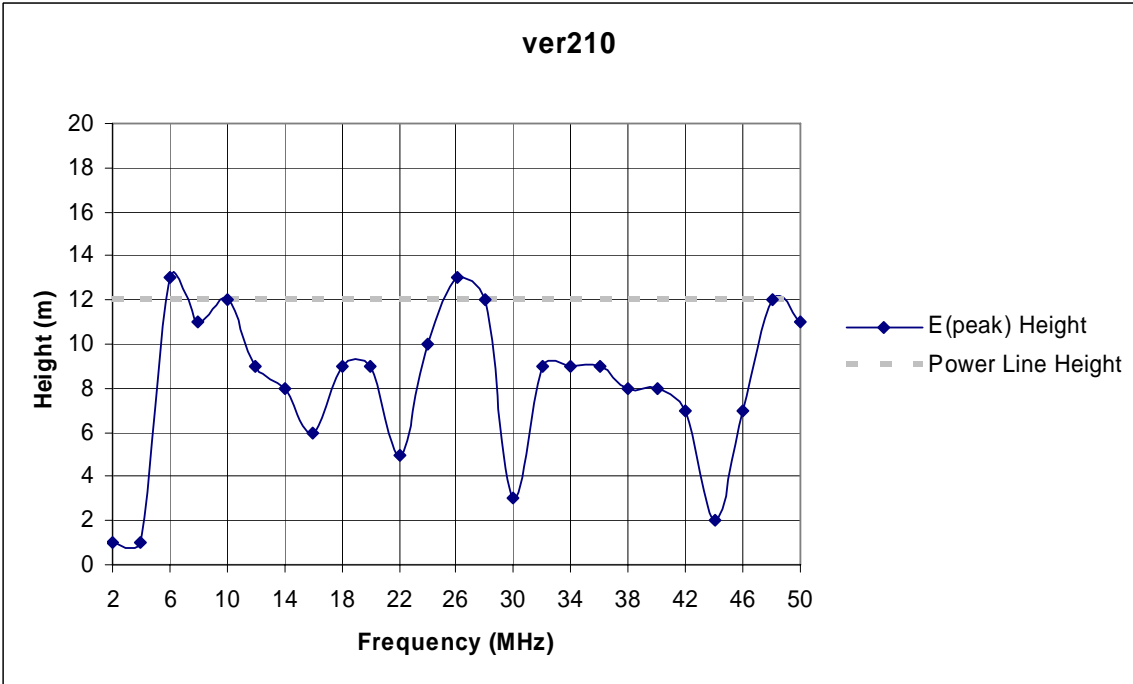


Figure A-15: Height corresponding to peak electric field strength as a function of frequency

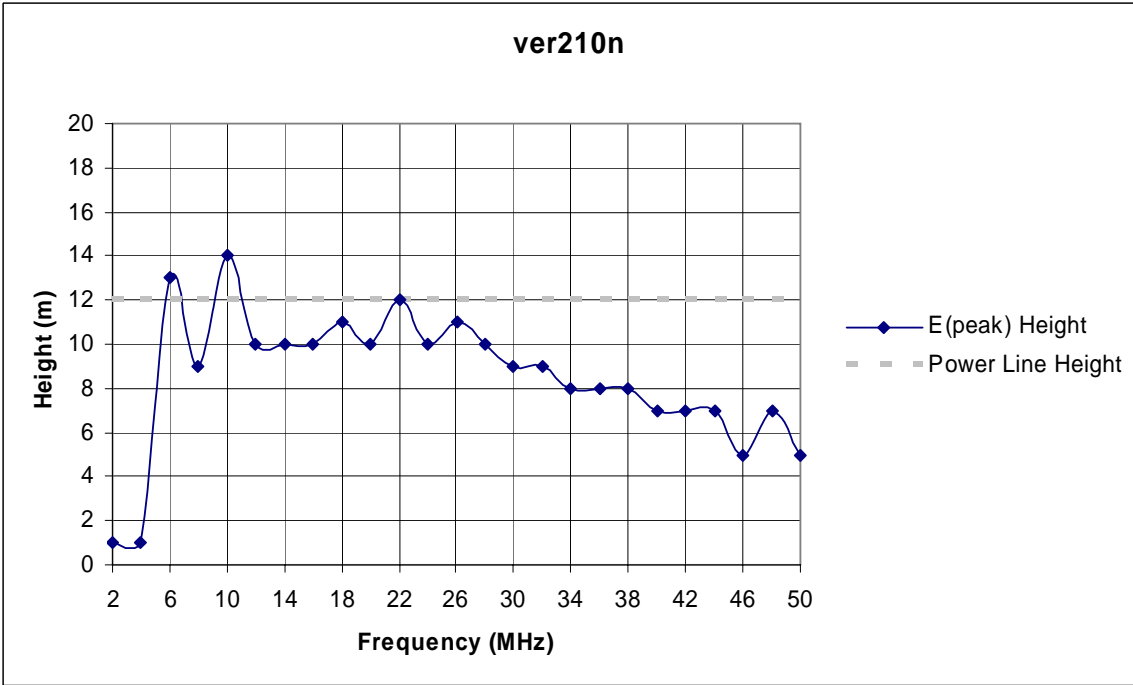


Figure A-16: Height corresponding to peak electric field strength as a function of frequency

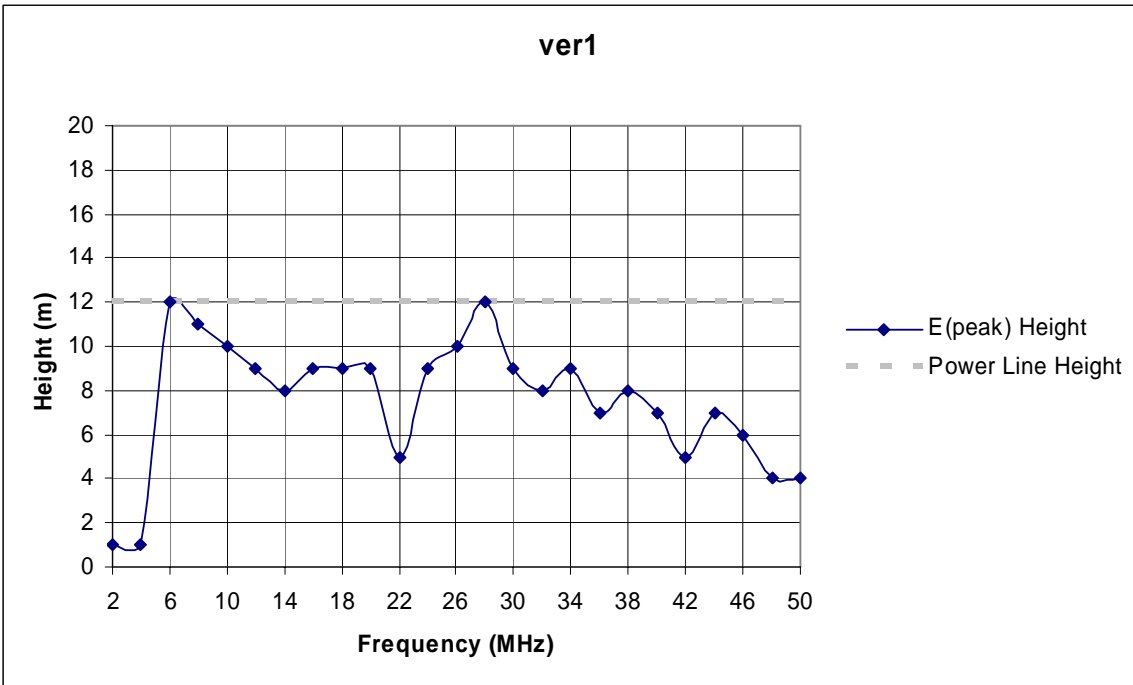


Figure A-17: Height corresponding to peak electric field strength as a function of frequency

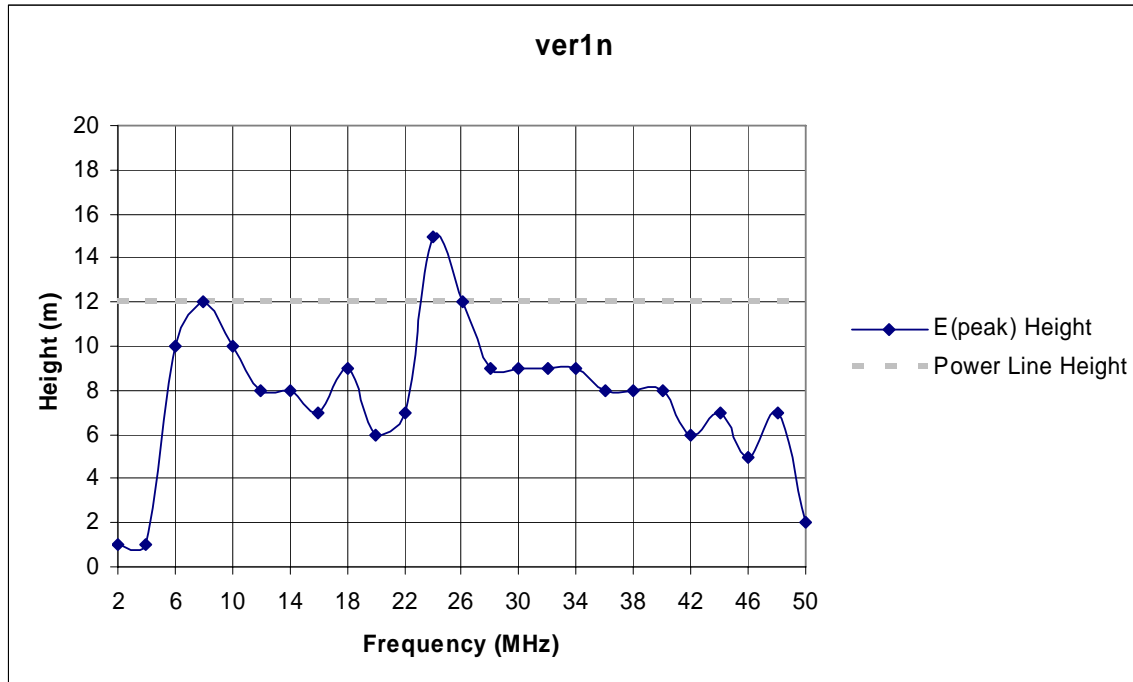


Figure A-18: Height corresponding to peak electric field strength as a function of frequency

A.3 COMPLIANCE MEASUREMENT HEIGHT FOR OPERATION BETWEEN 1.7 - 30 MHz

The Federal Communication Commission (Commission or FCC) Part 15 measurement guidelines specify that below 30 MHz, measurements are to be made with the antenna positioned at a height of 1 meter. In Section A.2, the height corresponding to the peak field strength was often located well above the 1 meter measurement height. The following plots show a comparison between the peak field strength determined from the measurement guidelines and the 80th percentile of peak electric field strength at any height along the length of the power line. The 80th percentile values eliminate the localized peaks that are unlikely to be encountered by a radio receiver randomly located in close proximity to an Access BPL power line.¹ The plots are shown for a number of NEC power line models at frequencies from 2 to 28 MHz.

¹ See NTIA Comments, at Technical Appendix, pp. 2-18.

