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TITLE CIRCULAR FORMAT SIZ-ZAG SCANNING OF VIDICON TUBES

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Circular format zig-zag scanning of vidicon tubes

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ABSTRACT

In an effort to increase camera readout speed, we have developed a nonconventional vidicon tube scanning technique. Because all vidicon targets are round, acquiring a full view requires overscanning with a conventional square format scan, resulting in 22% of the video field time wasted. Furthermore, conventional scanning employs horizontal flyback, which for high frame rates can be more than 10% of the total field time. Our nonconventional scanning technique eliminates flyback time by utilizing a triangular waveform rather than a sawtooth for horizontal deflection. This triangle wave is amplitude modulated in order to scan only the (circular) area of interest. The vertical deflection is a staircase ramp, with a step occurring at the end of each horizontal line. This maintains even spacing and a parallel relationship between horizontal lines, as opposed to skewed lines with conventional scans. To display the video output, the X-Y monitor must also be driven with these waveforms in order to maintain the correct temporal and spatial position of the video data. Sweep rates of 400 lines in a 1 ms field have been demonstrated. Test results using this technique show a frame time reduction of ~30%, with no loss of resolution or dynamic range, and no increased video bandwidth requirements.

1. INTRODUCTION

In applications where the full active area of the vidicon target must be utilized, or when the image of interest is round, the field time of a video camera can be reduced by scanning the vidicon tube in a zig-zag fashion with a circular format. This reduced field time is given by,

$$t_{\text{eff}} = t_{\text{sq}} \times \frac{\text{area}_{\text{cr}}}{\text{area}_{\text{sq}}} \times K = t_{\text{sq}} \times \frac{\pi}{4} \times .92(\text{typ}) = .72t_{\text{sq}} \quad (1)$$

where $K = 1 - (\text{time saved by flyback elimination} / t_{\text{sq}})$.

2. WAVEFORM CHARACTERIZATION

The ideal waveforms will zig-zag scan a circular format at a constant beam velocity with evenly spaced horizontal lines. The horizontal deflection will be a triangle wave that is both amplitude and frequency modulated (at a constant slope, the amplitude modulation will determine the frequency modulation). The vertical deflection will be a staircase ramp, generating a step for each line.

To characterize these waveforms, the length (peak deflection) of any given line in a field is determined by,

$$L = 2\sqrt{r^2 - (r - nx)^2} \quad (2)$$

where r = radius, n = line number, x = line spacing.

The (normalized) temporal position of any given line is determined by,

$$\frac{\Delta t}{t_{\text{sum}}} = \frac{\sum_{n=1}^N 2\sqrt{r^2 - (r - nx)^2}}{\sum_{n=1}^N 2\sqrt{r^2 - (r - nx)^2}} \quad (3)$$

where $n_{\text{max}} = 2r/x$.

Plotting line number (n) versus Eq. (3) yields the vertical deflection waveform. This plot is shown in Fig. 1A. Plotting Eq. (2) versus Eq. (3) yields the horizontal deflection envelope. This plot is shown in Fig. 1B. A close approximation of the horizontal envelope is the plot of $(\sin x)^{.25}$ shown in Fig. 1C.

Figure 1: Numerical plots of deflection waveforms.

3. CIRCUIT DESIGN

The circuit used to generate the deflection waveforms is shown schematically in Fig. 2. A sine wave is first generated using a Wein bridge oscillator. This sine wave is then rectified and fed into the root extractor circuit. The fourth root and its negative are used as positive and negative reference voltages for the triangle wave generator, yielding the desired amplitude modulated triangle wave for horizontal deflection. The square wave output of the triangle wave generator is differentiated and used to pump a staircase generator, resulting in a step for each horizontal line as required for vertical deflection. The staircase is reset by a comparator generated vertical sync pulse. Figure 3A shows the vertical and horizontal deflection waveforms with the resulting X-Y display. These waveforms are expanded in Fig. 3B to show detail.

4. COMPARISON

A Xedar model 503B video camera was selected to compare circular versus square format scanning. The square format case was set for 3.2 ms field, 12.5 μ s (256) lines for all tests.

To demonstrate the time saved by flyback elimination, a dark field video trace was acquired for each case. The vidicon tube was underscanned to avoid target ring interference. Figure 4C shows the preamplifier output (before sync generation) for a conventionally scanned 12.5 μ s horizontal line. The 1 μ s of flyback noise is apparent. Figure 4B is the preamplifier output of the zig-zag scan and Fig. 4A is its horizontal sync signal. As can be seen, flyback interference has been eliminated resulting in an 8% time reduction. Note that this percentage increases for shorter line times.

Figure 2: Circuit for generation of deflection waveforms.

Figure 3: Circuit output deflection waveforms.

Figure 4: Dark field video output, 20 μ s, 20 mv.

Figure 5: Comparison of vertical resolution.

For resolution tests, the full active area of the 18 mm vidicon target was scanned. Figure 4C shows the actual data time for the square format scan as 11.5 μ s/line, resulting in a beam velocity of 1.56 mm/ μ s. This beam velocity was achieved for the circular format scan by setting the center (longest) line time to 11.5 μ s. The circular format field time was set to 2.3 ms, determined by Eq. (1), which sets the number of lines to 256 given by,

$$no. lines_{cir} = \frac{t_{cir}}{\frac{\pi}{4} \times t_{line}} \quad (4)$$

where t_{cir} = circular format field time and t_{line} = longest line time

To compare vertical resolution, video was displayed and photographed on an X-Y monitor. Figures 5A and 5B show square and circular format scans, respectively. Vertical resolution appears to be 7.1 lp/mm for each, as would be expected from 256 lines over the 18 mm tube. Figure 5C is a circular format scan with a field time of 3.2 ms. Judging by Eq. (4), this gives 354 lines, or 9.8 lp/mm. This demonstrates that for equal field times, vertical resolution can be increased by using a circular format versus a square format scan.

Horizontal resolution was determined by viewing the video output on an oscilloscope. Each scan format resolved 16 lp/mm horizontally. The video displays of a star resolution pattern for the circular and square format scans are shown in Figs. 6A and B, respectively. The three bright tabs on the perimeter are characteristic of the silicon type vidicon tube.

Optical transfer data was acquired using a pulsed light source. These curves are shown in Fig. 7. Very little difference in sensitivity or dynamic range was observed between the two scan formats.

Figure 6: Star resolution patterns with circular and square format scans.

Figure 7: Optical transfer curves.

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