PPI Presentation of Time-Shared Videos Having Synchronized or Unsynchronized Antenna Rotation Rates

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The range of the sweep speeds provided is from 4 to 300 miles per radius, and the range of the repetition rates is from 60 to 3000 The picture diameter is 10 inches, and the indicator incorporates a fixed deflection coil (rotating magnetic field) [1]

MODIFICATIONS TO THE SPA-8A INDICATOR

Airport Surveillance Radar (ASR) and Beacon Time-Sharing

In this application, ASR radar and common-system beacon videos were presented on the indicator kinescope on a time-shared basis. The beacon-interrogator trigger was synchronized with the radar trigger, counting down from the radar pulse-repetition frequency (PRF) of 1200 to the 300-PRF beacon rate The antenna rotation rates of the radar and beacon were not synchronized It was possible to vary the antenna rotation rate or direction of rotation of either unit A 5F synchro unit was installed in the SPA-8A, and through the use of an external servo system, it rotated the cursor-sweep resolver shaft in synchronism with the beacon antenna The normal 9 1 time-sharing circuitry of the SPA-8A was modified to count down 3 1 In the display, three consecutive radar sweeps were presented and then one beacon sweep was shown The beacon video was inserted at the point normally used to apply range-ring video on the cathode-ray tube (CRT) cathode during the cursor-sweep time A Tektronix Model 112 amplifier was used as a temporary beacon-video amplifier

No operational tests were made of this time-shared display, however, a flight check was made to determine the accuracy with which the radar and beacon returns from the same aircraft were displayed From this test, it was determined that with proper adjustment of beacon-trigger delay and synchro alignment, the two returns could be made to coincide at all azimuths One discrepancy noted in this method of obtaining time-shared sweeps arose from the fact that the beacon-trigger count-down circuit was separate from the time-sharing count-down circuit in the SPA-8A When the switch on the front of the indicator was thrown from "cursor off" to "cursor on," sometimes it had to be switched back and forth until the two count-down circuits were starting with the same radar-trigger pulse, otherwise the beacon video would not be displayed in its proper range but would start later than normal at some time interval that was an integral multiple of the radar-trigger period In designing an operational unit, it would be necessary to provide positive synchronization between the display time-sharing and the radar/beacon count-down system

CPS-6B Radar Video Time-Sharing

Modifying the SPA-8A indicator for use with the CPS-6B radar to display the V and EW videos on a time-shared basis was simplified by a common 1 1 trigger and by fixed mechanical displacement between the V and EW antennas These antennas were mounted on a common pedestal and were displaced in azimuth 146° Had these antennas rotated independently, an additional servo amplifier would have been required as described above for the ASR beacon The individual sweep circuits for the normal and cursor videos, with their separate resolvers mechanically geared together, were time-shared at a 1 1 rate with little difficulty The over-all modifications to the indicator were as follows

1 Time-Sharing Count-Down Network Figure 7-29 of the SPA-8A maintenance manual illustrates the count-down circuit employed for a 9 1 time-sharing between normal and cursor videos In order to time-share the V and EW videos on a 1 1 basis, the 9 1 count-down circuit was eliminated and a flip-flop circuit was installed in its place

2 Sweep Circuits When employing a trigger PRF of 300, it was found that the maximum gate normally used for the sweep must be shortened to allow enough "dead time" for the driver circuit to be clamped to a quiescent condition before starting the next sweep. For this application, the maximum gate was set for a 200-mile range The resulting dead time between gating of the normal and cursor sweeps was sufficient to prevent unfavorable distortion at the beginning of the sweeps The resolver for the EW (cursor) sweep was connected through a gear arrangement to one side of the Diehl 2-phase motor, the resolver for the V (normal) sweep was connected to the opposite side The gearing ratio between both resolvers and the servo motor was the same A plus or minus 15° adjustment was incorporated in the design of the EW resolver gear box in order to provide a fine adjustment to obtain azimuth coincidence between targets common to the V and EW radar displays

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[1] A complete description of this indicator can be obtained from "Instruction Book for Indicator Group AN/SPA-8A," NAVSHIPS 91737, Bureau of Ships, Department of the Navy

3 Video Network The same time-sharing circuits were used for the normal and modified cursor-video circuit Capacitor C-1080 for the range-mark input to the cursor-video stage was disconnected and a video amplifier was built and inserted for EW video

FACTORS TO BE CONSIDERED WHEN TIME-SHARING

Time-sharing two video inputs is not desirable for all situations The radar-indicator presentation is a function of the time-sharing ratio, antenna-scan rate, given in revolutions per minute (rpm), PRF, pulse width, range sweep displayed, tube diameter, spot size, and integration quality of the tube phosphor Thus, for target discernibility, these factors must be considered for time-sharing if loss of targets resulting from "wedging" or inability of hits per target to integrate into one target are to be eliminated For applications of 1.1 time-sharing, some calculations have been made to illustrate the effect of these factors on target discernibility. Two different sizes of kinescope tubes (10- and 12-inch) were selected These calculations concern targets at the edge of the kinescope tubes

