# RECENT ADVANCES IN IMPUSE RADIATING ANTENNA TECHNOLOGY

**Everett Farr(1), Leland Bowen(2), Lanney Atchley(3), Carl Baum(4), William Prather(5), Tyrone Tran(6)**

***(1) Farr Research, Inc., 614 Paseo Del Mar, NE, Albuquerque, NM, 87123, USA, efarr@farr-research.com***
***(2) As (1) above, but email lhbowen@farr-research.com***
***(3) As (1) above, but email lanney.atchley@ieee.org***
***(4) Air Force Research Laboratory / DE, 3550 Aberdeen Ave SE, 87117, magdalena.lopez@kirtland.af.mil***
***(5) As (4) above, but email William.Prather@kirtland.af.mil***
***(6) As (4) above, but email Tyrone.Tran@kirtland.af.mil***

**ABSTRACT**

We summarize here a number of advances in Impulse Radiating Antennas, which are composed of a reflector and a broadband feed. We have demonstrated improved gain and reduced crosspol by using feed arms located at ±30° to the vertical, as opposed to the original design that placed the arms at ±45°. We have reduced the return loss (flattened the TDR) at the splitter, at the feed point (focus), and at the resistors in the feed arms. We have added a ground plane that enhances mechanical stability and reduces crosspol. We have also improved the mechanical stability of the feed point.

## INTRODUCTION

In previous work [1,2], we have identified certain problems in the first version of the Impulse Radiating Antenna, the IRA-1. In particular, the crosspol coupling is too high, the input impedance is poorly matched, and the mechanical strength is too weak. In this paper, we demonstrate that we have solved each of these problems with the IRA-2, and we have further improved these issues in the IRA-3. We also document the improvements that have been recently demonstrated in the splitter, which is used to feed the antenna. .

## THE IRA-2

The IRA is based on a 46 cm (18-inch) diameter aluminum reflector with a broadband TEM-mode feed. Based on information in [3], we redesigned the IRA so that the feed arms are located at ±30° to the vertical, instead of ±45°. This change resulted in a greatly improved version of the IRA that we call IRA-2. A photograph of the IRA-2 is shown in Figure 1. The feed point was reinforced with a UHMW polyethylene cap, and a metallic rod was added along the axis of the dish for support.

We consider now the experimental results for the IRA-2. The TDR of the antenna is shown in Figure 2. We see a large dip in the impedance in the region of the resistors, which will be addressed later in this paper when we provide results for the IRA-3. The normalized impulse response on boresight is shown in Figure 3, showing a FWHM of 34 ps. In Figure 4 we overlay the gains of the IRA-1 and IRA-2. The boresight gain of the IRA-2 is higher than that for the IRA-1, especially from 14 to 18 GHz. The crosspol rejection for the IRA-2 is considerably better than the IRA-1 except at frequencies below 6 GHz. In Figure 5, we present the pattern plots in the H and E planes.

Figure 1. IRA-2 (feed arms at ±30°) with feed point and resistor details.

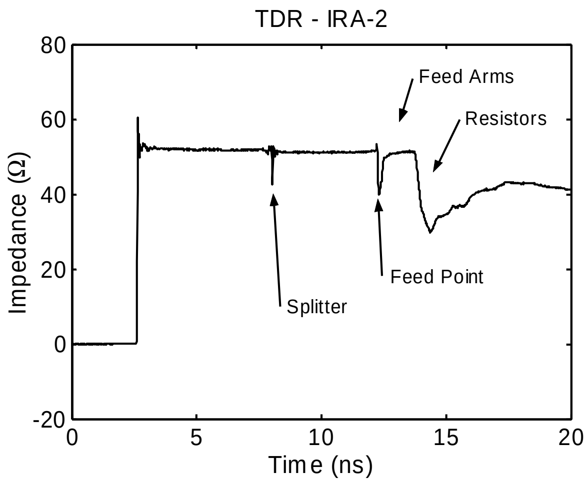


Figure 2. TDR of IRA-1 and IRA-2.

