10-GHz weather radar

A unique application for a Gunnplexer transceiver

Commercial weather radar systems have become quite popular in recent years and have proven their true life-saving ability. And over and above their use during dangerous storms, they have now become almost a part of our daily lives. The only drawbacks to these commercial radar systems are their inability to scan a small area (such as an individual's neighborhood), and the fact that commercial radar scans are generally made available only at fixed times.

To overcome these limitations, I have designed a mini weather radar system which is both inexpensive and easy to build. A short scanning range was my only criterion. Guidelines are provided for those interested in pursuing and refining this unique concept.

This mini weather radar is based on two simple facts: a radio signal travels one mile in 5.4 microseconds; and an electron beam can be timed to travel across a CRT's screen at a predetermined rate. If a radio wave leaves a transmitting antenna at the same time that a horizontal line begins on the left side of a CRT display, that radio wave will travel approximately 12.1 miles in the 63 microseconds it typically takes for one scan of a horizontal line in conventional TV.

operation

The first version of this unit is shown in **fig. 1**. An oscilloscope with horizontal trigger output is used with a 10-GHz Gunnplexer, an NE555 pulse modulating circuit, and a high gain amplifier to produce a distance-and-azimuth Amateur weather radar. The Gunnplexer's mixer uses the unit's constantly transmitted signal for a local oscillator, eliminating the need for a T/R device. A horizontal scan-initiating sync pulse from the oscilloscope's horizontal trigger output is used to key the NE555 oscillator, which becomes the modulating signal for the Gunnplexer's varactor input.

The Gunnplexer transmits its signal toward a distant object, such as heavy storm clouds, and its reflection is then received. The return signal heterodynes in the Gunnplexer's mixer, the output of which drives a high-gain amplifier. The amplified echoes are then fed to the oscilloscope's vertical input for display. Since the scan started during the pulse-transmission time, its round-trip delay time is indicated in **fig. 2** as displacement on the screen.

The Gunnplexer's modulating frequency should be between 200 kHz and 1 MHz. This frequency deter-

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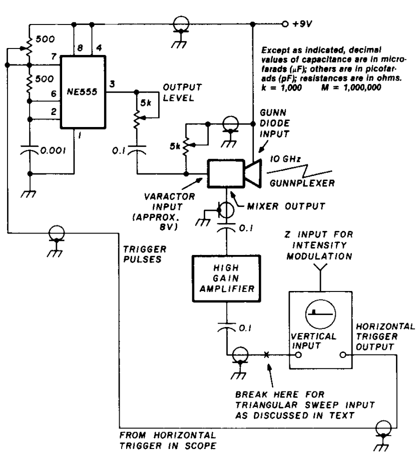

fig. 1. Arrangement of the first-generation Amateur weather radar, using an oscilloscope for generating timing pulses and displaying returned echoes.

mines the exact pulse width. Using the formula $F = 1/T$, a 200-kHz modulating frequency translates into approximately 5 microseconds: approximately one mile on the screen's display. A 1-MHz modulating signal encompasses approximately 1 microsecond (1/5 mile) on the screen. Although the Gunnplexer transmits a carrier continuously, only the brief modulating pulse causes indications on the CRT display. This unit will provide distance indications and information on the density of rain clouds, but it does not provide information on the direction of storm clouds. This shortcoming does not usually pose a problem.

refinements

The second version of this weather radar uses an NE555 triangular wave generator and adds a modified oscillating house fan motor to make possible directional (azimuthal) readings. An outline of this arrangement is shown in **fig. 3**. The fan motor causes side-to-side movement of the remote Gunnplexer, while a microswitch at one end of the sweep provides synchronizing pulses for the NE555. The output from the triangular wave circuit is applied to the oscilloscope's vertical input; the high-gain amplifier's output is applied to the intensity (Z) input of the oscilloscope. The oscilloscope is adjusted for a dark screen until an intensity-modulating echo is received. Range markers can be added to this system with another NE555 circuit, or can simply be drawn on the screen with a washable-ink felt pen. I also suggest that you replace the oscilloscope's P-1 phosphor cathode ray tube with a long-persistence-display P-7 equivalent tube.

During operation, horizontal sweep pulses from the oscilloscope trigger the NE555 modulation circuit, while vertical sweep is provided by the fan-motor-synchronized triangular wave generator. The Gunnplexer transmits a 200-kHz-modulated 10-GHz signal which is reflected according to cloud density and displayed on the screen. Horizontal displacement on the CRT indicates distance, and vertical height (with respect to the base line) indicates direction.