1 For an SPA-8A radar employing a 10-inch tube

Circumference = 79 7 centimeters (cm) at edge of tube

One degree subtends 79 7/360 x 10 = 2 21 millimeters (mm) per degree separation

a For a radar having the following conditions

Trigger = 300 PRF

Beam width = 1°

Scan rate = 6 rpm or 36 degrees per second

Sweeps per degree = $\frac{300}{36}$ = 8 4

Then the possible hits per target per degree = 8 4

The azimuthal separation between hits on a target is $\frac{2\ 21}{8\ 4}$ = 0 263 mm for a non-time-shared video, and $\frac{2\ 21}{4\ 2}$ = 0 526 mm for a 1 1 time-shared video

b For a radar having the following conditions

Trigger = 1200 PRF.

Beam width = 1°

Scan rate = 30 rpm, or 180 degrees per second

Sweeps per degree = $\frac{1200}{180}$ = 6 67

Then the possible hits per target per degree = 6 67

The azimuthal separation between hits on a target is $\frac{2\ 21}{6.67}$ = 0 331 mm for a non-time-shared video, and $\frac{2\ 21}{3\ 335}$ = 0 662 mm for a 1 1 time-shared video

2 For a 12-inch CRT, the circumference is 95 6 cm One degree subtends $\frac{95\ 6}{360}$ x 10 = 2 66 mm

a For a radar having conditions of 1a, the azimuth separation between hits on a target is $\frac{2.66}{8\ 4}$ = 0 316 mm for a non-time-shared video, and $\frac{2\ 66}{4\ 2}$ = 0.632 mm for a 1 1 time-shared video b For a radar having the conditions of 1b, the azimuth separation between hits on a target is $\frac{2\ 66}{6\ 67}$ = 0 398 mm for a non-time-shared video, and $\frac{2\ 66}{3\ 34}$ = 0 796 mm for a 1 1 time-shared video

Assuming that the range resolution of these indicators is approximately 180 spots per radial, the spot size for a 10-inch tube would be 0 71 mm, and the spot size for a 12-inch tube would be 0 85 mm If these spots are assumed to be circular rather than elliptical in shape, the approximate spot diameter in azimuth would be the same as already calculated The calculations also assume a spot of uniform brightness which is not necessarily true From the calculations for a 10-inch tube, the separations between the centers of hits in azimuth for a 1 1 time-shared condition were 0 526 and 0 662 mm respectively Therefore, using a spot size of 0 71 mm for a 10-inch tube, it would seem that no wedging should result as far as target discernibility is concerned In actual operation a condition may be prevalent wherein the video amplitudes for the hits have been limited, and these wide target pulses will result in a spot-size diameter greater than 0 71 mm The same reasoning can be applied to target discernibility for 1 1 time-sharing on a 12-inch tube

From these calculations it can be seen that 1 1 time-sharing gives the most desirable display Should a condition present itself wherein the videos are time-shared 1 2 or 1 3, it is possible that target loss will result or the hits per target will not integrate into one discernible target

PERFORMANCE TESTS

Tests of signal loss when using time-sharing were conducted on the SPA-8A indicator under operating conditions similar to those assumed in calculation No. 1 A scan rate of 6 rpm and 300 PRF was used Most of the tests were conducted near the edge of the 10-inch tube where the spot integration for a 1 1 time-shared condition was expected to be inferior The kinescope employed in this indicator was a 10-inch, P25, long-persistence phosphor tube The measured distance from the center of the tube to the outer target ring was approximately 4 6 inches

Various ratios of video signal-to-noise were observed under non-time-sharing and 1 1 time-sharing ratios, but no significant differences were noted except for the case of minimum discernible signal level In this test a simulated double-pulse target video was fed to the display and was adjusted for minimum discernibility under 1 1 time-sharing and non-time-sharing conditions The input amplitudes to reach PPI threshold were

Non-time-sharing (V)	Time-sharing (V)	Difference (db)
0 052	0 075	3 2

These figures indicate a loss of approximately 3 db when time-sharing very weak signals On signals above the threshold level of the CRT, this loss quickly minimized itself, and at the normal operating levels no signal loss could be measured consistently

The results of these tests indicate that the application of 1 1 time-sharing to the SPA-8A indicator will reduce the target brightness because fewer hits were being integrated per degree This reduction in brightness is approximately 3 db, however, no noticeable wedging in targets was introduced This modified SPA-8A indicator has received considerable use by the CAA at the ADC Station at Rockville, Indiana Traffic controllers using this indicator have found it very desirable to observe the entire surveillance capability of the CPS-6B system simultaneously without having to switch between the various radar videos

CONCLUSIONS

The modified SPA-8A indicator has proved an interesting application to display videos derived from radar systems having unsynchronized antenna rotation rates, or for radars of the CPS-6B type having V and EW videos at a fixed azimuth displacement

There are many factors which enter into the problem of displaying time-shared videos The applications in this report may not be suitable for all radar outputs, and careful investigation is required to prevent possible loss of targets as a result of wedging or inability of hits per target to integrate into one target