SFOF Digital Television Hardcopy Equipment

F. L. Singleton and K. Kawano
SFOF/GCF Development Section

The Space Flight Operations Facility (SFOF) digital television display subassembly has a hardcopy generation capability in addition to its display generation capability. The hardcopy capability is discussed in this article.

The display subassembly hardcopy equipment consists of a system control unit, twelve copy request units, a display image buffer and twelve hardcopy printers. The hardcopy equipment can make a print of any digital television display channel upon request.

I. Introduction

The SFOF Digital Television Assembly (DTV) has the capability to provide a hardcopy print of any DTV display channel when requested. This capability is provided within the display subassembly of the DTV. The DTV was previously discussed in Ref. 1. The display generation capability of the display subassembly is discussed in "SFOF Digital Television Display Subassembly," by F. L. Singleton in this issue. This article discusses the hardcopy capability of the display subassembly.

II. Requirements

The DTV is used in the SFOF for display of data for real-time usage. Each user has displayed data unique to his usage. In the course of operations, there will be displayed data that the user will need for a period longer than the normal update of his DTV display. This display may be needed to compare a parameter with subsequent displays or the display may need to be used in an area removed from the DTV display. Recall of stored data to a line printer for this purpose would not be practical. A conveniently located hardcopy system that allows printout of selected DTV images is required.

III. Design Approach

In order to meet the requirements for hardcopy output, the following decisions were made:

a. There will be several hardcopy devices distributed in the various user areas for user convenience.

b. An exact image of the DTV display will be printed for output accuracy.

c. High-speed printing is not required because of the low frequency of usage.

d. Any interference with display updates to produce a hardcopy will be minimized to maintain maximum throughput of DTV data.

Both the copy request units and hardcopy printers will be located in the various user areas of the SFOF.

Hardcopy requests will be initiated by the user at his copy request unit and the requested display will be printed by the printer associated with that copy request unit.

Copy requests will be input to the DTV computer subassembly and it will issue output instructions causing a print to be made. This will allow the computer subassembly to inhibit data output to a DTV display channel while its data is being recorded for printer output. However, it is desirable to reduce the amount of time data output is inhibited to a display generator of the display subassembly. Thus, an intermediate hardcopy controller will store the display data and output it to the hardcopy printer in the format and at the rate required by that printer. This controller is called the display image buffer (DIB) and it performs the various data transfer functions required to make a print of a display on a given DTV channel.

IV. Description of the DTV Hardcopy Equipment

The hardcopy equipment consists of twelve copy request units (CRU), the display image buffer (DIB), twelve hardcopy printers, and portions of the system control unit (SCU). A block diagram of the DTV display subassembly is shown in Fig. 1 with the hardcopy equipment identified in solid lines. A functional description of this equipment follows.

V. Copy Request Unit

The CRU is used to request printouts from a hardcopy printer. This unit is shown in Fig. 2. Each CRU consists of two thumbwheel digiswitches for DTV channel selection and an ENTER button for requesting hardcopy prints. The unit is interfaced to the computer subassembly through the SCU.

When a copy request button is pushed, an interrupt signal is routed to the computer subassembly by the SCU. The interrupt activates a hardcopy request sequence. The computer subassembly causes the SCU to output to it the digiswitch settings of all CRUs. Each CRU is associated with a specific printer and a request from that unit will cause a print to be outputted by its associated printer.

The computer subassembly will then connect to the DIB through the SCU and issue a record and print instruction. This instruction tells the DIB to record the selected DTV channel on the print channel associated with the requesting CRU and output that data by the printer.

The *enter* button light on the CRU is normally lit to indicate that it is ready to accept requests. When the button is pressed, the light will go out until the computer has taken the request. Any subsequent request will not be honored until the light turns back on. Once a request has been honored, another request can be made; however, before this second request can be acted upon, the print cycle for the first request must be completed. Therefore the light will remain out for the second request until the first print cycle is completed. At that point another request will be honored and will be acted upon when the second print cycle is completed.

There is a CRU associated with the maintenance monitor TV in the display subassembly. It is named the display request unit (DRU) and is located directly below the maintenance monitor. Its operation is exactly the same as that of a CRU except that the output is an immediate video display on the maintenance monitor. The image on the monitor is generated directly from the DIB disk memory. This monitor and DRU are used exclusively for DTV maintenance purposes.

VI. Display Image Buffer

The DIB acts as the hardcopy controller within the display subassembly. The DIB interfaces with the SCU, the display generators, and the hardcopy printers. The DIB contains the disk memory storage of hardcopy output data and the selection and interface logic to transfer any display generator DTV channel video signal into its disk memory storage and to convert this video data into printer-compatible data and output it to hardcopy printers.

The DIB is activated by a Record and Print instruction originating in the DTV computer subassembly as a result of a hardcopy request. Each instruction is transmitted to the DIB via the SCU. The instruction identifies the display generator, the display generator DTV channel, and the printer channel to be selected.

