

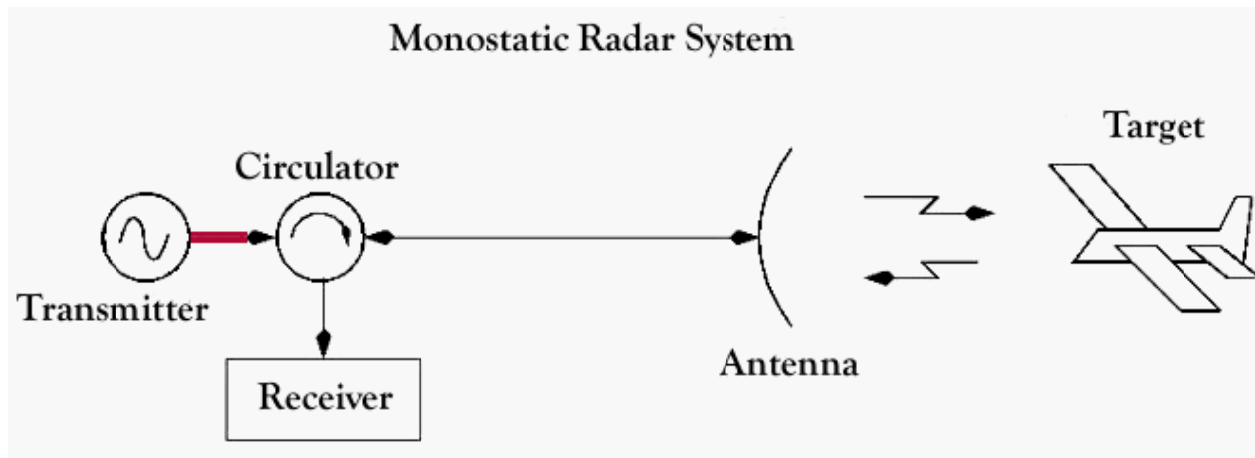
# Wideband, High-Power Circulators for HF Communication Systems