2 MHz Plots

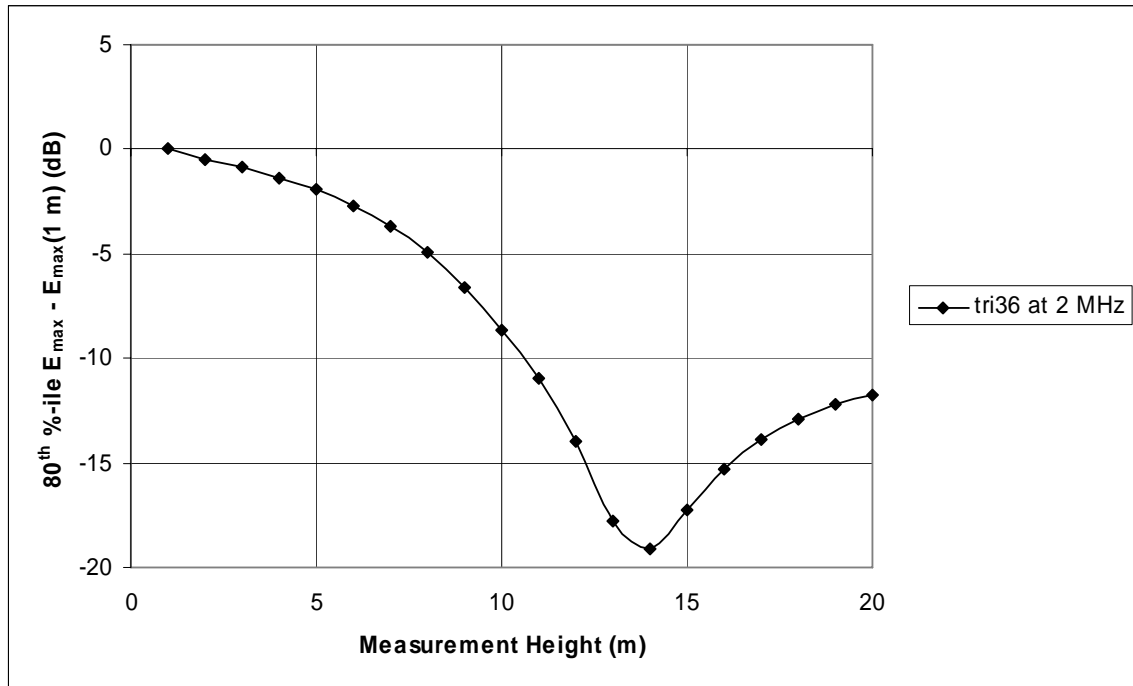


Figure A-19: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

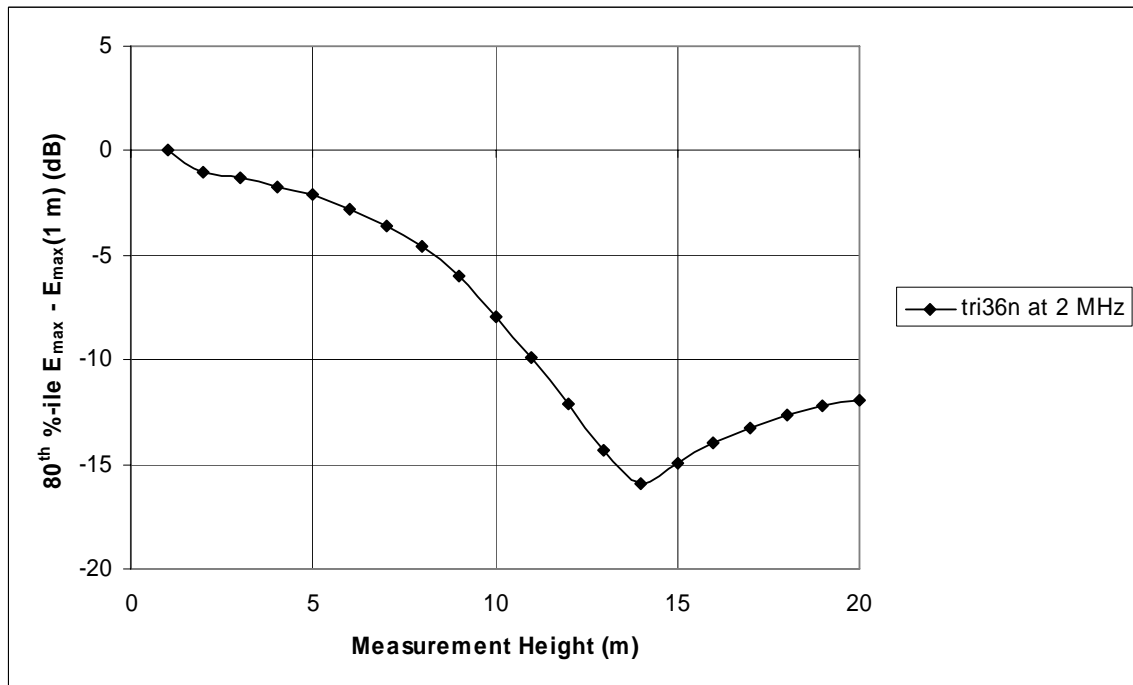


Figure A-20: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

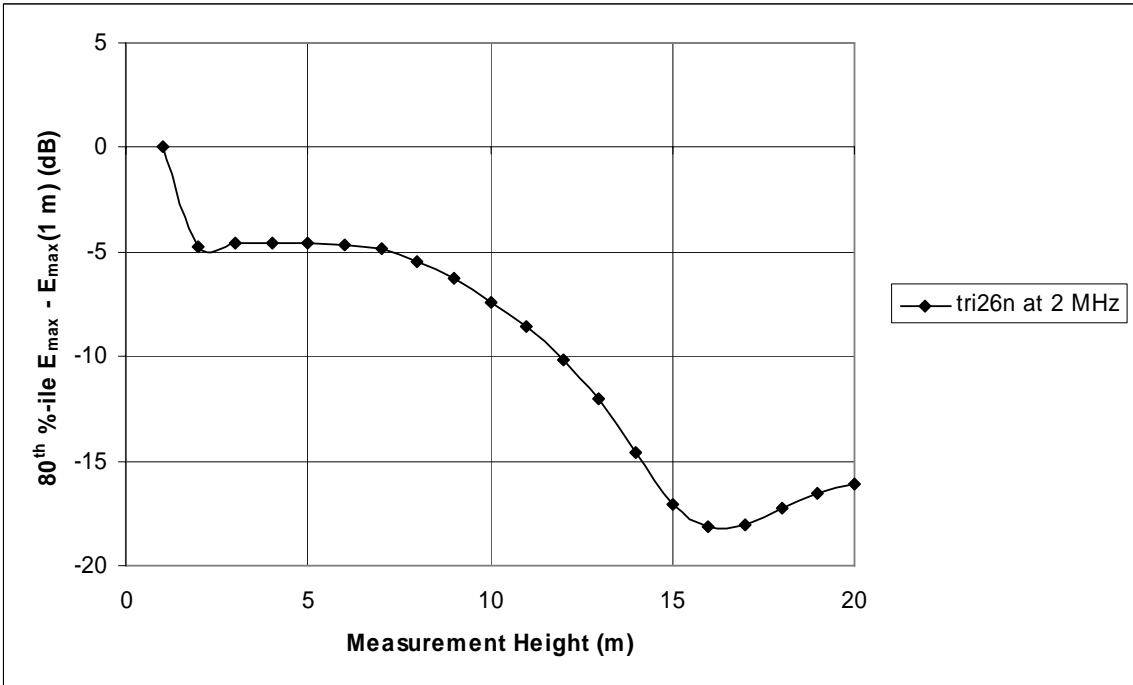


Figure A-21: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

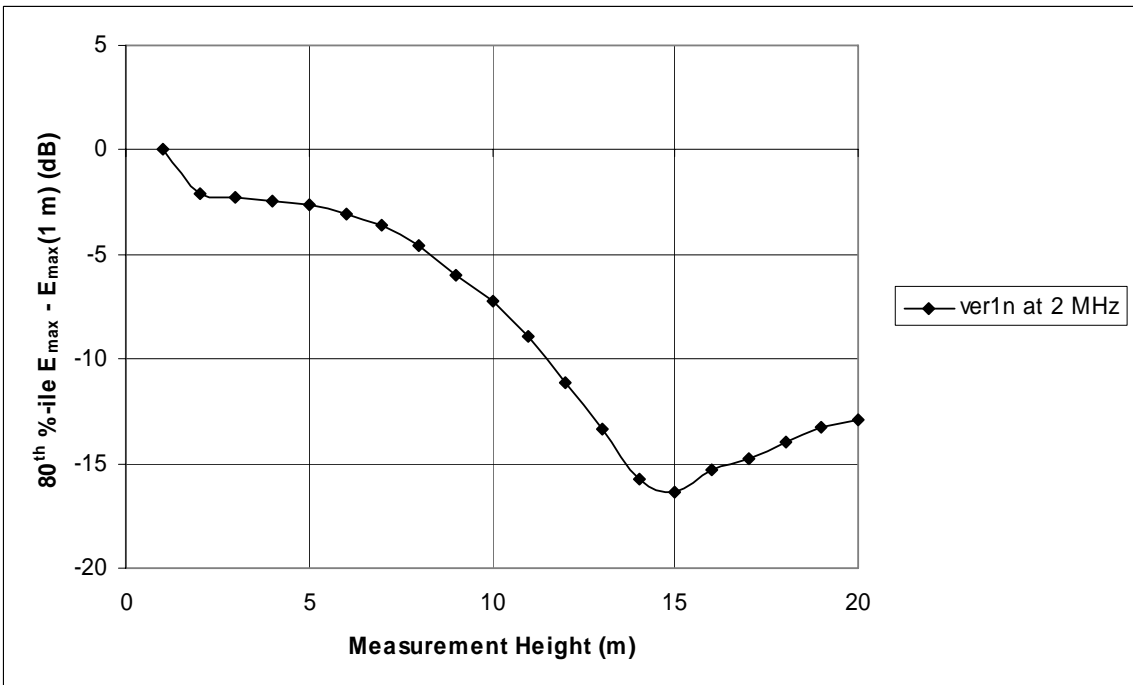


Figure A-22: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

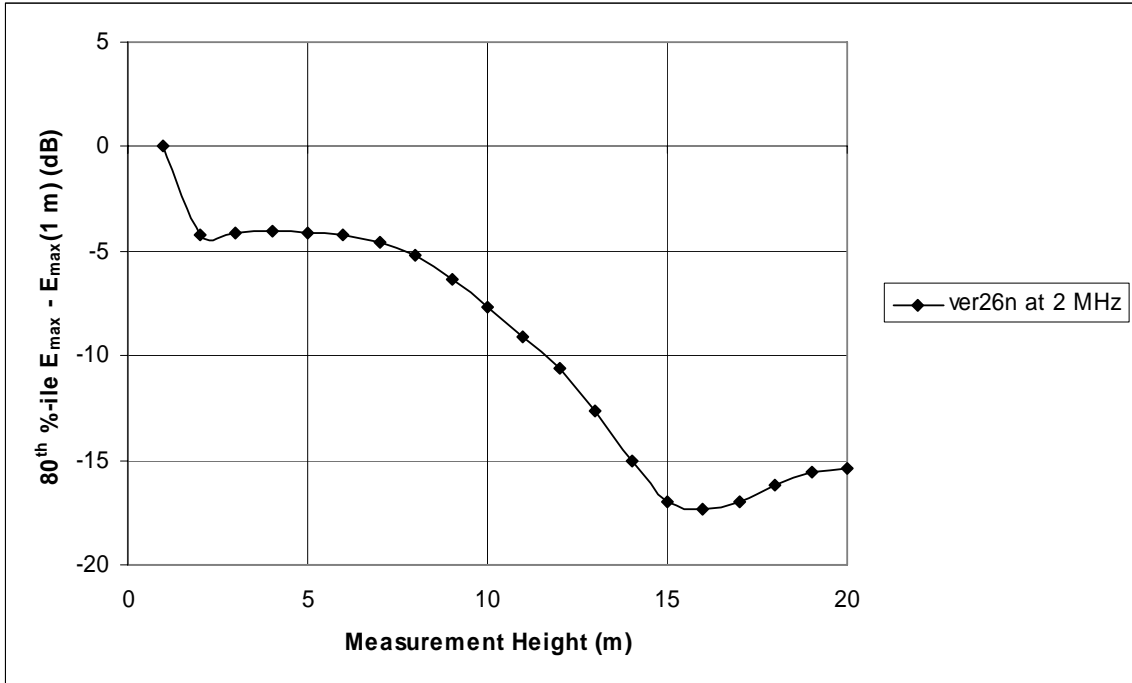


Figure A-23: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

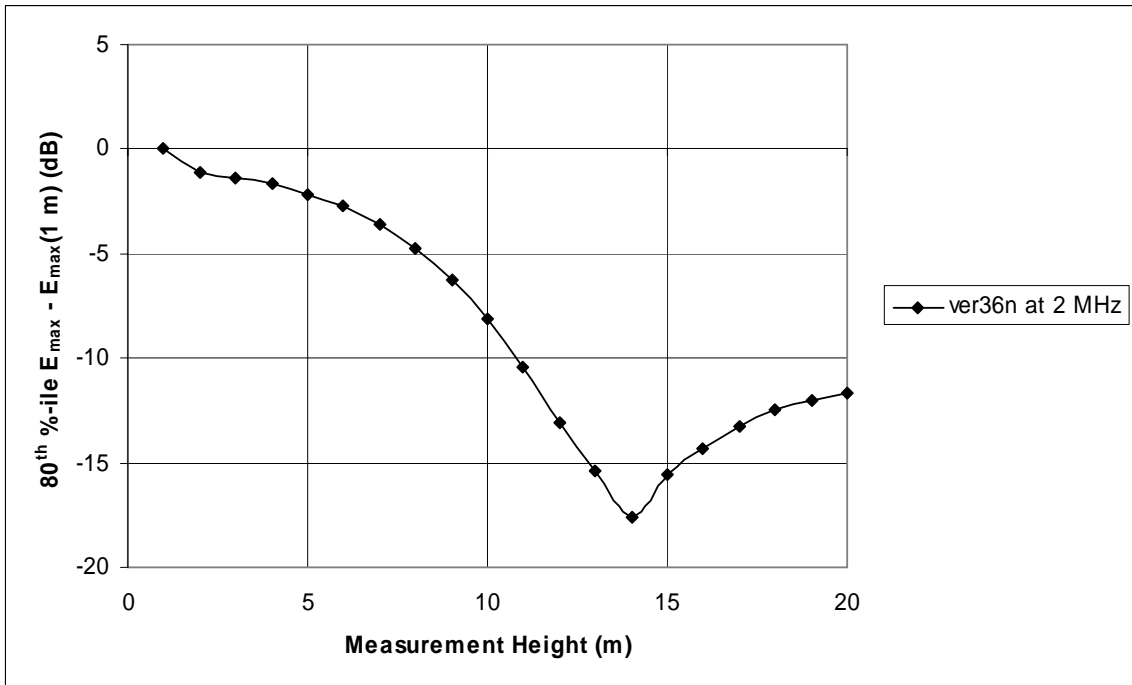


Figure A-24: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

4 MHz Plots

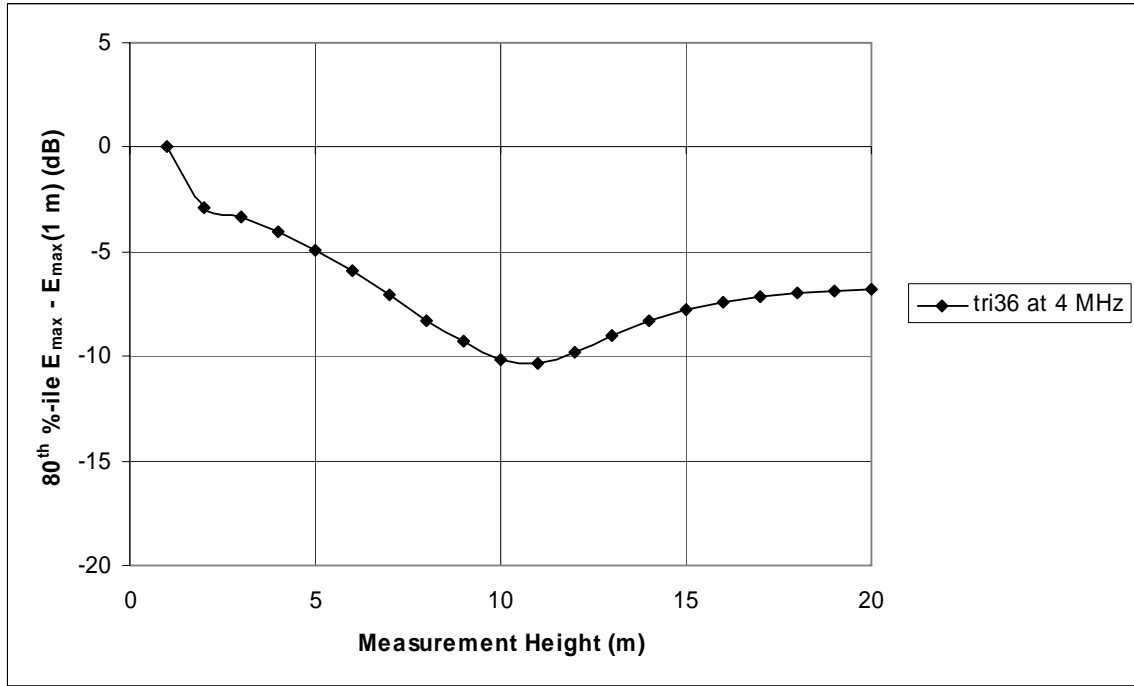


Figure A-25: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

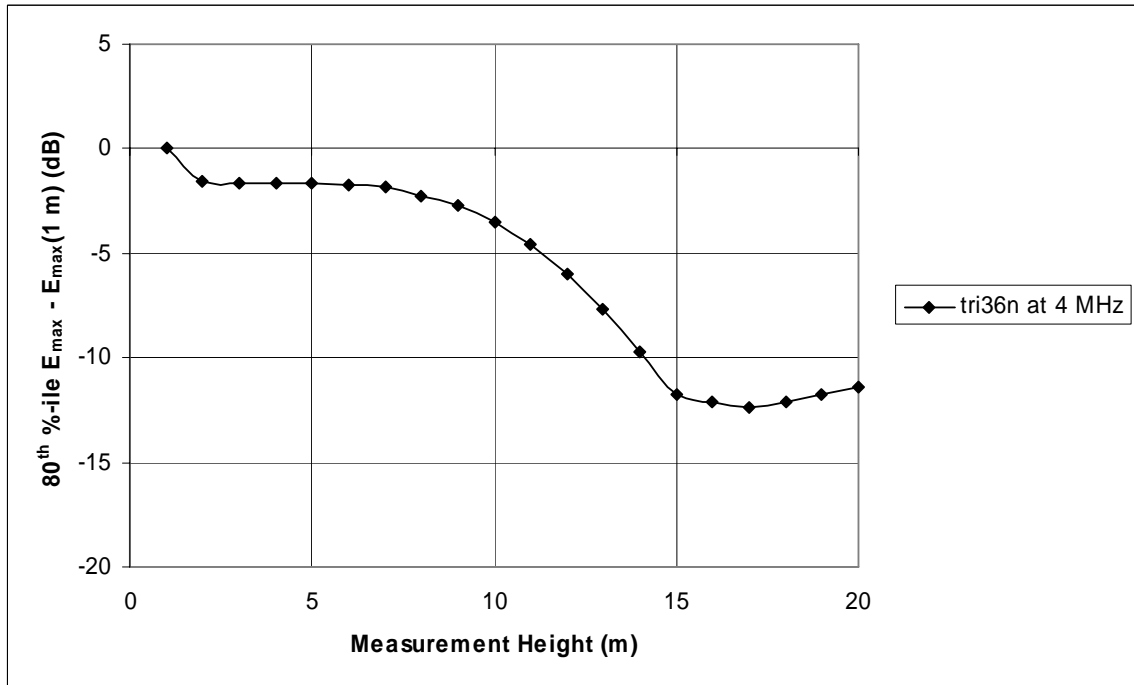


Figure A-26: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

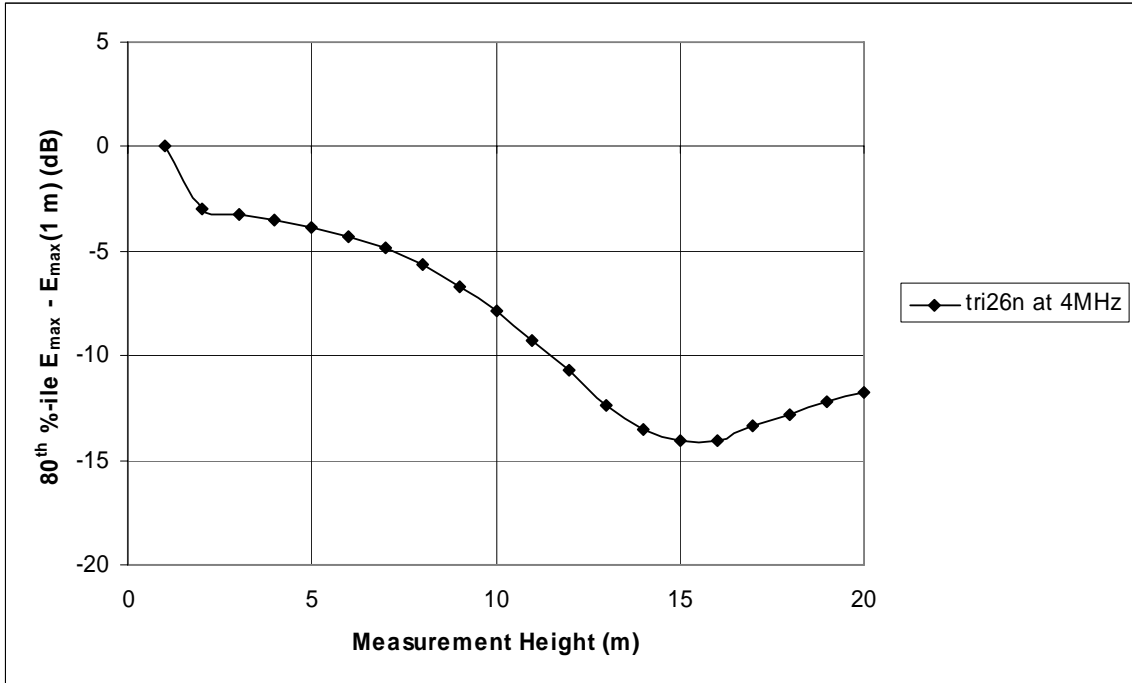


Figure A-27: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

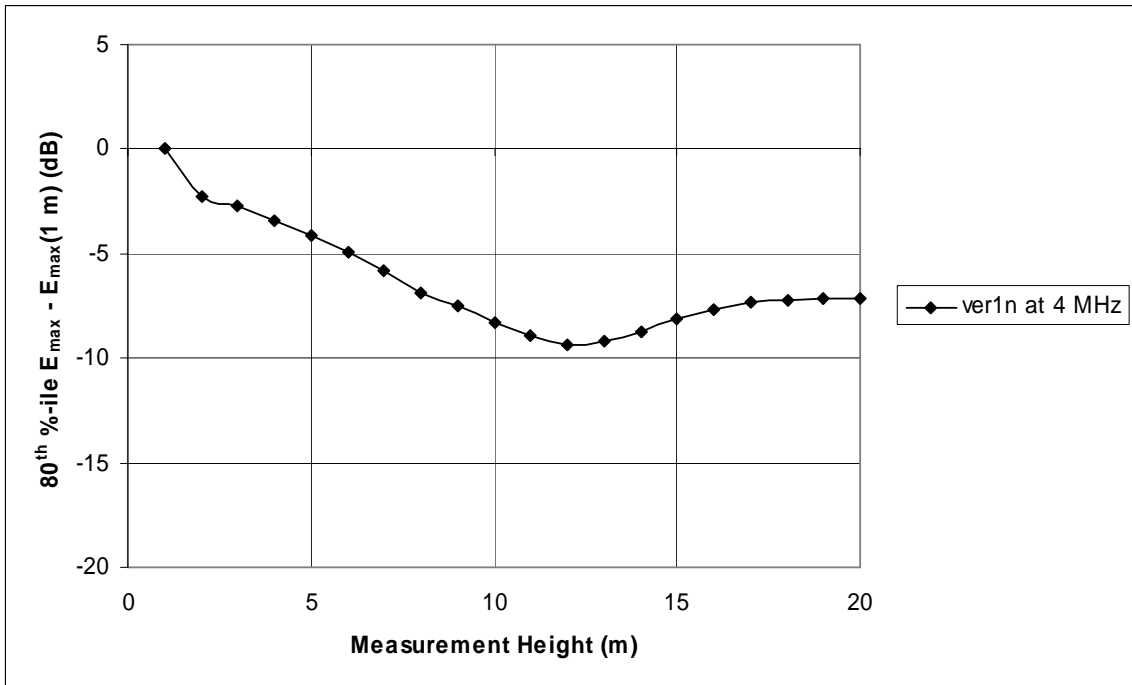


Figure A-28: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

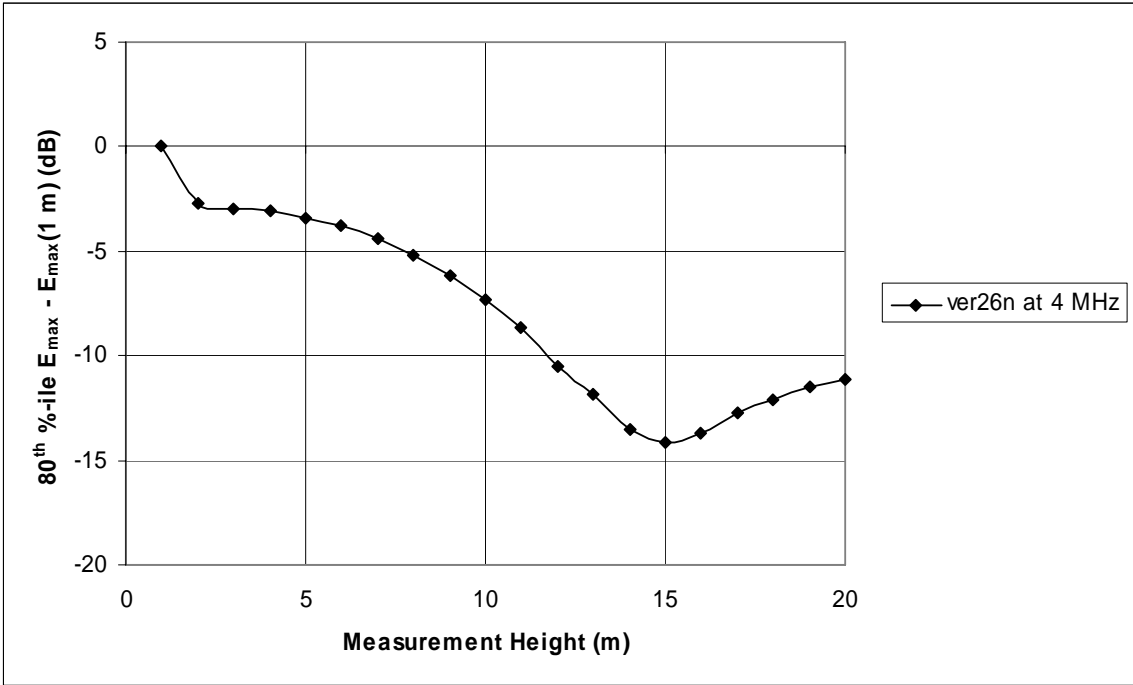


Figure A-29: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

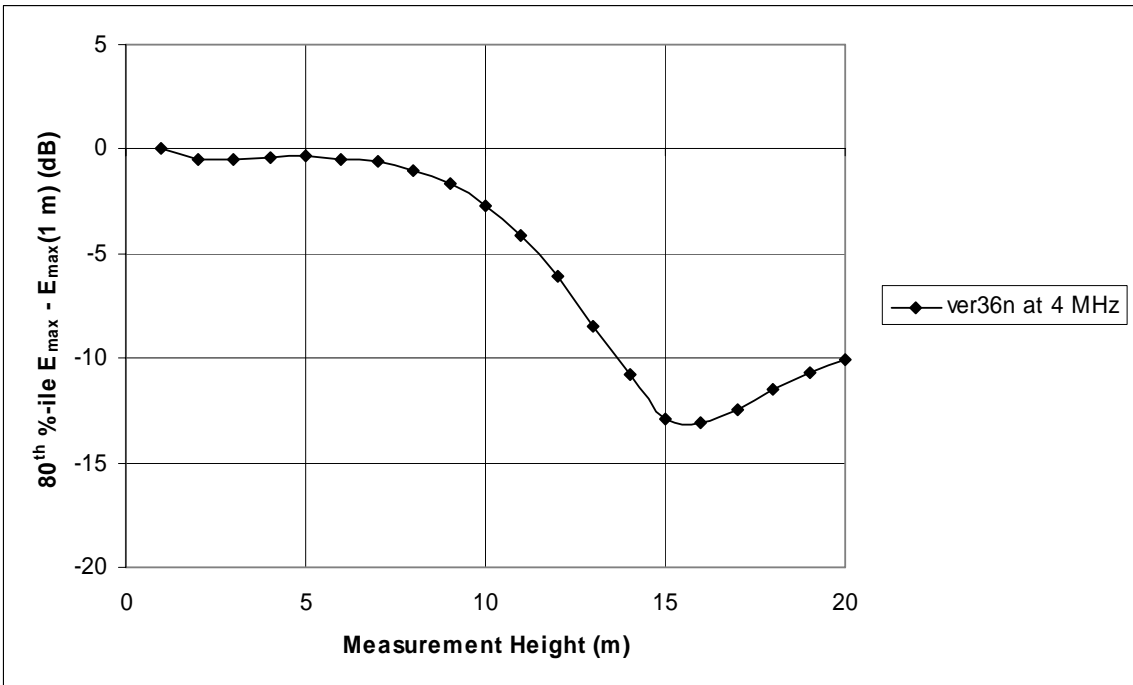


Figure A-30: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

6 MHz Plots

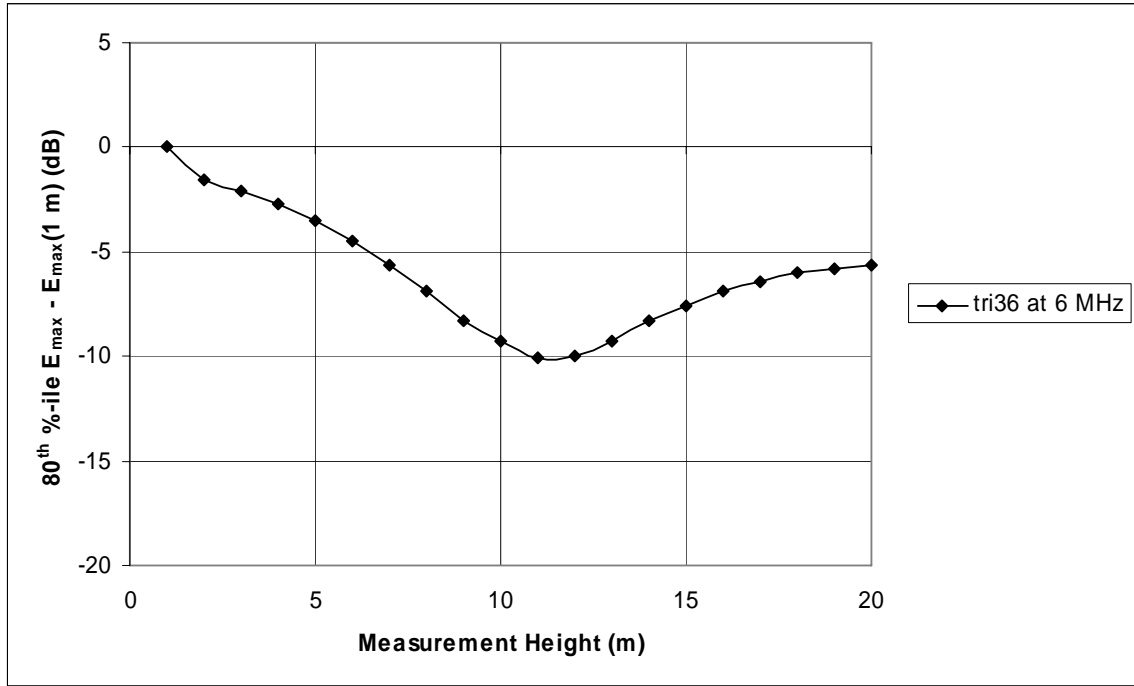


Figure A-31: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

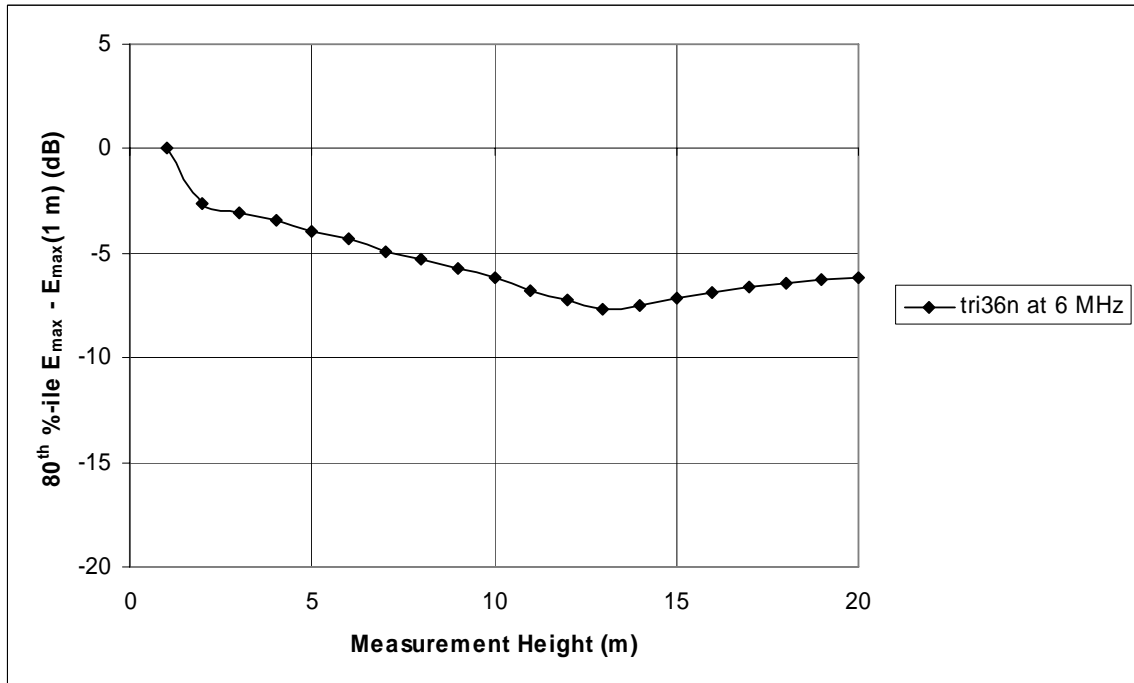


Figure A-32: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

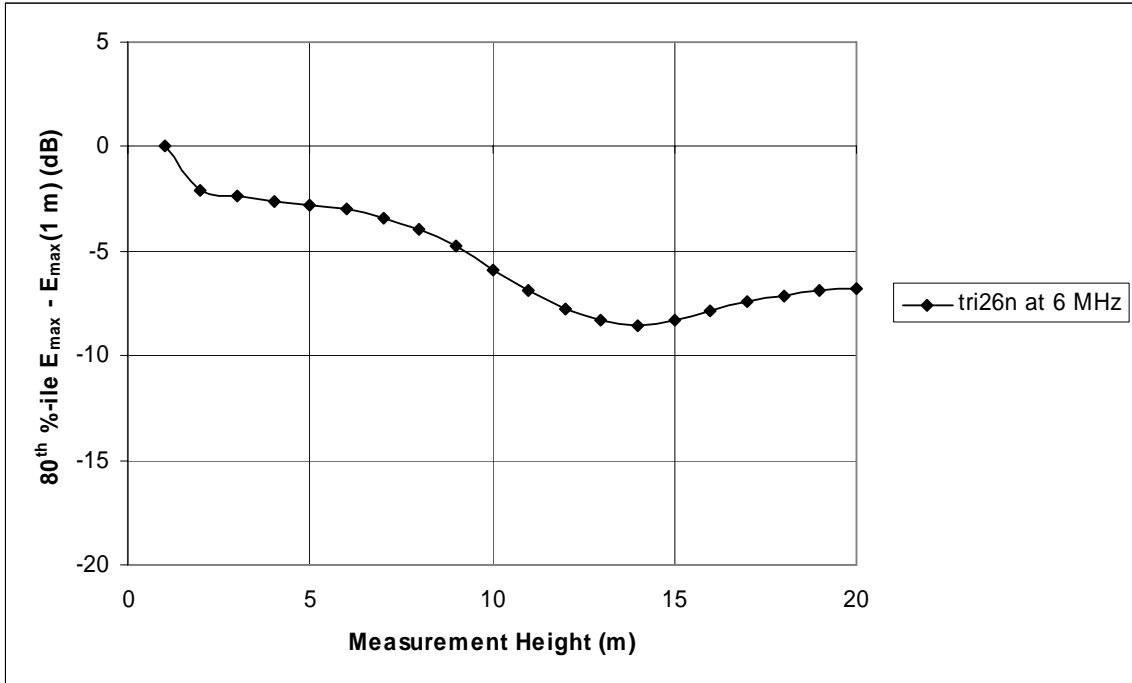


Figure A-33: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

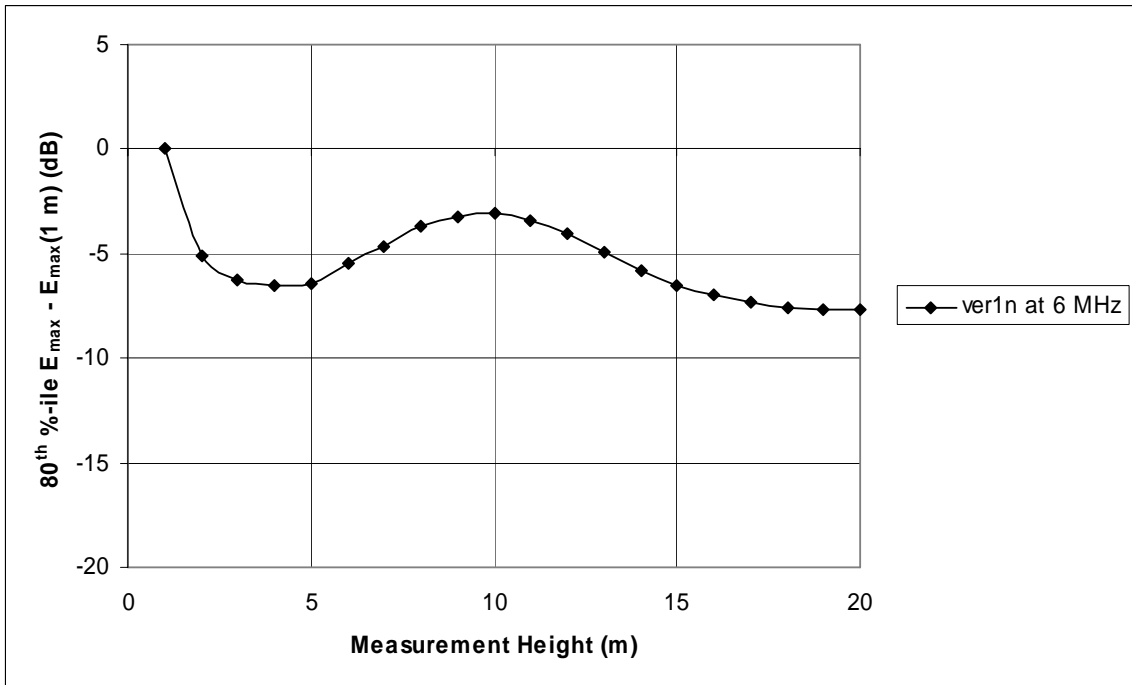


Figure A-34: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

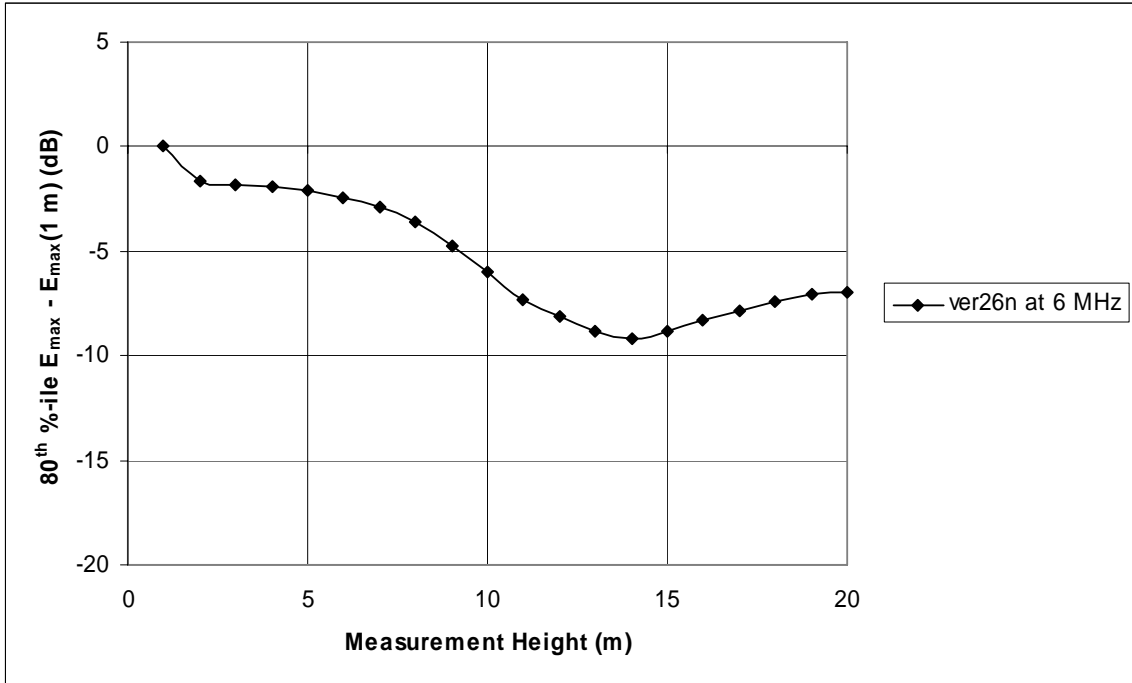


Figure A-35: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

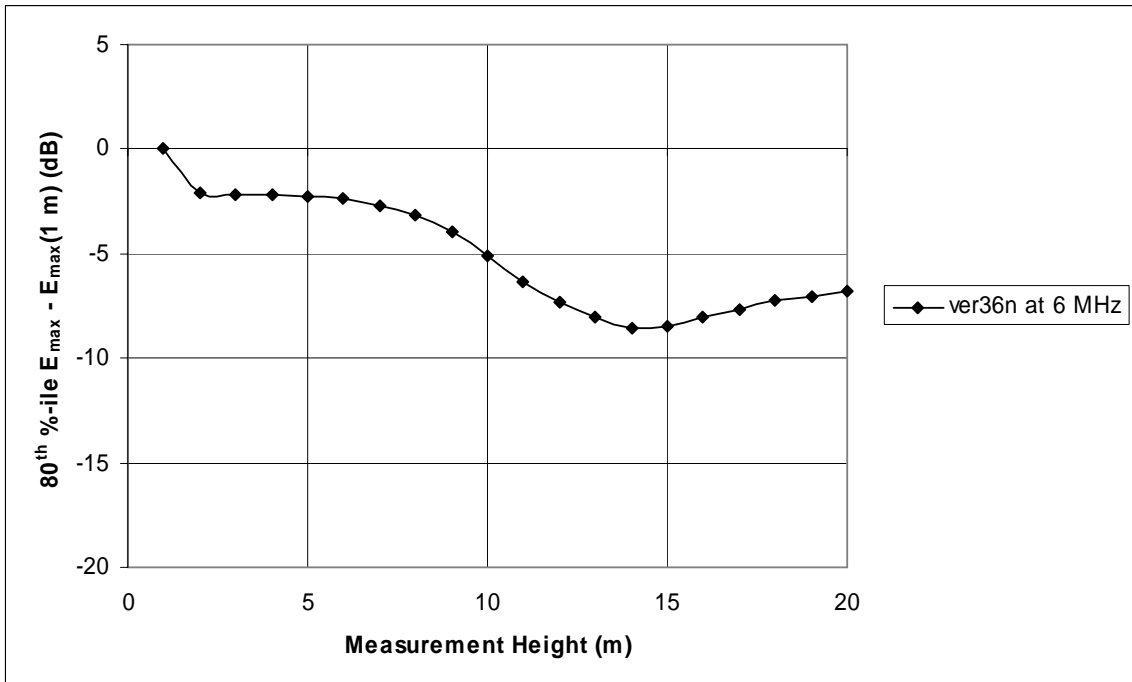


Figure A-36: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

8 MHz Plots