Each Record and Print instruction causes the following operations to occur: (1) The DIB outputs a select

signal to each display generator selecting the specified display generator channel; (2) The DIB selects the printer channel for recording on the disk memory, (3) The DIB enables the selected display generator input to the disk memory, and (4) The DIB records the video data from the display generator on the disk memory channel. (5) The DIB also issues a printer start signal, and after the printer is up to speed, (6) it outputs digital data at printer rates to the hardcopy printer. After the end of data transmission the DIB then (7) outputs a paper advance signal until the correct paper width for a 21.6 × 27.9 cm (8.5 × 11 in.) sheet of paper has been output.

Upon issuance of a Record and Print instruction, output of video display data to the affected display generator will be inhibited until the data is transferred from the display generator to the DIB disk memory storage. This data is transferred at a 3-MHz rate. Upon completion of transfer, the display generator is released for updates. The transfer normally requires two disk revolutions (1/15 s). Never is this inhibit time greater than 1/10 s. The above sequence is the Record portion of the Record and Print operation.

The Print operation for each instruction includes the following: (1) The DIB issues a paper start signal to the selected printer which starts the paper while the printer motor comes up to speed. After 0.5 s of paper movement, the DIB (2) starts data readout from its storage. (3) Data which creates the first scan line of a video image is transferred to the print buffer at 63 kHz rate. (4) The data is then printed as a row of dots as it would appear on a TV screen. (5) At the next scan line time (1/60 s) the next line is printed. This process takes place until all 480 lines, which constitute the visible DTV image, are printed. This process requires 8 s. At the conclusion of this process, the print cycle is over. However, the paper movement continues for another 2.5 s to allow for the bottom margin of the print. Each print cycle is about 11 s. A new print cycle will not be initiated until this paper movement is completed.

During the operations described in the foregoing,several more instructions to record and print images from other display channels to other printers may occur. Each command will be honored in sequence by the transfer of the image from the display storage to its print storage. However, once a print cycle has started, all printers are synchronized with it and no new cycle can be initiated until its completion. Thus, all new print requests will wait in their storage until a new print cycle starts. A new cycle can be started immediately after the conclusion of its predecessor and no paper stoppages need to occur on a printer already in motion. All the waiting printers will now start in unison and proceed with the print process described above. The printer just concluding its prints has the margin paper advance time mentioned above to receive a new print image.

The DIB is presently configured for 12 printer outputs and one monitor output.

VII. Hardcopy Printer

The DTV hardcopy printer is a Gould, Model 4800, electrostatic printer. A photo of this printer is shown in Fig. 3. The printer prints on a 27.9 cm-(11-in.) wide roll of paper which is continuously advanced during the print cycle. The printing process occurs by passing the paper over a write head where the paper is charged with a print pattern. The paper is then passed over a liquid toner bath where it picks up charged particles to form dark images on the white paper. As the paper advances it dries so that the copy output is nearly dry as it comes out of the printer and is completely dry within seconds after it comes out of the printer.

The printer accepts a 63 kHz digital bit stream input and converts it into an exact image of the DTV display, 640 elements by 480 lines. The image occupies an area 15.2 × 20.3 cm (6 × 8 in.) within a page of 21.6 × 27.9 cm (8.5 × 11 in.). The printer paper advance and line printing are both controlled by signals from the DIB. A sample of the hardcopy print is shown in Fig. 4.

The hardcopy printer and the copy request units are designed so that they may be located up to 305 m (1000 ft) from the DTV.

VIII. Expansion Capability

The Display subassembly is designed to have expansion capability. The hardcopy unit, currently, has the capability to drive 12 printers and one TV monitor. The unit is capable of 19 printers and a monitor or 20 printers without a monitor.

Currently, there are 12 CRUs. The unit is capable of up to 32 CRUs including the DRU. The current DTV software does not use more than one CRU per printer. However, future software will allow more than one user the capability to get prints from one shared printer.

IX. Conclusion

The SFOF Digital Television Assembly is provided with a hardcopy capability to support operations and development. An exact replica of the real time-display may be printed for near-real-time usage.

The hardcopy capability can be expanded for future usage. Currently, the DSN system operations area, the *Mariner* Mars '71 mission support areas, and the development areas are being supported by DTV hardcopy capability. The *Pioneer F* mission support areas are being configured and will also be supported by DTV hardcopy capability.

Reference

1. Singleton, F. L., "SFOF Digital Television Assembly," in *The Deep Space Network,* Space Programs Summary 37-65, Vol. II, pp. 86–91. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 30, 1970.