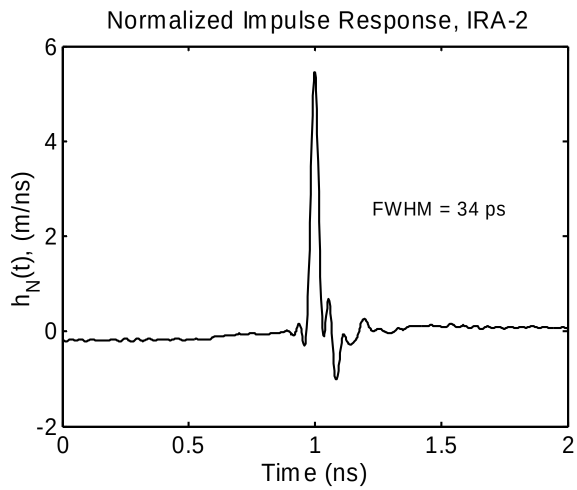


Figure 3. Normalized Impulse Response.

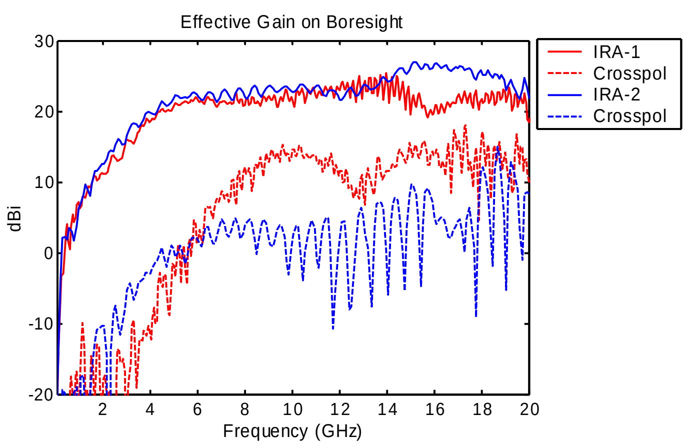


Figure 4. Comparison of IRA-1 and IRA-2, including crosspol.

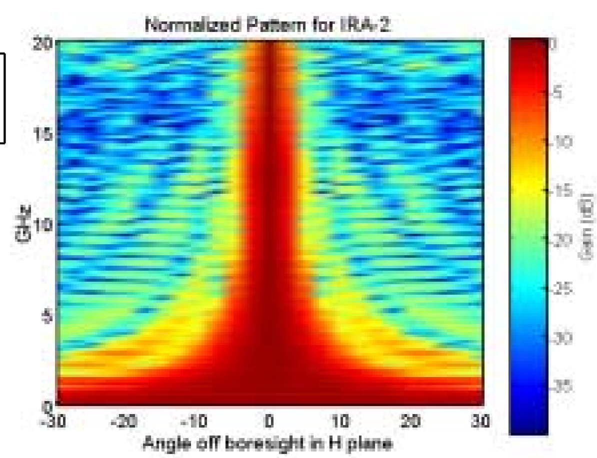


Figure 5. Pattern in the H plane

## THE IRA-3

The next major modification to the IRA was the addition of a ground plane on the horizontal plane of symmetry. It was hoped that adding the ground plane would further reduce the crosspol coupling to the antenna by shorting out the horizontal component of the E field. With this version, we also tuned the resistors so they would present a flatter TDR (better impedance match) to the input. Finally, we added a ring-like support structure near the feed point to support the feed. The new antenna is shown in Figure 6, and the resistor configuration is shown in Figure 7.

We now consider the results for the IRA-3. The TDR is shown in Figure 8, where we see the response is much smoother due to the improved resistors. The normalized impulse response is given in Figure 9, showing FWHM of the impulse response is 35.5 ps. The effective gain is shown in Figure 10, and it is compared to that of the IRA-2. Both the peak gain and average crosspol rejection are improved in the IRA-3. The normalized antenna patterns are shown in Figure 11.