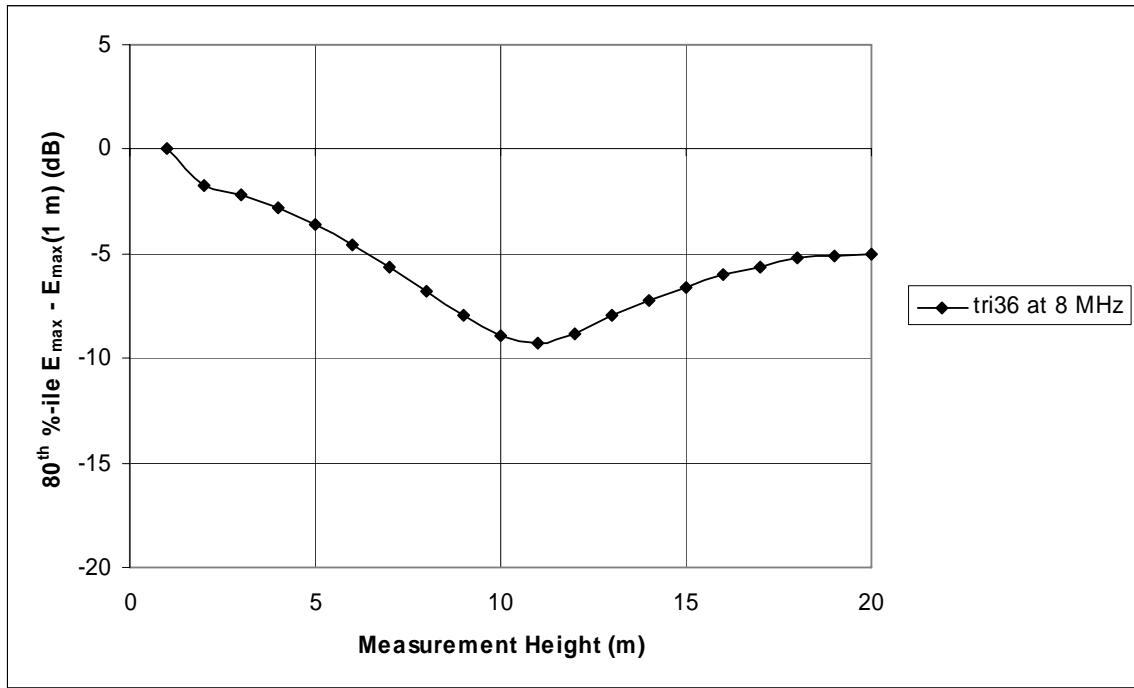


Figure A-37: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

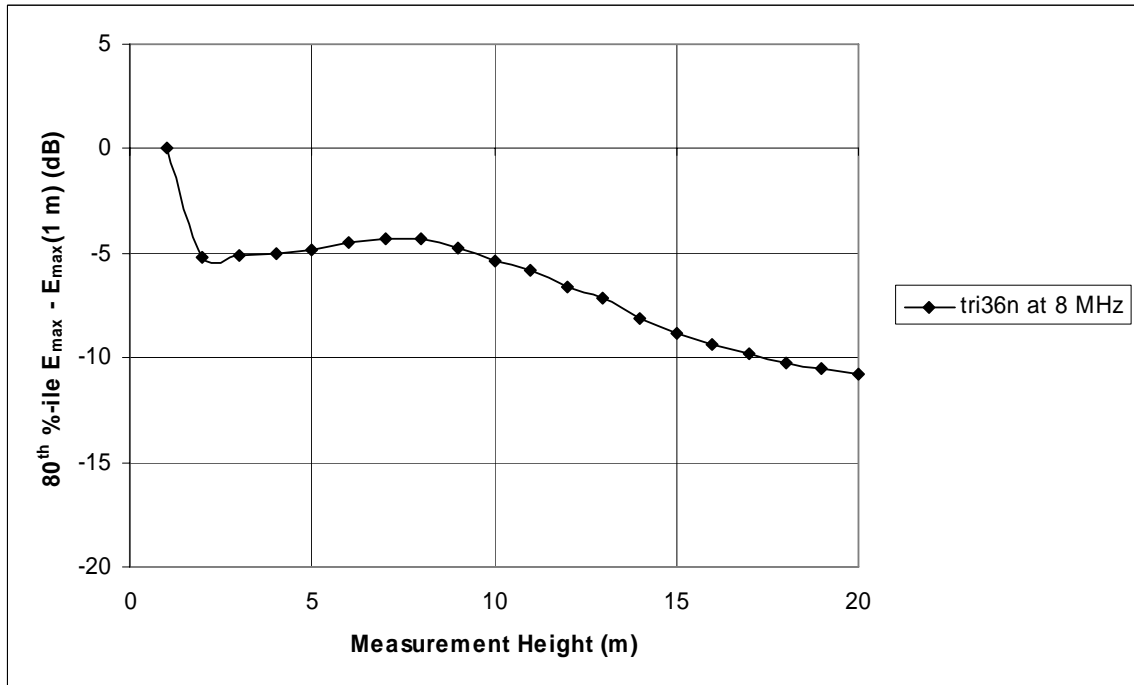


Figure A-38: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

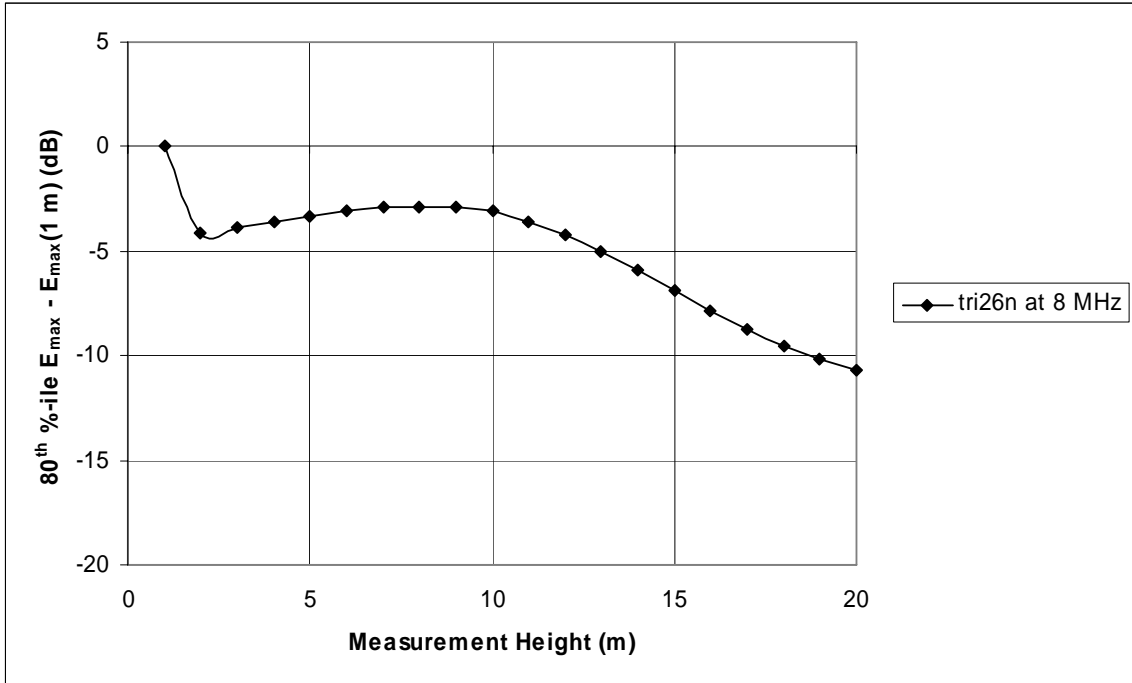


Figure A-39: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

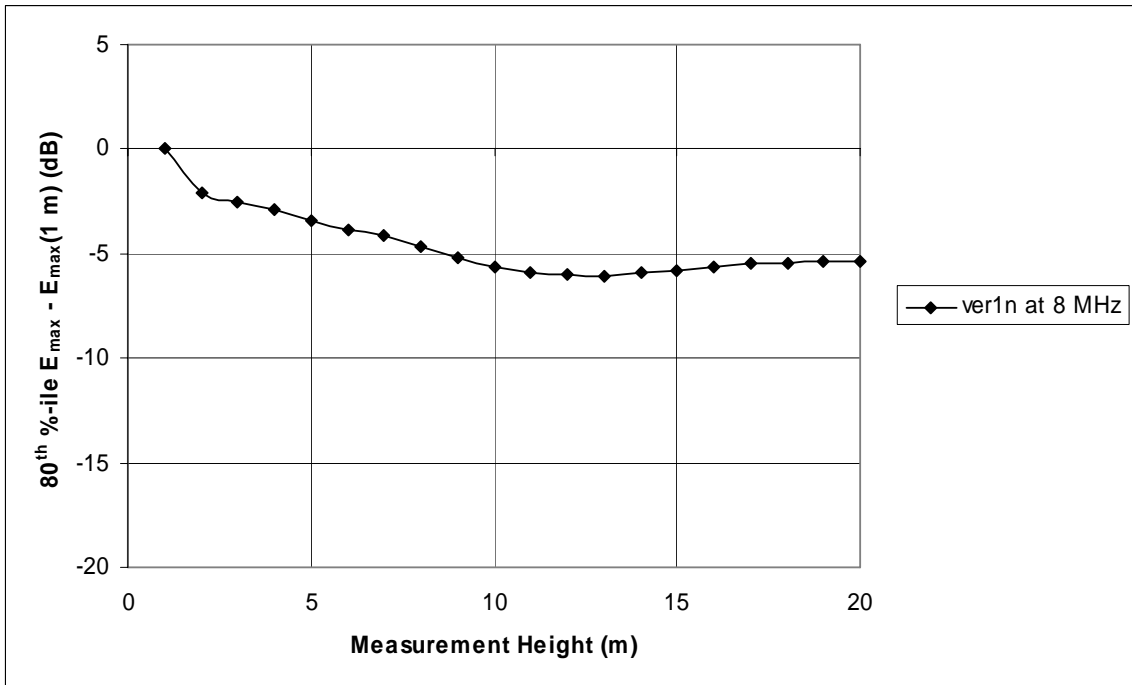


Figure A-40: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

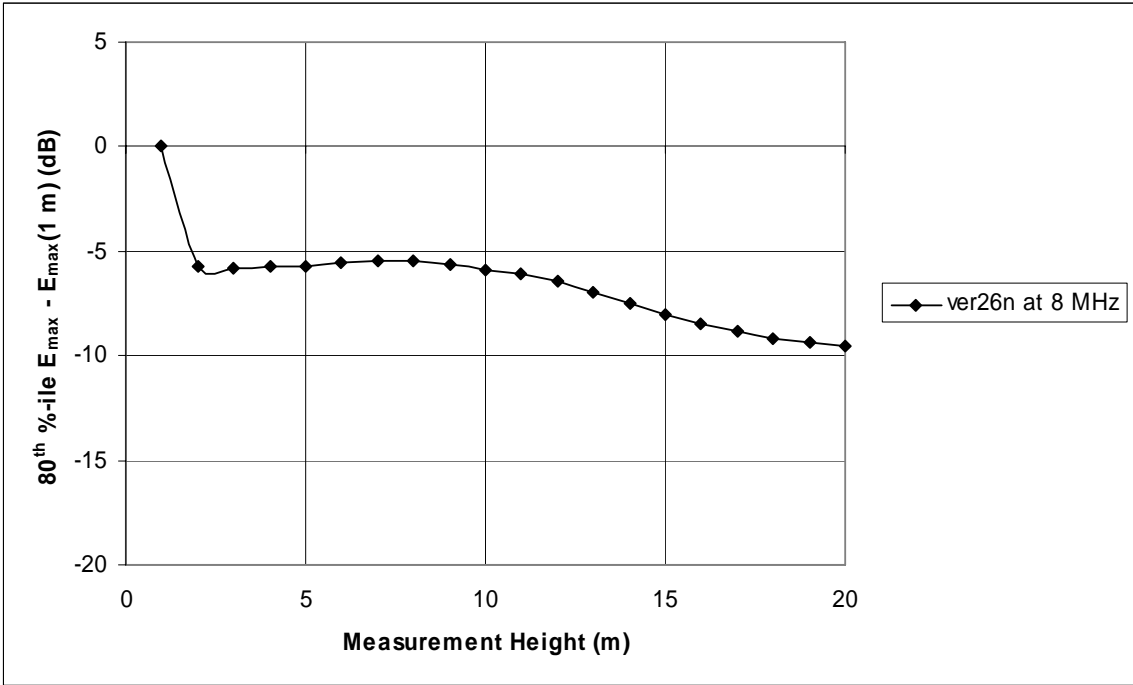


Figure A-41: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

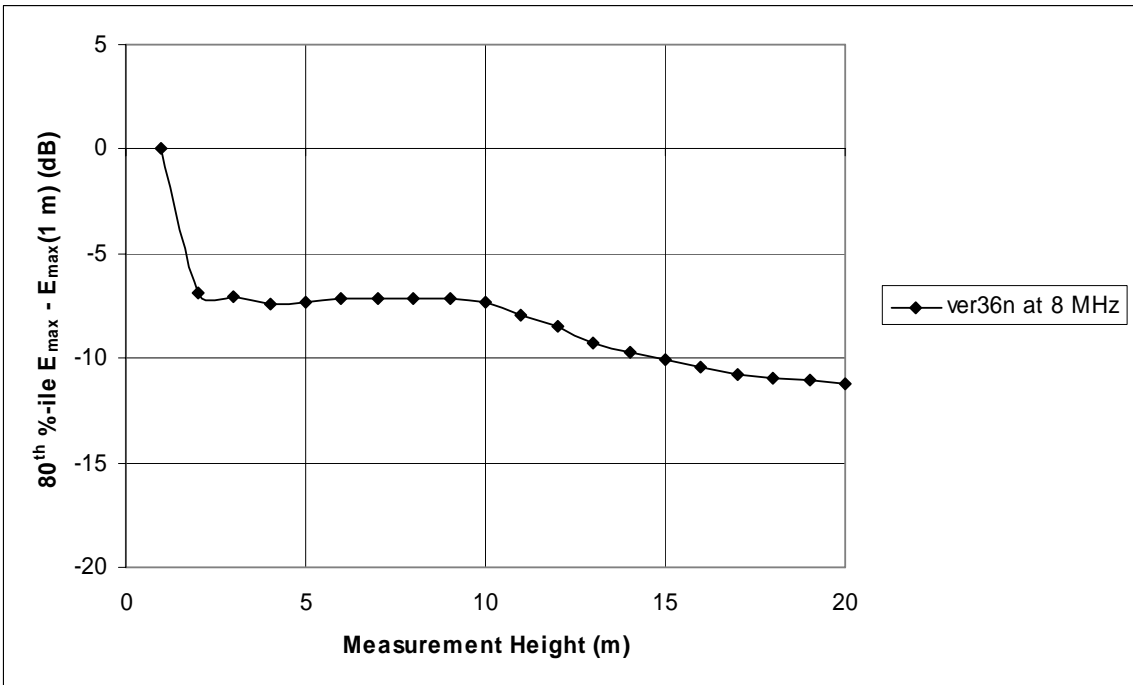


Figure A-42: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

10 MHz Plots

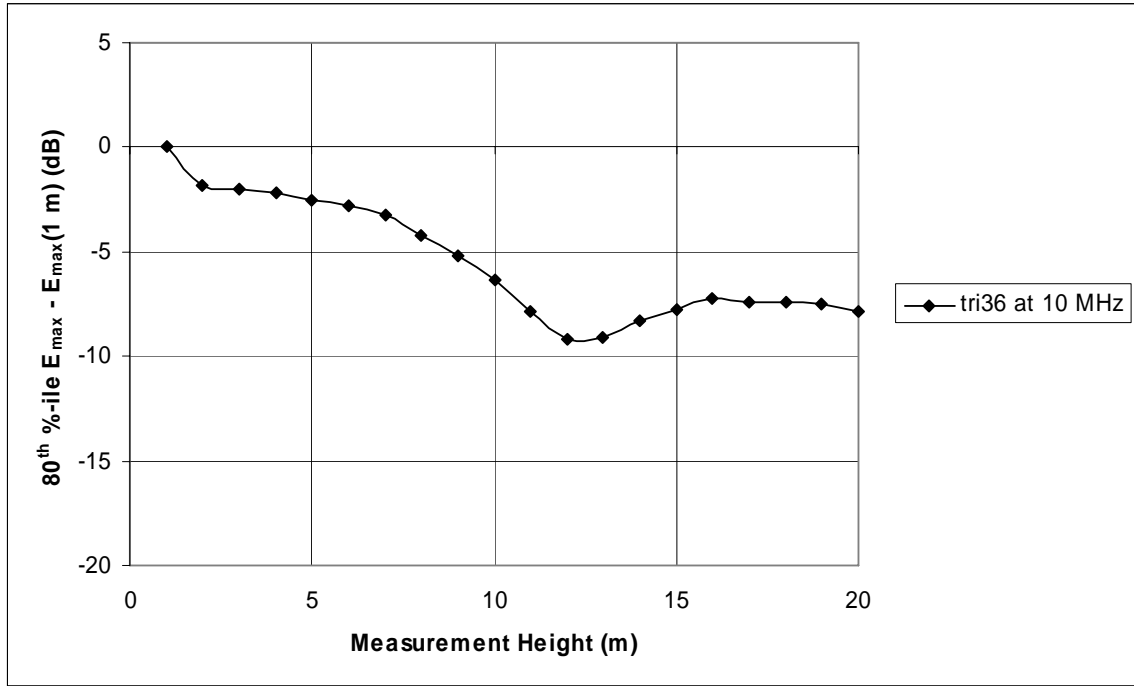


Figure A-43: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

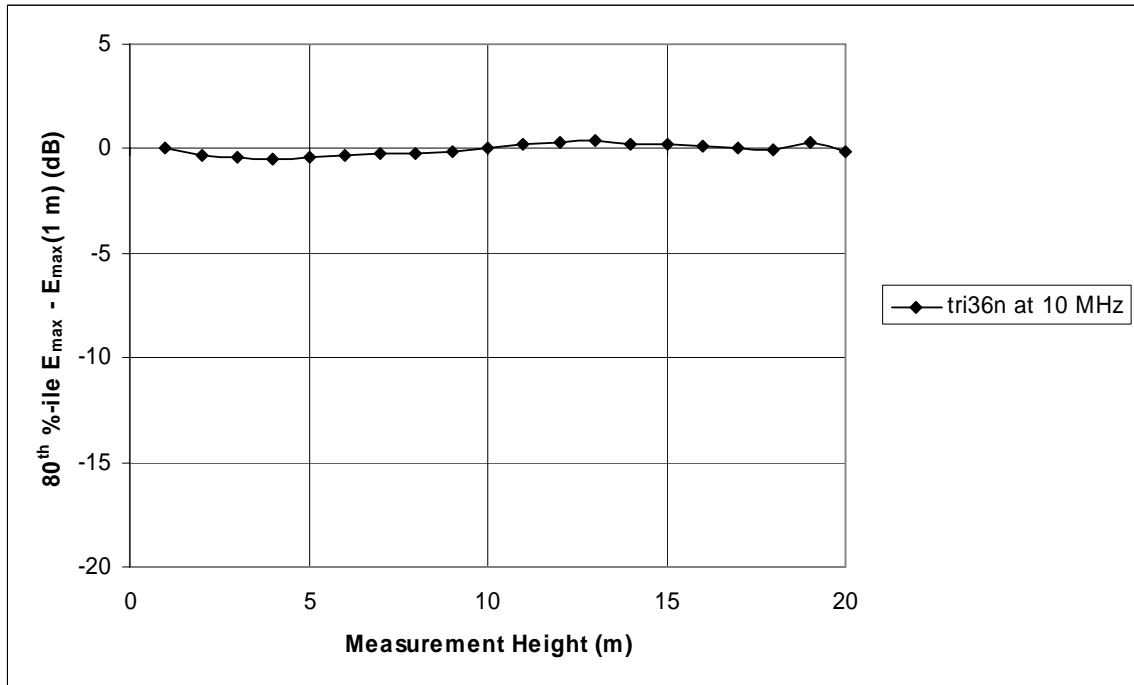


Figure A-44: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

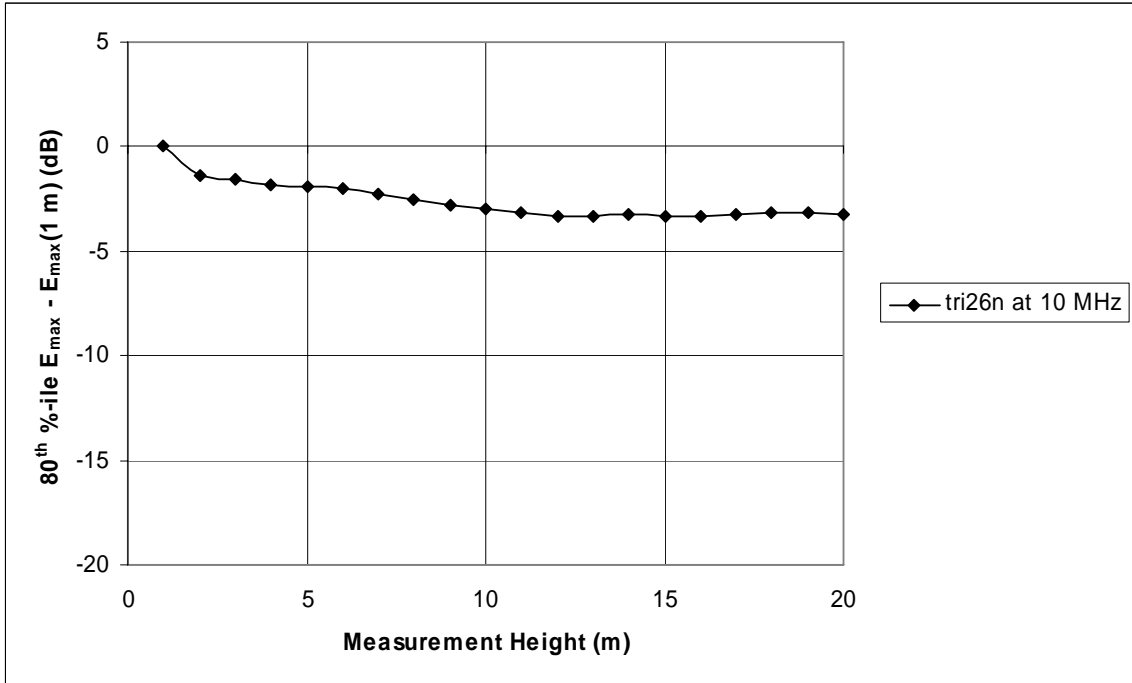


Figure A-45: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

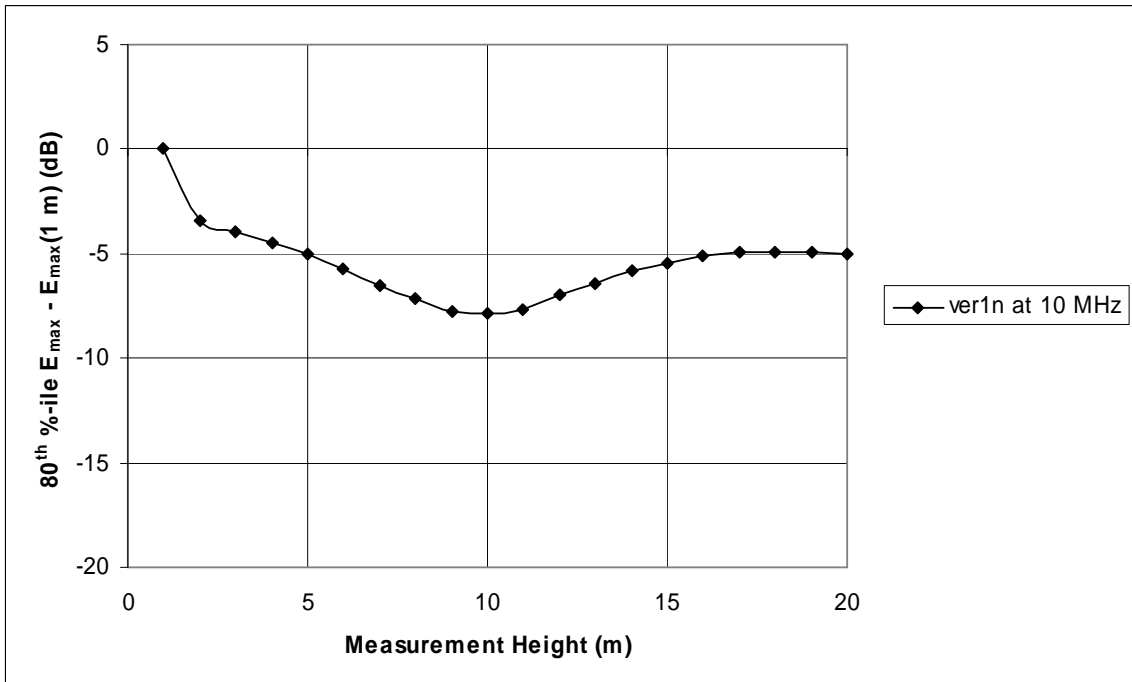


Figure A-46: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

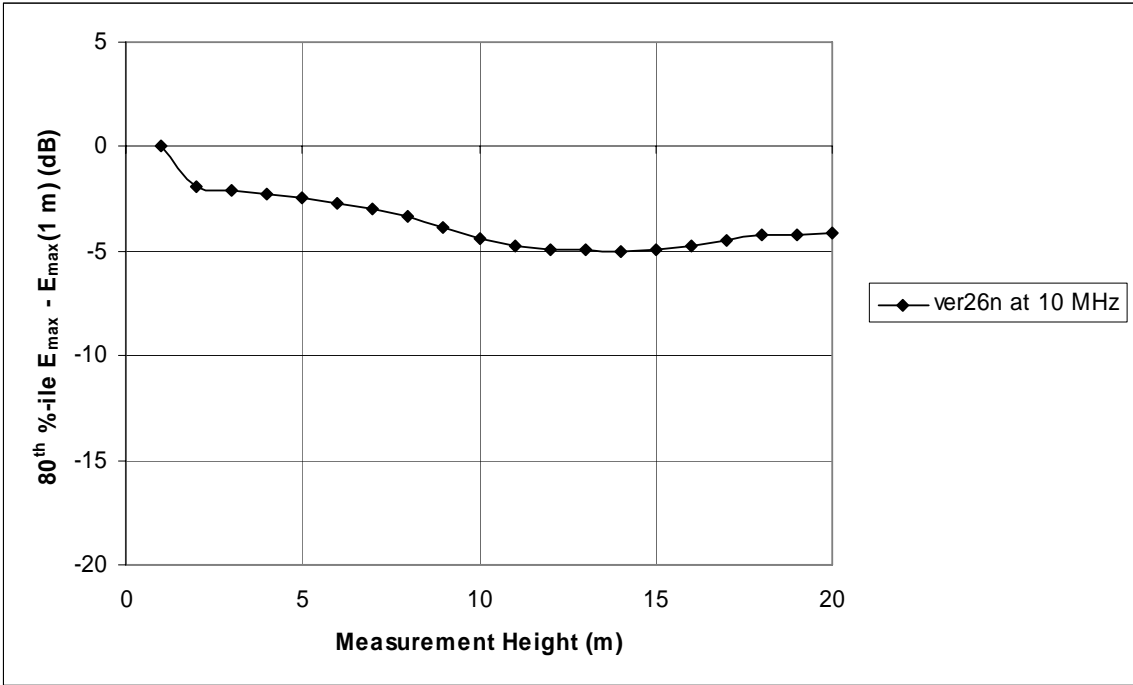


Figure A-47: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

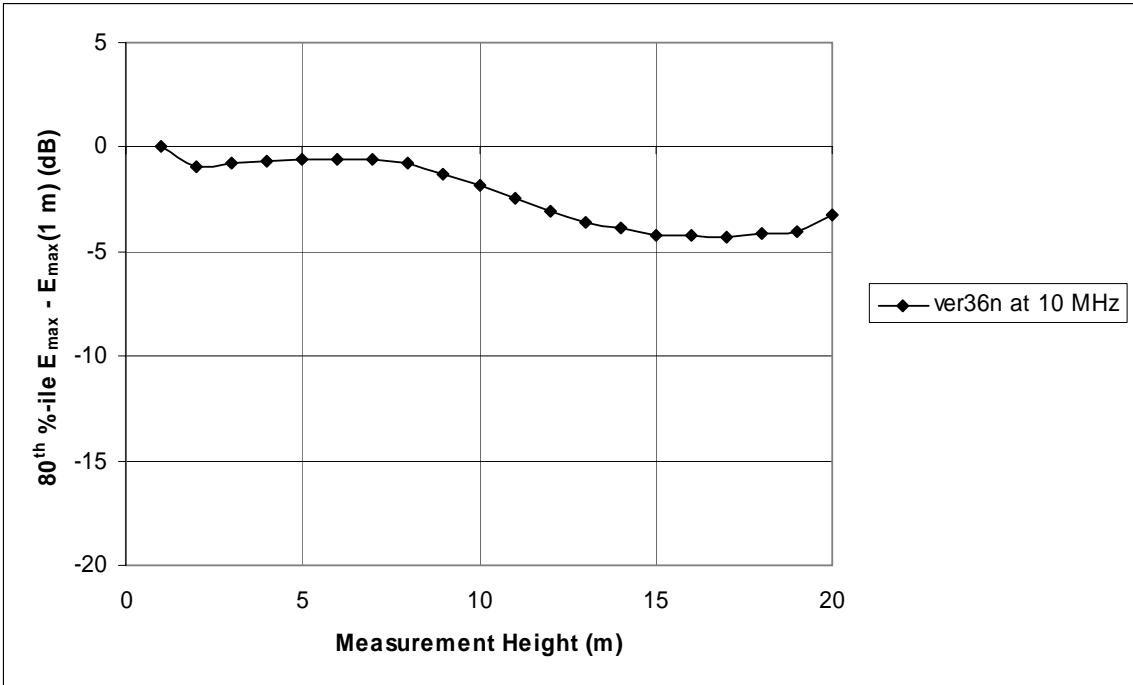


Figure A-48: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

12 MHz Plots

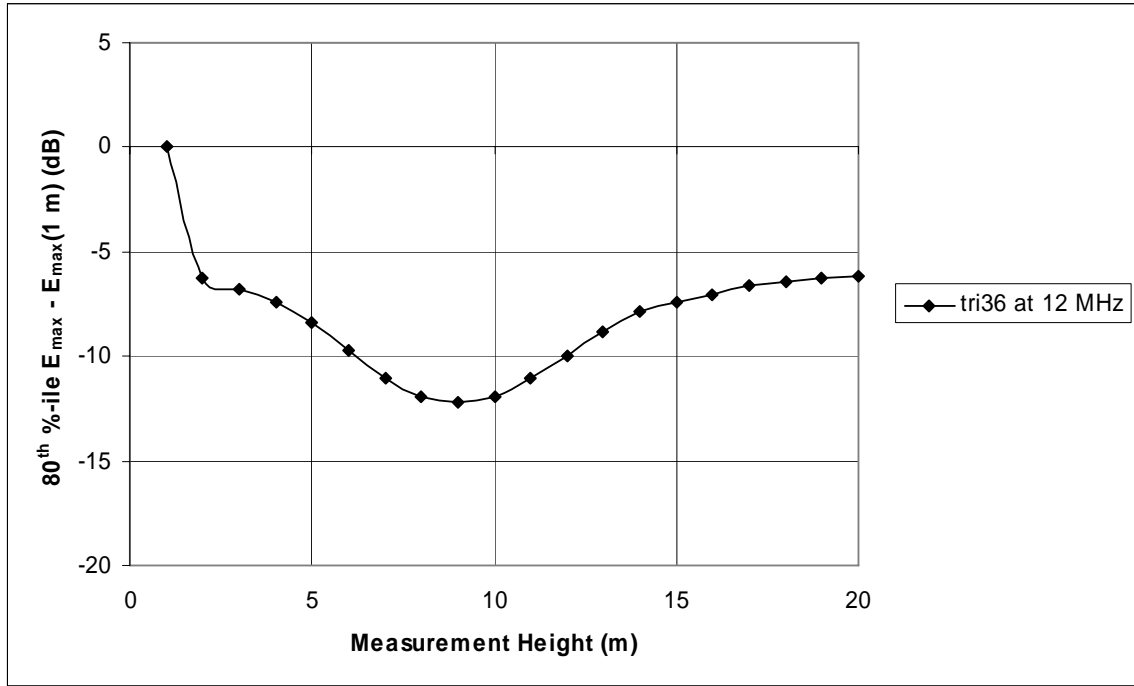


Figure A-49: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

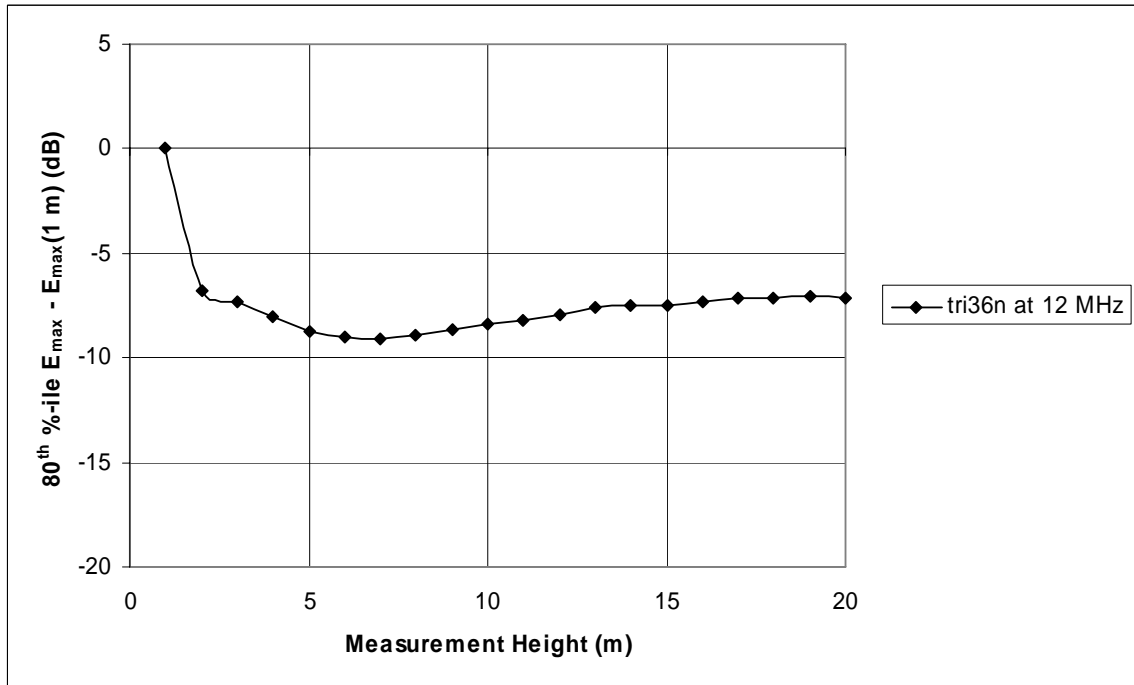


Figure A-50: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

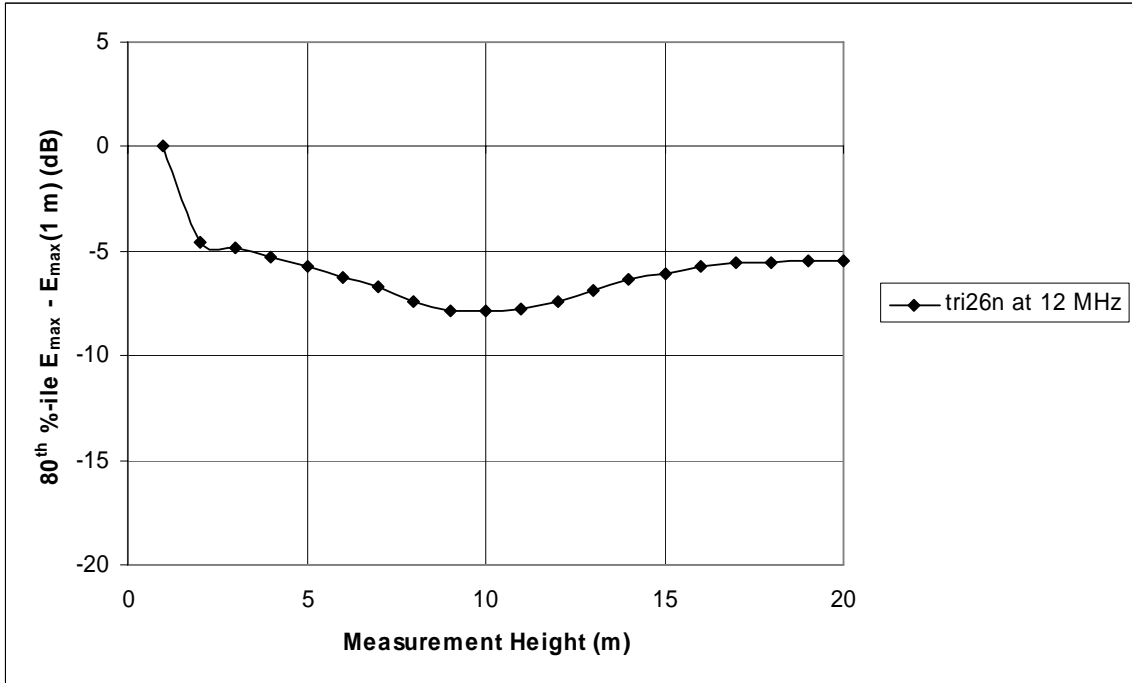


Figure A-51: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

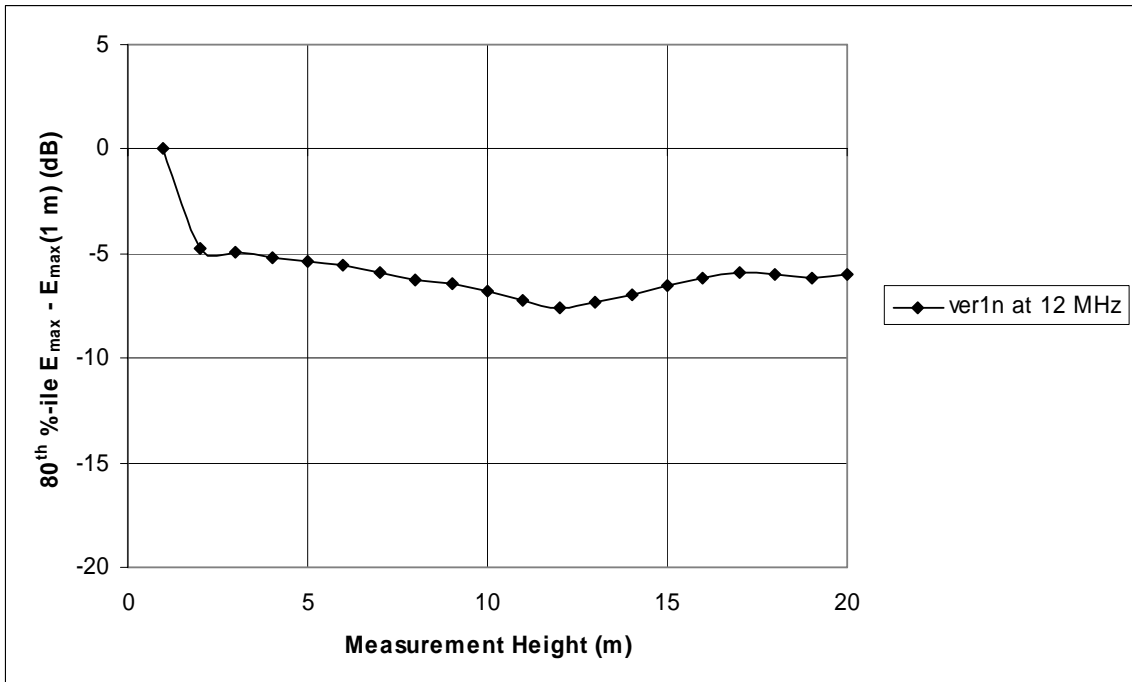


Figure A-52: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

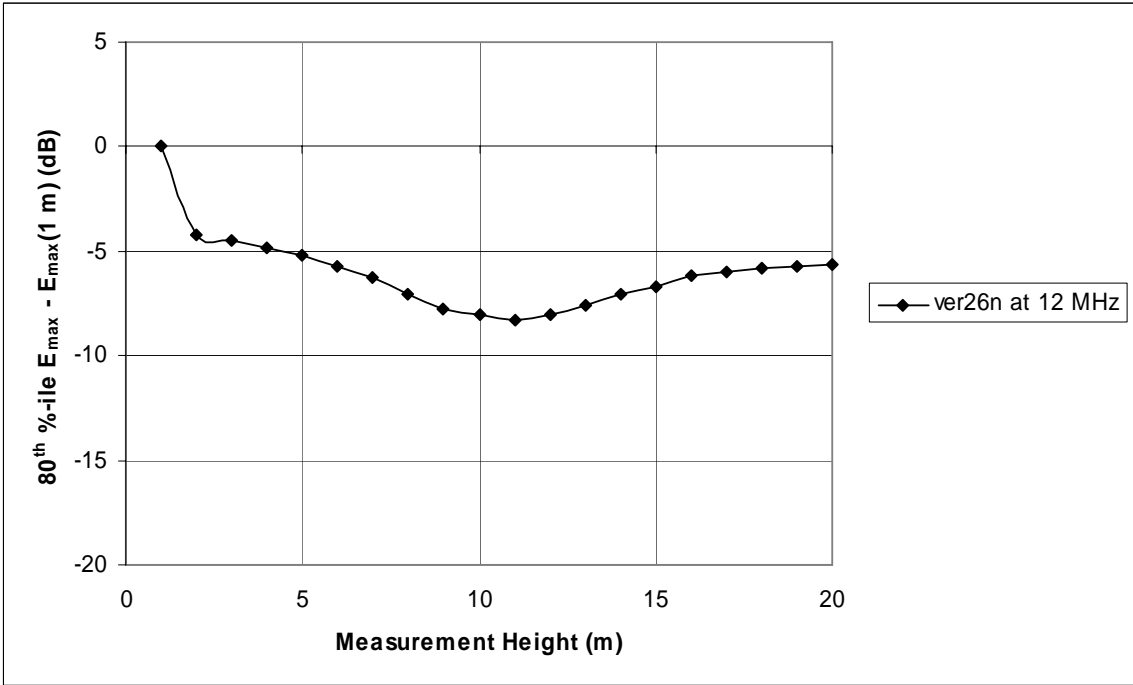


Figure A-53: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

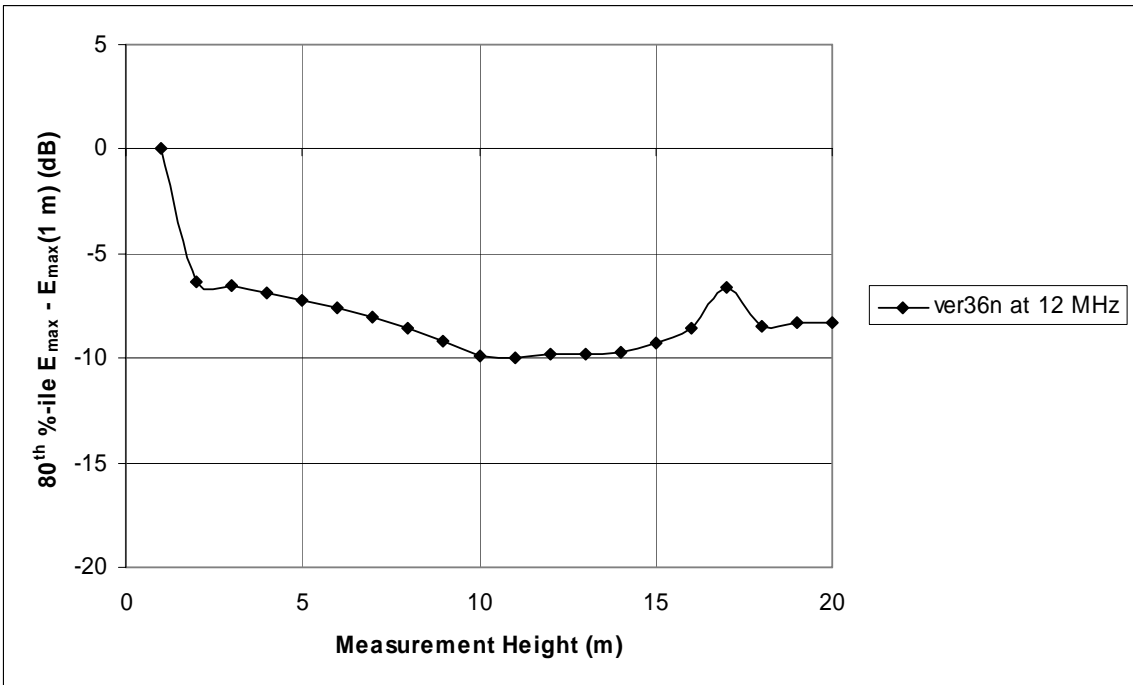


Figure A-54: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

14 MHz Plots

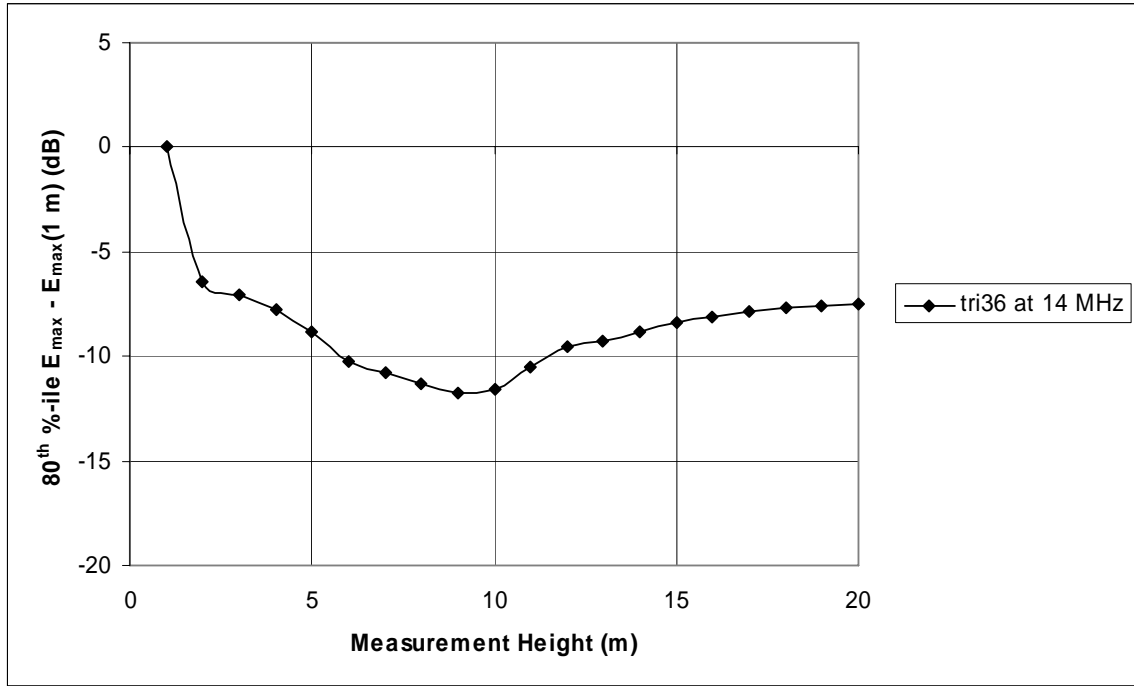


