

# REDUCTION OF BASE TELEVISION BANDWIDTH BY SPECIAL SAMPLING TECHNIQUES

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**Summary.** There are many possible ways to reduce the bandwidth of a wideband television system. One of these methods is called Spiraldot which samples the pixels in such a way to keep the data rate resolution high in the center of the TV display but permits reduced resolution and data rate at the extreme edges of the TV image.

Bandwidth reductions of 8/1 are possible. A random access memory is required at each end of the data link.

**Introduction.** Television (TV) data links are ultimately limited in adequate signal-to-noise ratio as the range to the vehicle is increased. In the past, TV data link ranges have been extended by the use of directive antennas and increased radio frequency (RF) power.

There are other ways to increase the TV data link range. Available options include the reduction of the base bandwidth of the television video itself without sacrificing observable resolution and motion. It has always been the goal of video engineers to be able to transmit television images using narrow bandwidth over wire and RF communication systems.

Many years ago, Professor Sid Deutsch at the Brooklyn Polytechnic Institute did much work on a random scanning system which produced a sampled TV picture by adding small deflection voltages to the regular scanning sawtooth voltages. This gave a random writing action over the entire screen due to the movement of the beam itself.

The work of Deutsch and other contributors led to the building of several breadboard systems which produced mildly acceptable television pictures. The system did preserve motion and the resolution was reasonable but the entire picture appeared "busy". It was for this reason that the system was eventually abandoned when Deutsch moved on to other work.

**Sampledot.** The work done at the Brooklyn Institute did inspire many people to contribute to the technique. One of the recent investigators is R. F. Stone at the Space Laboratory, General Electric Company, Valley Forge, Pennsylvania. Stone saw the "busy" raster problem as one that could be rectified from a human factor viewpoint by reducing

the area of “busyness” to a small matrix 4 x 4, 8 x 8 or 16 x 16 pixels. By Z axis sampling and utilizing the normal scanning raster, he was able to circumvent some of the deflection problems that limited Deutsch in his work. He decided to perform the sampling along a scan line in groups of 4, 8 or 16 pixels. This means that only 1/4, 1/8 or 1/16 of the total number of pixels (500) are transmitted during a typical line time of 63.4 microseconds. The samples are then boxcarred and transmitted as a lower bandwidth RF signal. These stretched samples are received, resampled and the time interval is made equal to the original pixel width and written in sequence on a regular P4 phosphor TV monitor. It takes four, eight or sixteen fields to transmit and receive the entire number of pixels in the picture. The second line of the sampled raster is sampled in a similar way but the samples are not taken in the same horizontal position on the TV line. A pseudo random sampling scheme is used which prevents artifacts of sampling from deteriorating the picture.

The sampling scheme just described is called “Sampledot” by General Electric (GE) engineers. The entire system is analog. Delay lines are used for sampling and the transmitted image is viewed on standard TV monitors. The appearance of the picture is as though the image is being viewed through a screen mesh. The integrated resolution and motion seem to be preserved but there are definite artifacts remaining in the picture.

Naval Avionics Facility, Indianapolis (NAFI) engineers have viewed this GE system several times. It is their opinion that the system has merit but it needs the advantages of storage to erase some of the undesirable artifacts in the image. There has always been the question of choosing a random code for the sampling process and GE has arrived at a code by design and experiment that appears to be acceptable.

The Naval Avionics Facility has developed a simple memory using available semiconductor Random Access Memory (RAM) devices for converting planned position indicator (PPI) radar images to TV format. The success of this scan converter demonstration led NAFI in the direction of optimizing Sampledot for security and low bandwidth data links.

The RAM memory has the capability of writing and reading in a completely random manner. No analog or digital shift register memory can do this. The RAM memory has been connected to a NOVA minicomputer where, by keyboard entry, any code can be entered to test the principle of Sampledot. A previous attempt had been unsuccessful when a shift register memory was used. Sampling artifacts resulted because of the cyclic nature of the clocked shift register.