Figure 6  Photo of the IRA-3.

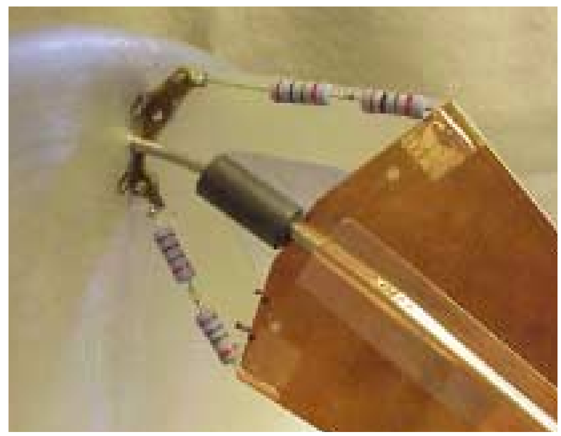

Figure 7.  Four 200 Ω metal film resistors in IRA-3.

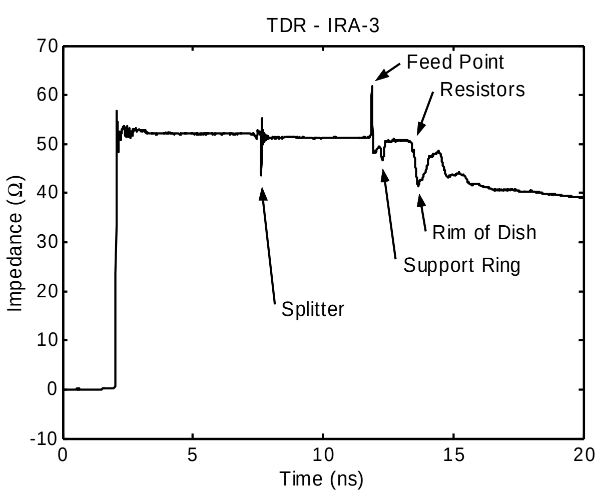


Figure 8.  TDR of final IRA-3.

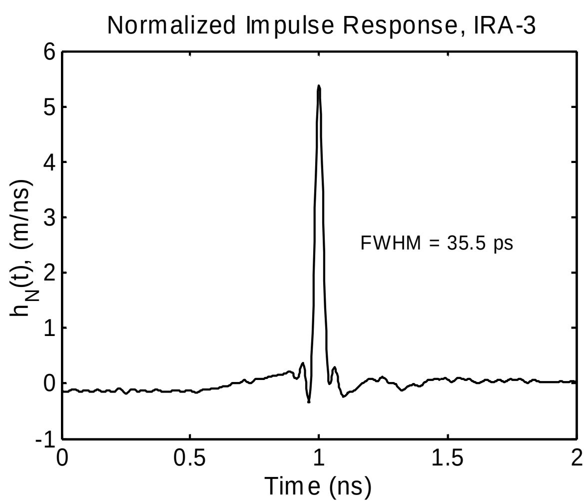


Figure 9.  Normalized impulse response of the IRA-3

## IMPROVEMENTS IN THE SPLITTER

Finally, we have developed an improved splitter that is used to feed the antenna. The splitter consists of a 50-ohm input, that is immediately split into two 100-ohm cables. Previously, we used a splitter that was provided by Prodyn, however, we were able to develop a splitter with a more smooth TDR. A comparison of the TDRs of the two splitters is shown in Figure 12.