The received echoes are heterodyned with the Gunnplexer's carrier, amplified, and applied to either the oscilloscope's Z modulation port or vertical input (depending on the particular version of weather radar you build). Although a low-power 10-GHz Gunnplexer can transmit and receive over line-of-sight distances

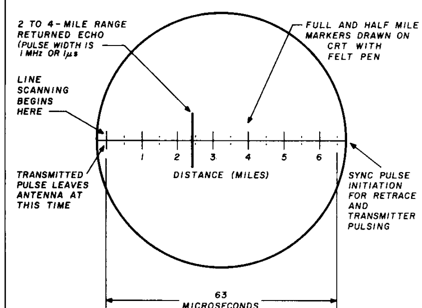

fig. 2. Visual display obtained with first-generation Amateur weather radar. The 10-GHz Gunnplexer transmits a modulation pulse at the same time a scan line begins on screen at left. The time periods shown provide a range of approximately 6 miles.

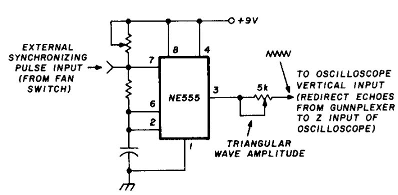

fig. 3. Triangular wave generator for vertical deflection in synchronization with Gunnplexer movement, as described in text. Circuit insertion point is shown in fig. 1.

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in excess of 20 miles, I suggest that you limit its range in this application to less than 12 miles (a number chosen because of the oscilloscope's horizontal scan rate and the frequency of the Gunnplexer's modulator). This safety margin ensures reliable operation and permits accurate interpretation of the displayed information.

a third mini radar

A third version of the mini weather radar is being developed now, and its capabilities look promising. This system employs a used black-and-white TV set rather than an oscilloscope, using the TV circuits to generate precisely timed transmitter pulses and to display the reflected signals. Since the set's tuner and i-f stages are bypassed, with the radar information applied directly to the video amplifier section, usable TVs could be picked up inexpensively at TV repair shops.

An outline of the system is illustrated in **fig. 4**. Narrow-width (and highly accurate) horizontal AFC pulses obtained from one of the low-voltage windings on the TV's horizontal output transformer trigger the Gunnplexer's NE555 modulator. This arrangement establishes radar timing while maintaining horizontal line sync in the television. A single-shot multivibrator or Schmitt trigger proves useful for buffering flyback pulses. Alternatively, a dropping resistor may be placed in the keyed AGC line for lowering that voltage to approximately 5 volts. A schematic diagram of the TV is needed for locating the keyed AGC line and determining its voltage level (don't "hunt around" in the horizontal output section: HIGH VOLTAGE!). The desired modulator-keying line is usually found connected to the AFC's discriminator diodes. You will also see a "second line" carrying sync pulses from the sync separator stage in the AFC's discriminator. That guidepost will help you locate the desired AGC keying takeoff point.

Output from the Gunnplexer's modulator is applied to that unit's varactor. The returned echoes are amplified to approximately 4 volts by a wideband amplifier similar to a single video stage in a television set, and applied to the TV's video amplifier section (a suitable injection point for this signal is quite often between the contrast control wiper and ground. If an ac/dc TV is used, be sure this point is not hot). The resultant echoes are displayed as intensity variations on the screen, with distance and timing calibrations provided by techniques similar to those in the second unit, described earlier. The next step in this system's development will include electronically sweeping the 10-GHz radar signal in sync with the TV's 60-Hz vertical scan rate. An illustration of the resultant display is seen in **fig. 5**.

A fourth generation Amateur weather radar is presently on the drawing board, and this version holds some truly exciting possibilities. Basically, this system employs an inexpensive home computer, such as the Apple II or TRS 80C, for generating all the required timing pulses and for creating a color-level display similar to that of commercial units. Since these microcomputers are easily programmed for various timing ranges and color presentations, they are quite useful for Amateur radar work. The integration of A-to-D and D-to-A converters in these units makes computer interfacing relatively simple.

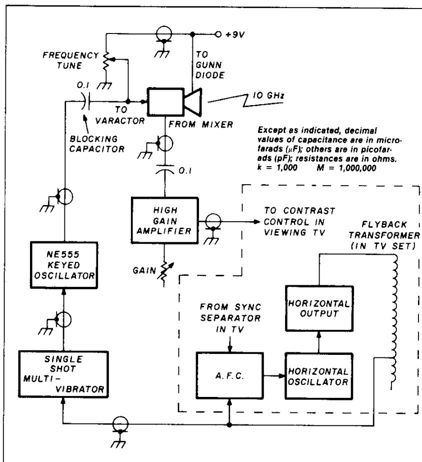

fig. 4. The third-version Amateur weather radar uses a modified television set for timing and display of target information.

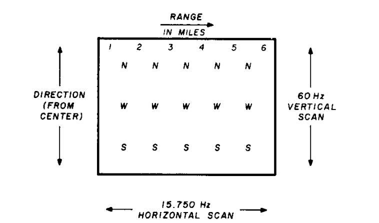

fig. 5. Display of sector scan as accomplished by version-three Amateur weather radar. A modified TV set is employed.

Alden Electronics (Washington Street, Westborough, Massachusetts 01581) manufactures a weather chart recorder (Model 9321), available in assembled or kit form, that displays data generated by NOAA and other sources. — **Editor**

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