Video tapes were made of the RAM scan converted video using various codes controlled by the minicomputer. Some very bad codes were recorded which showed a venetian blind effect or other cyclic artifacts. A pseudo random sampling matrix of 8 x 8 appeared to give the best picture. It should be kept in mind that the NAFI method of viewing Sampledot is entirely different from that used by R. F. Stone at GE. Stone used a normal P4 set for viewing with no quantizing of the video anywhere in the system. NAFI's method first quantized to 4 bits and wrote into the RAM memory in a pseudo random matrix as previously described. The RAM memory was scanned in a normal raster fashion for viewing at normal 60 Hz field rate.

An interesting result was observed when the digital Sampledot system is compared to the GE analog system when both were viewed on a standard P4 monitor. Due to the fact that several fields must pass before a pixel is replaced (infinite pseudo decay), there is a "star trek" effect in the digital Sampledot system that is different than ever observed in the other system, in that, the part of the scene that moves seems to explode while moving and the pieces come back together when the motion stops. In order to minimize this effect, it will be necessary to design a digital decay characteristic for the display. As an example, if an 8 x 8 matrix is used, the pixels could be slowly degraded to black level over 8 pixel field time periods. This pseudo decay circuit has been designed but not laboratory tested.

It is felt by NAFI engineers that digital Sampledot with digital RAM storage could produce a low bandwidth system of acceptable picture quality. It is also felt that the format used by GE is not the optimum scheme for loading the memory. The optimum method is called "Spiraldot" by NAFI.

**Spiraldot.** Low bandwidth TV systems must eliminate fields or pixels, or terms, if they are to be successful. Some of the recognized ways of doing this are listed below.

1. Transmit only part of the total number of pixels in a field during field time period (Sampledot)
2. Transmit only part of the total number of fields (Framegrab)
3. Modify content of individual pixels (Hademard)
4. Transmit only differential changes in the pixel content (Delta)
5. Transmit parts of a given field at different rates and resolution.

The last system (5) is called Spiraldot by NAFI engineers.

Consider a TV raster that is stored in an RAM memory. The memory can be written or read in any manner whatsoever. The area of the picture needing the highest resolution and data rate is the center of the raster. A spiral writing pattern does this best. Due to the geometry of writing, the center is written faster than the outside area. The Sampledot sampling pixels in the center are closer together and do not result in the screen mesh overlay that is observed in regular Sampledot. A diagram of the Spiraldot sampling format is shown in Fig. 1. In this particular sampling pattern, the center is updated at a 60 Hz rate with full resolution and field rate. The second area is updated in a 1 of 2 resolution cell update at a 60 Hz rate. The third area is a 1 of 4 update, followed by a 2 of 8 update in the outside area during the same 60 Hz field time.

In addition to the Spiraldot sampling format, there is a scheme of producing continuous motion in all areas of the image by the occasional writing of a low resolution picture. The theory for this concept is well described in Ref. 1.<sup>1</sup>

The claims made for this particular sampling format are that

1. high resolution and motion are preserved in the center of the screen;
2. motion is preserved elsewhere in the image but at lower resolution; and
3. artifacts are not expected in the final image.

Tests run on a previous digital Sampledot system at NAFI showed the data rate and resolution to be adequate for remotely piloted vehicles (RPV) and television weapon delivery.

In case it is desired to have a faster update of the center of the image, the single sync pulse can be transmitted at a faster rate to reset the counter in the RAM circuitry controlling the writing in the RAM memory.

A Spiraldot system should be designed to test the projected advantages of the system. It should be capable of utilizing different sampling patterns and field data rates. The TV image should be of considerably better quality than observed with Sampledot and still have good motion capability. If the principles described in this paper are verified, a data link should be designed to take advantage of the 4/1 or 8/1 potential in bandwidth reduction. (A block diagram of the system is shown in Fig. 2.)