Figure A-55: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

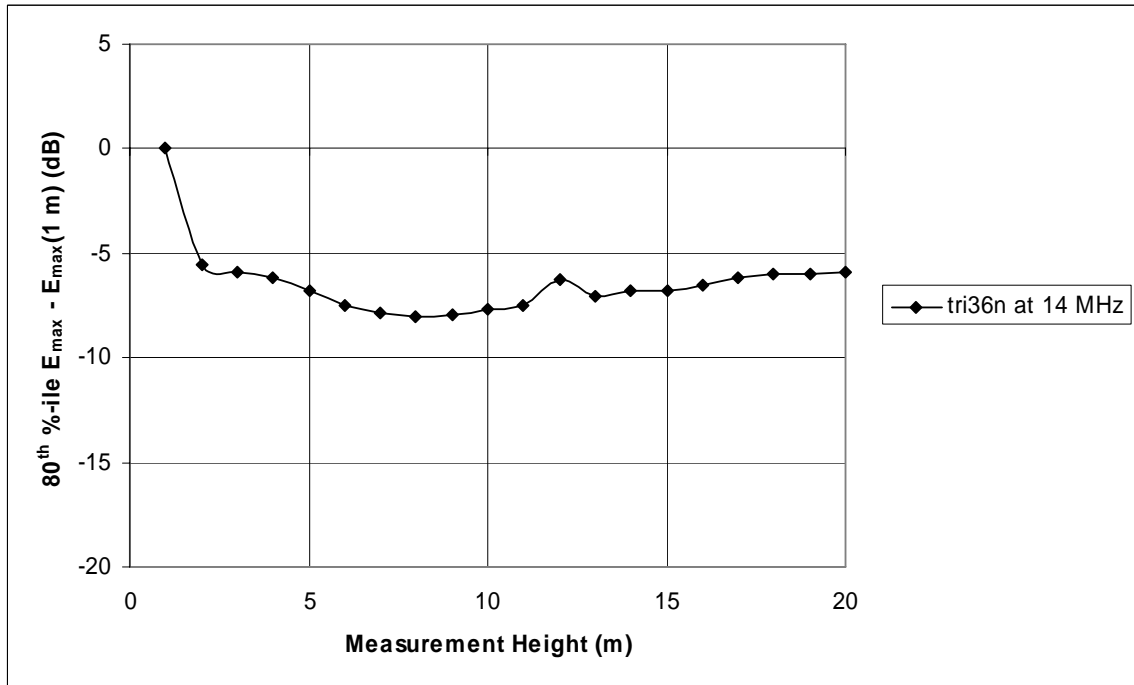


Figure A-56: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

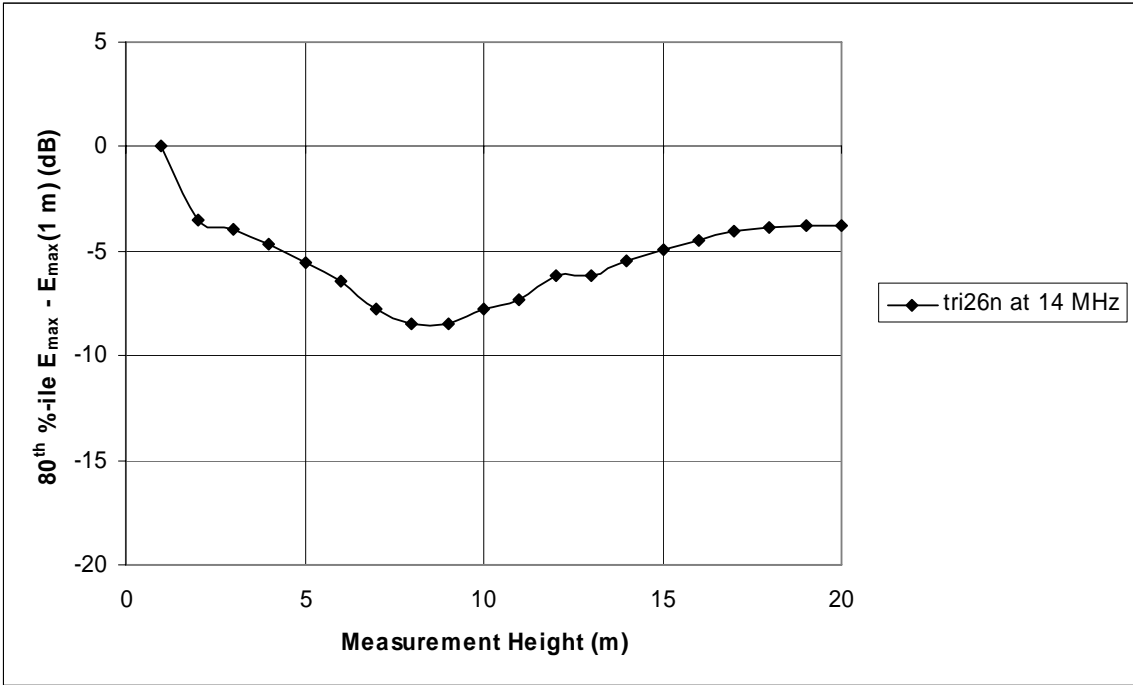


Figure A-57: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

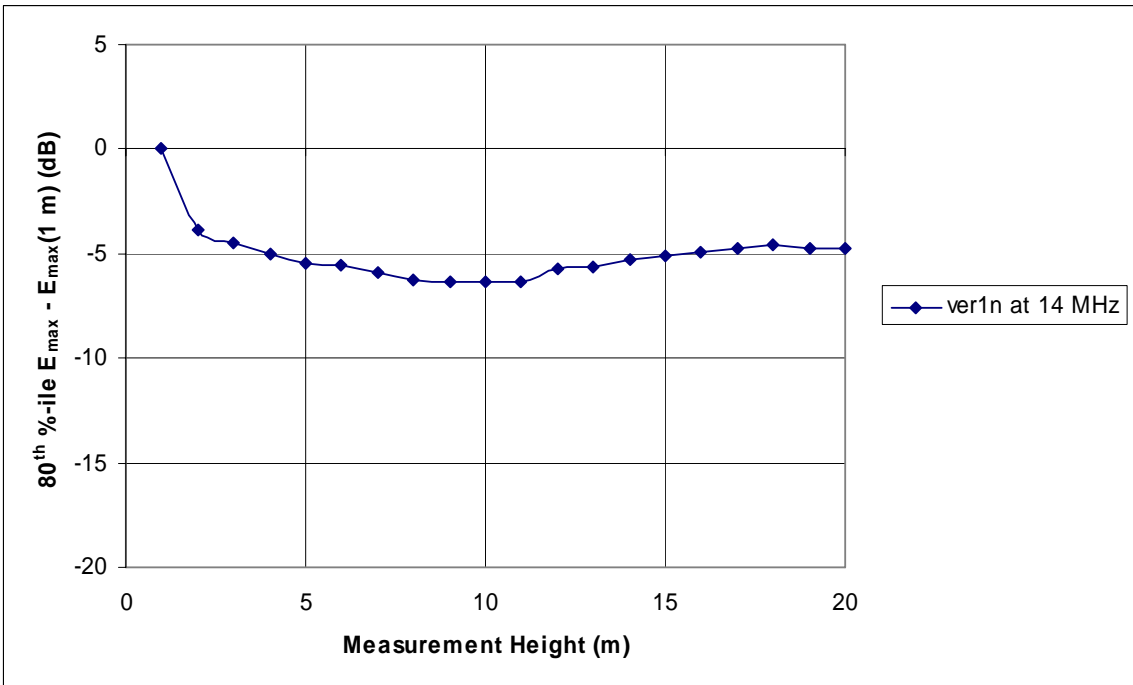


Figure A-58: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

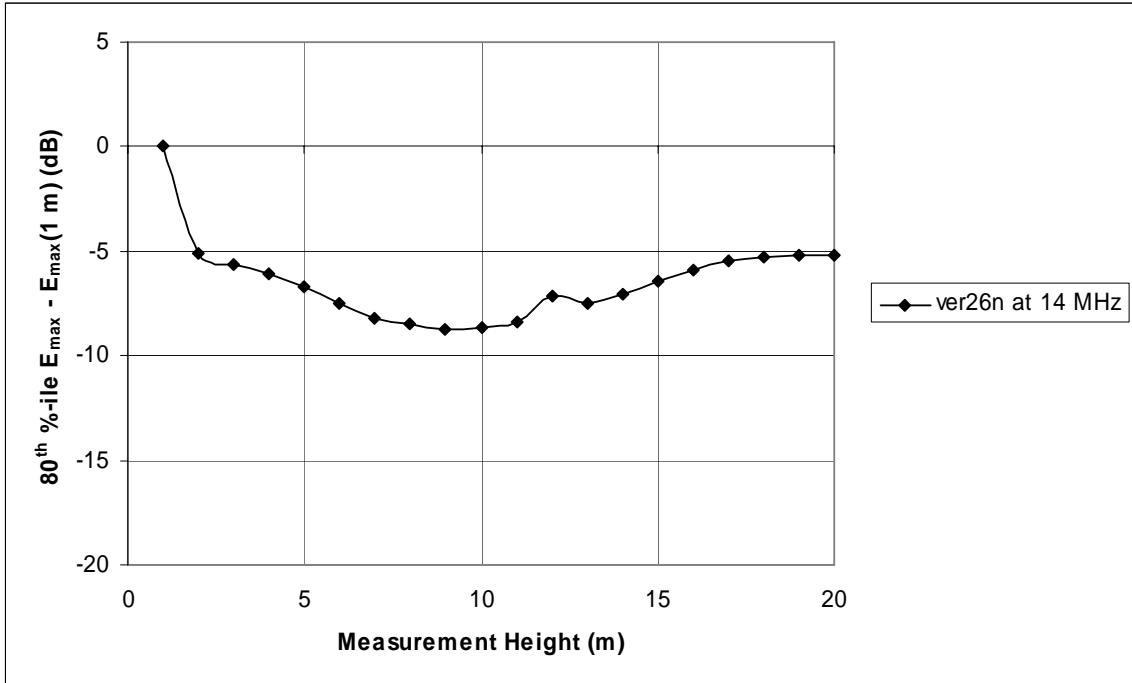


Figure A-59: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

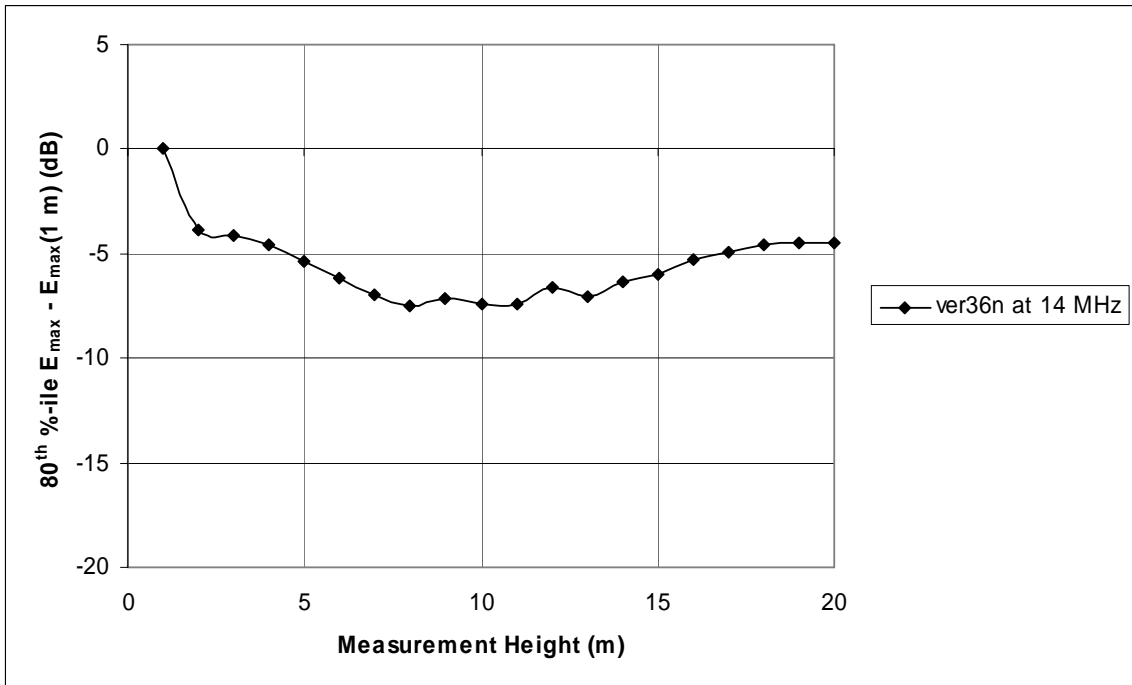


Figure A-60: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

16 MHz Plots

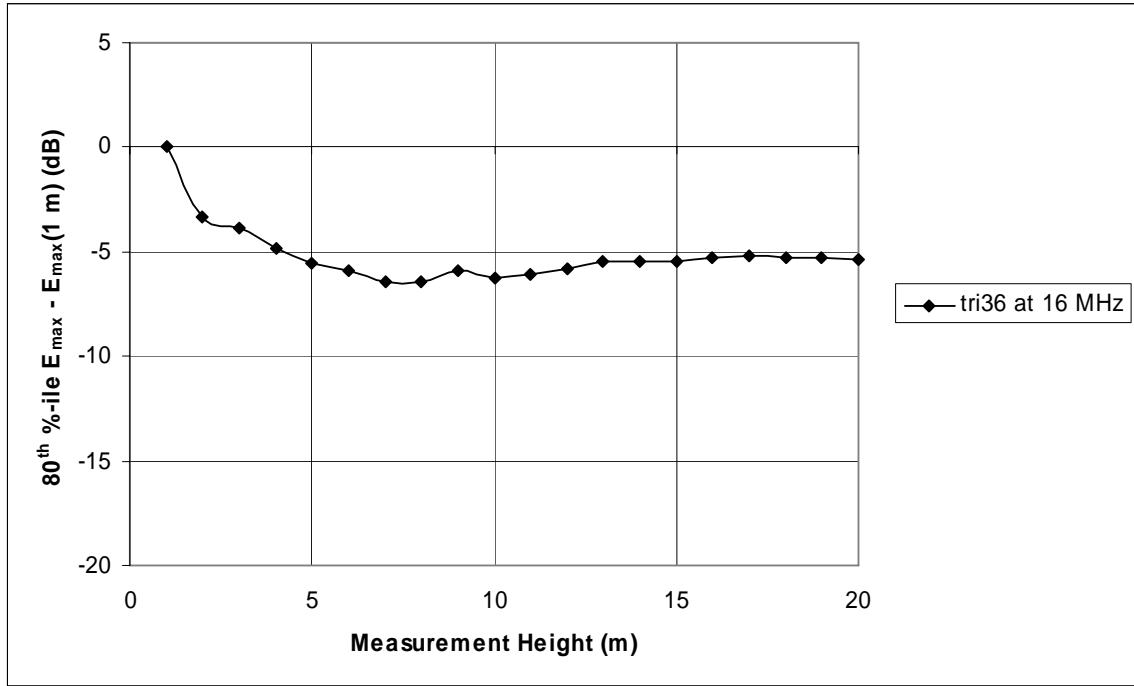


Figure A-61: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

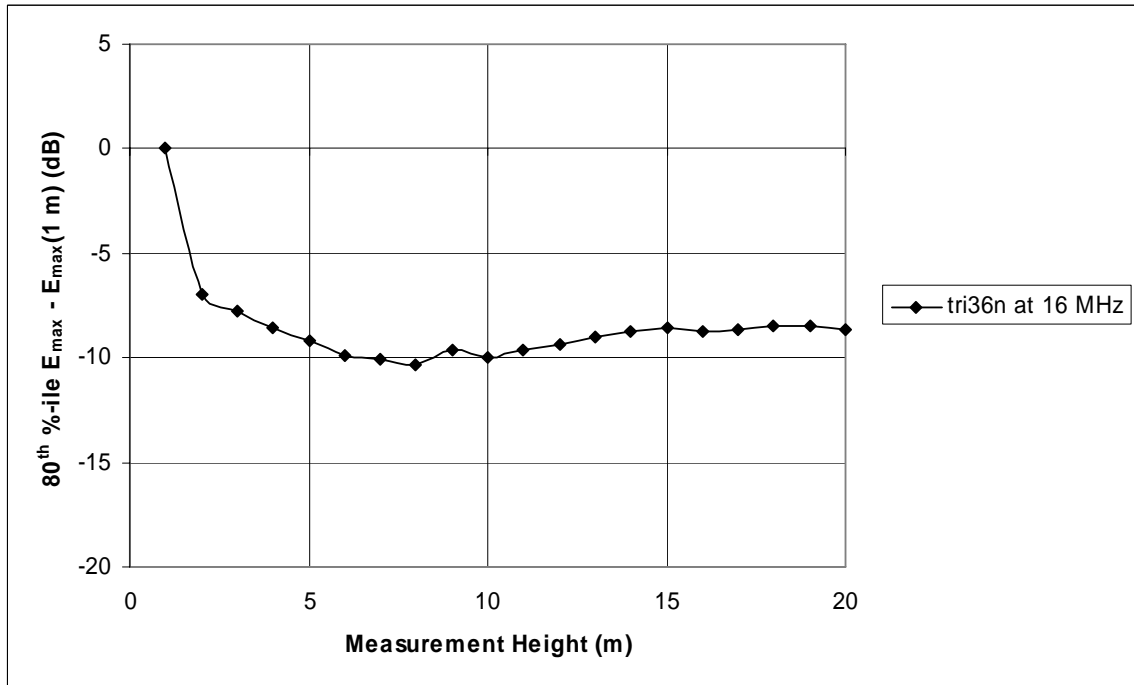


Figure A-62: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

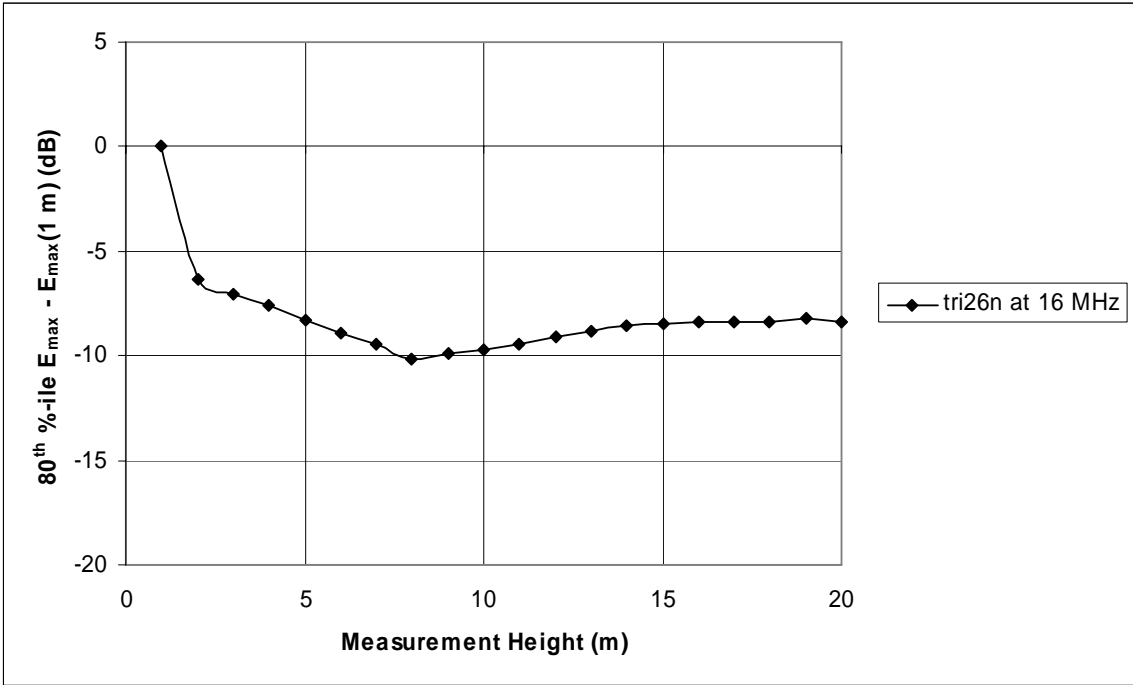


Figure A-63: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

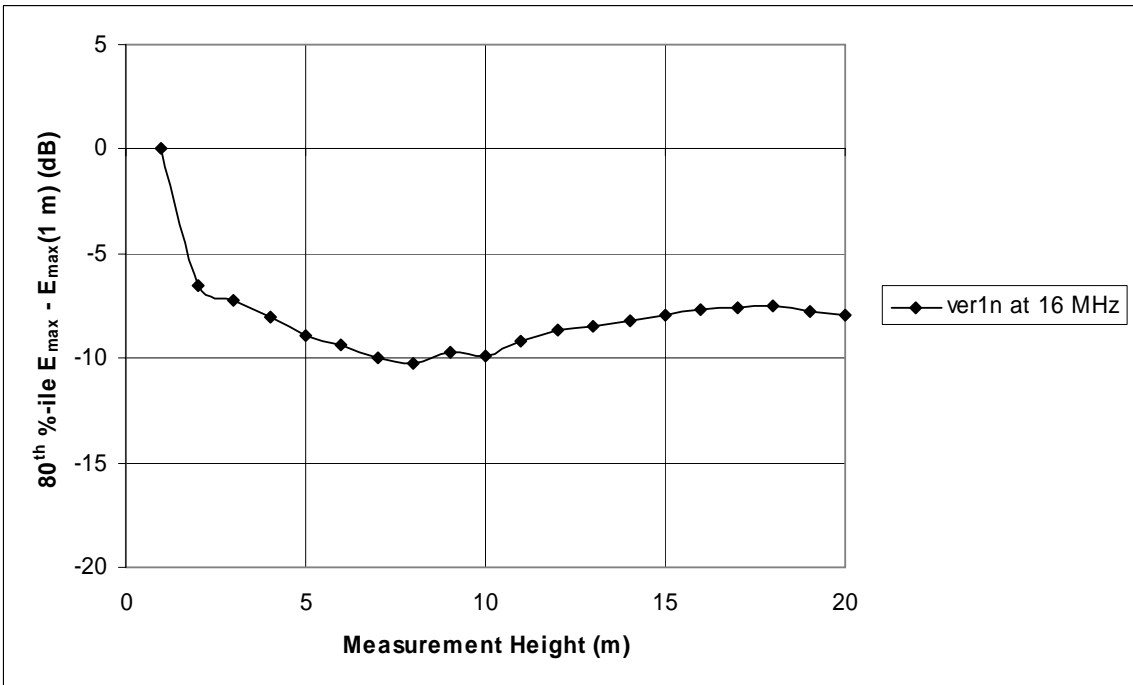


Figure A-64: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

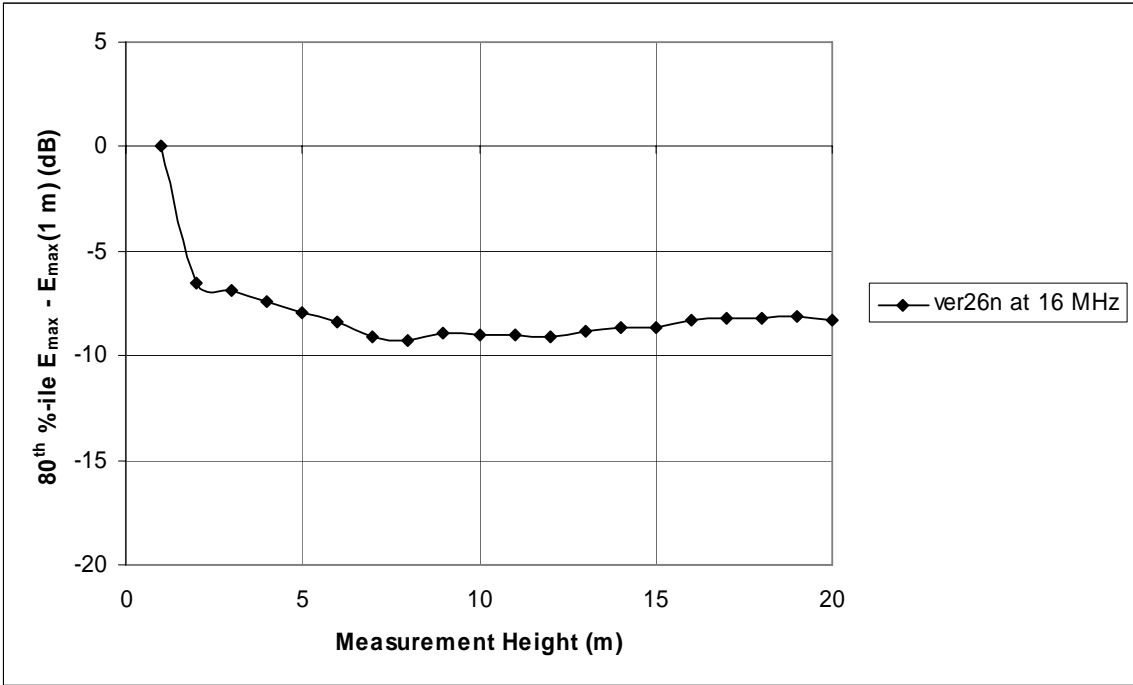


Figure A-65: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

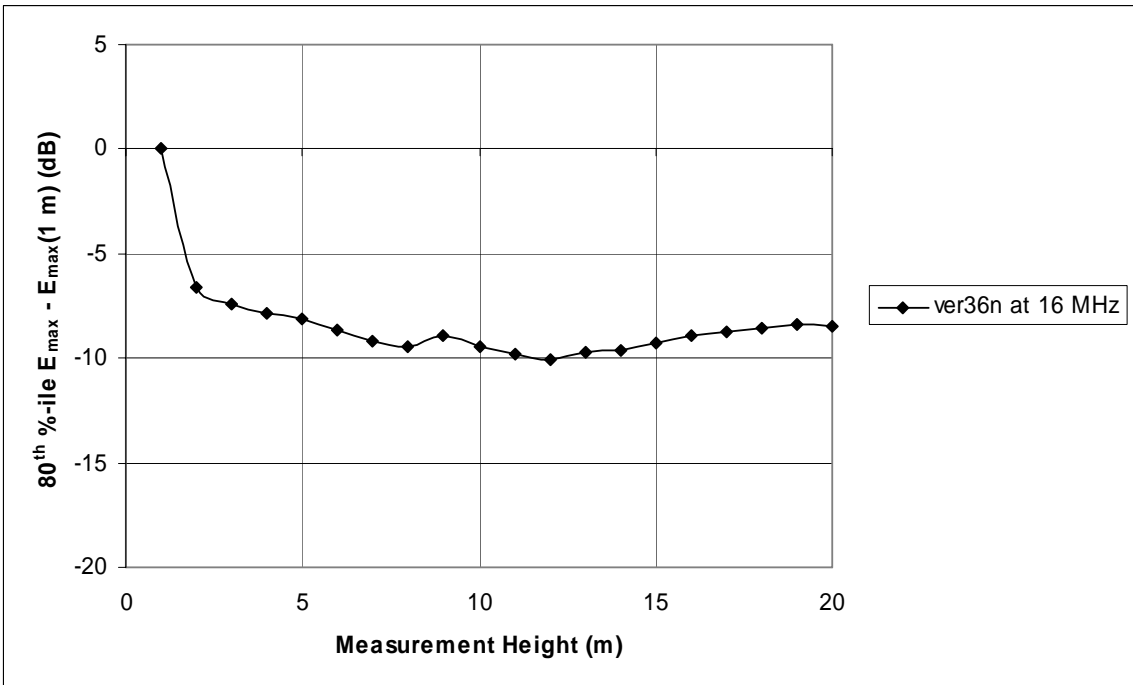


Figure A-66: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

18 MHz Plots

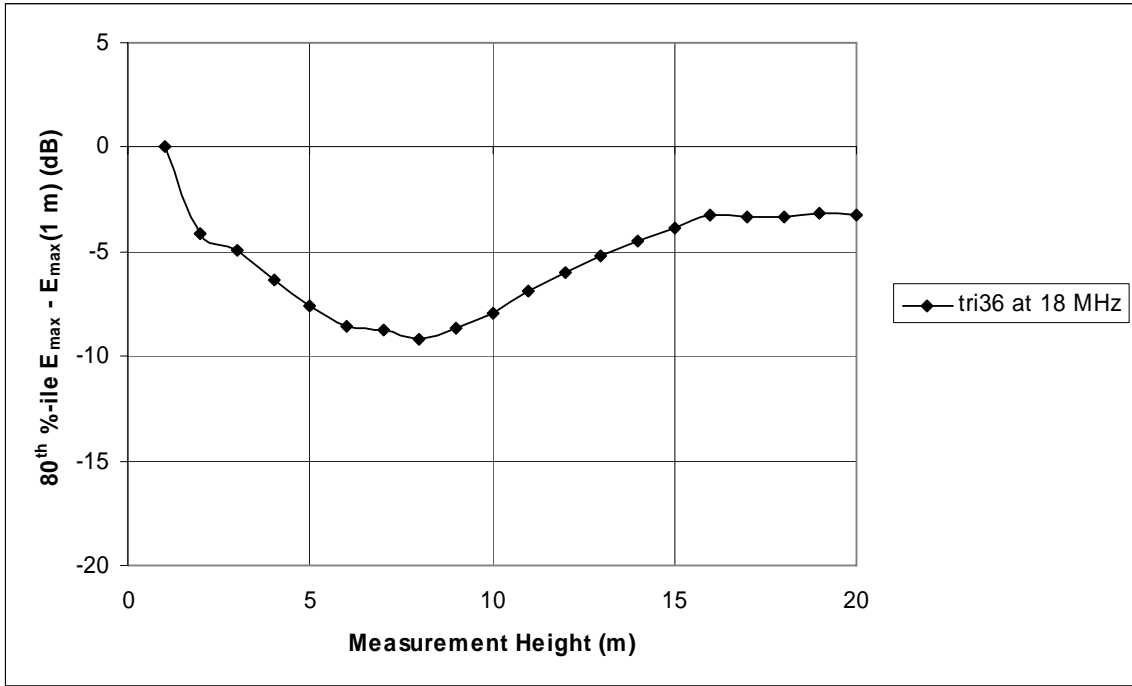


Figure A-67: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

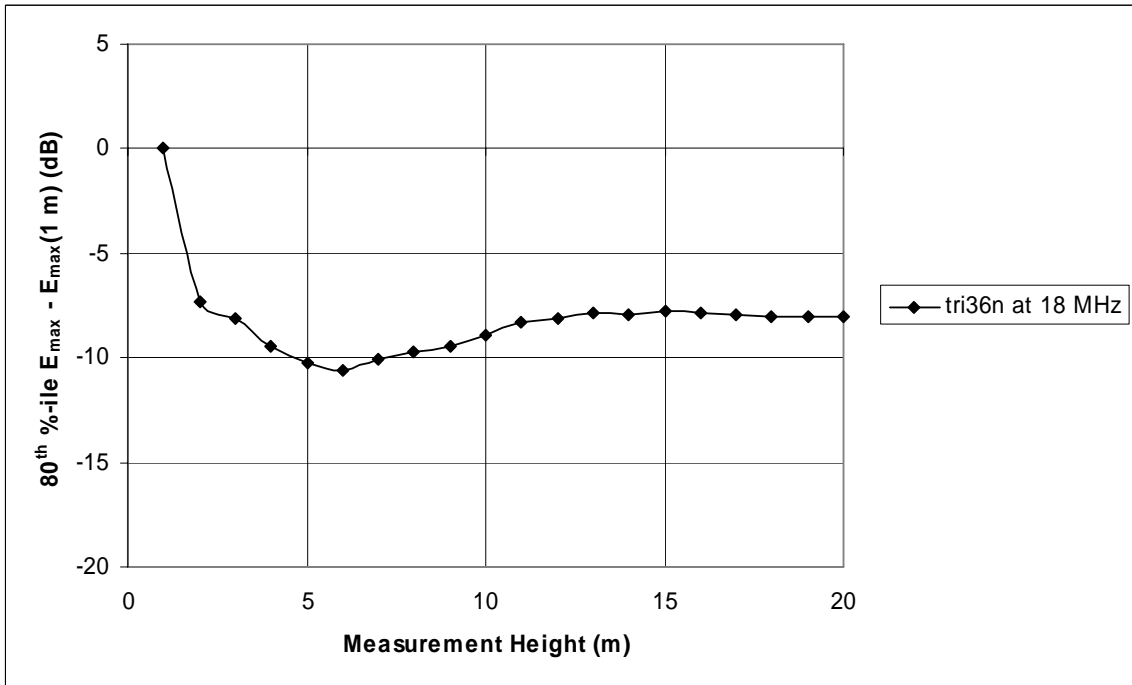


Figure A-68: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

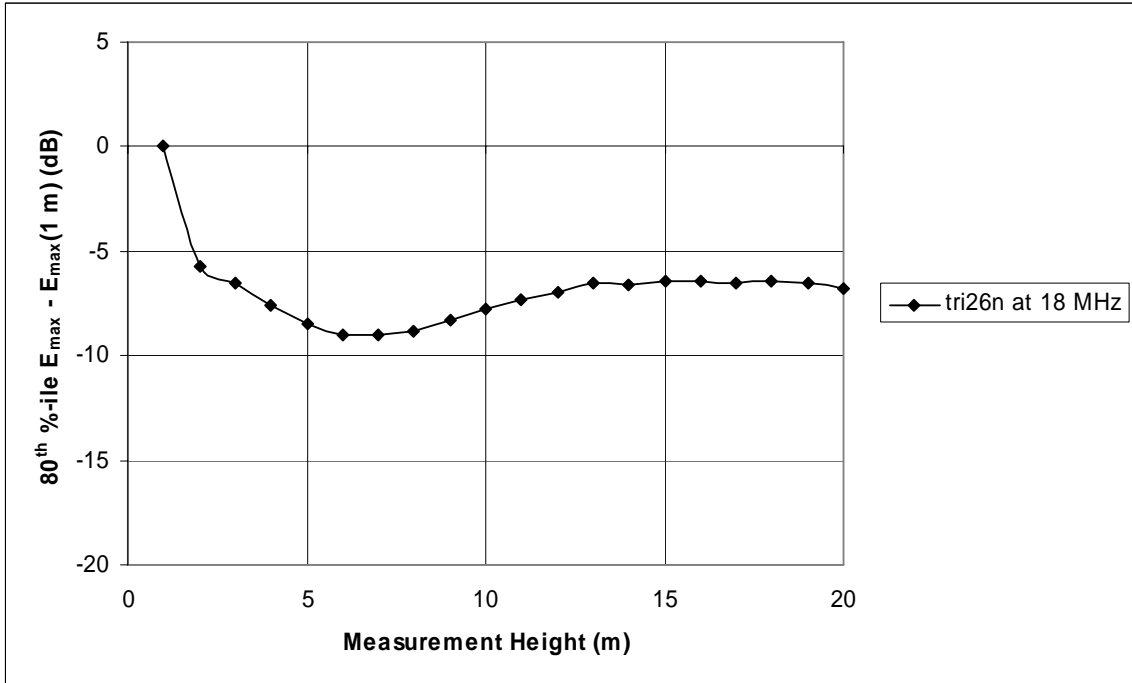


Figure A-69: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

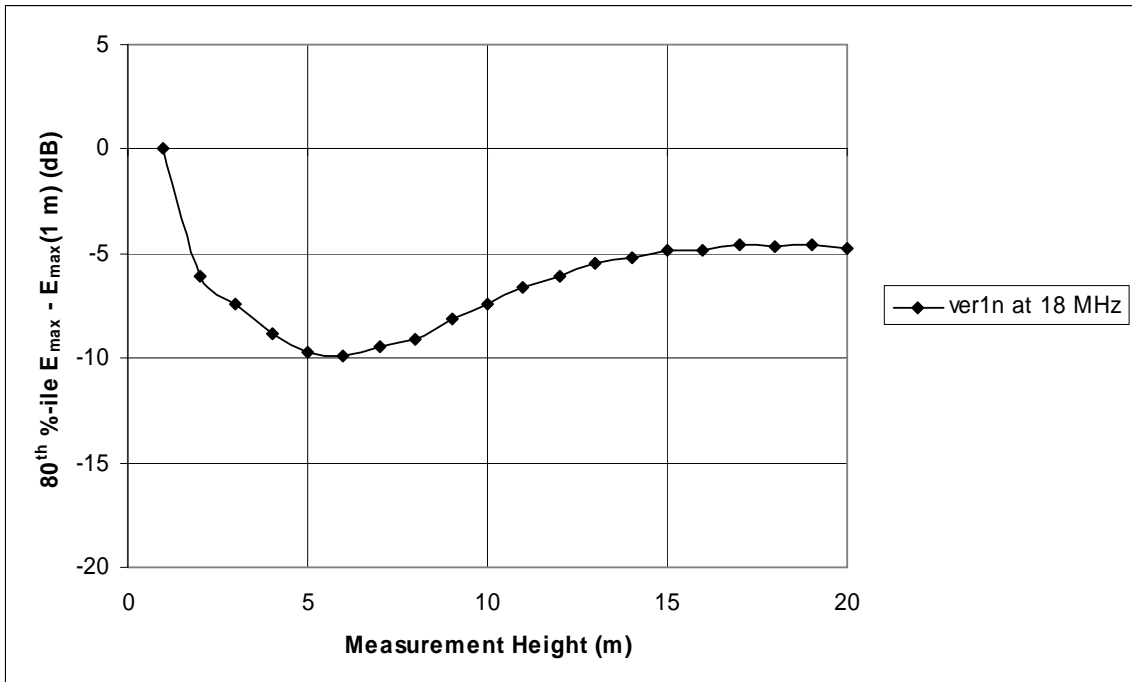


Figure A-70: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

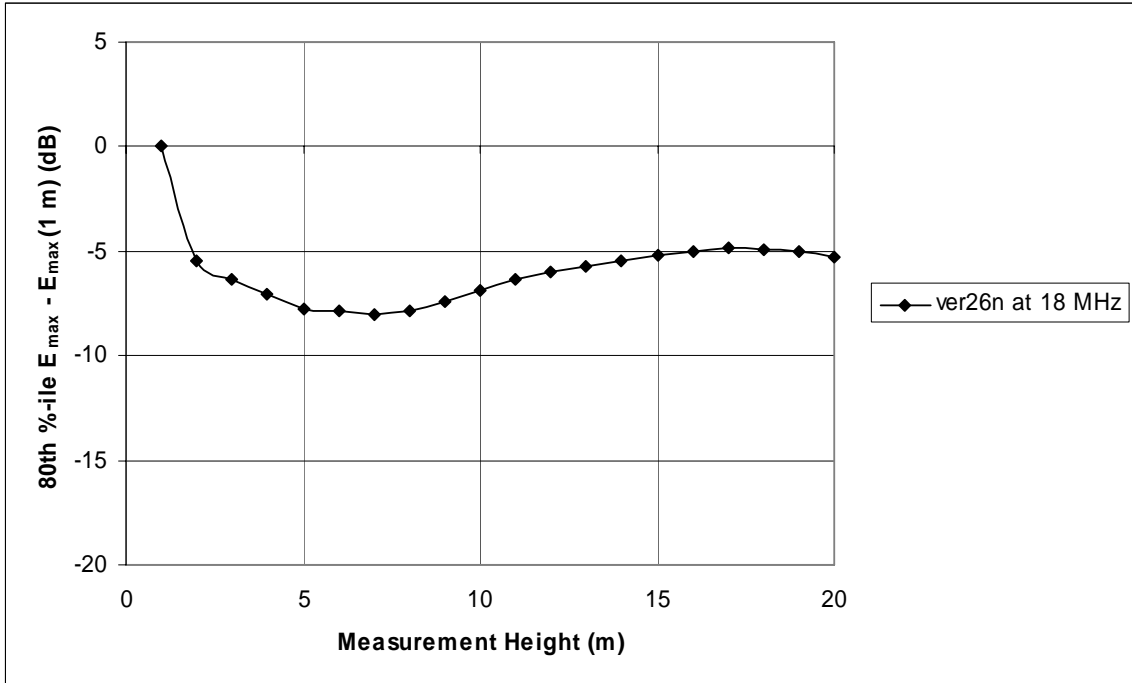


Figure A-71: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

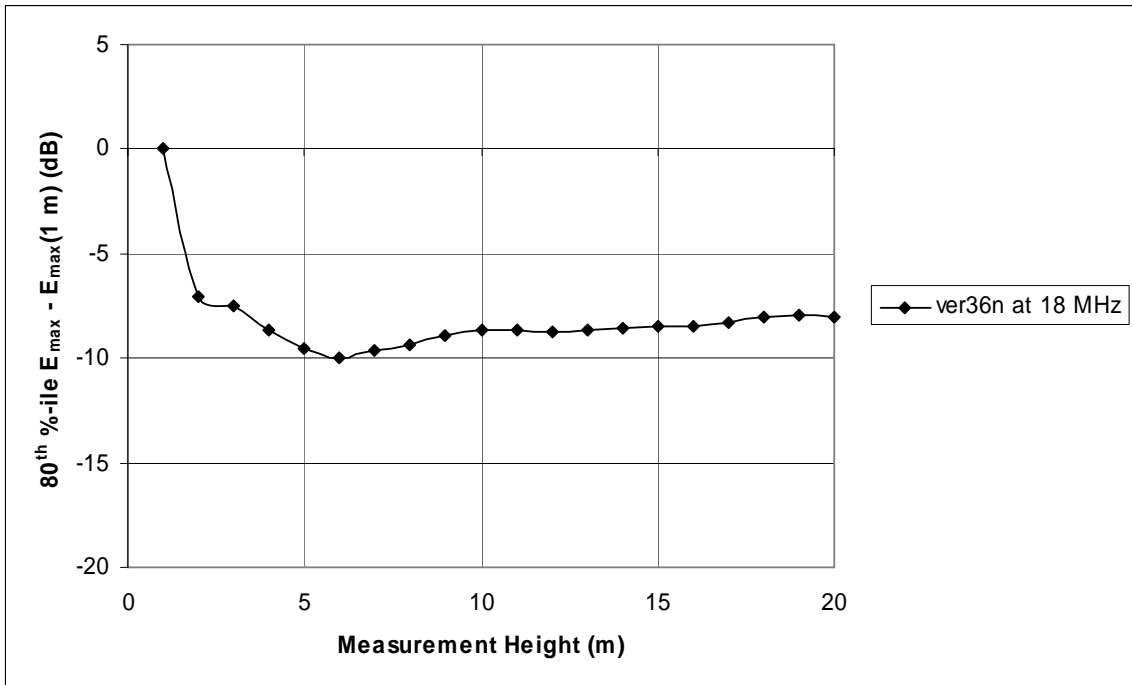


Figure A-72: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

20 MHz Plots

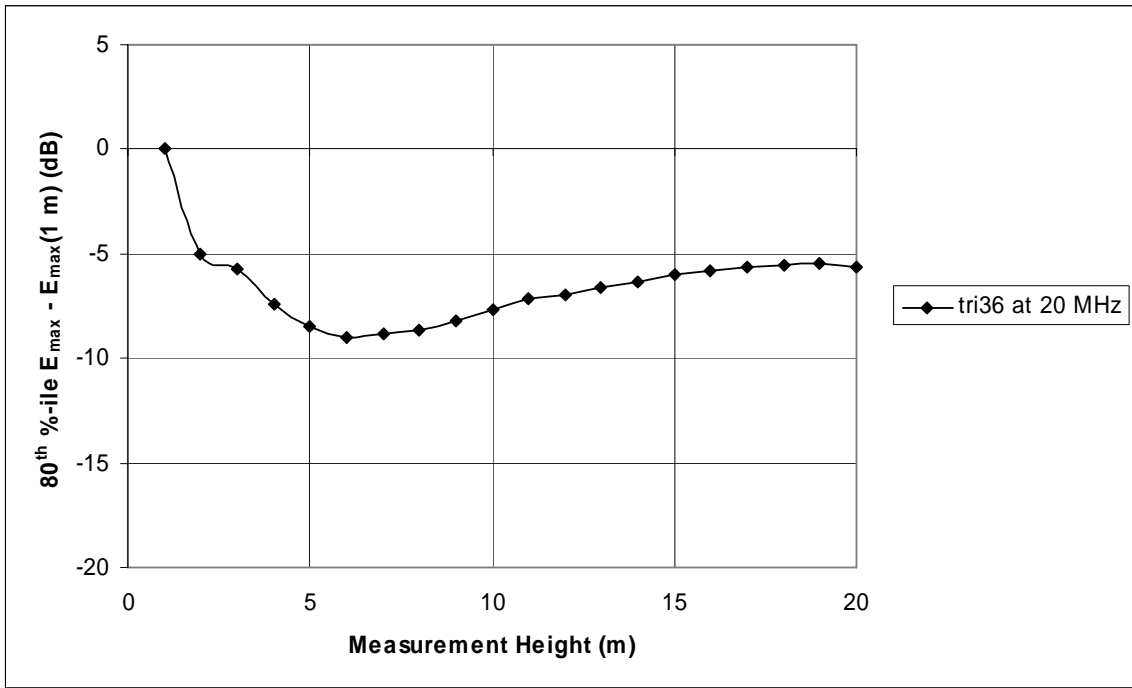