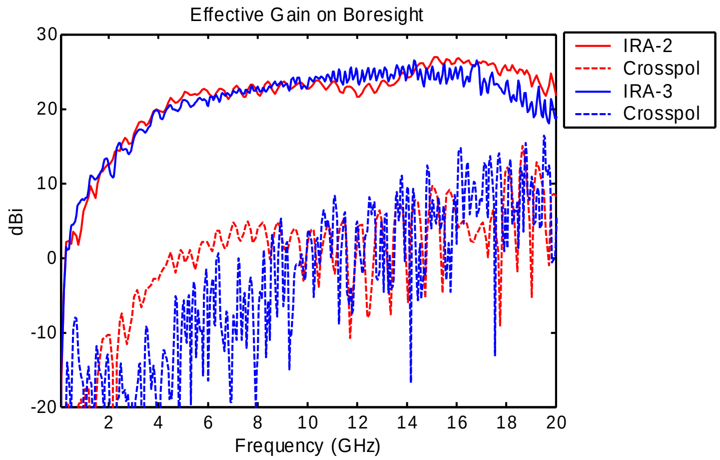

Figure 10.  Effective gain of the IRA-3 on boresight

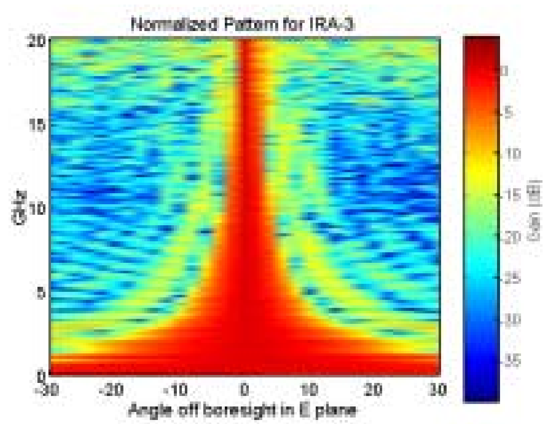

Figure 11.  Pattern of the IRA-3 in the E-plane

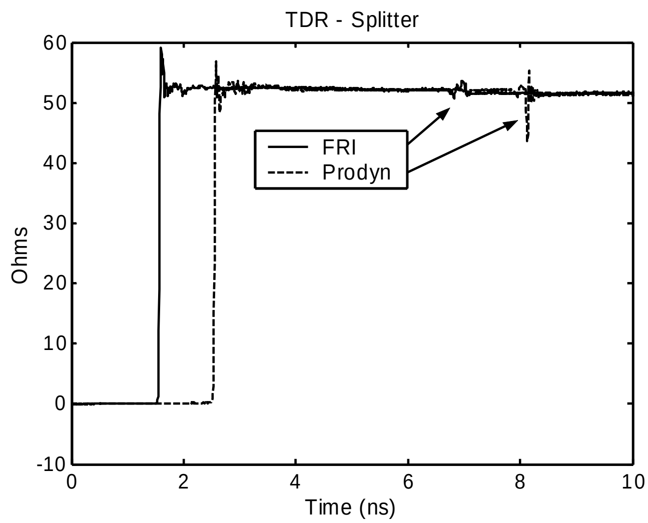

Figure 12.  Comparison of splitters made by Prodyn and Farr Research.

## CONCLUSIONS

Recent improvements to the IRA have given it higher gain, lower crosspol, improved structural stability, and improved input impedance matching.

## REFERENCES

*Note:  Sensor and Simulations Notes are published by AFRL and are available from the authors, or from the editor of the series, Dr. Carl E. Baum, 3550 Aberdeen Ave. SE Kirtland AFB, NM  87117-5776.*


[1] E. G. Farr, L. H. Bowen, G. R. Salo, J. S. Gwynne, C. E. Baum, W. D. Prather, and T. Tran, Studies of an Impulse Radiating Antenna and a Pulse Radiating Antenna Element for SAR and Target Identification Applications, Sensor and Simulation Note 442, March 2000.

[2] L. H. Bowen, E. G. Farr, C. E. Baum, T. C. Tran, and W. D. Prather, Experimental Results of Optimizing the Location of Feed Arms in a Collapsible IRA and a Solid IRA, Sensor and Simulation Note 450, November 2000.

[3] J. S. Tyo, Optimization of the Feed Impedance for an Arbitrary Crossed-Feed-Arm Impulse Radiating Antenna, Sensor and Simulation Note 438, November 1999.