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<sup>1</sup> B. G. Haskell and R. L. Schmidt, "A Low Bit Rate Interframe Coder for Videotelephone", (The Bell System Technical Journal, Oct., '75, Vol. 54, No. 8)

## EXPLANATION OF SPIRALDOT FORMAT

### Field 1

1. In area 1, a new pixel is written.
2. In area 2, both pixels are written with the average of two new pixels.
3. In area 4, all four pixels are written with the average of 4 new pixels.
4. In area 8, all eight pixels are written with the average of 8 new pixels.

### Field 2

1. In area 1, a new pixel is written.
2. In area 2, the left pixel is replaced with a new pixel sample.
3. In area 4, the two left pixels are replaced with the average of two new samples.
4. In area 8, the four left pixels are replaced with the average of 4 new samples.

### Field 3

1. In area 1, a new pixel is written.
2. In area 2, the right pixel is replaced with a new pixel sample.
3. In area 4, the two right pixels are replaced with the average of two new samples.
4. In area 8, the four right pixels are replaced with the average of 4 new samples.

### Field 4

1. In area 1, a new pixel is written.
2. In area 2, both old pixels remain.
3. In area 4, all four old pixels remain.
4. In area 8, all eight old pixels remain.

### Field 5

1. In area 1, a new pixel is written.
2. In area 2, both pixels are written with the average of two new pixels.
3. In area 4, the first pixel is replaced with a new pixel sample.
4. In area 8, the fifth and sixth pixels are replaced with the average of two new pixels.

### Field 6

1. In area 1, a new pixel is written.
2. In area 2, the left pixel is replaced with a new pixel sample.
3. In area 4, the fourth pixel is replaced with a new pixel sample.
4. In area 8, the third and fourth pixels are replaced with the average of two new pixels.

### Field 7

1. In area 1, a new pixel is written.
2. In area 2, the right pixel is replaced with a new pixel sample.
3. In area 4, the second pixel is replaced with a new pixel sample.
4. In area 8, the seventh and eighth pixels are replaced with the average of two new pixels.

### Field 8

1. In area 1, a new pixel is written.
2. In area 2, both old pixels remain.
3. In area 4, the third pixel is replaced with a new pixel sample.
4. In area 8, the first and second pixels are replaced with the average of two new pixels.

Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8

AREA 1 SAMPLES ARE ABOVE.

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AREA 2 SAMPLES ARE ABOVE.

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AREA 4 SAMPLES ARE ABOVE.

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AREA 8 SAMPLES ARE ABOVE.

SHADED AREAS ARE THE LOCATIONS OF NEW DATA ALSO DESIGNATED "N".