Figure A-73: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

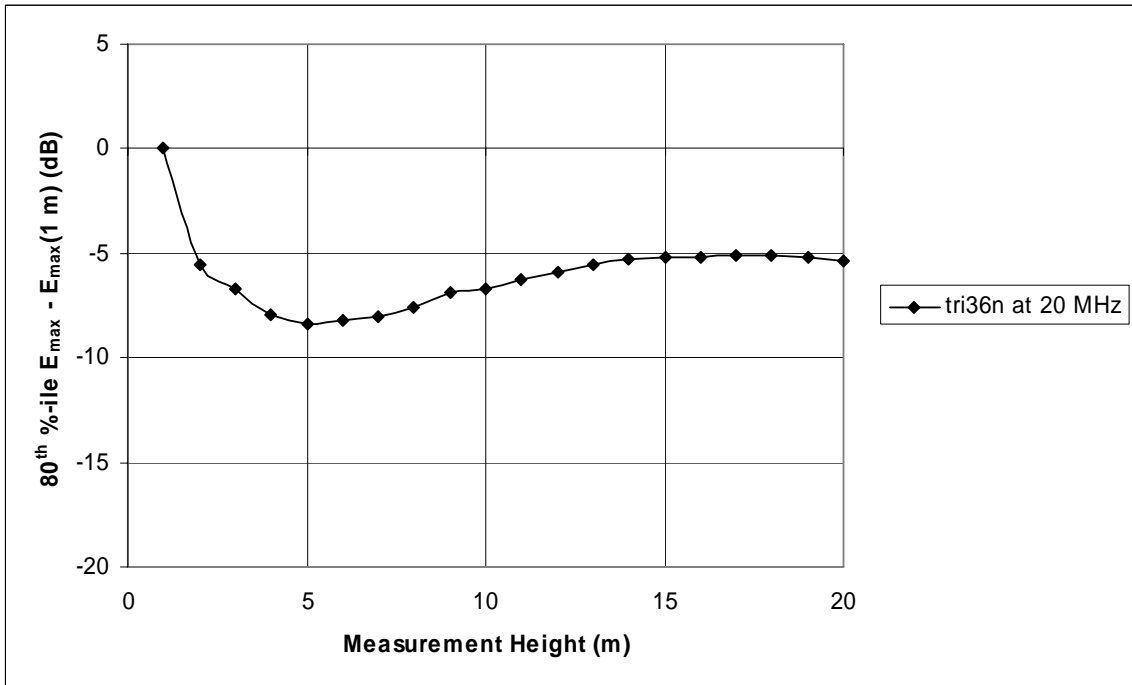


Figure A-74: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

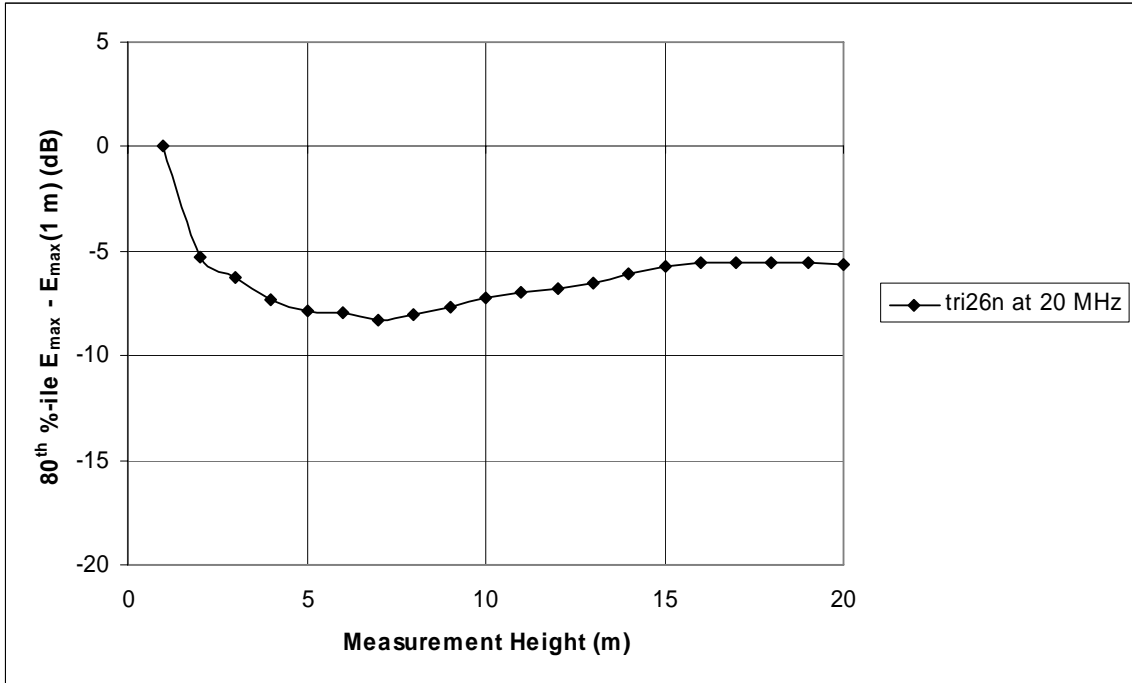


Figure A-75: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

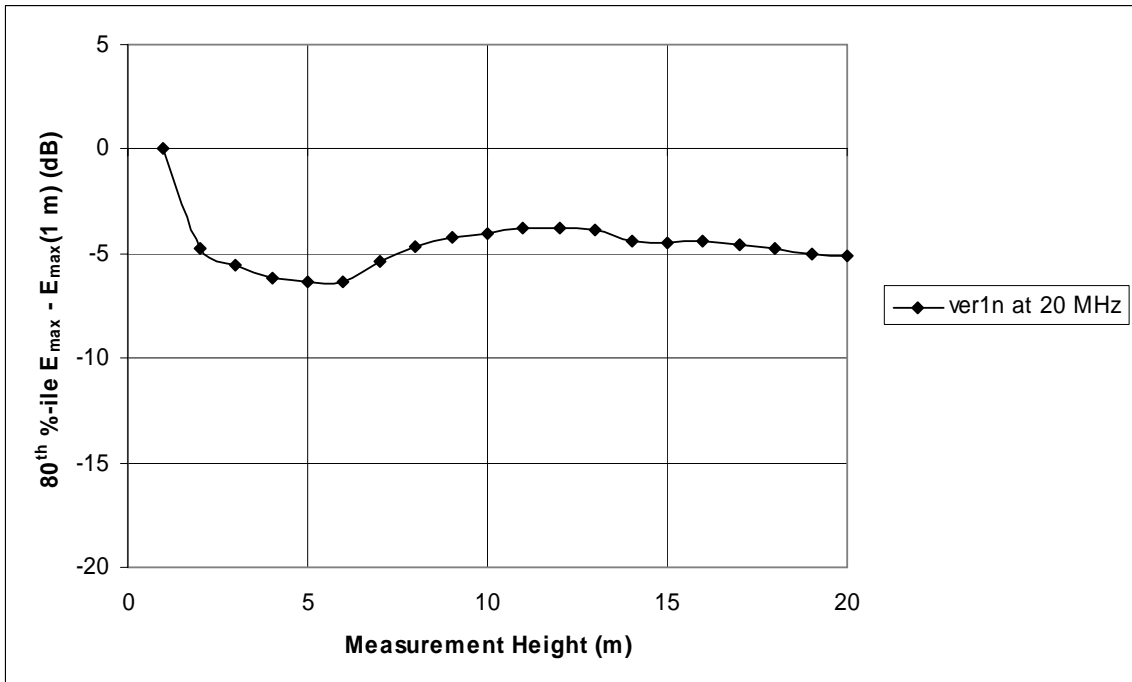


Figure A-76: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

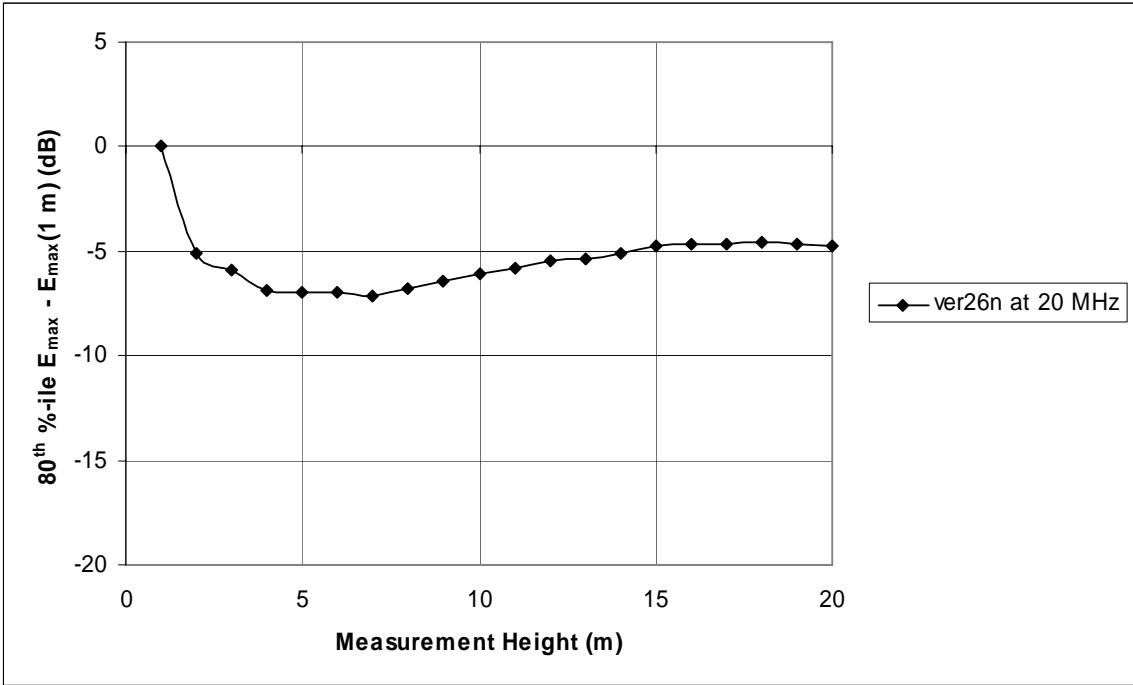


Figure A-77: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

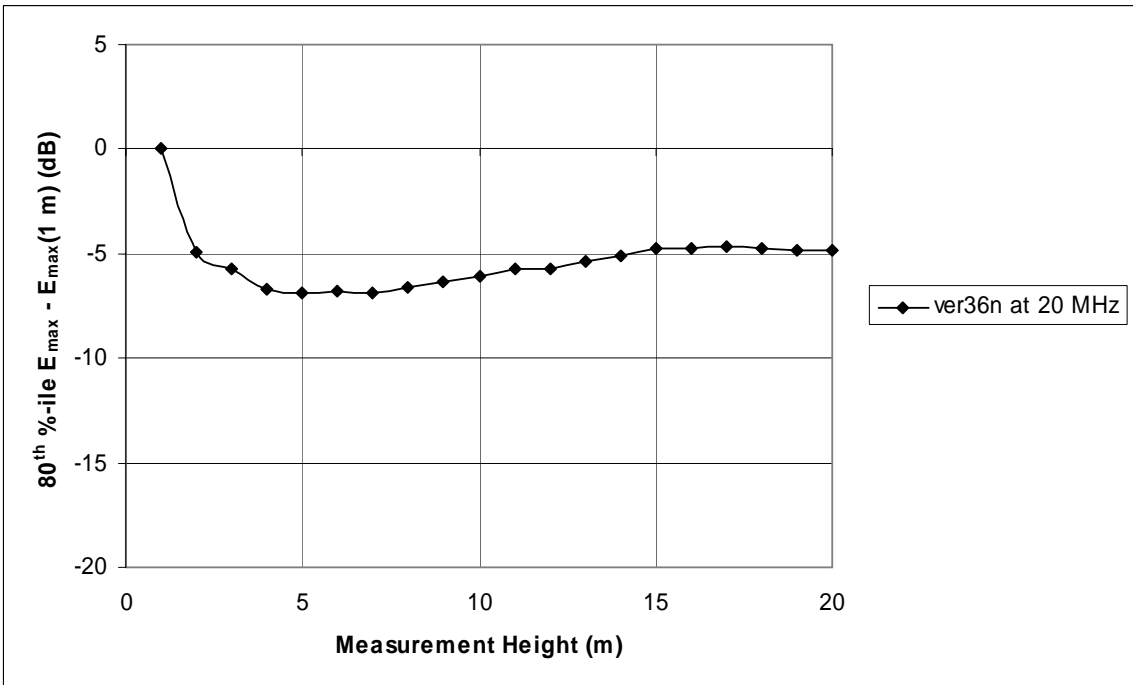


Figure A-78: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

22 MHz Plots

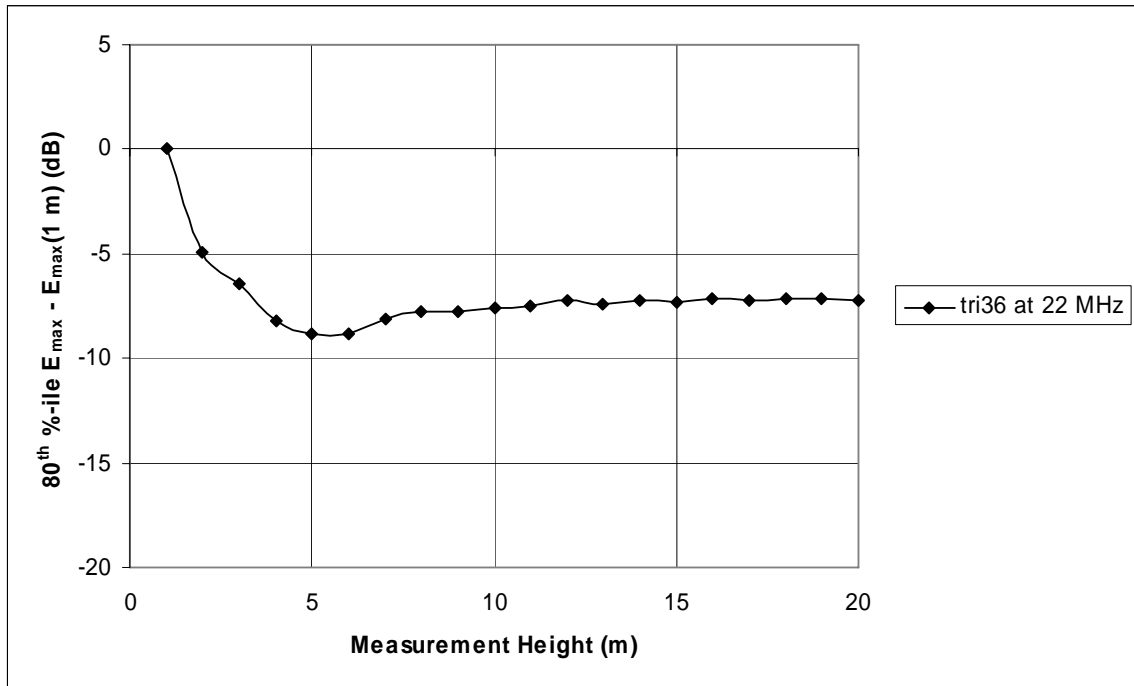


Figure A-79: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

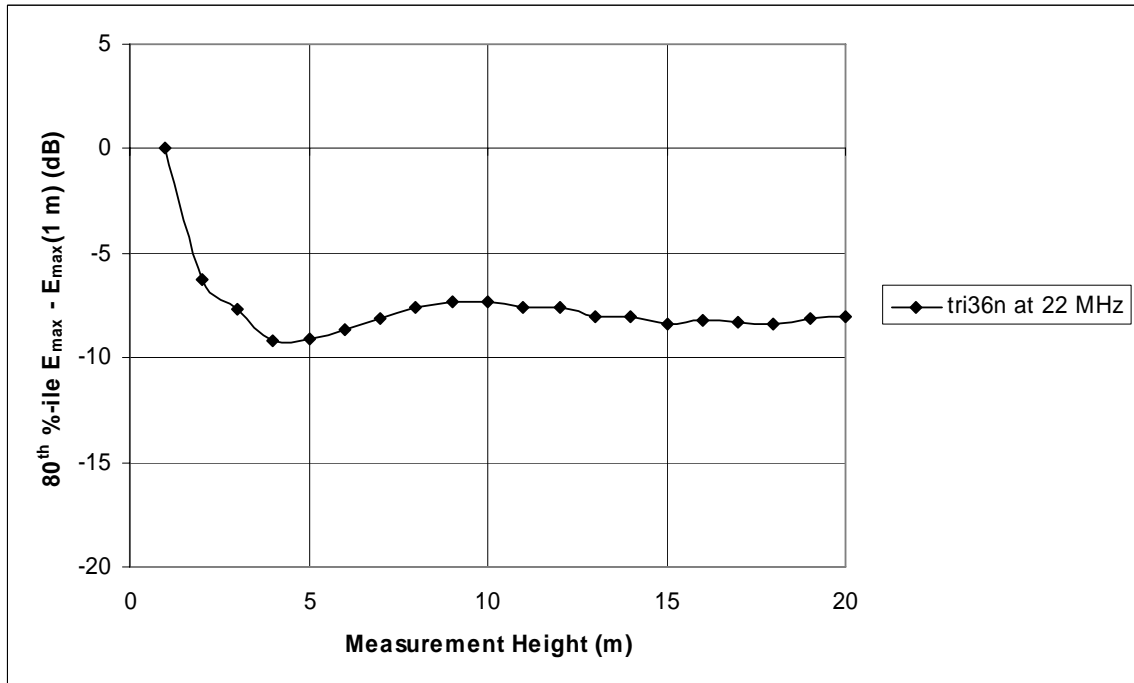


Figure A-80: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

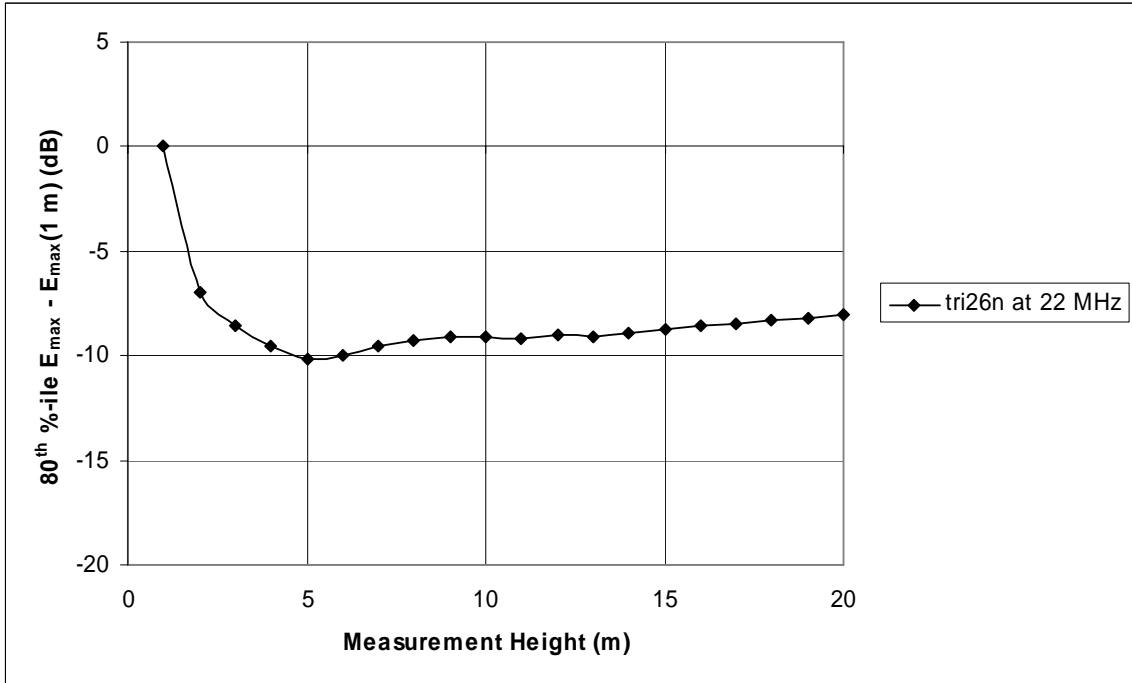


Figure A-81: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

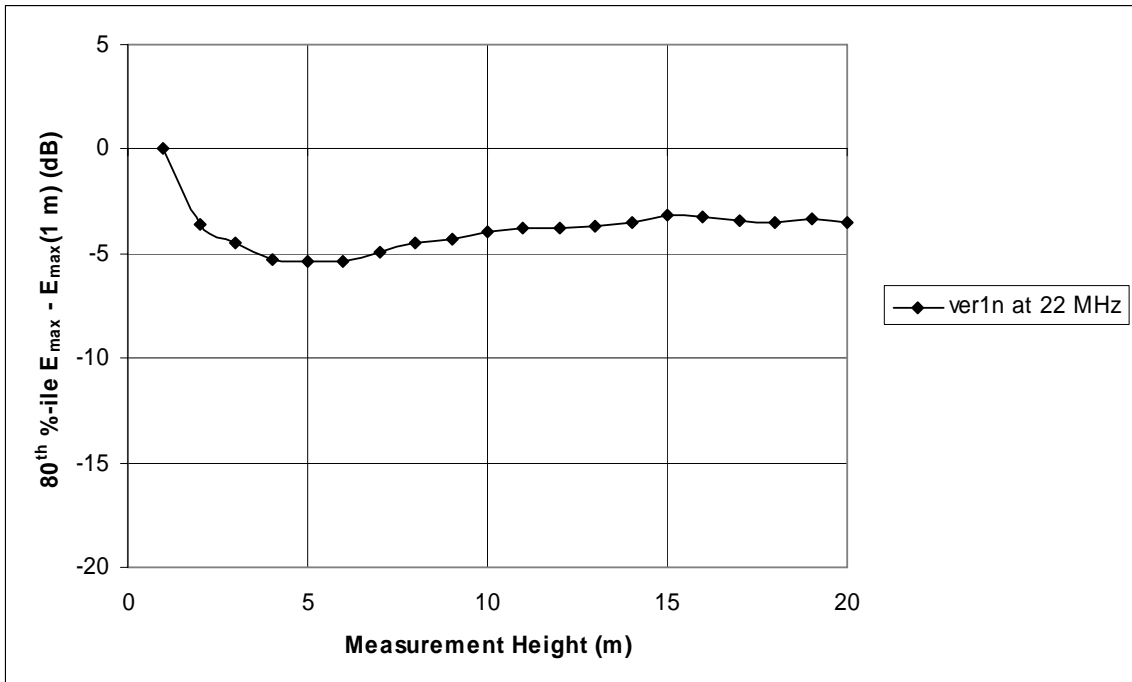


Figure A-82: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

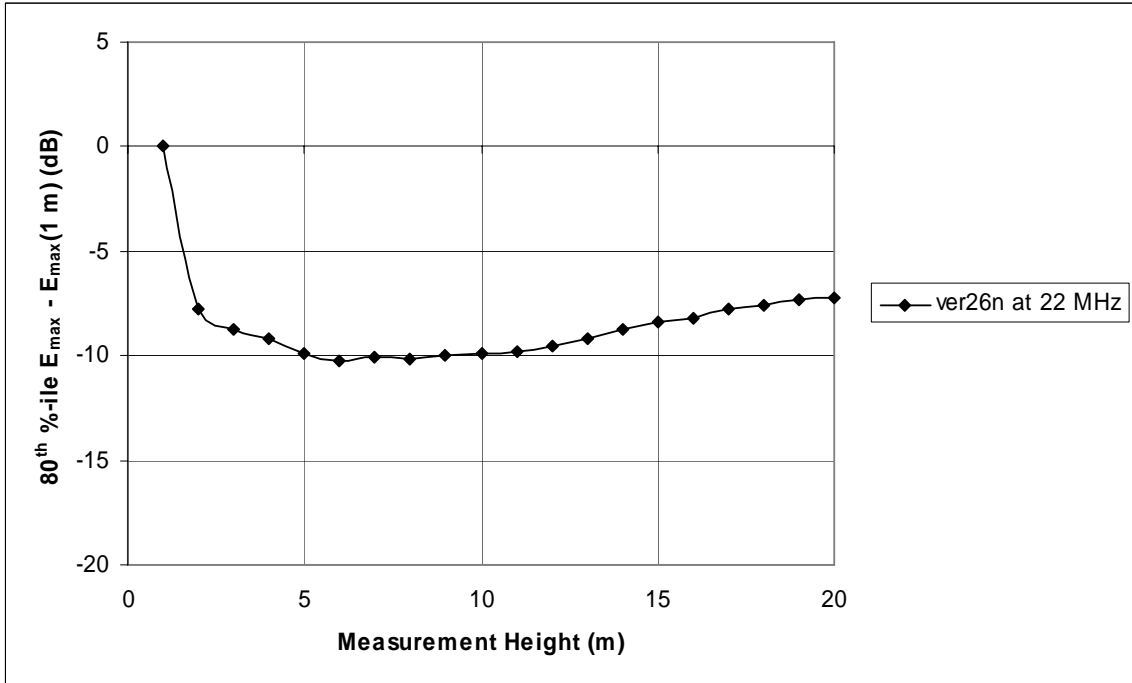


Figure A-83: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

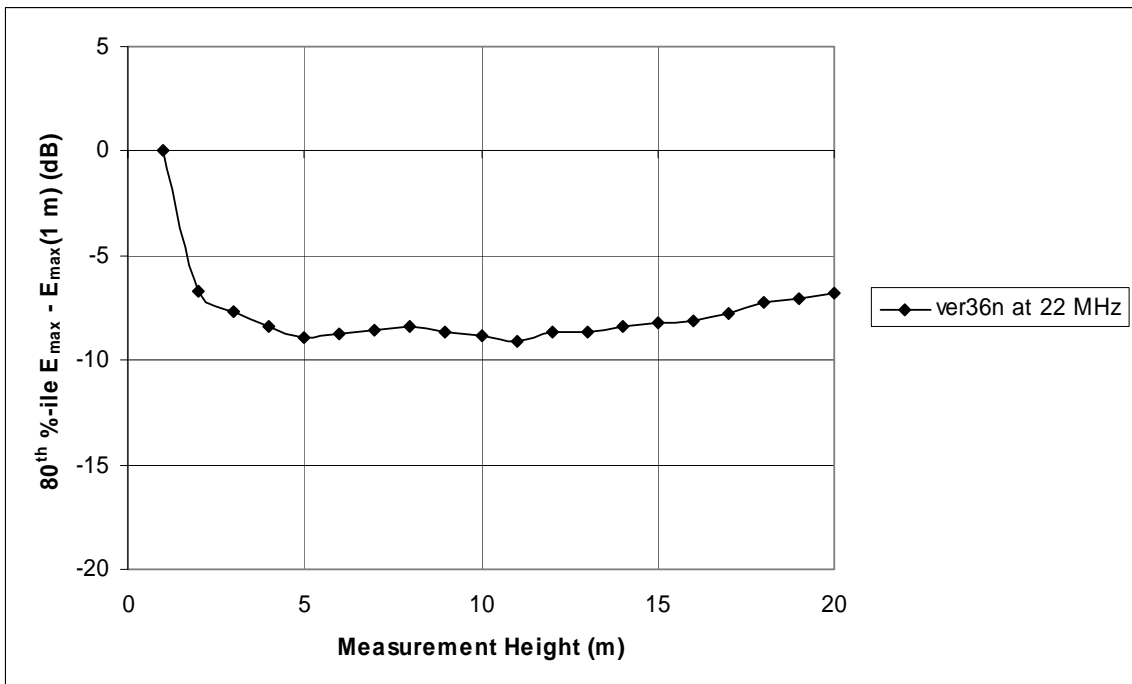


Figure A-84: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

24 MHz Plots

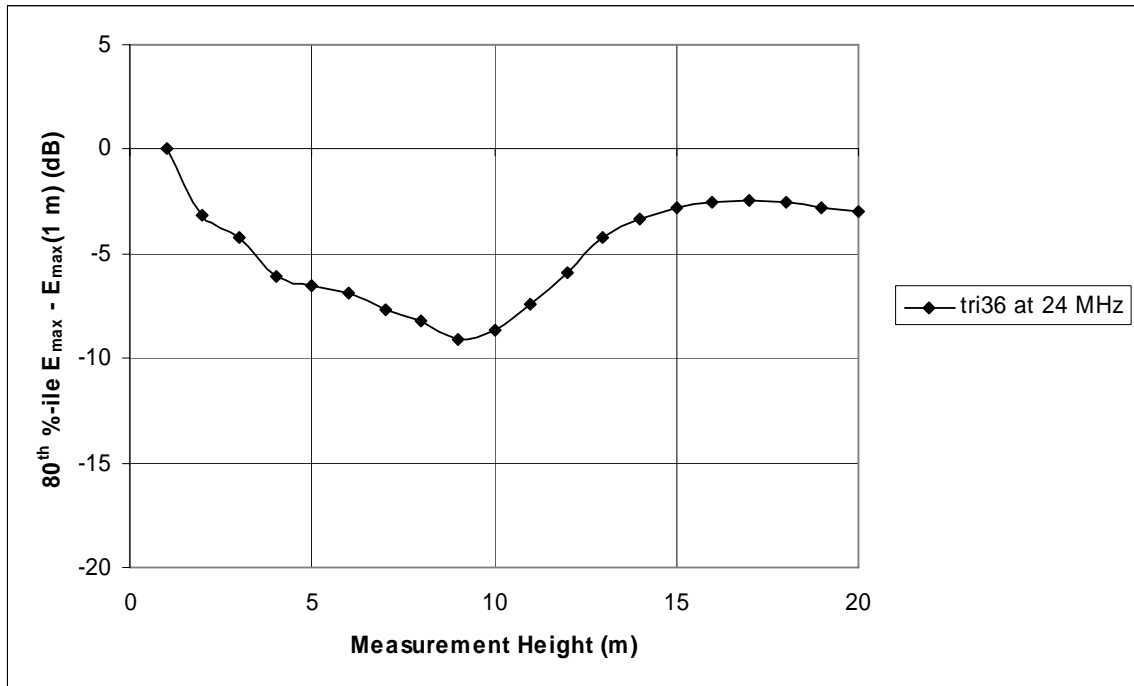


Figure A-85: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

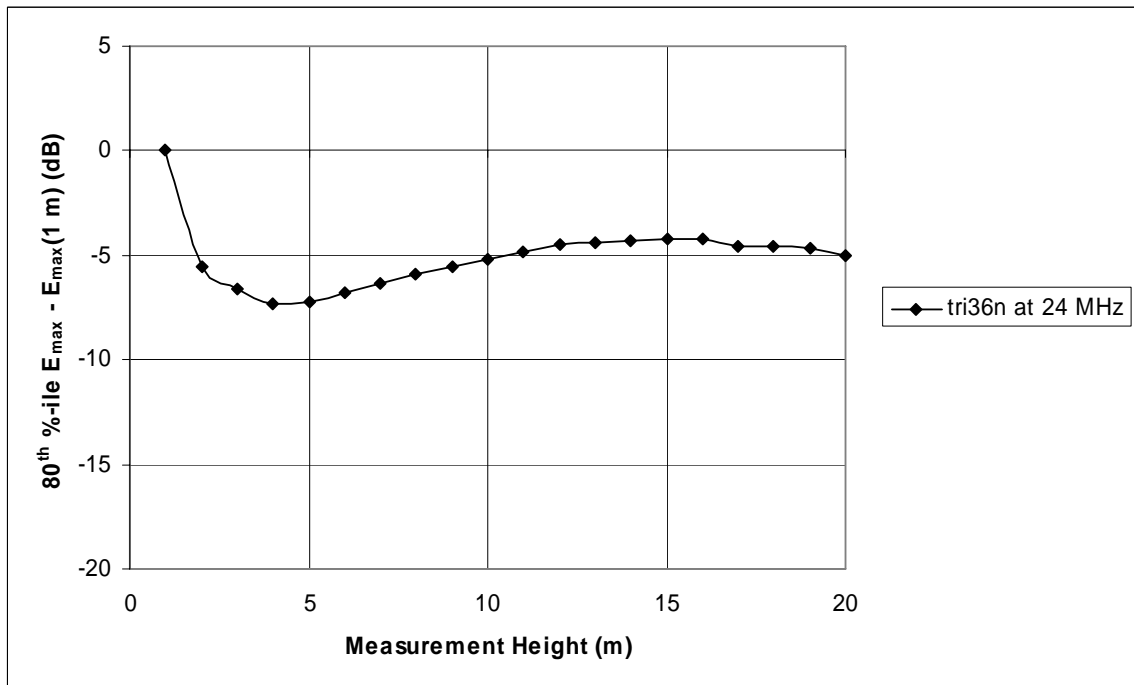


Figure A-86: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

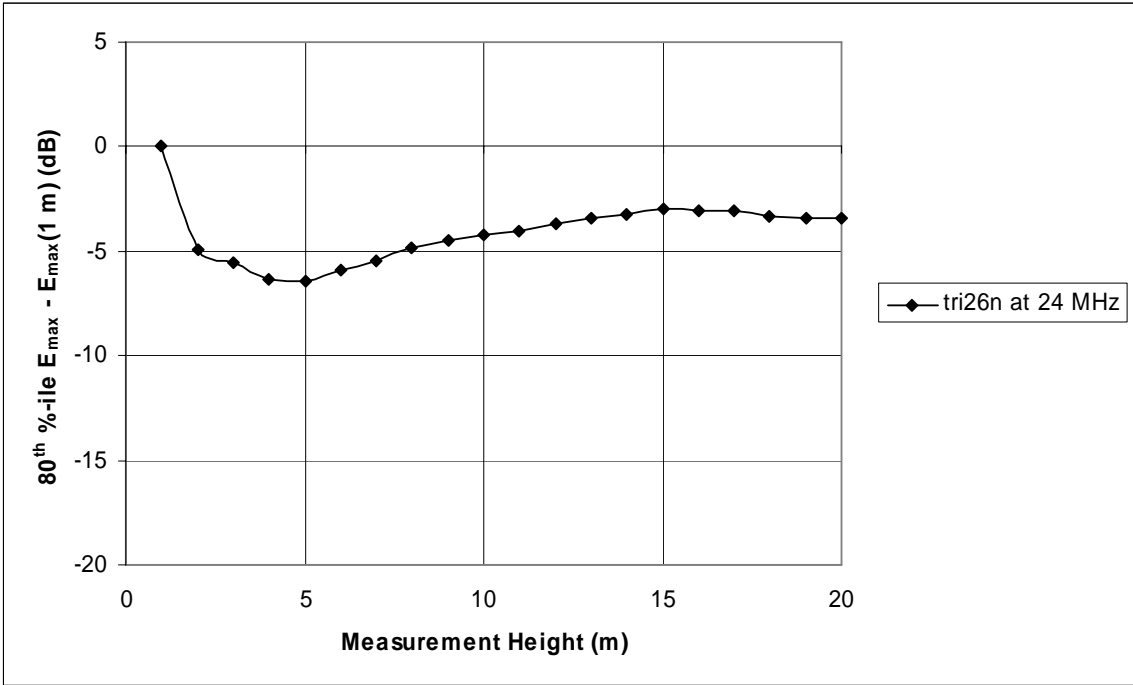


Figure A-87: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

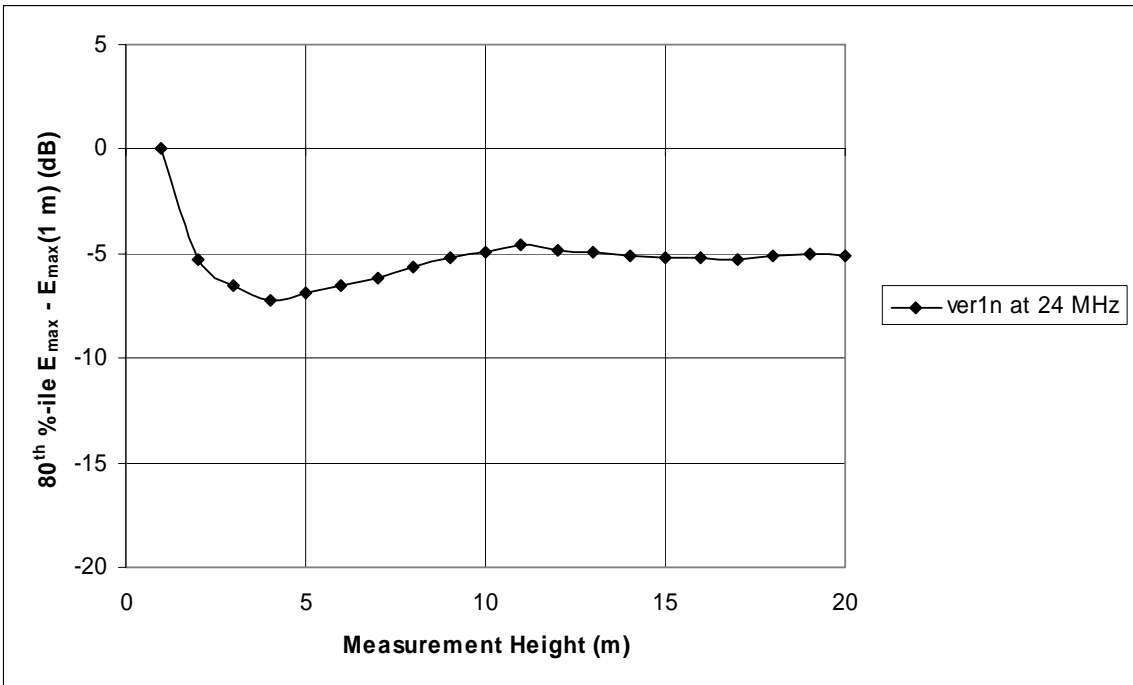


Figure A-88: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

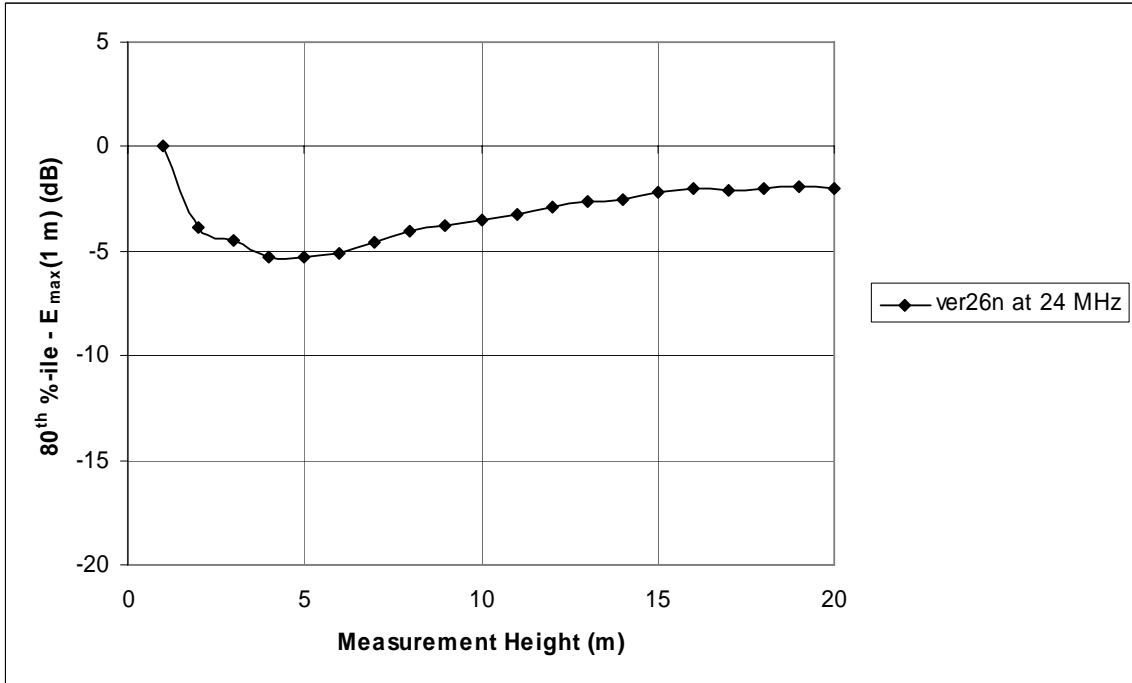


Figure A-89: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

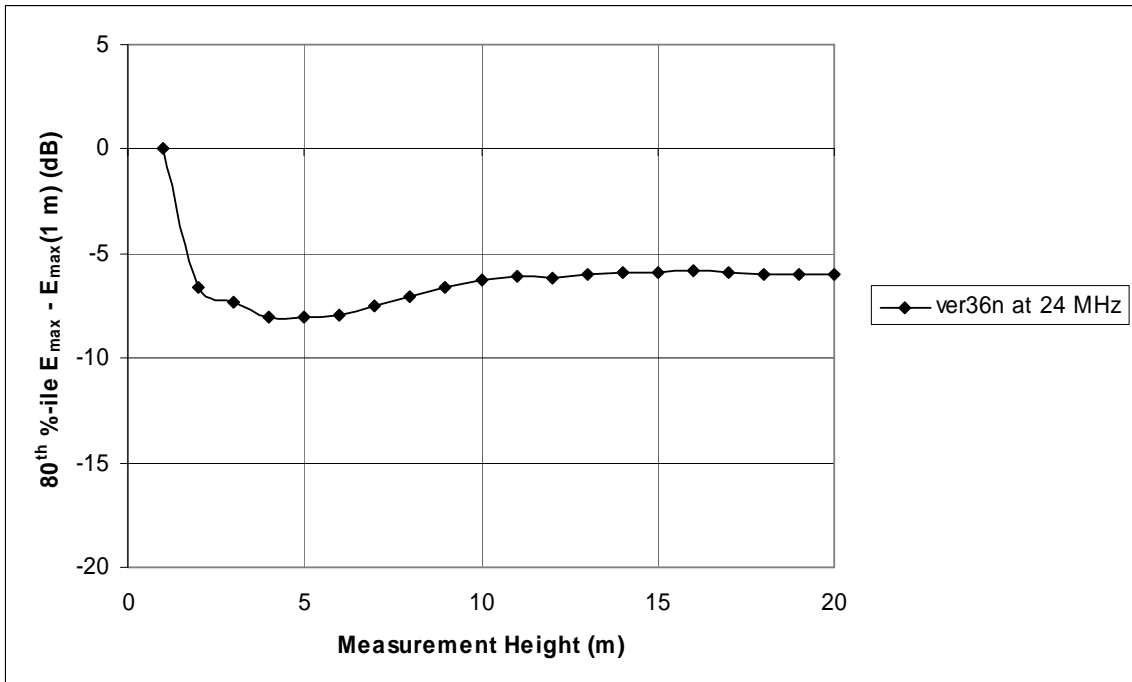


Figure A-90: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

26 MHz Plots

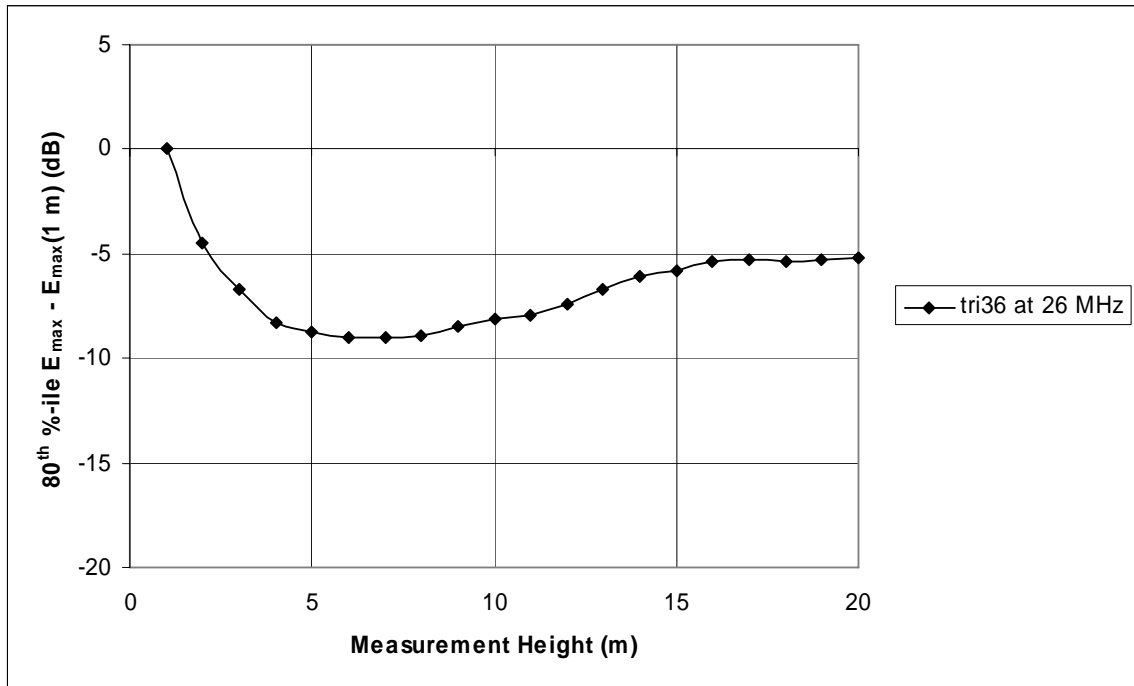


Figure A-91: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

