6.3B DESIGN CONSIDERATIONS FOR HIGH-POWER VHF RADAR TRANSCEIVERS: THE POKER FLAT MST RADAR PHASE CONTROL SYSTEM

W. L. Ecklund and P. E. Johnston

Aeronomy Laboratory
National Oceanic and Atmospheric Administration
Boulder, CO 80303

Sixty-four separate 50-kW peak-power transmitters are distributed throughout the 200 x 200 meter Poker Flat MST radar antenna array. The relative phase of each transmitter is automatically controlled by a 64-channel unit located in the main building at the edge of the antenna. In this note we describe the phase control unit and present several photographs which show how the controller is constructed.

The Poker Flat antenna consists of 4, 100 x 100 meter coaxial dipole arrays with superimposed orthogonal elements. Each polarization/quarter consists of 32 strings of 48 dipoles each, and each set of 4 strings is driven by a separate transmitter. Thus 8 transmitters drive each polarization/quarter and the phase control unit described here consists of 8 sets of 8-channel rack-mounted modules all interconnected. One 8-channel module controls the 8 transmitters in a single polarization/quarter. The phase-control rack containing the modules is shown in Figure 1. Figure 2 shows an individual 8-channel controller with cover removed. The operation of a single channel will be described in the following paragraphs.

Figure 3 shows a simplified block diagram (within the dashed lines) of one channel of the phase controller. A sample of the RF outpulse pulse from a transmitter located in the antenna array is obtained from the built-in directional coupler and sent to the phase control unit via a phase-matched 256-meter coaxial cable (the "cable radar" used to phase match the cables from 64 transmitters is described in paper 6.3C, p. 427, this volume). The RF pulse sample from each transmitter is brought to the top of the phase-controller rack. Carefully measured sections of RG-58 (0 cable in Figure 3) extend from the rack-top fittings to the channel inputs on the back of each 8-channel module. These sections determine the relative phase shifts of all the transmitters and determine the transmitted beam zenith angle. A phase reference pulse is derived from the transmitter master oscillator and is divided first in an 8-way power splitter which feeds each of the eight rack-mounted modules. The reference is again split 8-ways inside each module so that each channel obtains a phase-matched reference pulse (0 reference in Figure 3). The transmitter RF drive pulse is also split 64 ways and fed to the voltage controlled phase shifter in each channel.

In operation the RF pulse from a transmitter coupler is power divided (Figure 3) and compared with the phase reference in a mixer. The mixer output is low-pass filtered and sampled near the center of the resulting video pulse by an amplifying sample-and-hold integrated circuit. Phase control is effected by maintaining the mixer output pulse near zero volts by amplifying the sample-and-hold output which then drives the voltage-controlled phase shifter in the direction to null the mixer output. The voltage-controlled shifter achieves over 360° phase shift in the range from 0.7 to 24 volts. When the voltage into the shifter tracks to either voltage limit the wrap-around control resets the voltage so that the shifter is always operating within its control range.

Part of the RF pulse from the transmitter coupler is fed to a front panel connector where the phase and amplitude of each channel can be conveniently monitored for calibration. Part of the RF pulse is also fed to a peak detector so that the relative output of the transmitter can be monitored. This monitor-

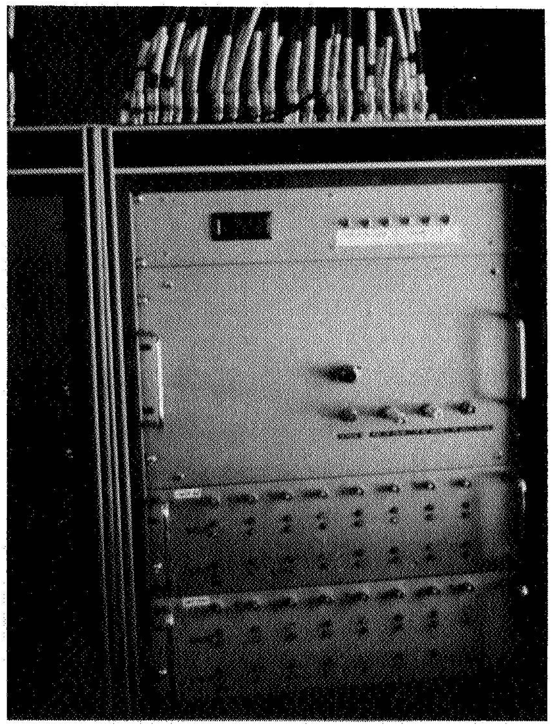

Figure 1.