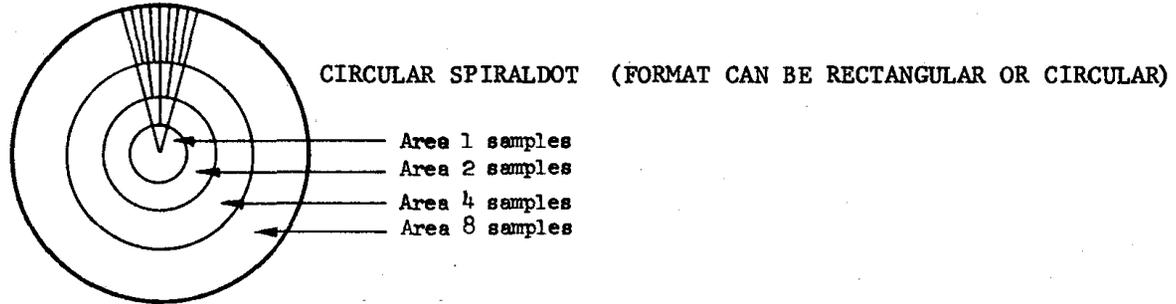


Fig. 1 - Format of Spiraldot

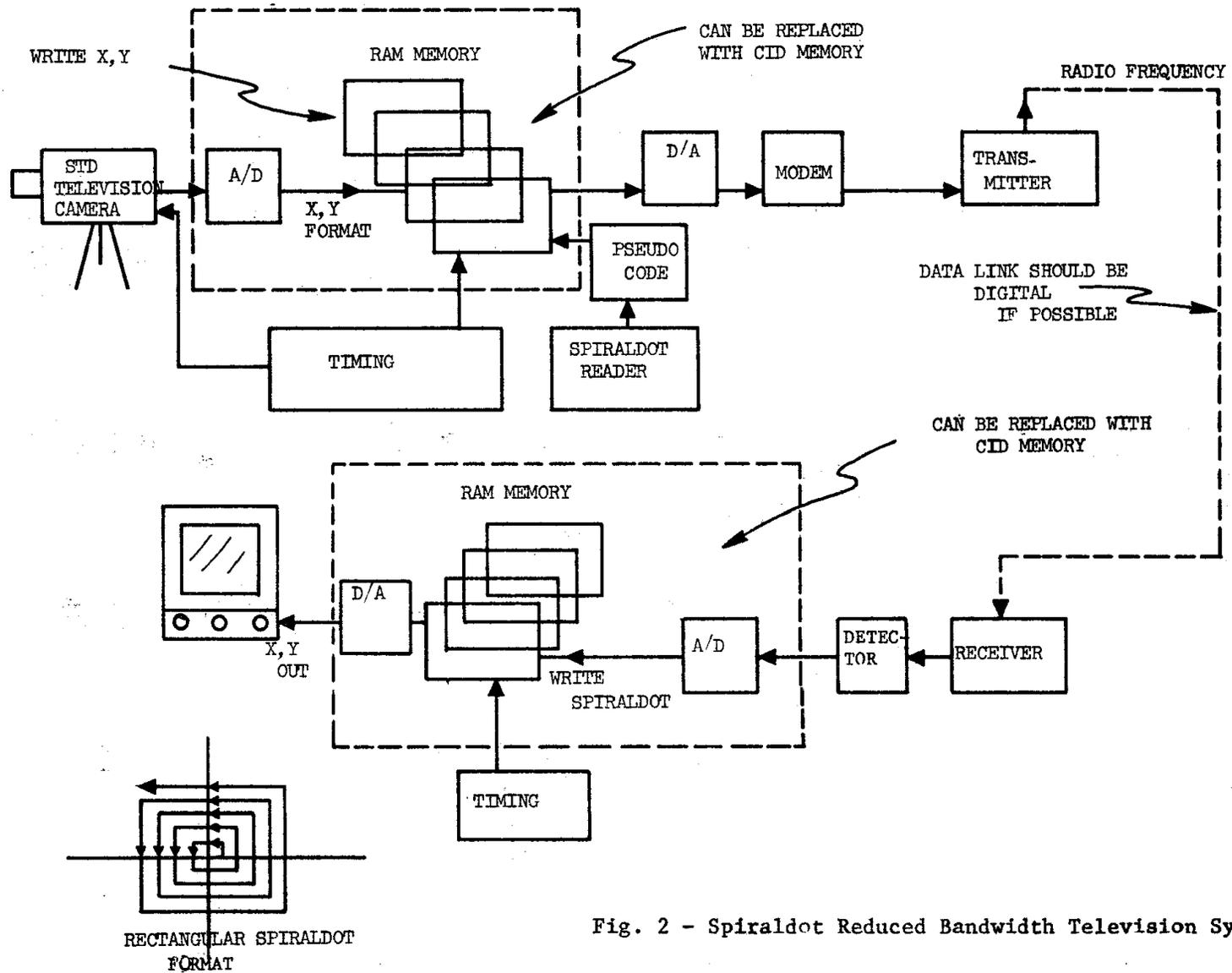


Fig. 2 - Spiraldot Reduced Bandwidth Television System