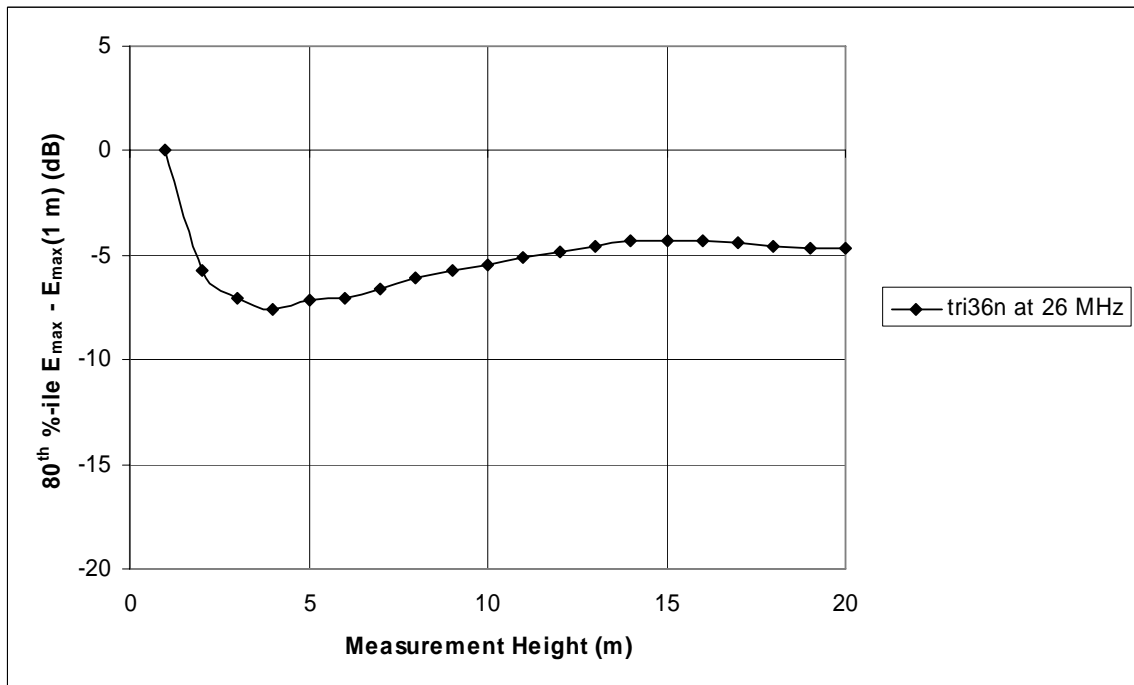


Figure A-92: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

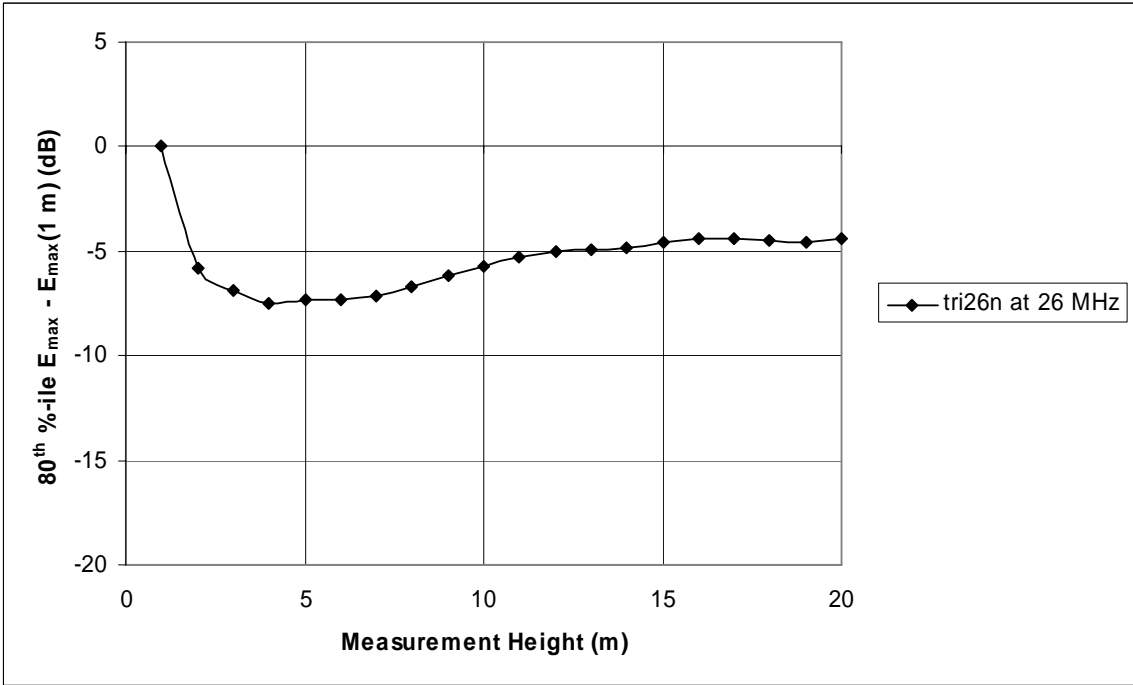


Figure A-93: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

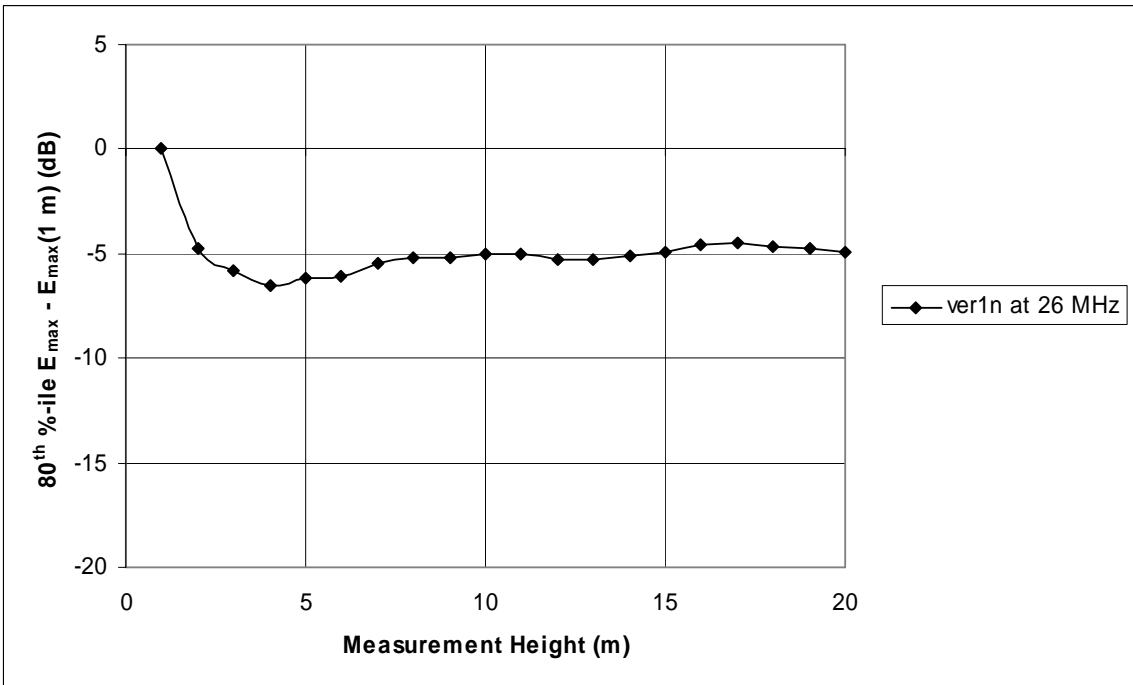


Figure A-94: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

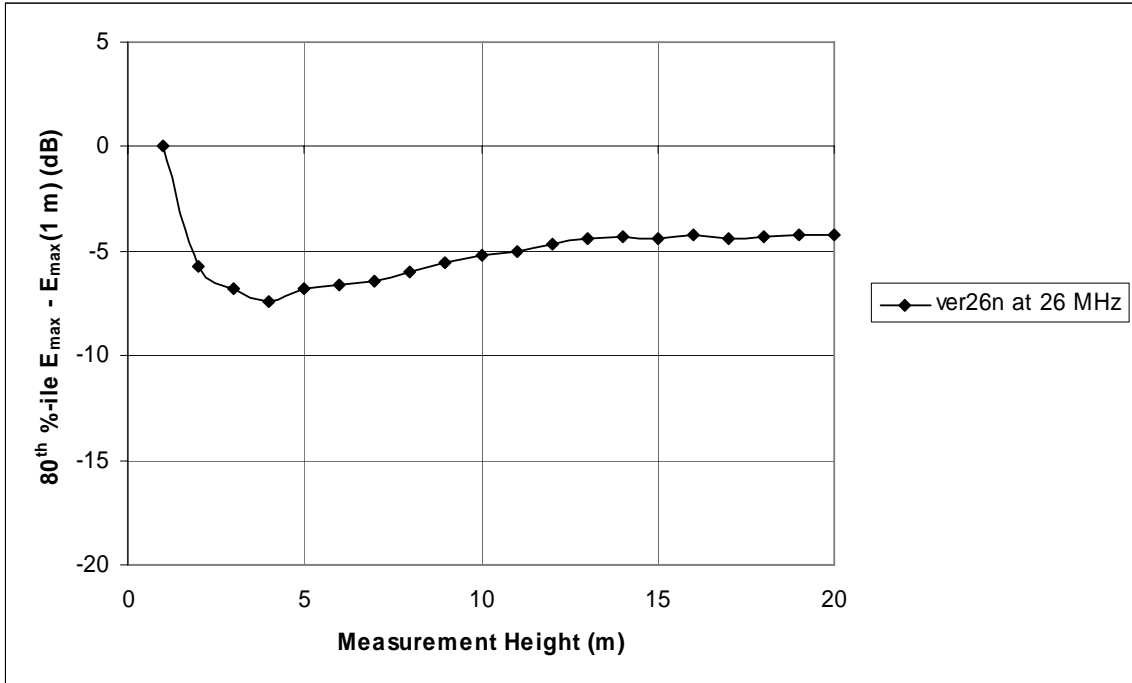


Figure A-95: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

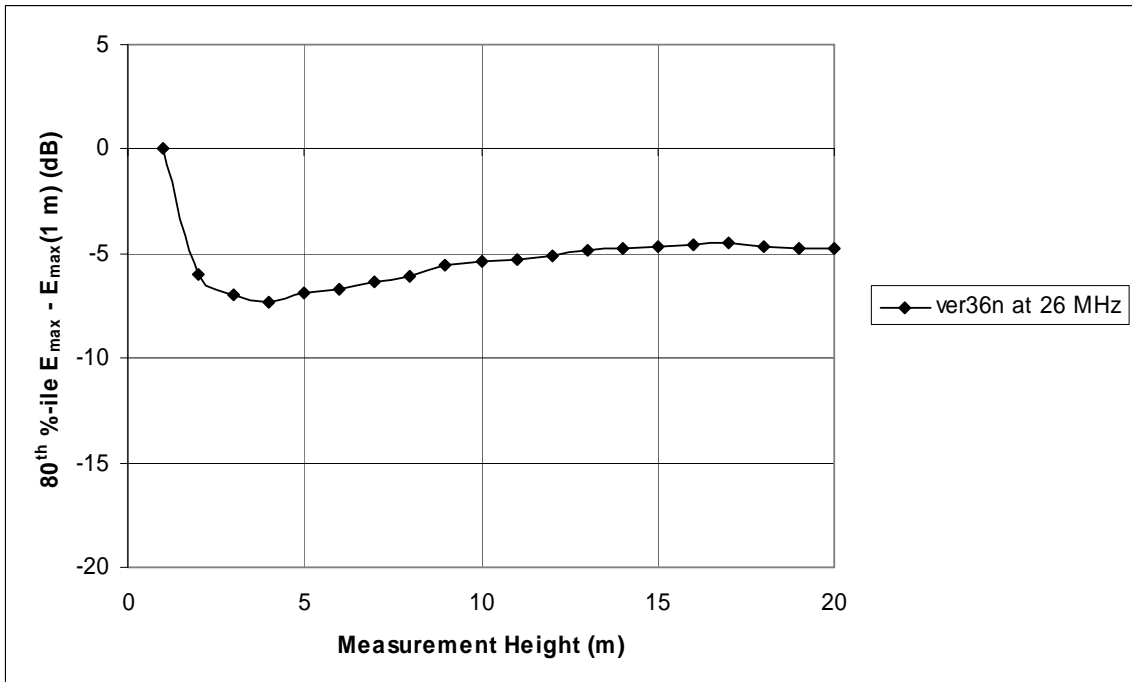


Figure A-96: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

28 MHz Plots

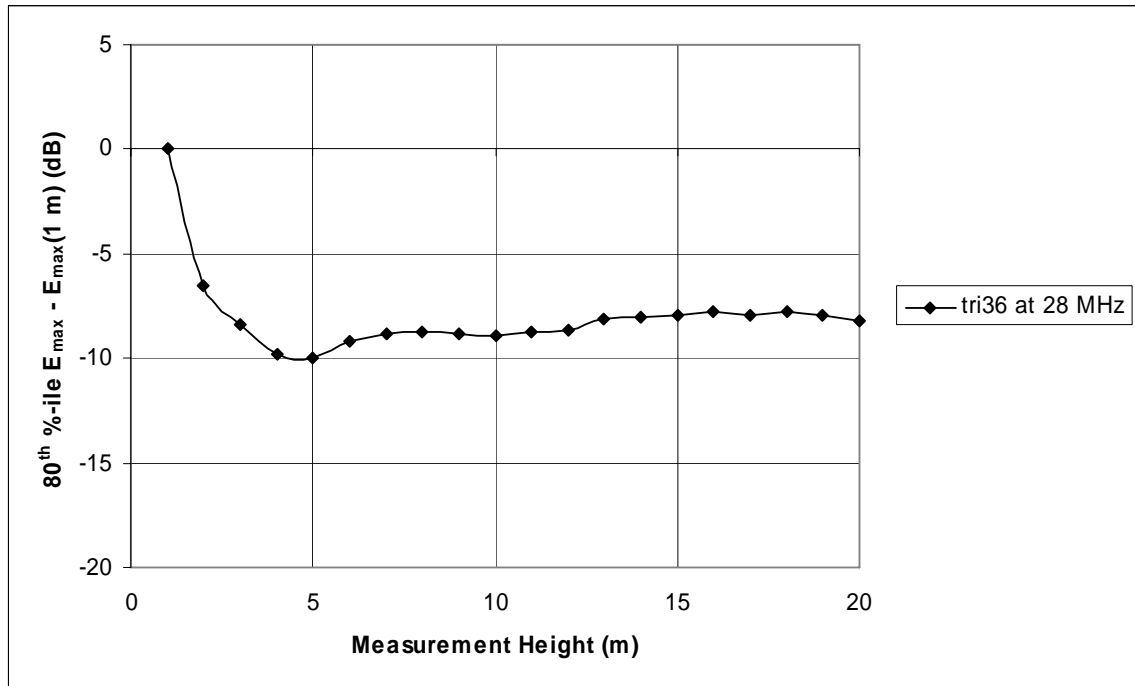


Figure A-97: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

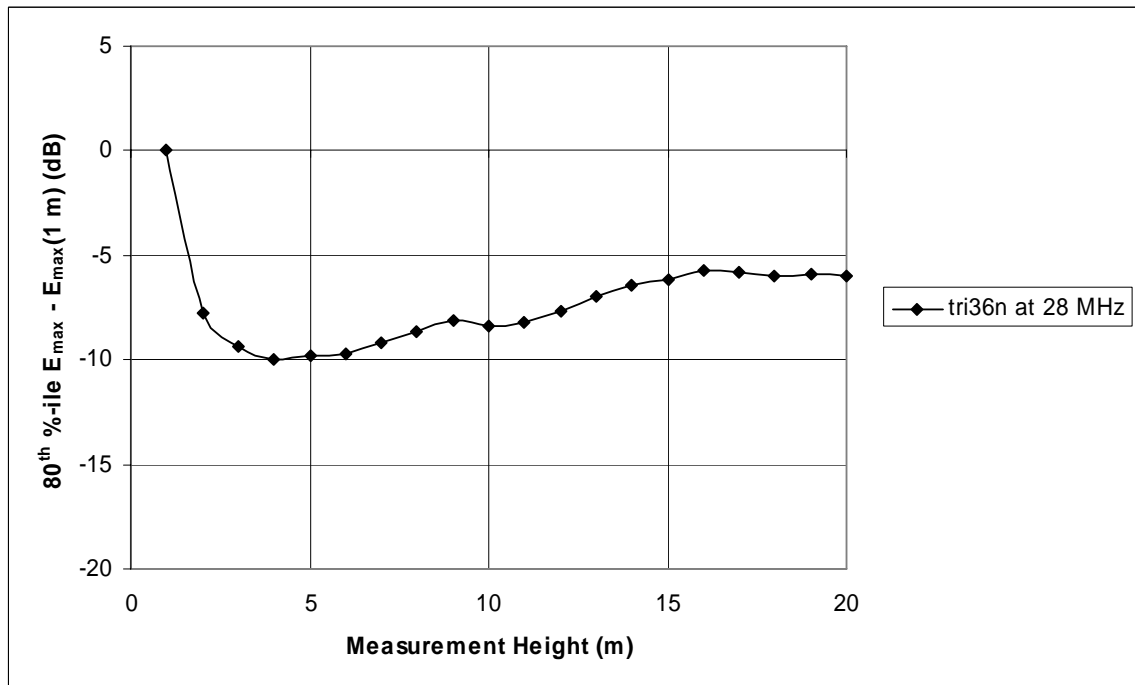


Figure A-98: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

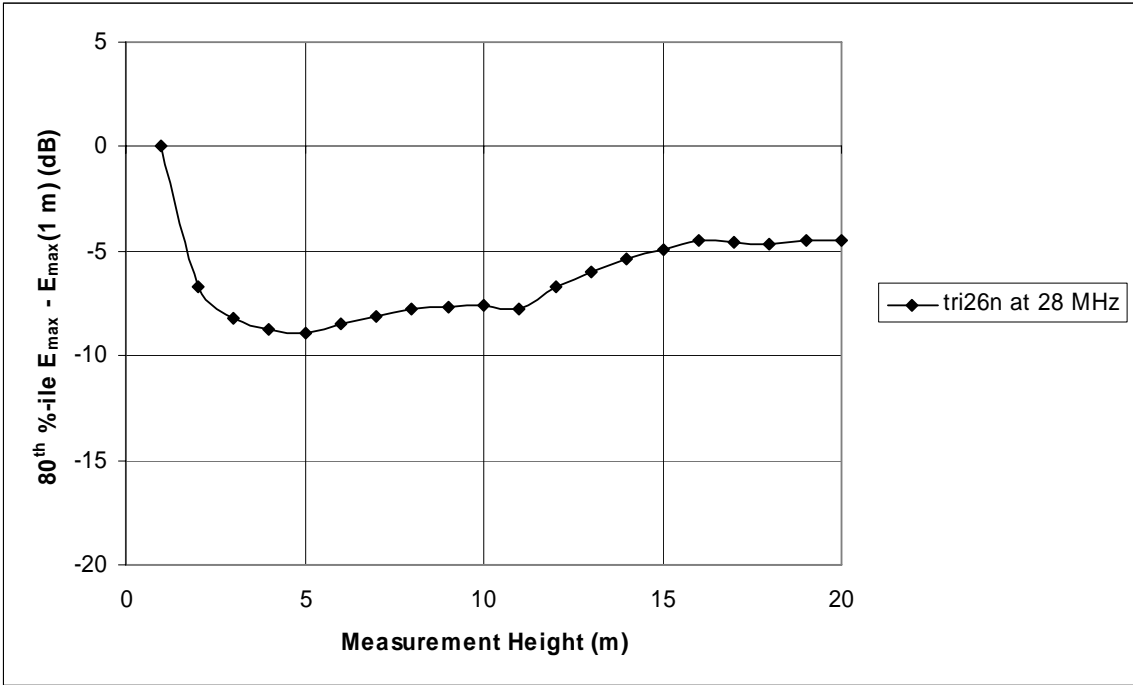


Figure A-99: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

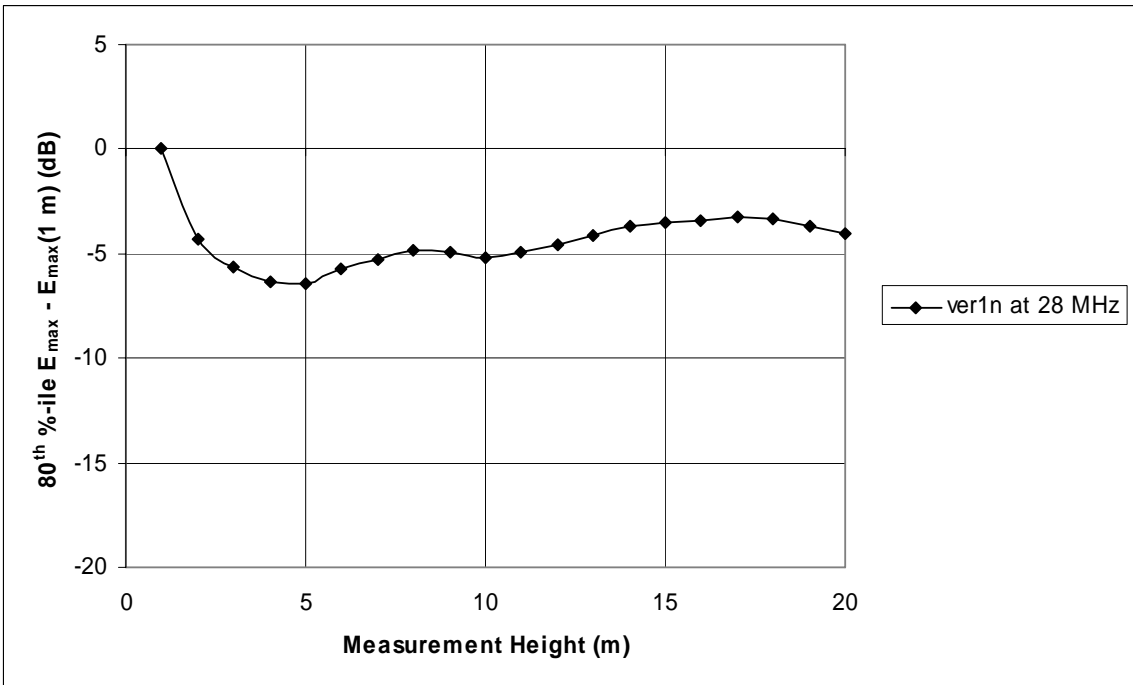


Figure A-100: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

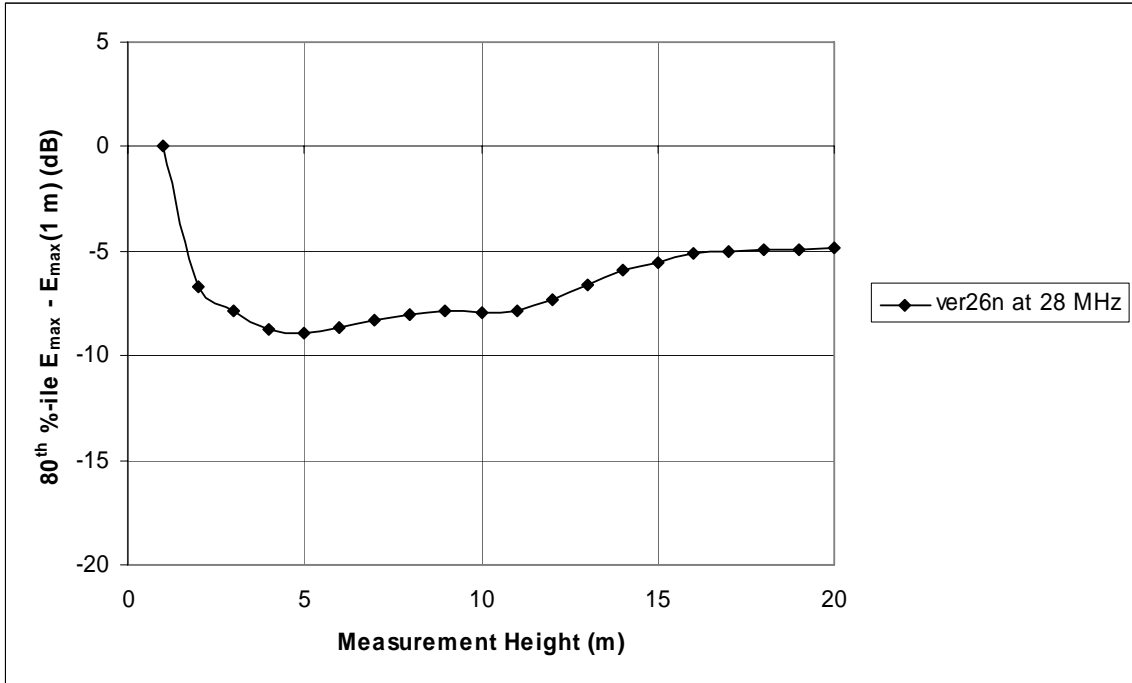


Figure A-101: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

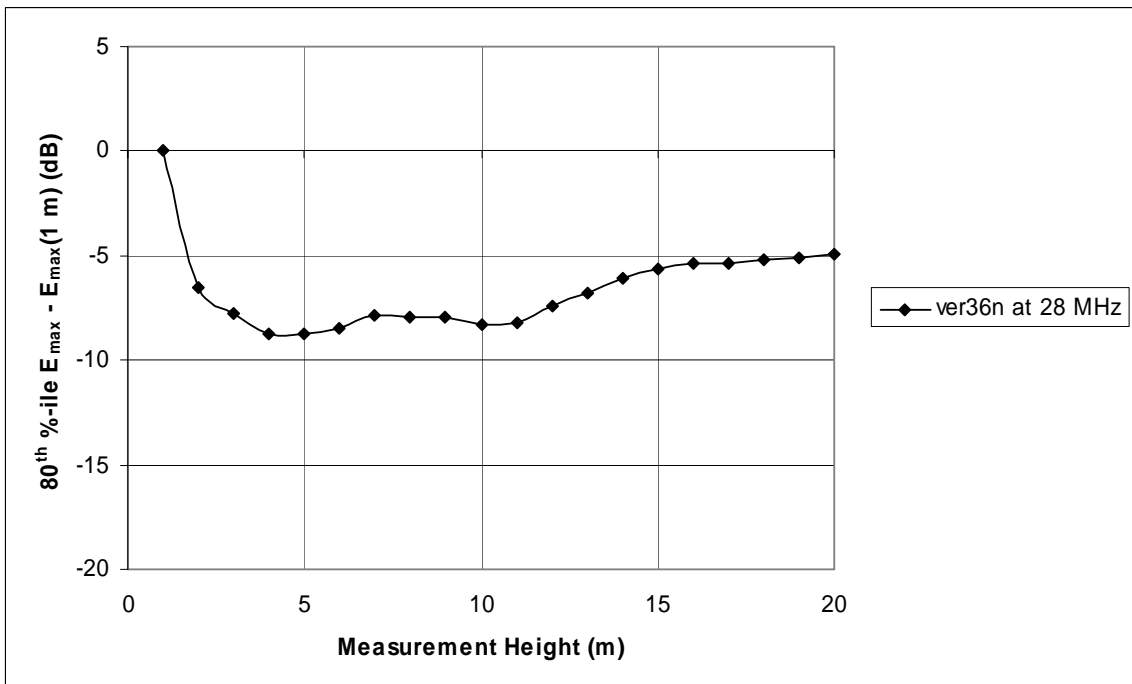


Figure A-102: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at a 1 meter measurement height

A.4 COMPLIANCE MEASUREMENT HEIGHT FOR OPERATION AT 30 MHz AND ABOVE

The Commission's Part 15 measurement guidelines specify that at or above 30 MHz, measurements are to be made with the antenna positioned at a height ranging from 1 to 4 meters. The electric field strength should be measured in both the horizontal and vertical planes. The following plots show a comparison between the peak field strength determined from applying the measurement guidelines to the power line simulations to compute the 80th percentile of peak field strength at any height along the length of the power line. The rationale for use of 80th percentile values was previously addressed in Section A.3. The plots are shown for a number of NEC power line models at the frequencies of 30, 40 and 50 MHz.

