C-BAND TM SMART ANTENNA

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ABSTRACT

This paper addresses the system requirements of the C-Band TM antenna that will take the place of the S-Band TM antenna used in applications on munitions and targets that require a quasi-omni directional antenna pattern. For these applications, the C-Band TM effective radiated power (ERP) must be approximately 3 dB higher than the S-Band TM ERP to achieve the same system performance due mainly to weather and environmental differences. From a systems stand-point, this will be a problem for the following reasons: power amplification at higher frequencies is usually less efficient, there is a limit on prime power due to battery capabilities, and a more complex corporate feed at C-Band as compared to S-Band will produce more loss. This means that a more fruitful approach would be to use smart antenna ideas to achieve the required higher ERP as compared to current approaches of using higher power transistors and more battery power. Several smart antenna ideas are introduced in this paper, switchable driven element antenna is described including active amplification at each element.

KEY WORDS

Antenna, transmit antenna, TM antenna, smart antenna

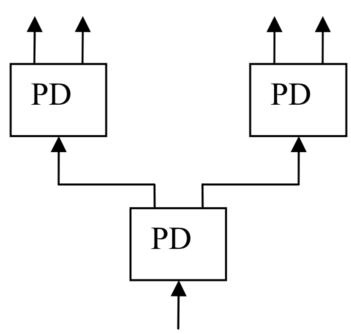
INTRODUCTION

Reference 1 gives an excellent systems point of view for the problems of going from L/S-Band telemetry (TM) to C-Band TM. The requirements are an ever increasing encroachment of the existing L/S-Band TM by commercial interests and an increasing data rate required by the testers to shorten the acquisition cycle of increasingly sophisticated systems. Reference 1 documents that the increase in free space attenuation at C-Band relative to S-Band is proportional to the frequency ratio squared is offset by the increased gain of the receive antenna that is inversely proportional to the frequency square. The receive antenna beam width will be less by the ratio of the frequencies so this may be a problem in tracking with a much smaller beam width. This may also be an advantage since most of the tracking is done at a low elevation angle of 0 to 10 degrees and a smaller beam width will have an advantage at low elevation angle. Since this is about wash, Reference 1 ascertains that the weather and environment will require an additional 3 dB of power to maintain the same signal availability (99.99%) at C-Band as compared to L/S-Band due to atmospheric losses. The bottom line from Reference 1 is that a 3 dB added effective radiated power (ERP) is required at C-Band to maintain the same system performance as provided currently at L/S-Band. Reference 1 further effectively addresses the system components of the transmitter, receiver, and receive antenna. This paper addresses the transmit

C-Band TM antenna as compared to the S-Band TM antenna that is typically installed on the target or munitions.

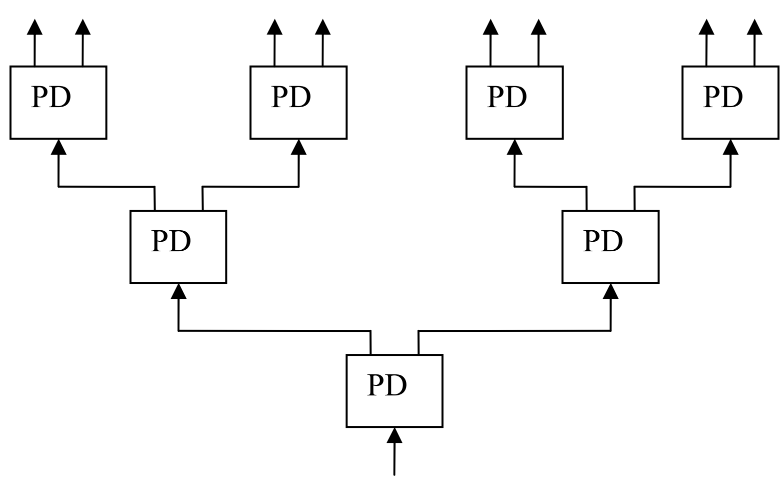
BODY

The transmit TM antenna for the target or munitions is required to have a quasi-omni directional coverage. A minimum variation is usually specified in the roll plane and is achieved by spacing the antenna elements around the circumference at a distance of less than a wavelength between elements. For example a 155mm cylindrical S-Band TM has four elements equally spaced around the circumference and has an acceptable gain variation in the roll plane. The corporate feed to drive the four elements consists of three equal amplitude and phase power dividers to drive all of the elements equally in amplitude and phase from one input integrated into the antenna as shown in Figure 1a. For C-Band, the antenna would have to have twice as many elements to have similar gain variation in the roll plane. The resulting eight elements will require seven equal amplitude and phase power dividers to drive all of the elements equally in amplitude and phase from one input as shown in Figure 1b.



Input

a. S-Band four elements



Input

b. C-Band eight elements

Figure 1. Transmit Corporate Feeds.

It is fairly obvious that the added complexity of the C-Band corporate feed will be harder to implement and have more loss as compared to the S-band corporate feed. This loss will have to be made up by added power output to achieve the required ERP and is estimated to be in the area of 0.5 dB for the 155mm application.

To sum up the TM transmitter systems problem, the C-Band transmitter will have to have an additional 3 dB for weather and environment and 0.5 dB for the corporate feed for a total of 3.5 dB more than the S-Band for equivalent performance. Since it will be hard to get more power from the transmitter at C-Band, smart antenna ideas will be presented to increase ERP by increasing the gain towards the TM receiver.

If it is assumed that the TM receive station is on the ground then the power radiated to the TM station will be from the bottom hemisphere or half of the antenna elements. Therefore, if the top hemisphere could be switched off and all of the power be radiated to the bottom hemisphere then the ERP would be approximately 3 dB higher due to the effective 3 dB increase in antenna gain toward the TM receiver. Even if the munitions are not roll stable, the vertical position can be determined and the proper antenna elements could be switched off and on.

Another area that ERP can be increased is in the efficiency of the overall transmit system. Due to the distinct separation in the power amplifier and antenna development this ideas has not been tried even though several developments have made this idea feasible. The current approach is to use a high power transistor or parallel set of transistors at the output of the TM amplifier to achieve the desired power output. The output of the power amplifier goes to the TM antenna that uses several sections of power dividers to divide the power to all of the antenna elements. If the power transistor is put at each antenna element then a smaller transistor with a higher efficiency can be used. Current developments of power transistor bias integrated circuits allow for easy control with extremely fast turn on and off. Each antenna element could be fed a low level signal that could be amplified by the transistor at the element. Logic could be developed to turn on the proper transistor to optimize the gain toward the receiver while at the same time minimizing the prime power used. A simple control could provide the hemisphere coverage to compensate for pointing errors.

What has been described so far is amplitude control of the signal at each antenna element. Although more complicated, the addition of phase control to each element would provide a MIMO (multiple-input multiple-output) type antenna where the gain is optimized towards the receiver. Since the TM transmit antenna is output only, utilizing the techniques developed for MIMO antennas would be limited. Also phase control at the power levels of the TM transmitters is not easily implemented.

CONCLUSION

For the C-Band transmitting system, 3 dB plus ERP must be added to be equivalent to the L/S-Band transmitting system performance. It appears that the added ERP can more easily come from antenna developments versus higher power transmitter developments.

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REFERENCES

1. Mayer, Gerhard and Chalfant, Timothy; "TRENDS IN AERONAUTICAL FLIGHT TEST TELEMETRY", AFFTC-08334, The International Consortium for Telemetry Spectrum, International Seminar, Aero India 2009, Bangalore, India, February 11-15, 2009.