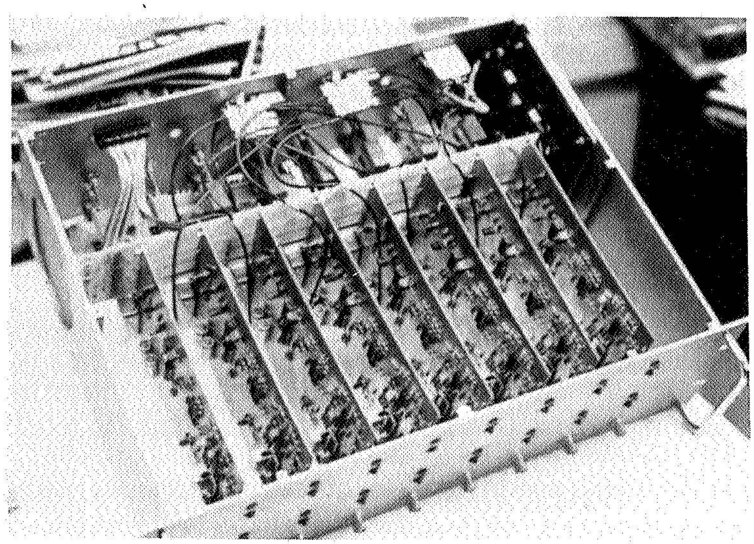

Figure 2.

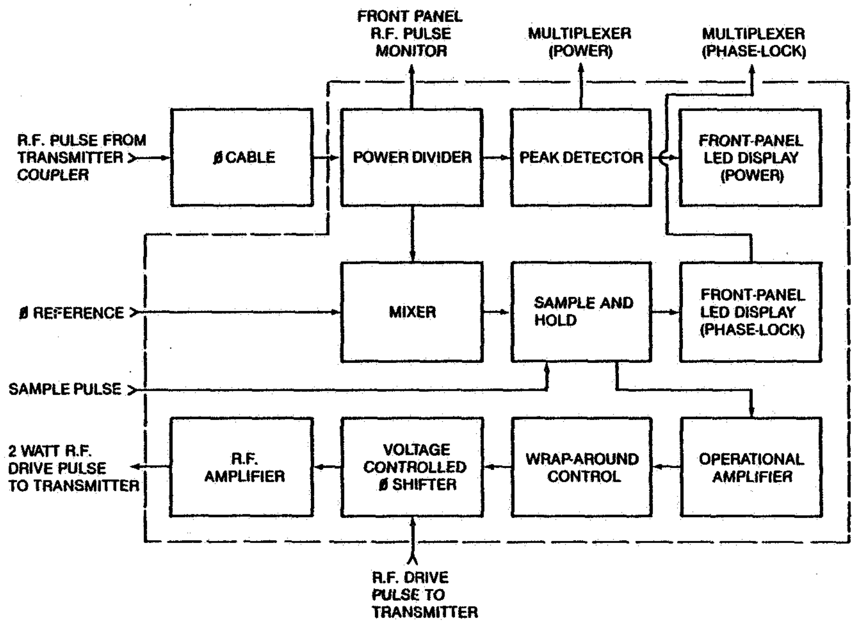

Figure 3.

ing takes place in two ways. For a quick-look determination of transmitter operation the signal is fed to a comparator which drives a pair of red/green LEDs (light emitting diodes) on the front-panel display (green indicates reasonable transmitter output, red indicates no or low output). The signal is also available at the input of a computer-controlled multiplexer so that individual transmitter outputs can be automatically logged. Individual outputs can also be manually addressed and read from a front-panel digital voltmeter. An additional pair of red/green LEDs on the front panel indicates proper phase locking. An error of a fraction of one degree causes a red light indication which is also available at another multiplexer input so that phase-lock can also be computer-logged. The LED indicator lights have proved to be very useful in providing a "quick-look" determination of system status.

The time constant of the phase-control feedback loop has been adjusted so that phase locking is achieved in about 1 second after transmitter turn-on. The phase is automatically controlled to within a fraction of a degree, and the relative phase of each unit can be adjusted by about 4° by a zero control on each sample and hold. Any channel can be quickly checked for proper operation by placing a 13-dB attenuator on the RF amplifier output and feeding the RF pulse back into the power divider input. The lengths of the RG-58 phase control cables could be changed in steps by low-power coaxial relays to obtain rapid scanning of the transmitted beam over a limited zenith angle.