30 MHz Plots

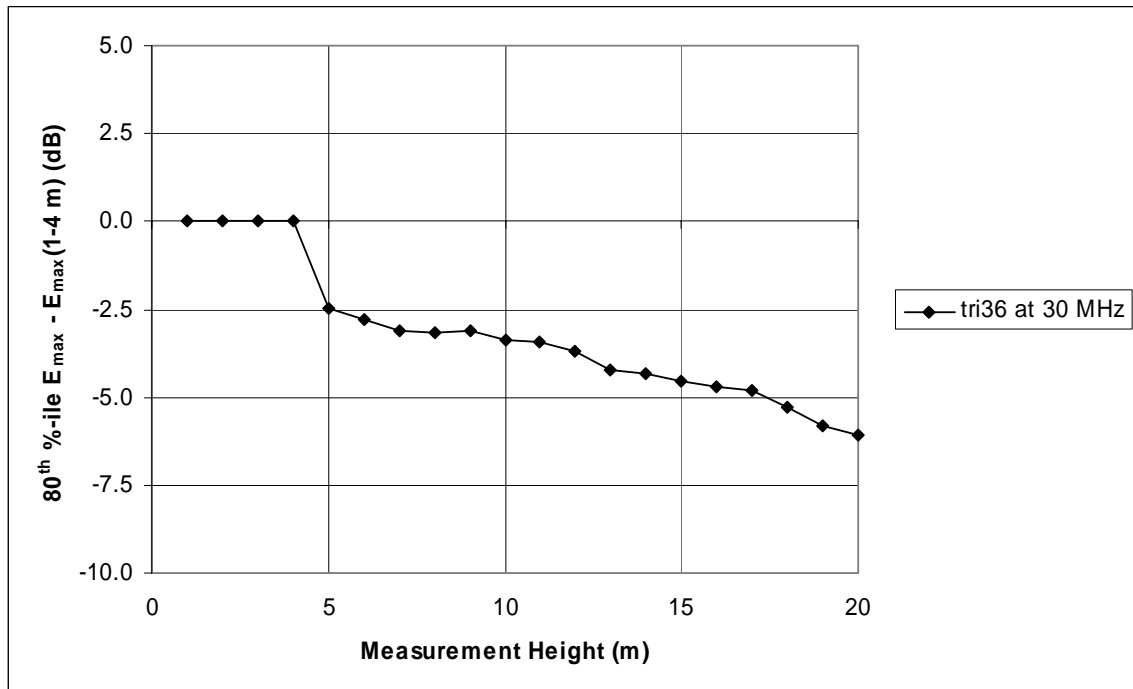


Figure A-103: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

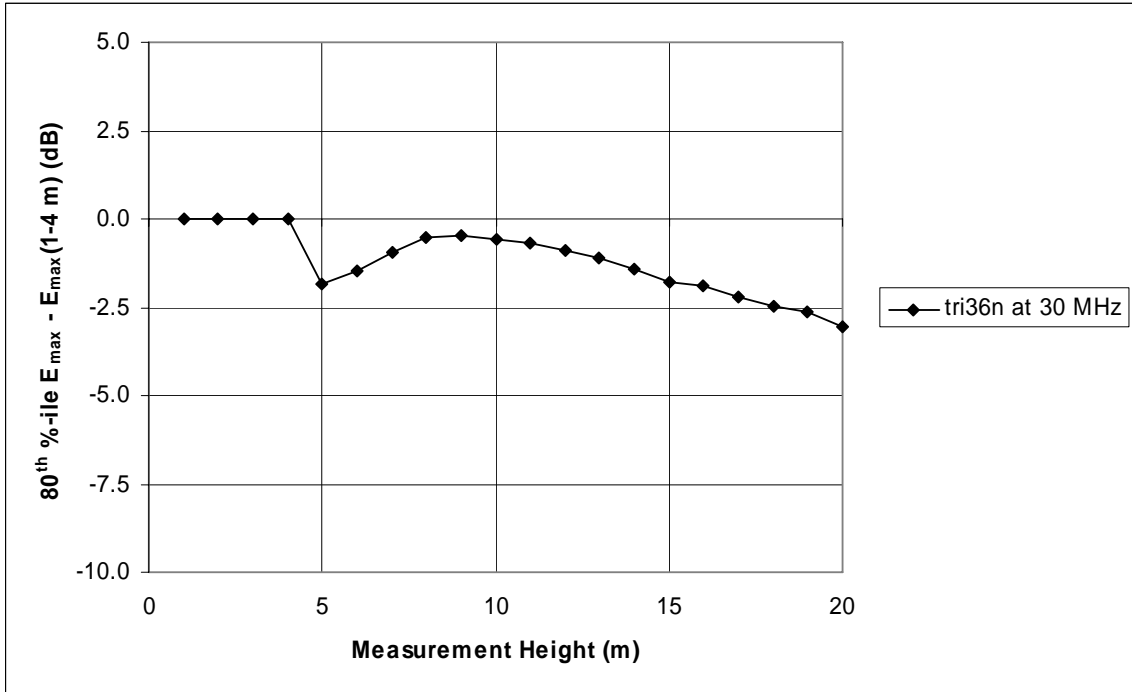


Figure A-104: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

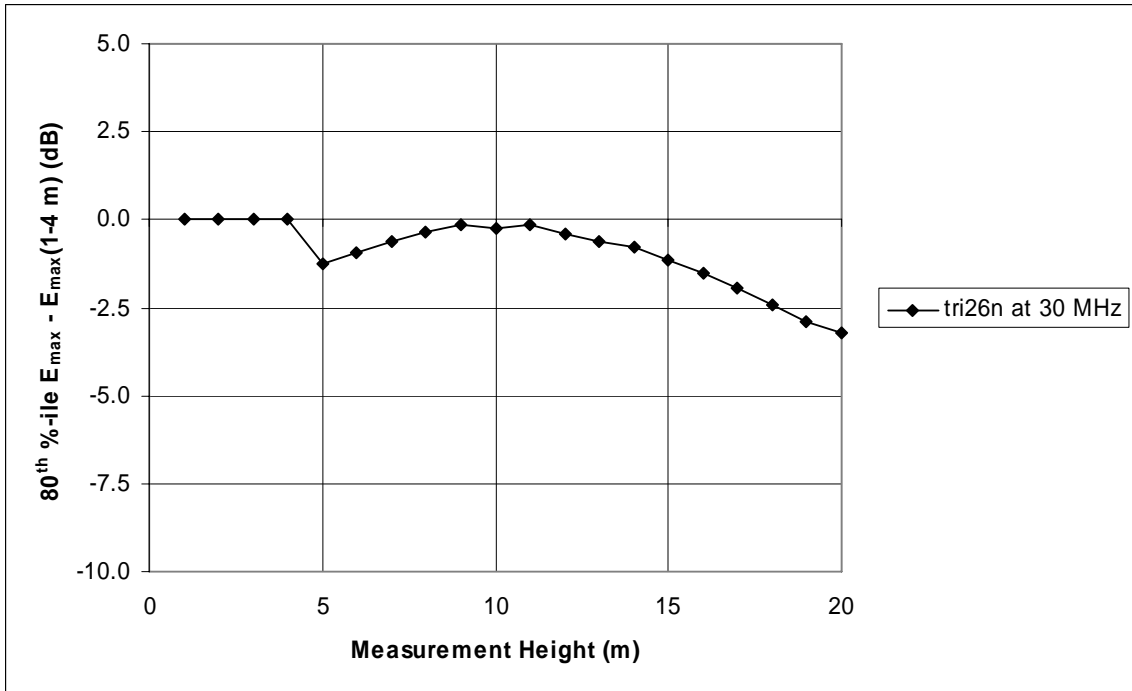


Figure A-105: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

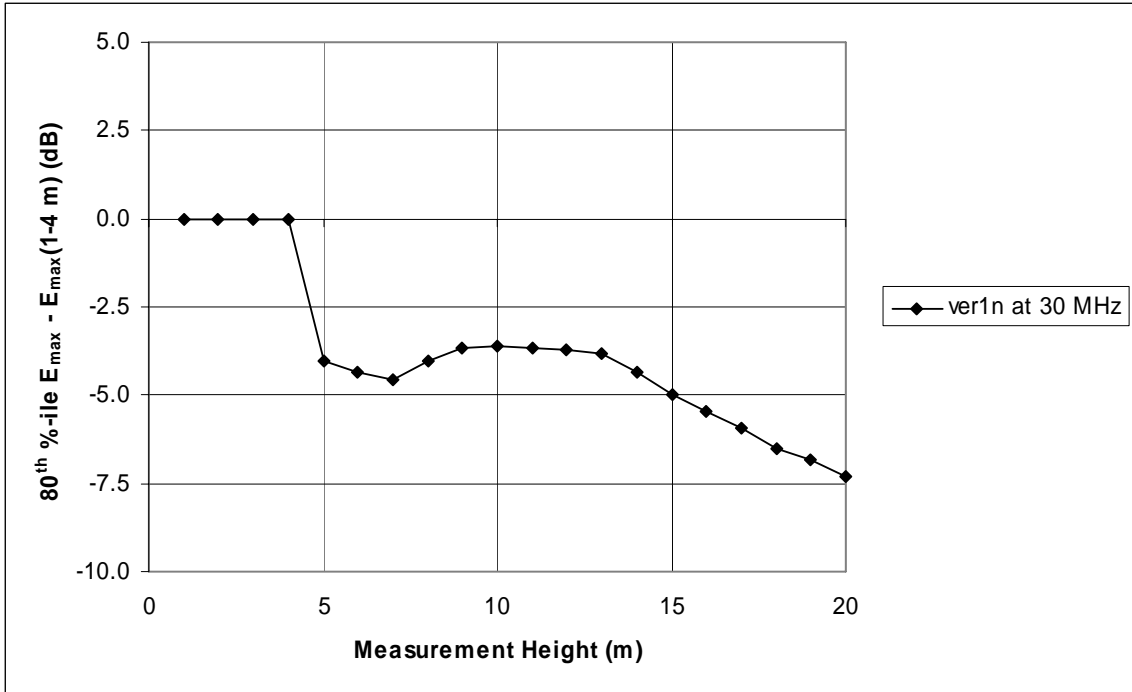


Figure A-106: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

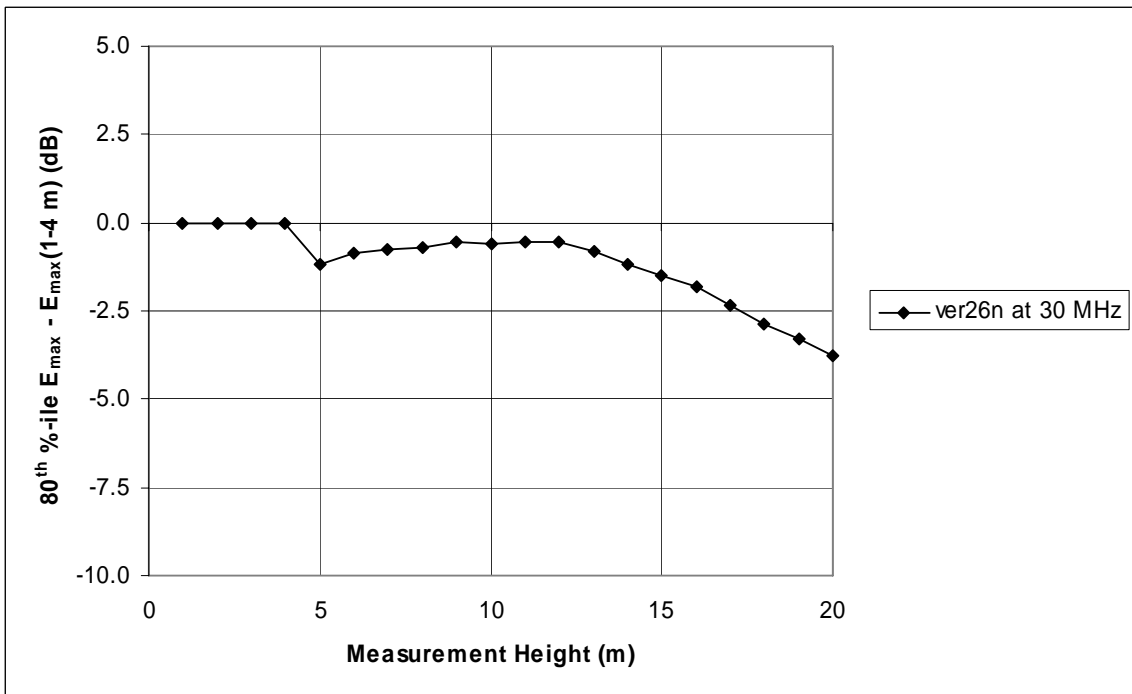


Figure A-107: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

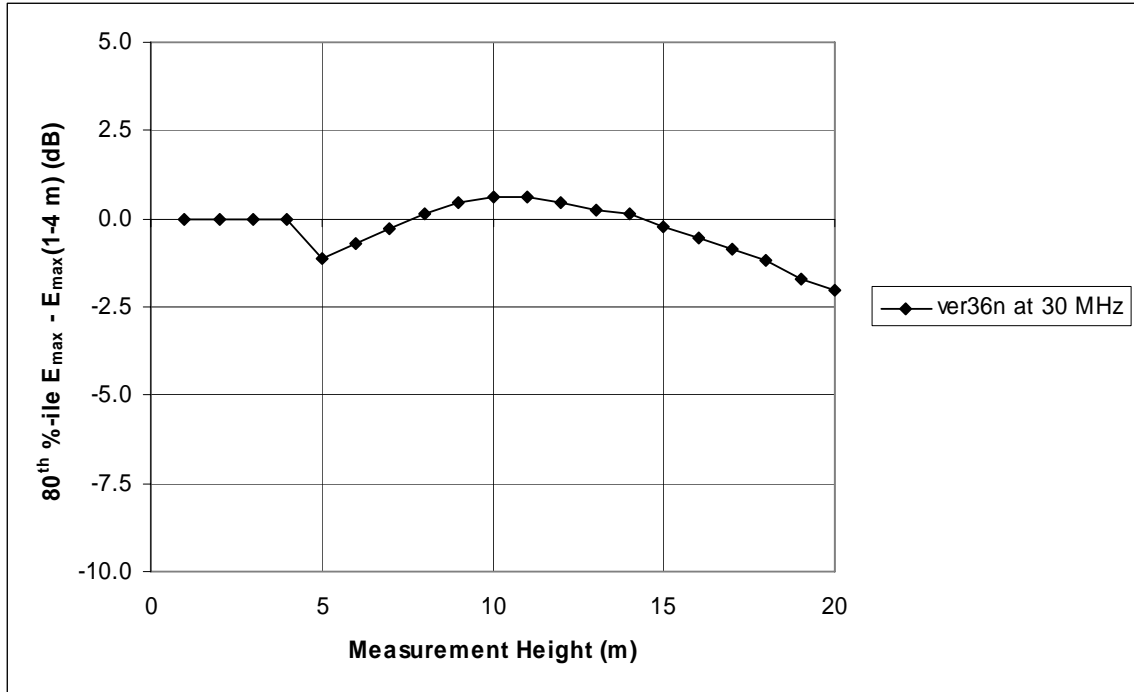


Figure A-108: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

40 MHz Plots

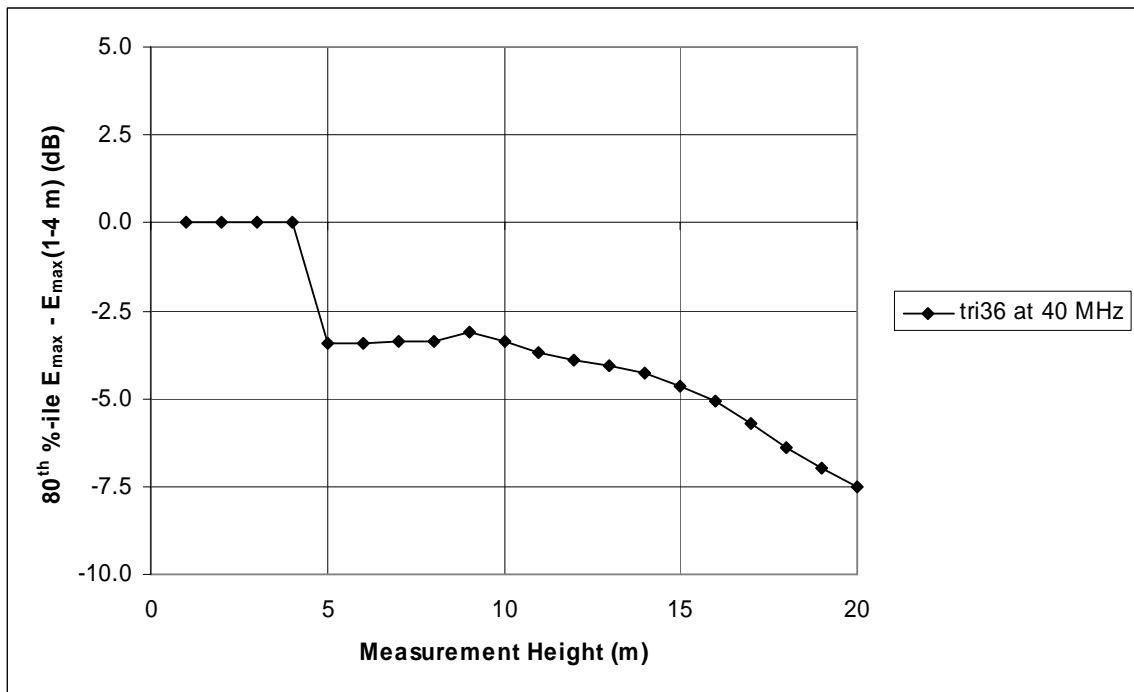


Figure A-109: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

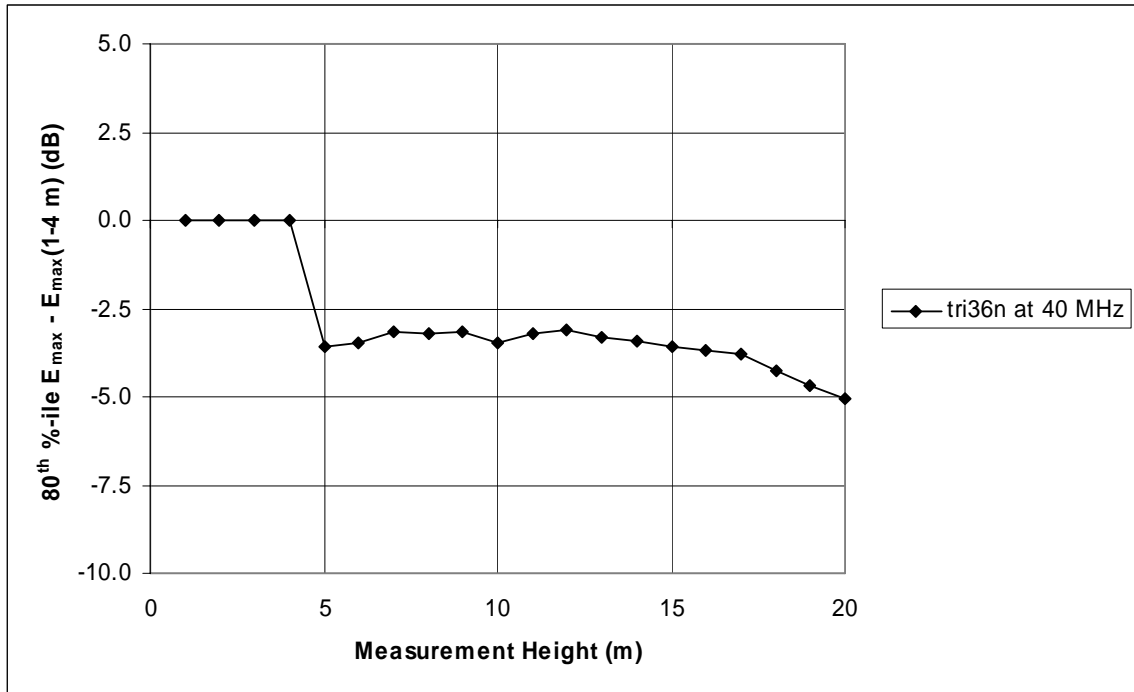


Figure A-110: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

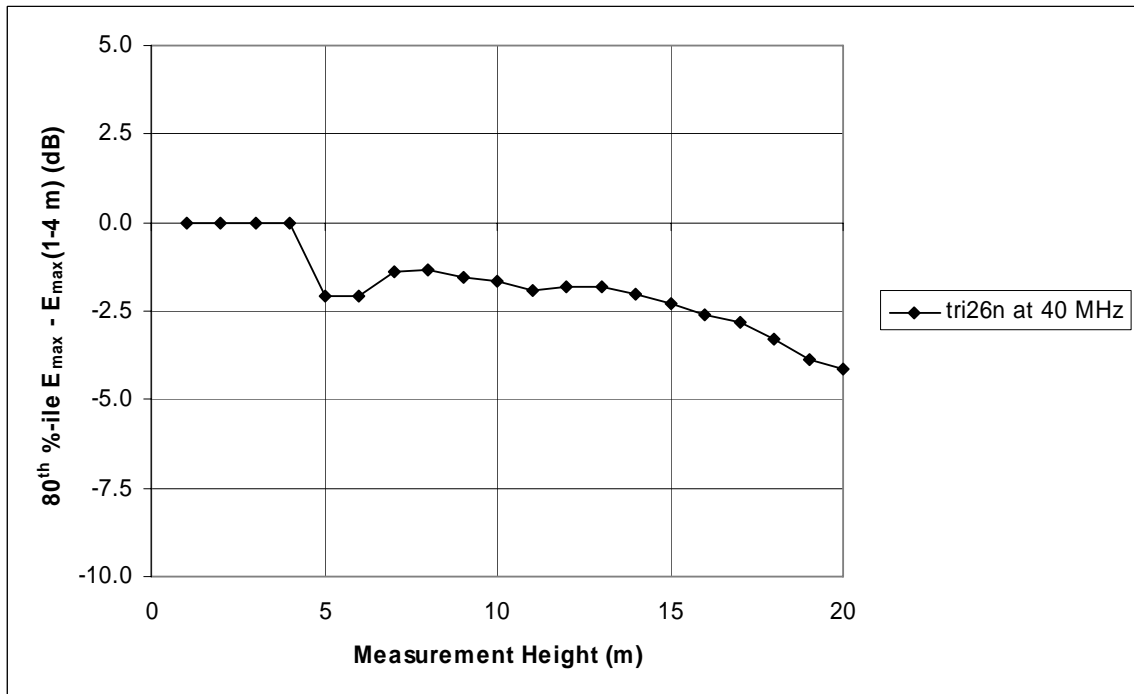


Figure A-111: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

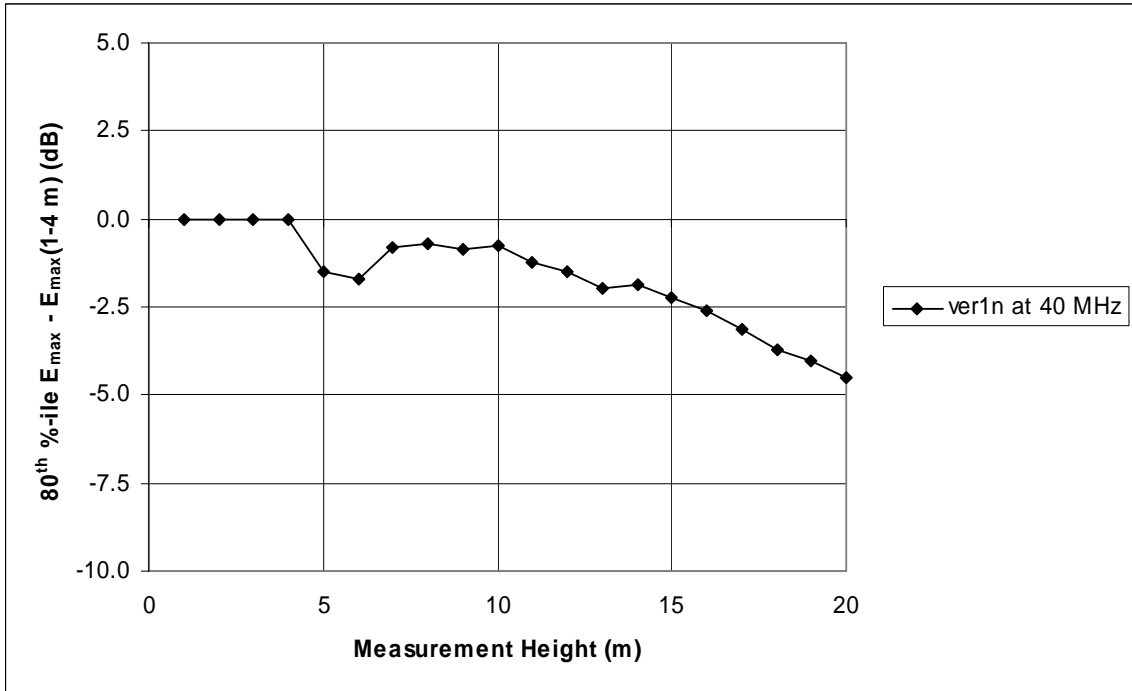


Figure A-112: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

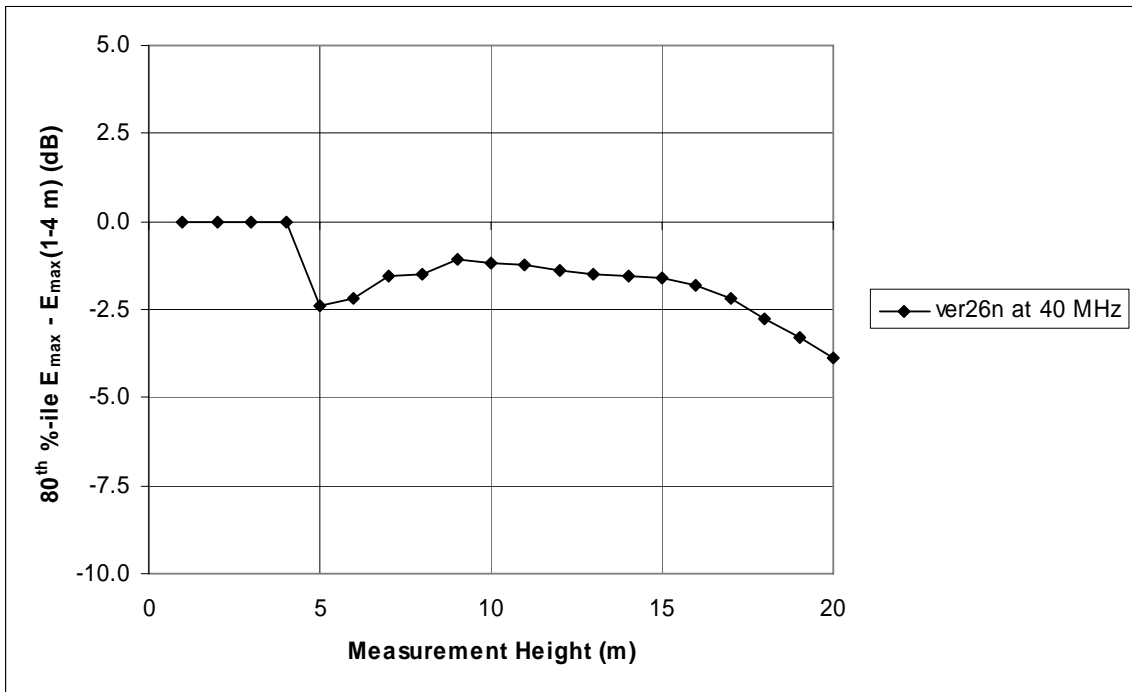


Figure A-113: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

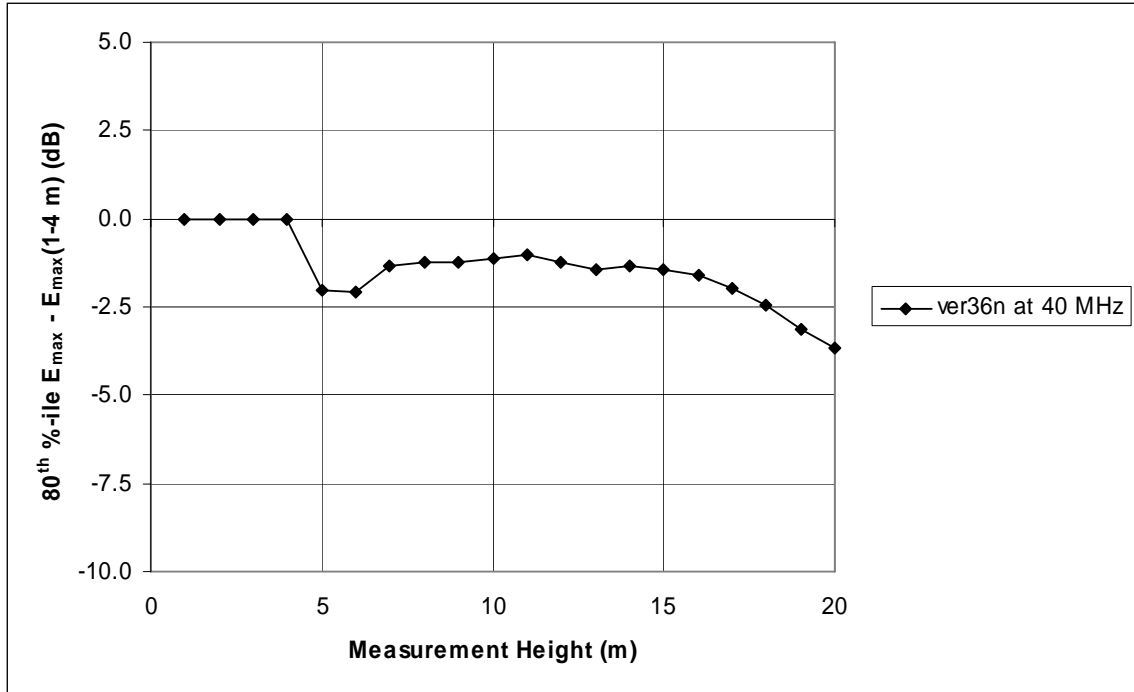


Figure A-114: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

50 MHz Plots

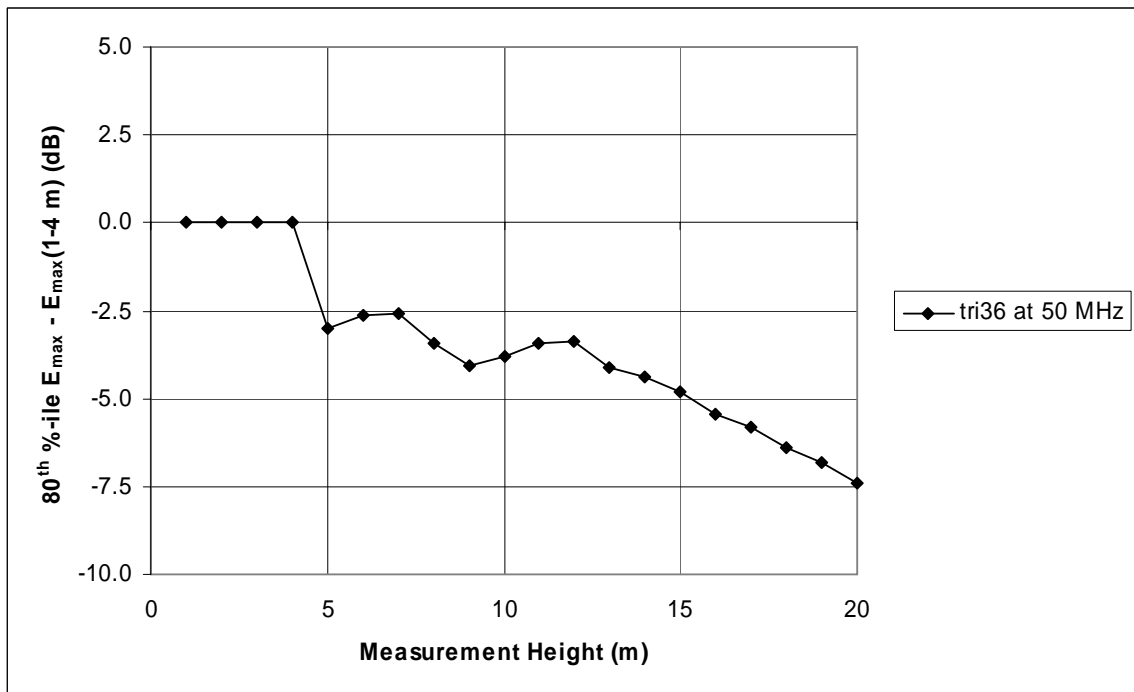


Figure A-115: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

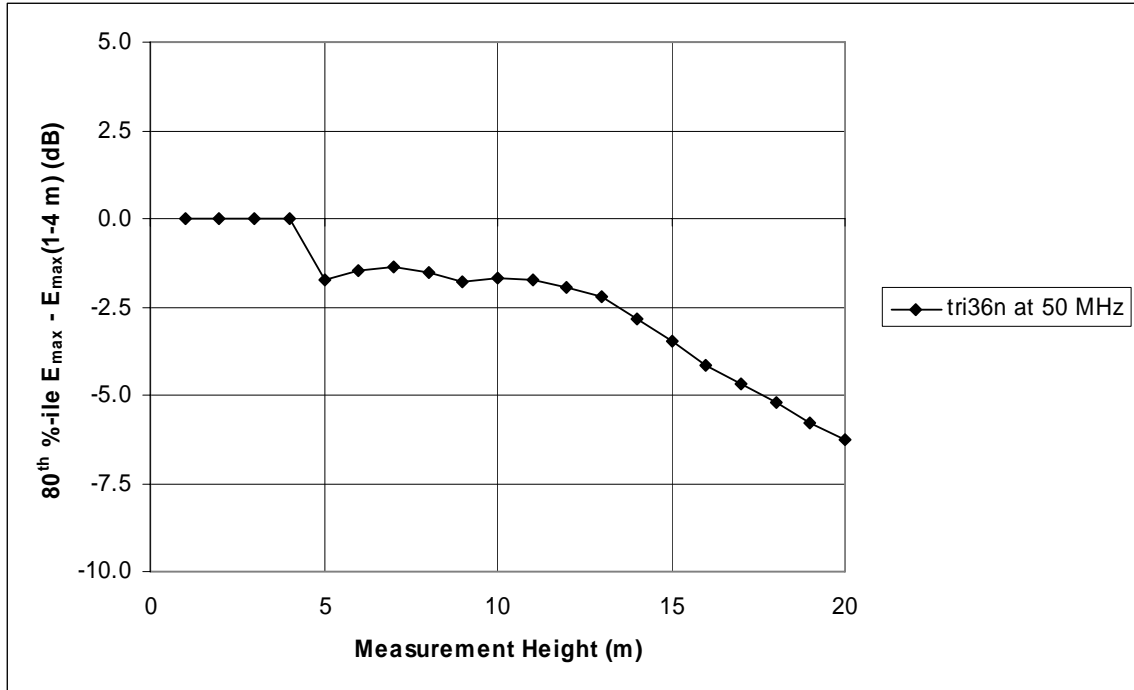


Figure A-116: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

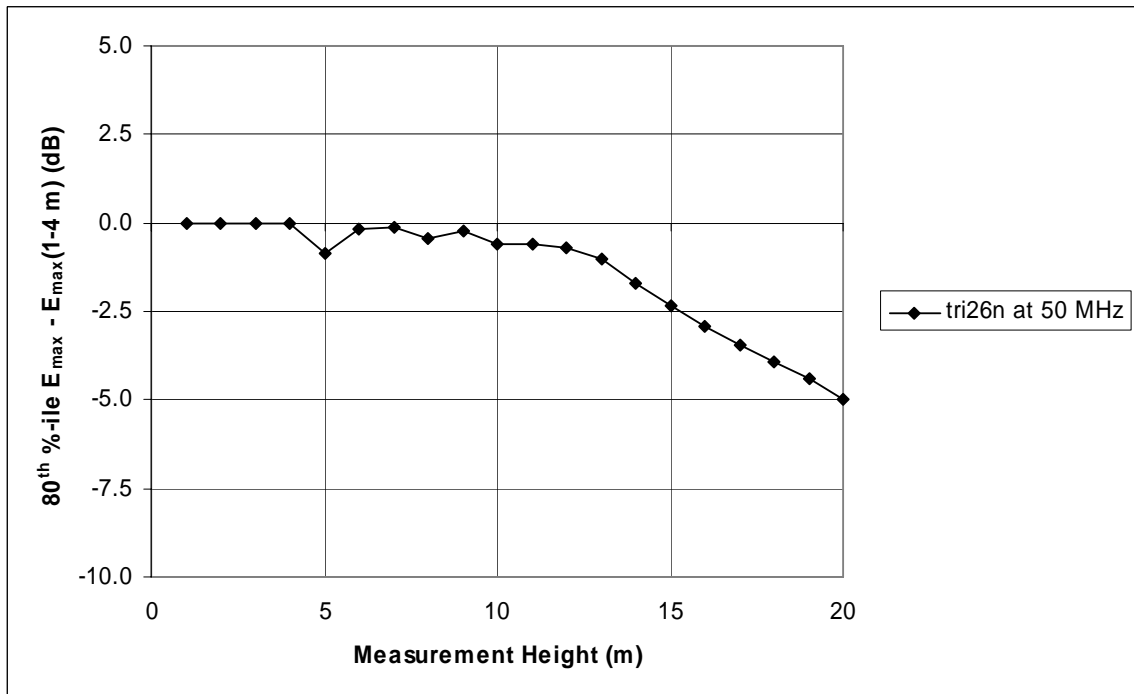


Figure A-117: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

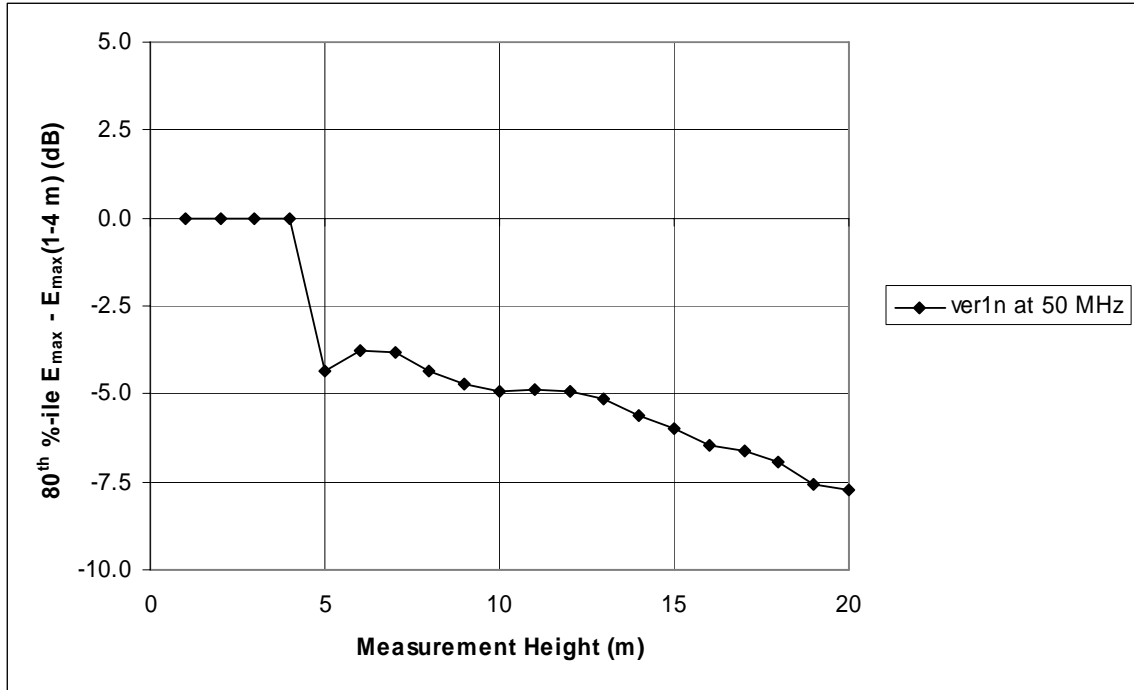


Figure A-118: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

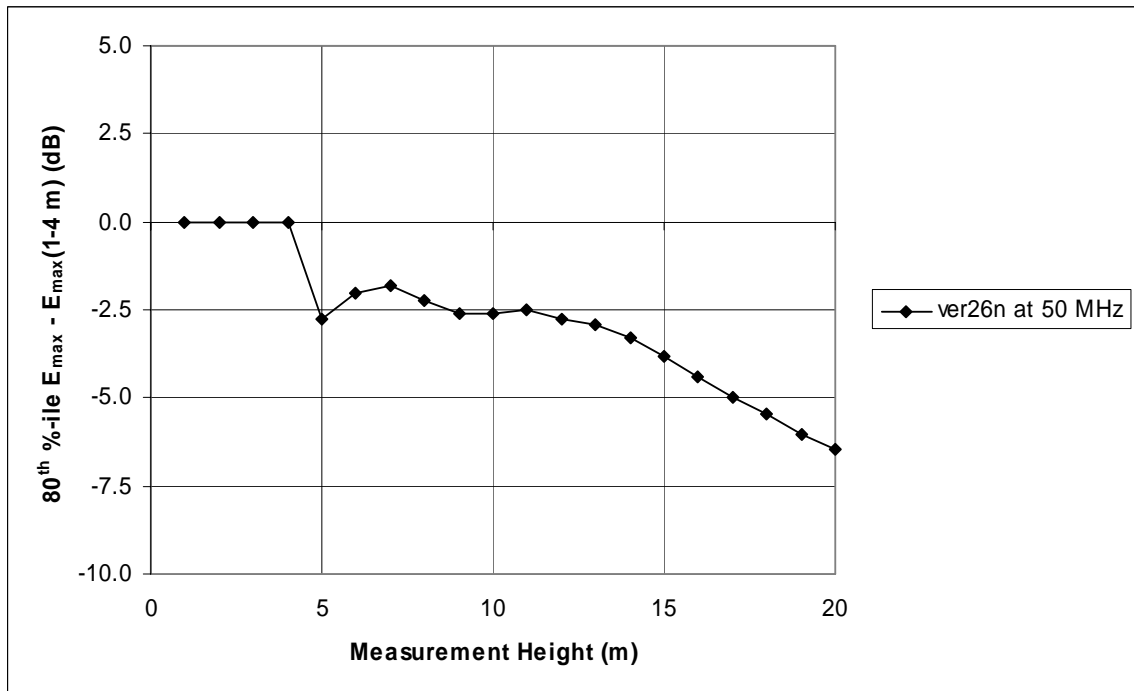


Figure A-119: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

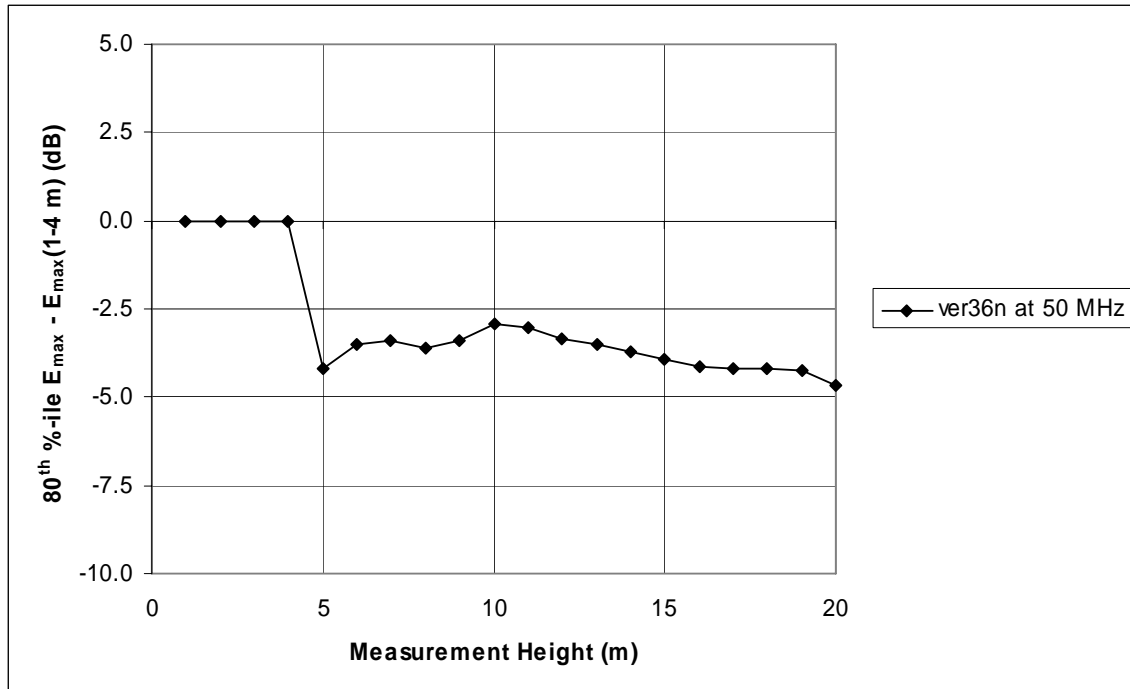


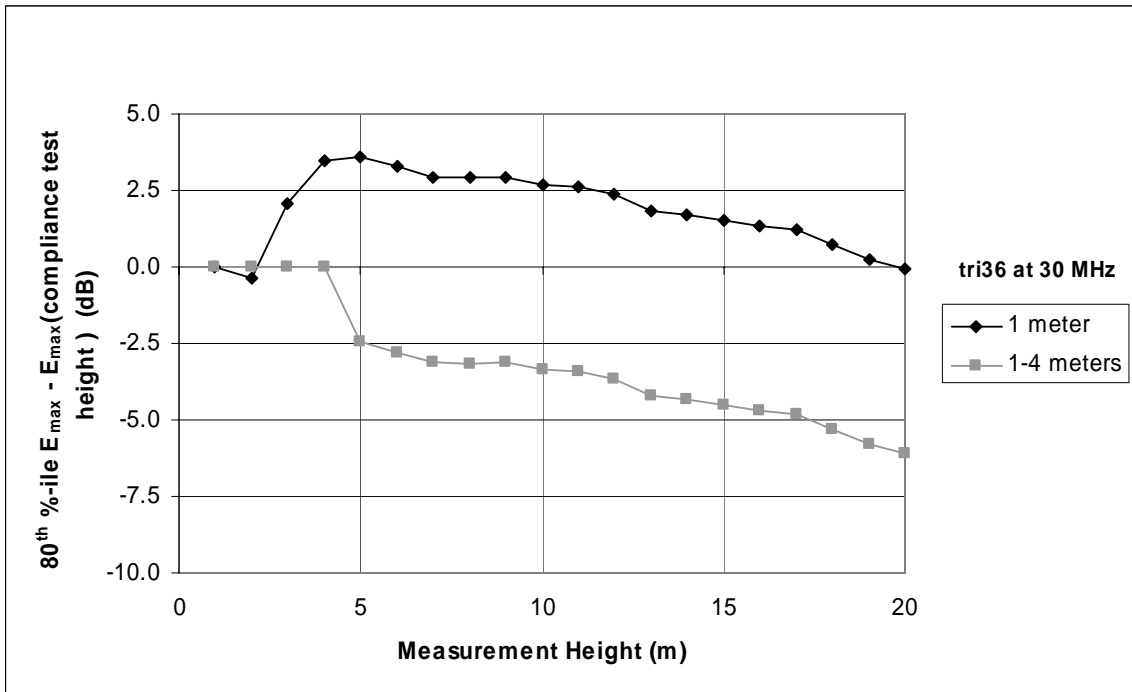
Figure A-120: 80th percentile of peak electric field strength along the power line relative to the peak electric field strength at the 1 to 4 meter measurement height

A.5 HEIGHT CORRECTION FACTOR ABOVE 30 MHz

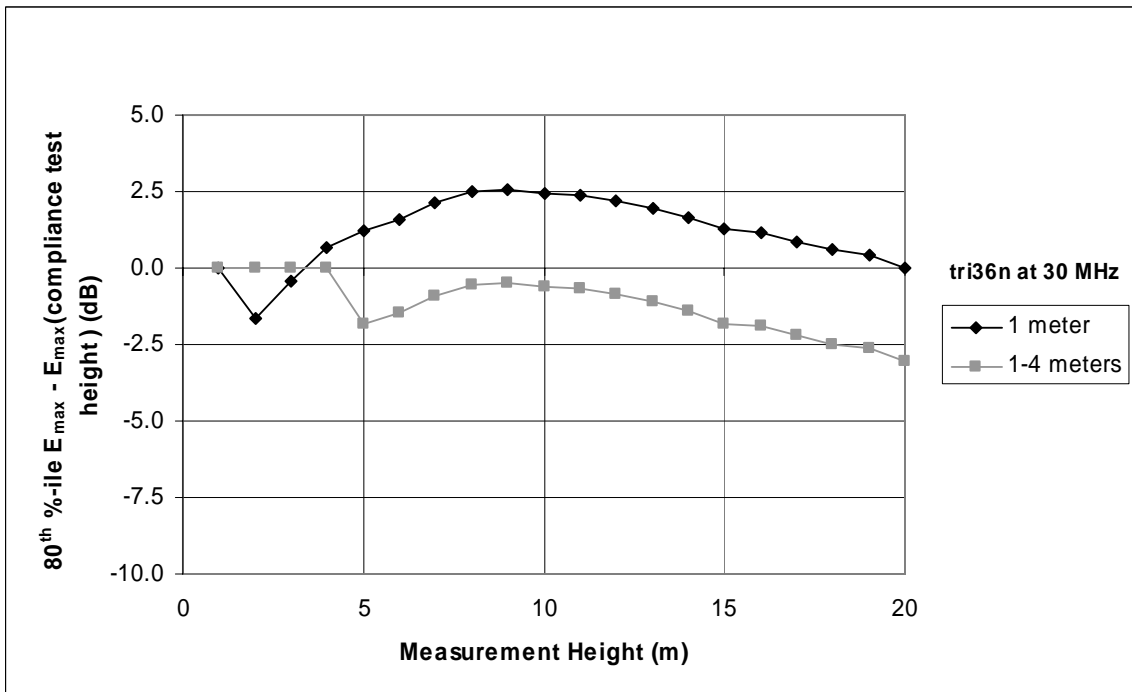
Above 30 MHz, the option to perform compliance measurements at a 1 meter measurement height coupled with a 5 dB height correction factor provides a much simpler measurement approach than to perform measurements over a 1 to 4 meter range of measurement antenna heights. Figures A-121 through A-138 show the comparison between use of a 1 to 4 meter measurement height and the optional use of a 1 meter measurement height.

The results shown in these figures indicate that use of the optional 1 meter measurement height tends to underestimate the peak electric field strength by 2.5 to 7.5 dB. Thus, the use of the optional 1 meter measurement height coupled with a 5 dB correction factor will, in general, provide similar results to measurements performed using a 1 to 4 meter measurement height.