Jeffrey L. Young and Ken Noren

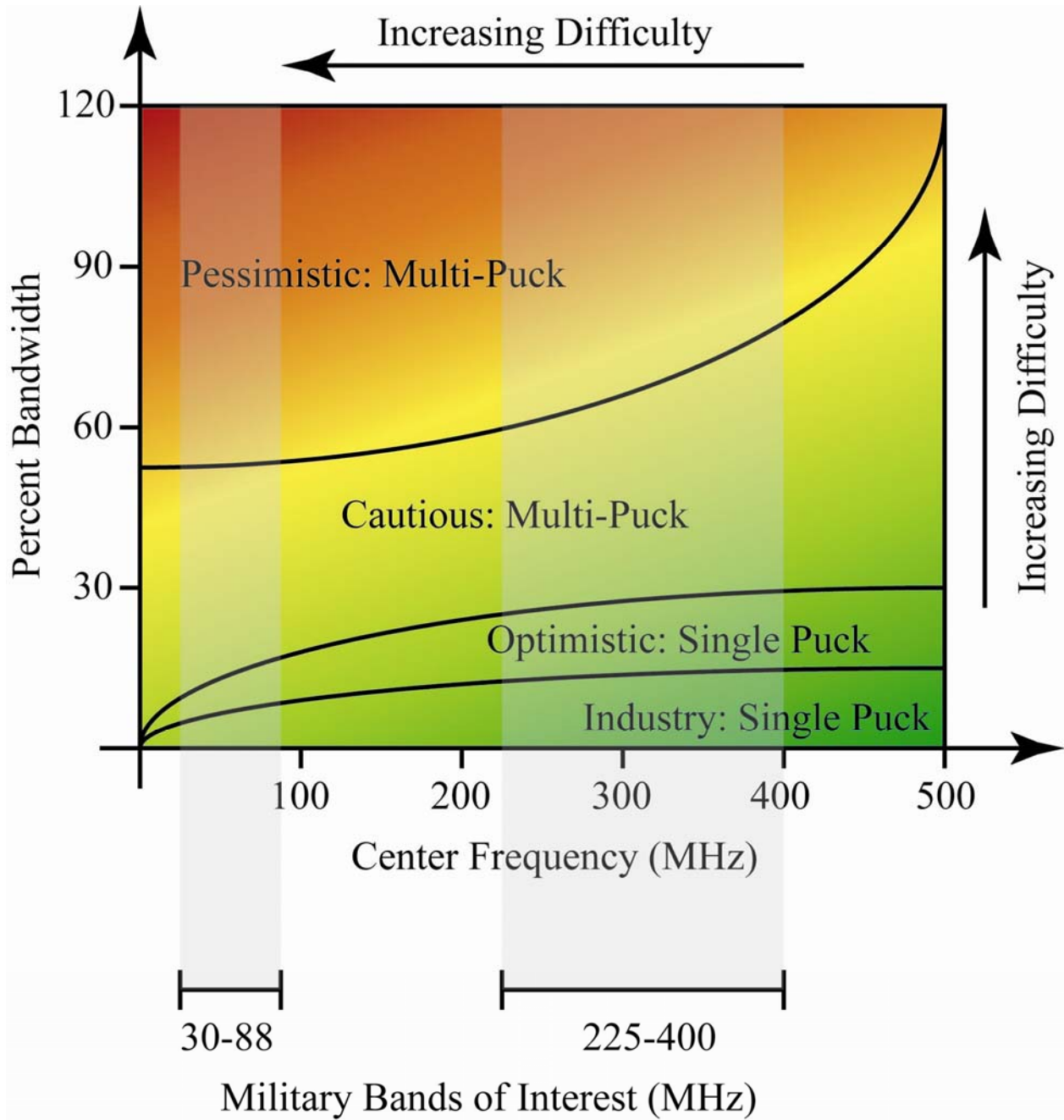
Department of Electrical Engineering

Senior Design, Fall 2009

The United States Navy uses the HF, UHF and VHF frequency bands for person-to-person, ship-to-person and ship-to-ship communication systems, since such signals have sufficiently sized wavelengths for non-line-of-sight applications. To reduce size, weight and cost it is common to use a single antenna for both transmit and receive mode. This is accomplished by means of a circulator that can direct a signal to a particular port depending on the direction of signal flow. The situation is depicted below for a monostatic radar system.



As with any communication system, bandwidth and power handling capability are crucial. Yet, modern circulator technology has yet been able to achieve both of these in the HF, UHF and VHF bands. From a bandwidth point of view, the chart below depicts the current state of technology and also shows that wideband at low frequencies is very difficult.



**Specifications:**

- 1) Insertion Loss: 0.5 dB max
- 2) Isolation: 15 dB min
- 3) Return Loss: 15 dB min

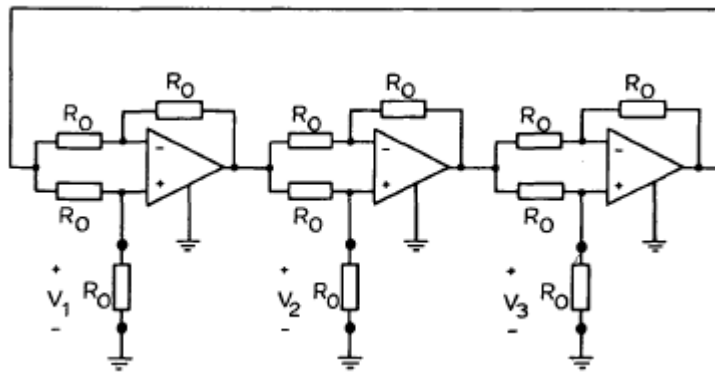
Low Risk

Medium Risk

High Risk

Most commercially available circulators are made of ferrites due to their excellent power handling capabilities. Yet, these devices are narrowband. Active circulators that employ operation amplifiers can be wideband, but are typically low power devices that operate in the sub-HF bands. However, with the improvement in the bandwidth and power capabilities of discrete and integrated transistors there is now reason to believe that active circulators may in fact be suitable for this Navy application.

A senior design team is challenged to develop an HF circulator that pushes the envelope in terms of power, bandwidth or both in the HF band. Ultimately, a 30-88 MHz circulator that can deliver 50 W of power is desired. A typical topology using operational amplifiers is shown below. A question to be determined in this project is whether commercially available operational amplifiers, video amplifiers or discrete transistors are available for this application. The second question is whether the topology shown below is the best one for this application.



This project is being funded by the US Navy under BAA 07-037. The faculty advisers are Profs. Jeffrey Young and Ken Noren. Prof. Young has considerable experience in circulator modeling, design, simulation and test. Prof. Noren has the same in analog electronics modeling, simulation, design and test. Students working on this project will have access to state-of-the-art measurement equipment in the Applied EM Waves Laboratory, BEL 206. For more information about this laboratory see <http://www.mrc.uidaho.edu/em/>. Highly motivated students who seek a significant challenge in solving a crucial problem for Navy are especially encouraged to consider this project. Moreover, it is highly desirable that students who work on this project have or will take several technical electives in the electronics and electromagnetic curriculum (i.e. 310, 330, 41X and 43X).