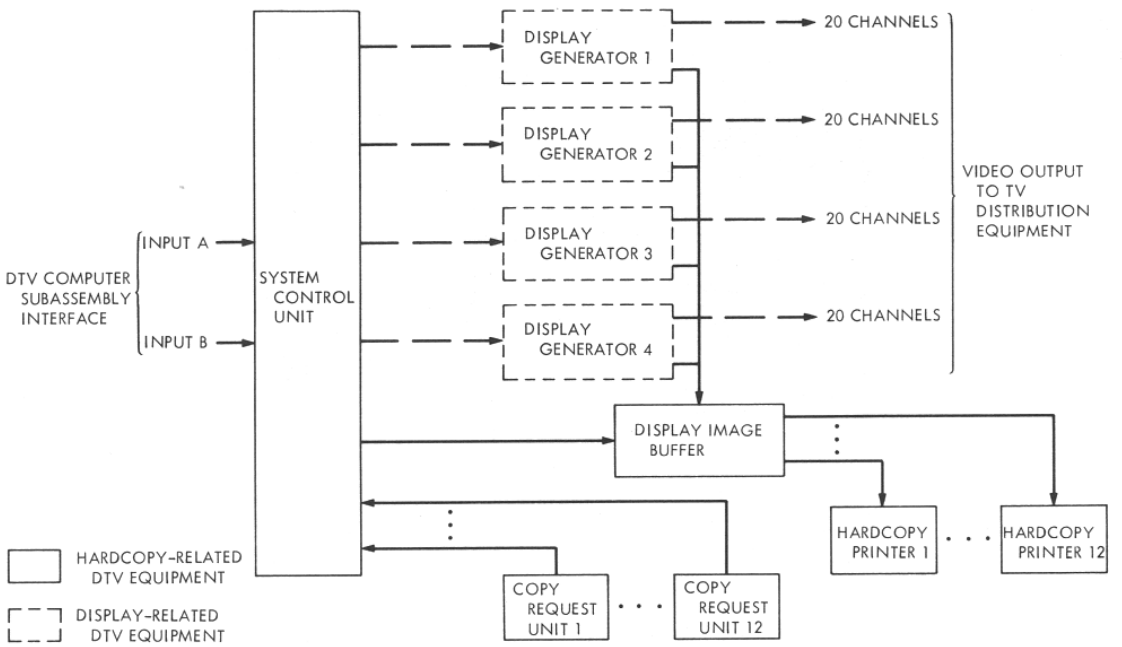

Fig. 1. DTV display subassembly block diagram

Fig. 2. DTV copy request unit

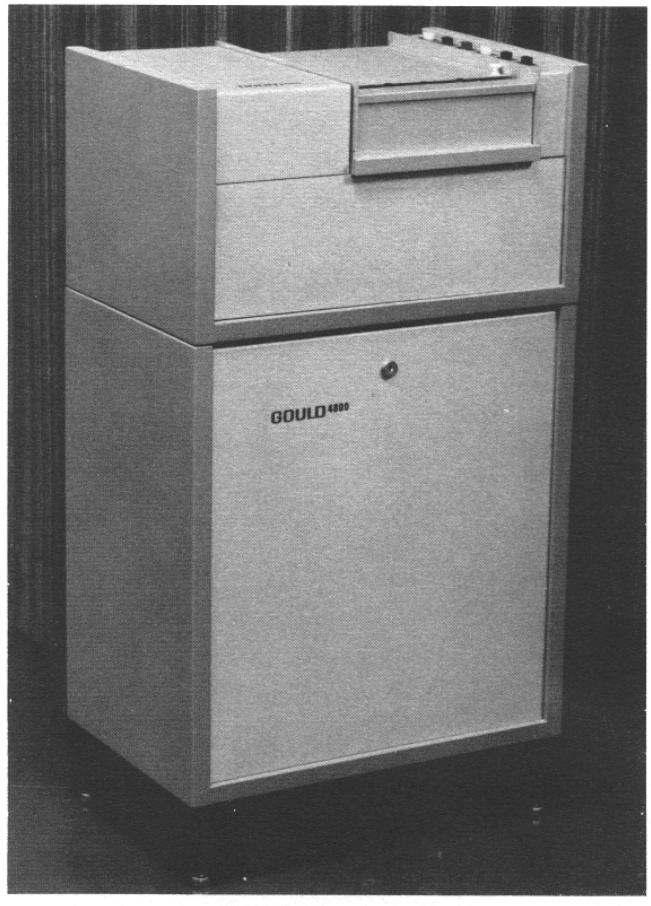

Fig. 3. DTV hardcopy printer

PRINT WIDTH 20 cm (8 in.)

PRINT HEIGHT 15 cm (6 in.)

```
SC-84 DSS-14   17:00:58 312-13   FORMAT646
DPQ=2
 S/C ID          STP NUMBR       G CONF E
  M71-1           0410.1        R1D2TACB
  15:32:11
 P GYRO/SS       Y GYRO/SS       R GYRO/FP
    51              79              66

 P POS/AGA       Y POS/BGA       R POS CRS
    59              69              64
                                  -.2039E-01
 CT INTENS       +X-Y N2 M       COUNTER 2
    68             .2699E+01          1
   .1250E+01
 ADAP GATE       -X+Y N2 M       COUNTER 3
     0             .2690E+01          2
   .0000E+00
 CT CONE         S/C POWER       30V REG P
     0             .2147E+03        .3491E+00
   .0000E+00
```

Fig. 4. Typical hardcopy print example