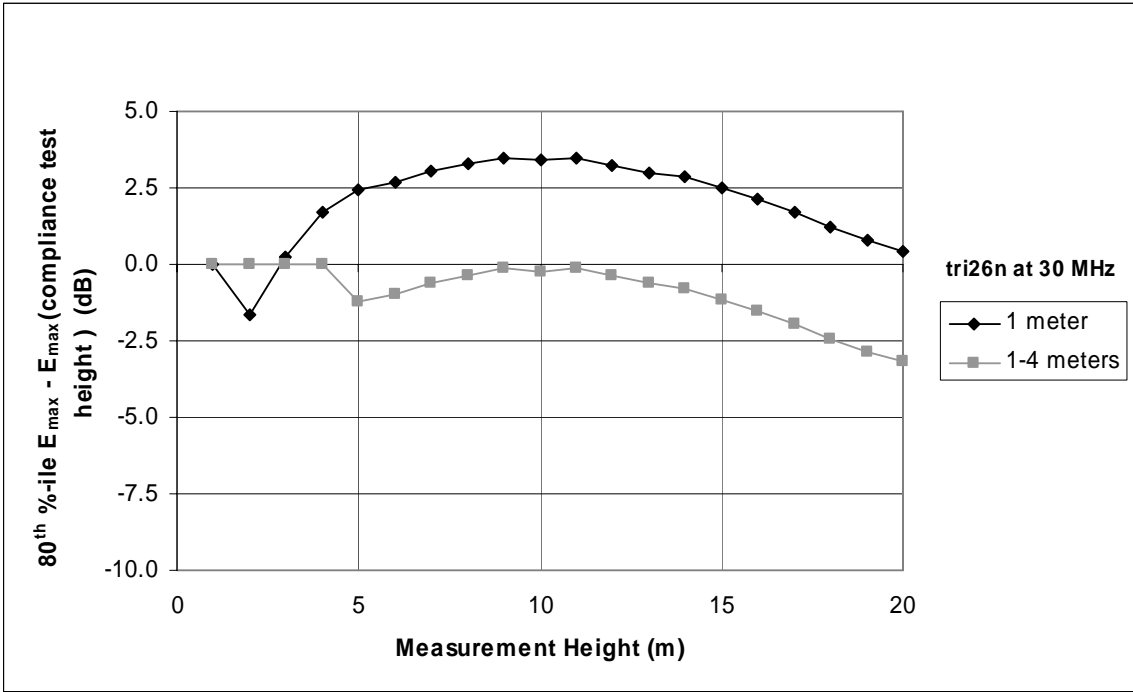
30 MHz Plots



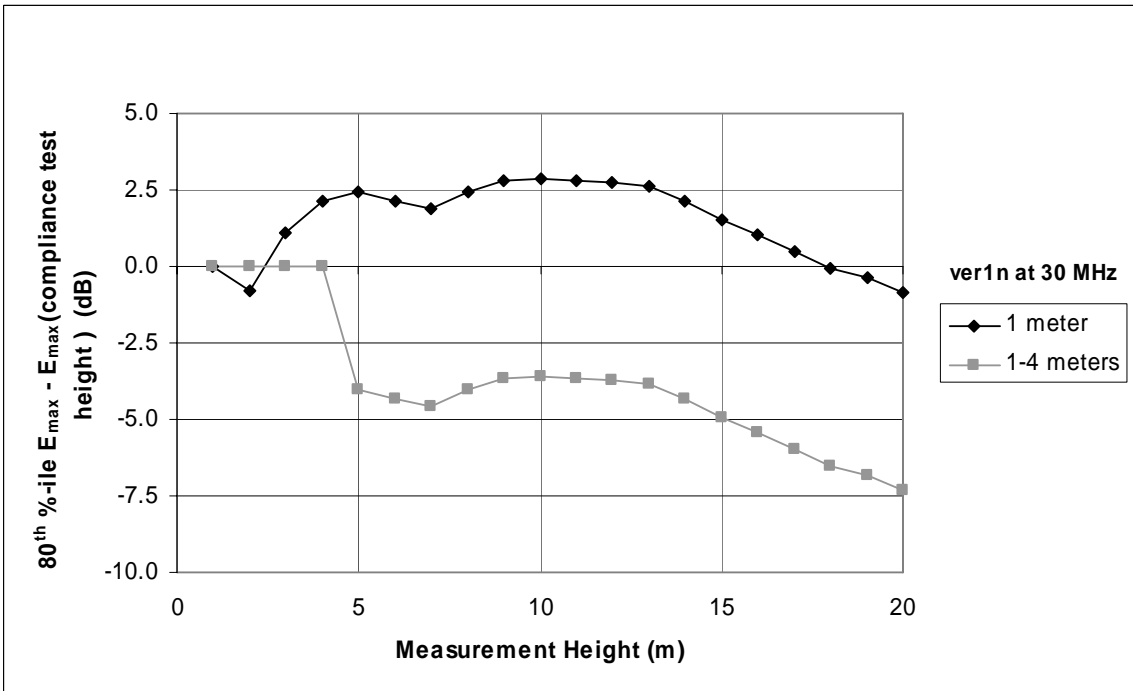
A-121: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



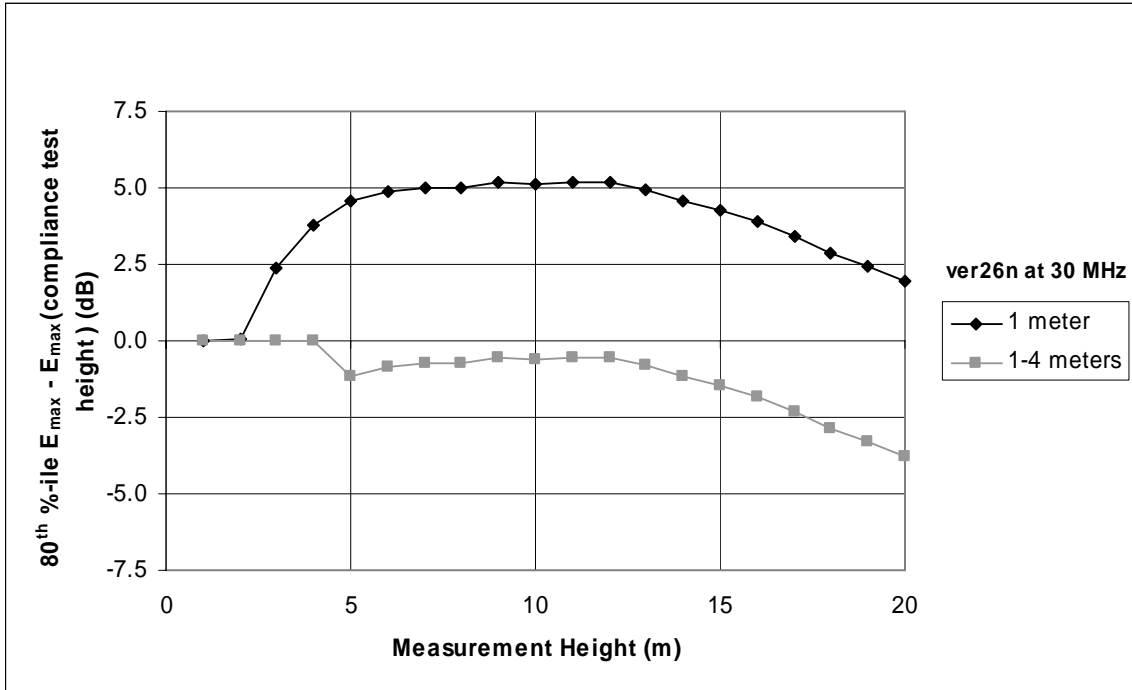
A-122: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



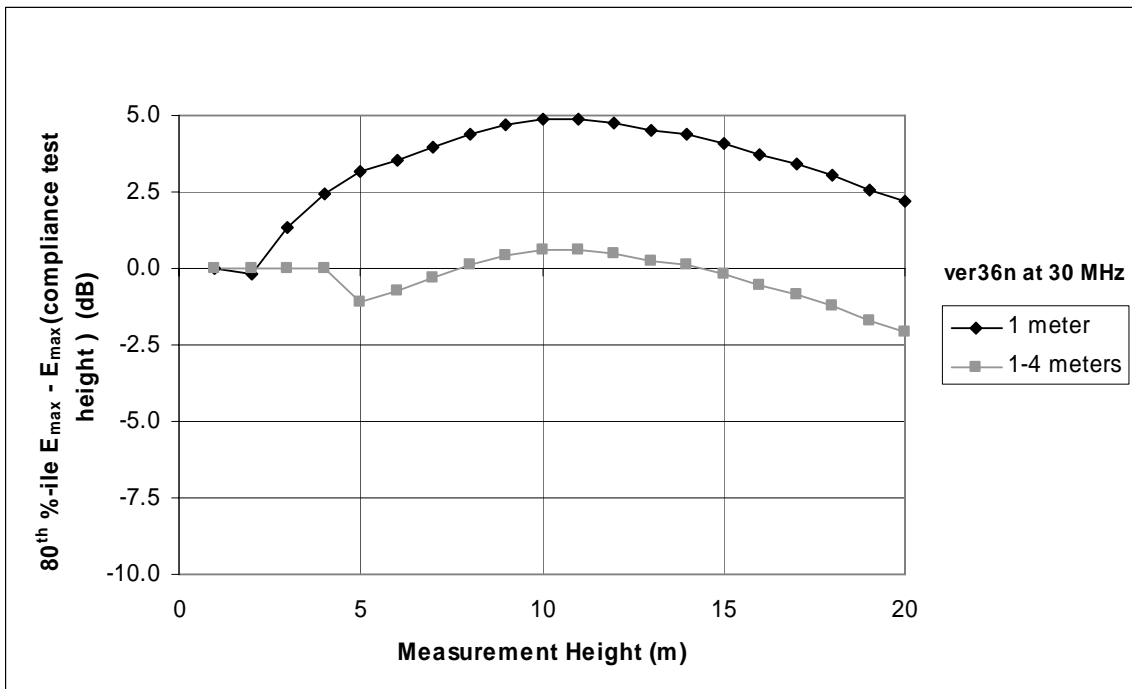
A-123: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



A-124: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters

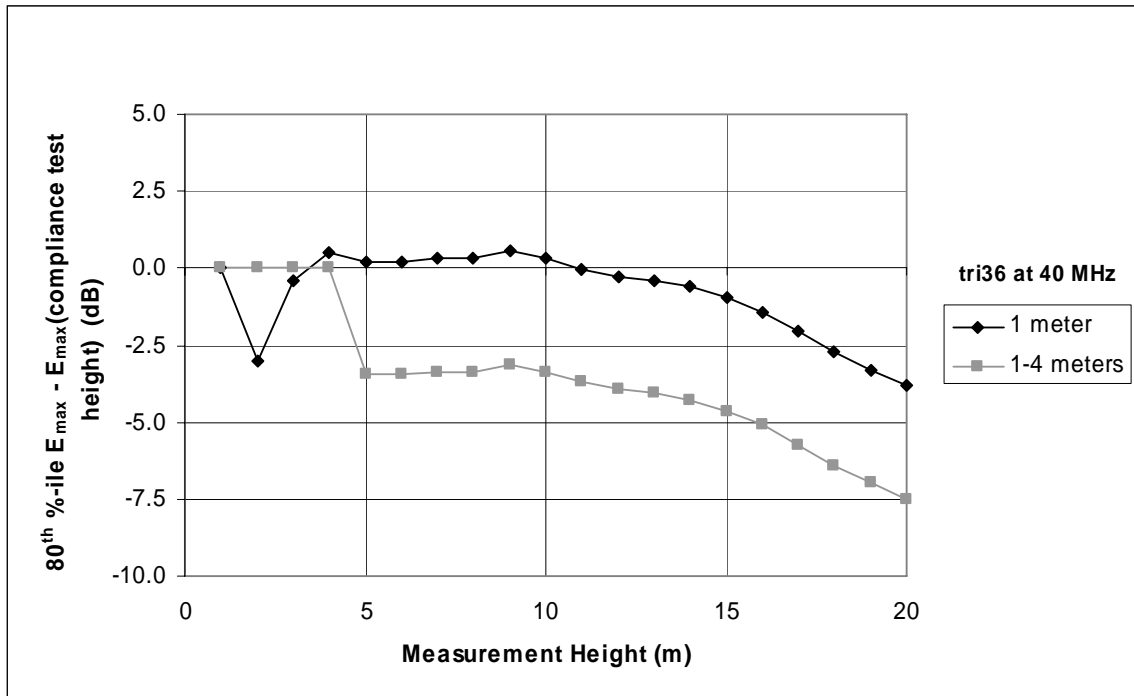


A-125: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters

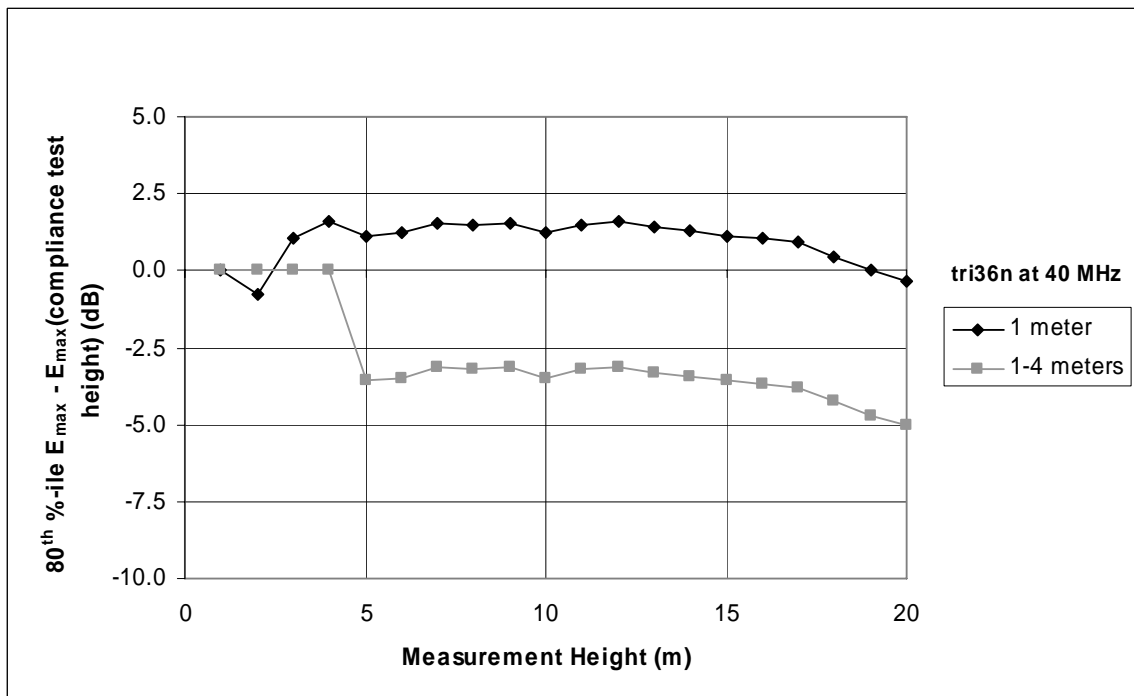


A-126: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters

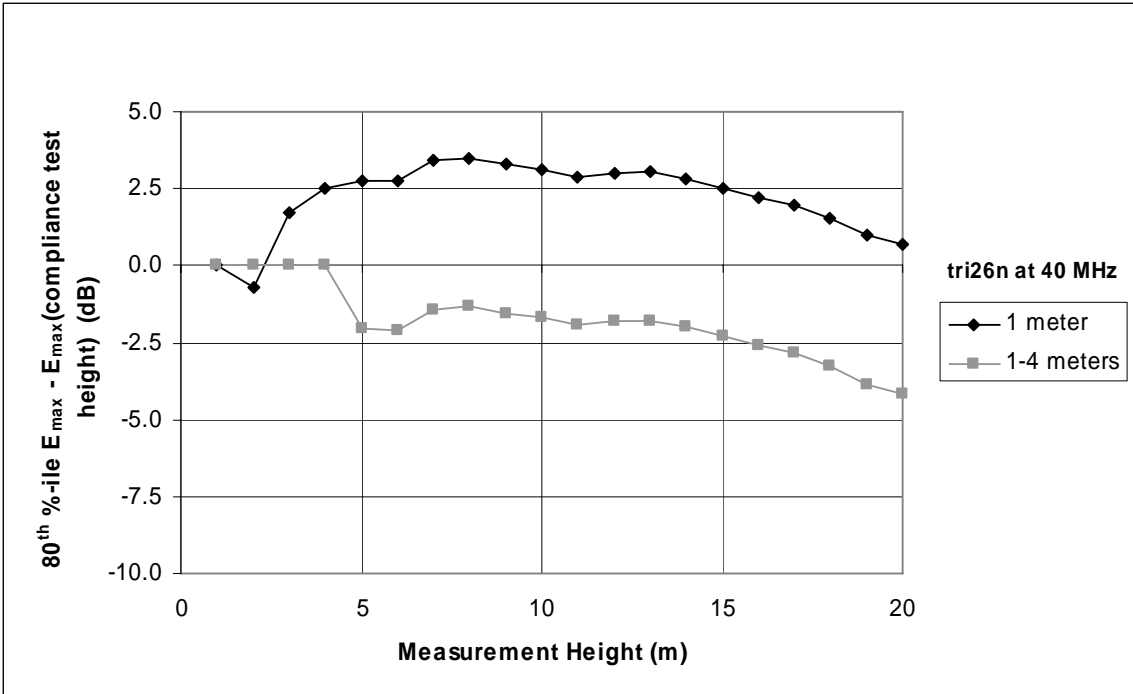
40 MHz Plots



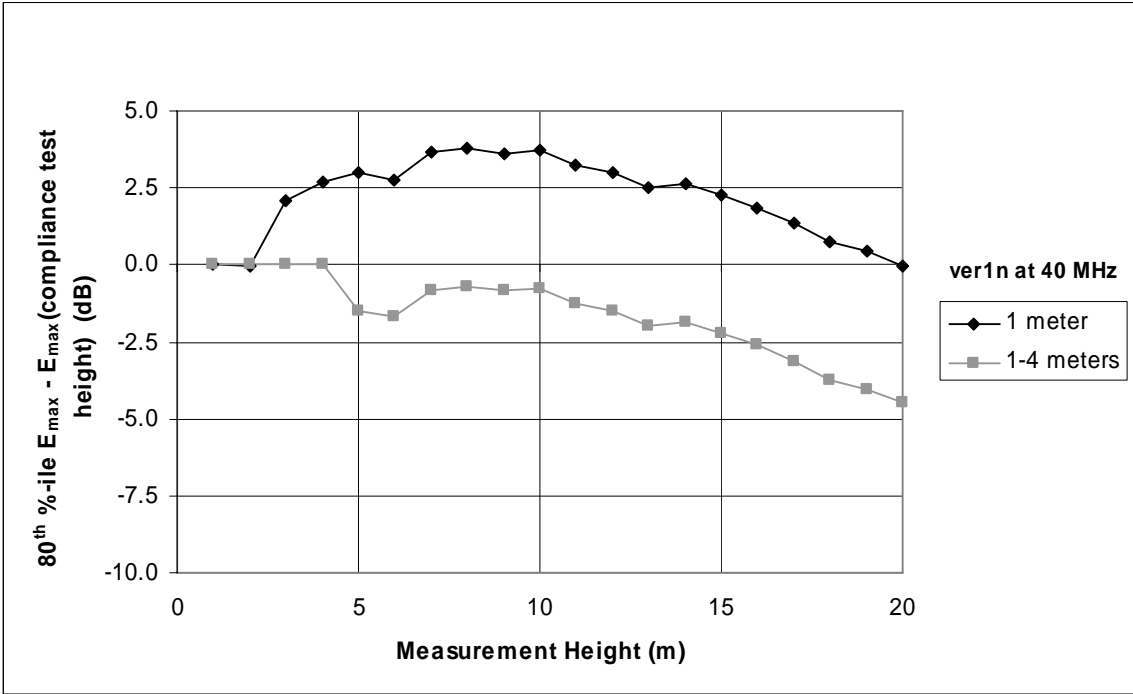
A-127: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



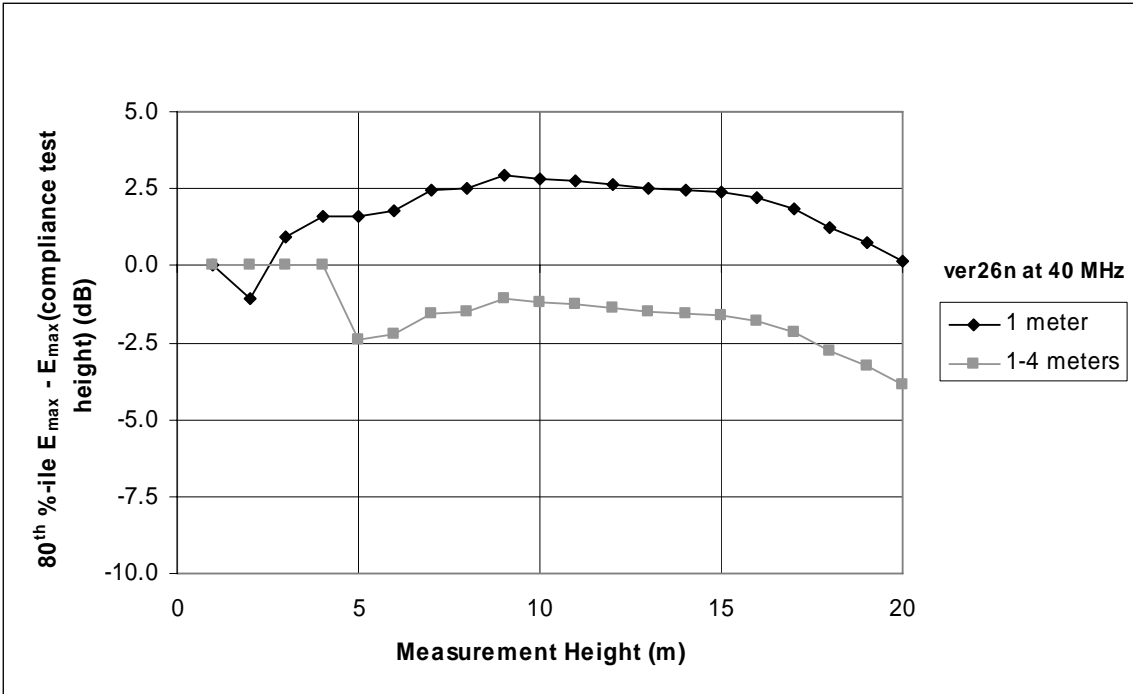
A-128: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



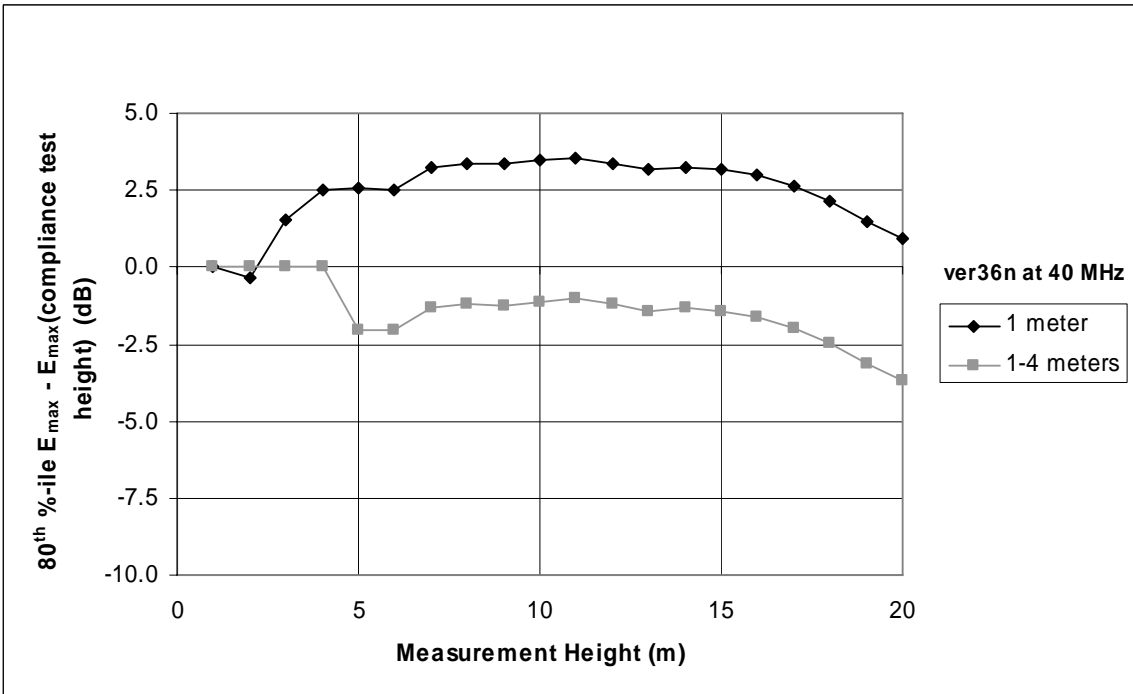
A-129: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



A-130: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters

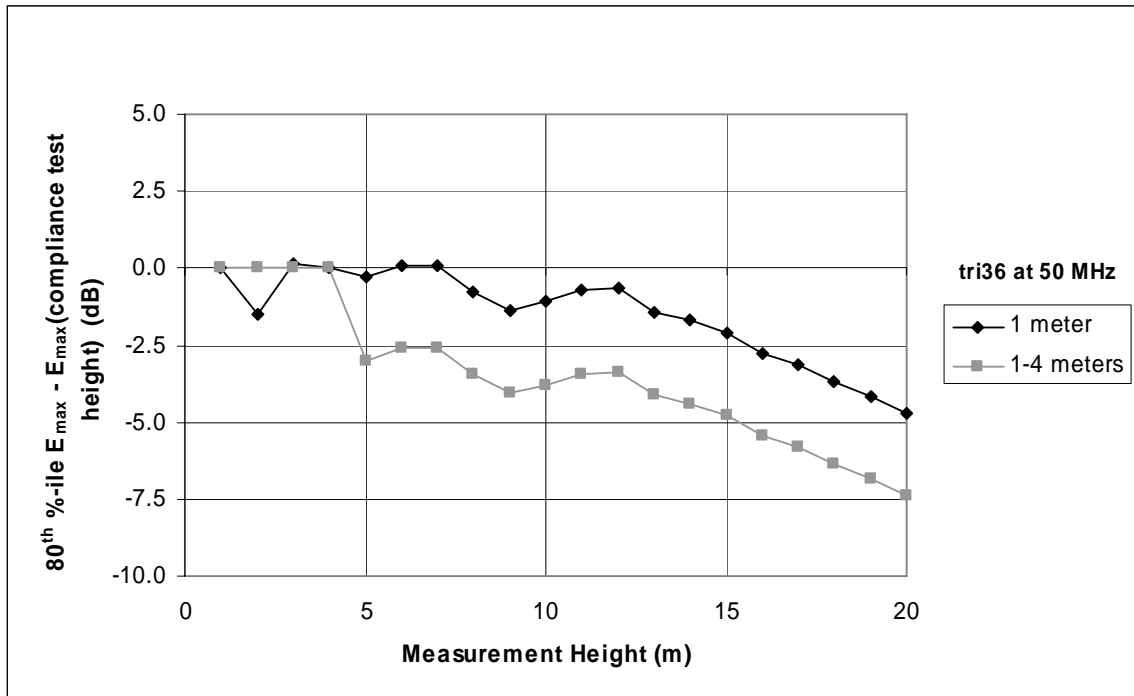


A-131: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters

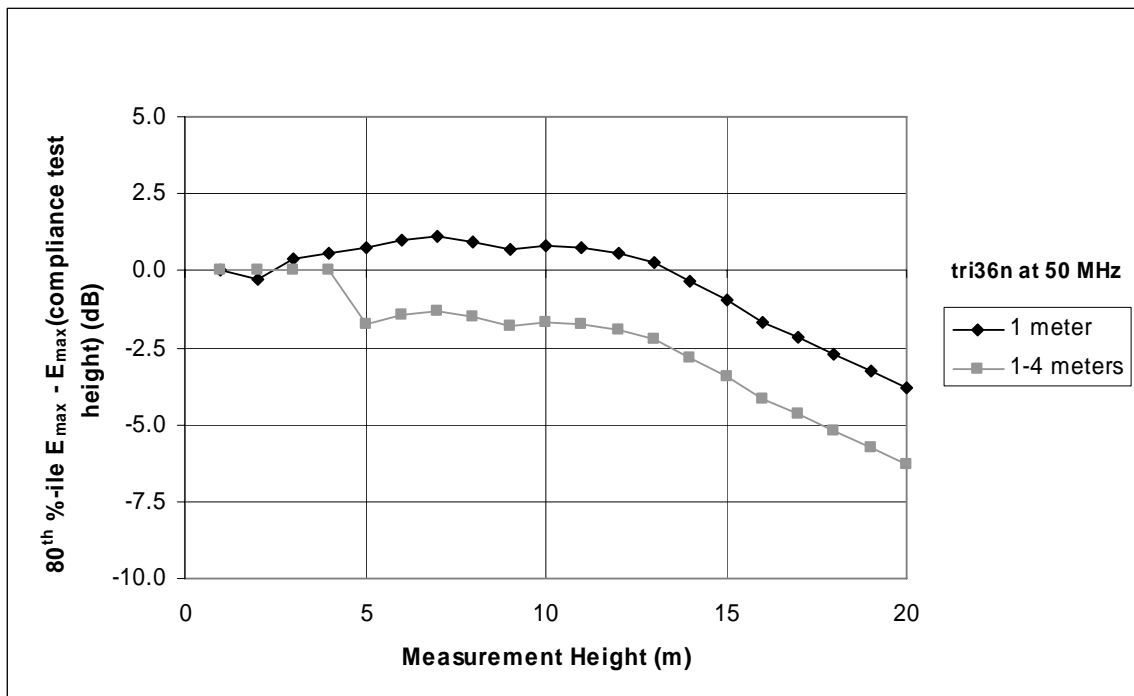


A-132: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters

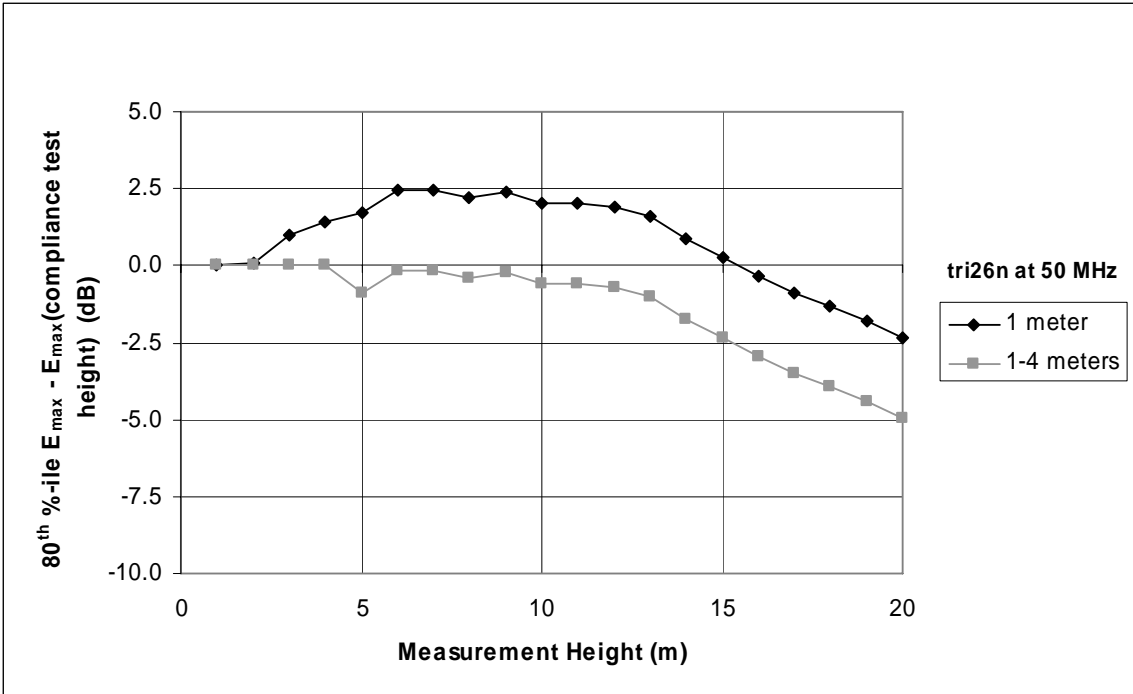
50 MHz Plots



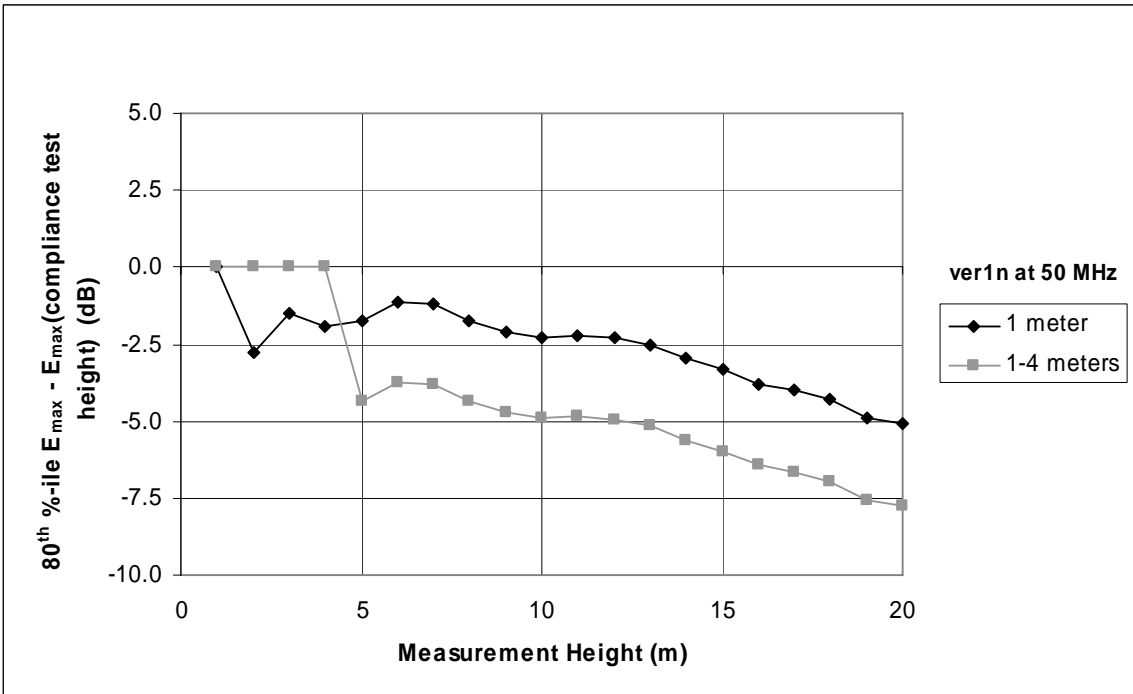
A-133: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



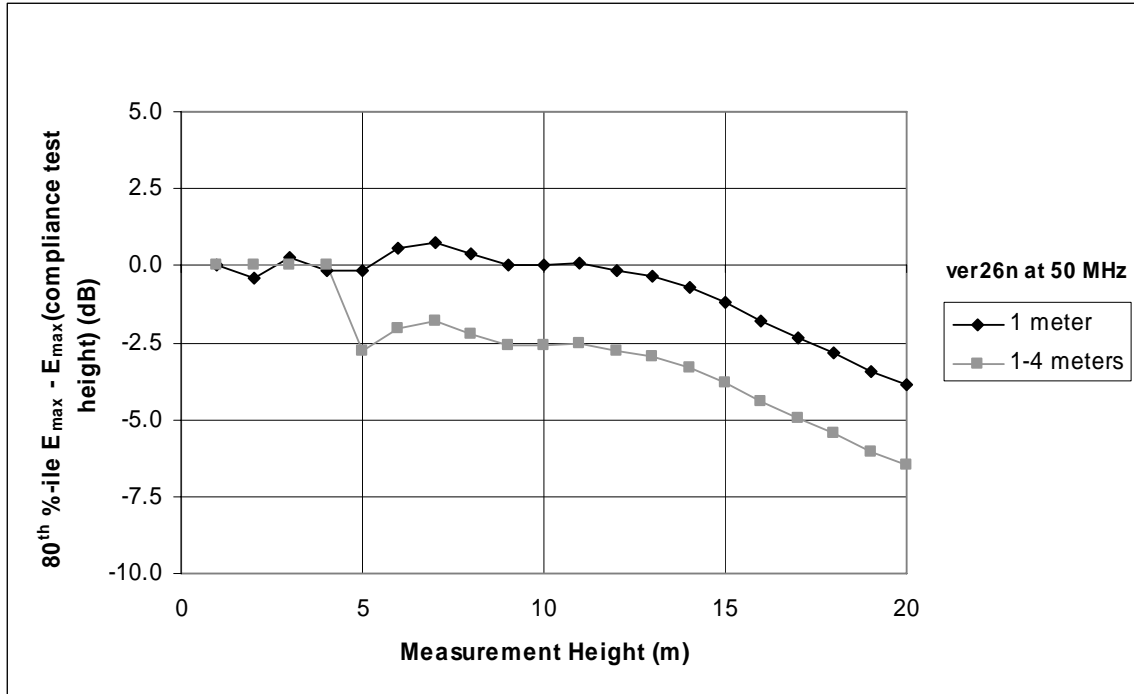
A-134: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



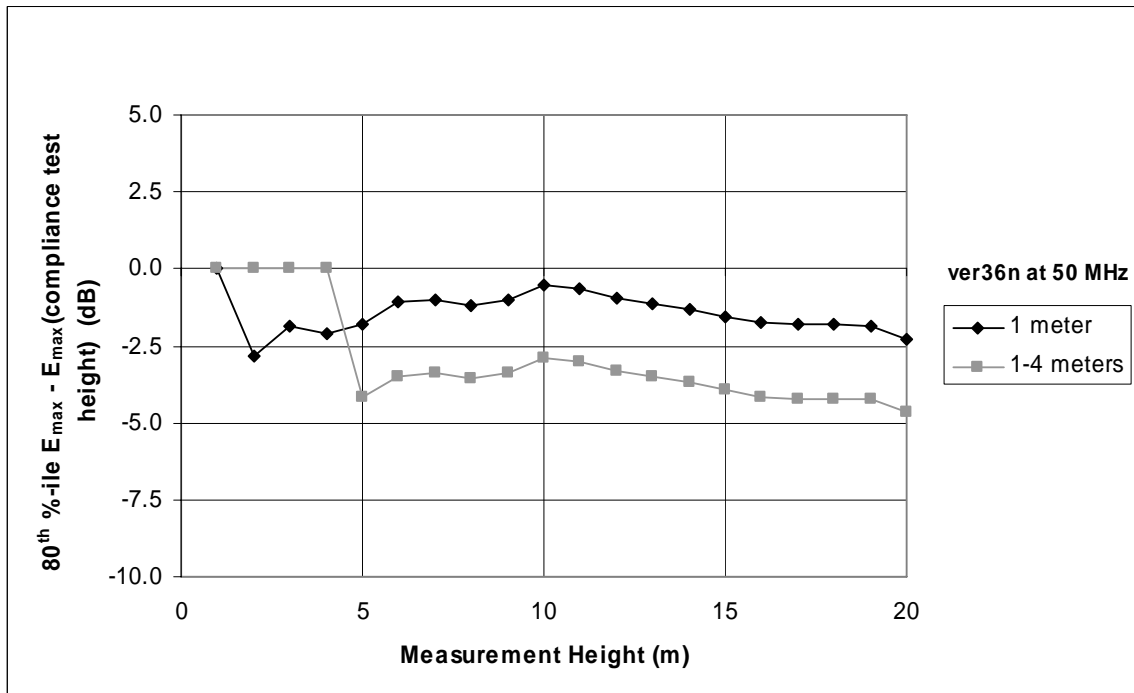
A-135: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



A-136: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



A-137: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters



A-138: Comparison of electric field strength as a function of measurement height, if compliance measurements were performed at heights of 1 meter, or at 1 to 4 meters