

SOFTWARE FOR THE CONCURRENT BASED TELEMETRY DATA HANDLING SYSTEM (TDHS)

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ABSTRACT

The TDHS, designed and built for WSMR (White Sands Missile Range), is hosted by a Concurrent 3280 Processor. The TDHS software is a combination of new software designed specifically for this system and conversion of software that Fairchild Weston offers as standard products on other host computers. The system software is based on a menu system and provides a friendly user interface. The software supports the latest EMR products (including an 8715 Preprocessor and an 8470 Digital Discriminator), intercomputer data transfer and very high speed storage of data to disk and tape. TDHS also provides quick-look data display during real-time on strip charts and Concurrent based displays. Data processed by the Concurrent host can be sent back to the 8715 for distribution in the same manner as the incoming telemetry data. Immediately after data acquisition all data can be viewed on the color graphic and alphanumeric terminals.

INTRODUCTION

In the early 1980's, White Sands Missile Range (WSMR) began the development of specifications for a new Telemetry Data Handling System (TDHS) to replace a 15-year old system which used an IBM 360 computer for the set up, control, and

processing of telemetry data. The IBM 360 system capability was limited to 50K processed data samples per second. Real-time display was limited to strip charts and response time to projects was greater than desired. Logging capability was limited to digital magnetic tape and set up software was entered via punched card formats.

The requirement for a new system with state-of-the art technology was generated by the change in type of developed weapons systems to more sophisticated systems and testing requirements. Modern weapon systems development involves the simultaneous monitoring of parameters from multiple weapon systems, e.g., the aircraft, the weapon (missile) and the target (another missile or aircraft) which are tested to simulate near-combat environments. This essentially triples the data requirements. Furthermore, the sophistication of weapons under development and the integration of weapons systems into the aircraft systems require the monitoring of more parameters. Clearly, the old system which monitored a single missile from a static launching position was unable to handle the new requirements.

During the development of the procurement package for the new TDHS, an interim system evolved to support specific, high-visibility, high-priority weapons systems, such as an Army medium range ballistic missile, and an Air Force advanced air-to-air missile. The software requirements for these and other similar projects were incorporated into the specifications for the TDHS, along with greater capability for expansion to meet additional requirements and higher data rates. In addition, it became apparent that a single system would be insufficient due to the need to support data requirements for highly sophisticated weapon systems, avoid system failure in the support of real-time missions, provide real-time processing and concurrent playback, provide rapid turnaround time between missions, and continue development and enhancement of both hardware and software. Consequently, the proposal for the new TDHS included the acquisition of two identical systems, i.e., TDHS-A and TDHS-B. Due to the numerous parameters and their processing, a more sophisticated menu-driven data base was required. This would allow individual parameter information to be entered and easily changed using simple English and commonly used telemetry terminology. This would also allow for easy retrieval and rapid analysis of the types of processing performed.

In addition to set up software, requirements for the new TDHS include real-time processing software to send processed data to strip charts, video displays, current value tables, graphics displays and data logging to disk or tape as well as data to other Concurrent computers. The old system did not contain any capability for real-time graphics display. The real-time graphics display will enable the project

personnel to make decisions in a real-time environment such as whether to fire or abort. This could prevent the firing of a faulty missile and allow modification or change before attempting another launch thus saving time and money by avoiding destruction of a multi-million dollar weapon system. Also, the graphics display can be used to play back the logged data allowing for graphic analysis of the data. The new system will log directly to disk which allows more rapid play back analysis of data. This increases the capability to give quick response to project personnel for use in decision making. The new system allows quick retrieval of parameter processing by entering the measurement's name. The new requirements for testing multiple weapons systems increased the need for higher data rates. Consequently, the specifications for the new TDHS included a requirement for logging 400K data samples per second as compared to the old capability of 50K per second.

The contract for development of the TDHS was awarded to Fairchild Weston in late 1987 with a delivery schedule in April 1989. Several design reviews and emerging technology resulted in modifications to upgrade the system in the development phase. The system will not remain static as the capability to expand and upgrade as needed to meet new requirements and incorporate emerging technology was envisioned at the outset of the proposal. In fact, an upgrade to the system to handle a 1553 aircraft data bus to conform to newly developed Inter-Range Instrumentation Group standards (IRIG 106-86, chapter 8) is currently underway. The design and development of hardware and software for this enhancement is being accomplished by Fairchild Weston and installation is planned for late 1989.

SYSTEM DESIGN

In the system as designed by Fairchild Weston, all of the telemetry data is merged, time tagged and processed by the 8715 Preprocessor. The system design includes the routing of data by the preprocessor to reduce the burden on the host computer. The preprocessor routes the data to its destination; DACs, discrettes, display port (Current Value Table), archive port, or to a second Concurrent 3280 system which is not part of the TDHS. The CVT is a buffer in the Concurrent 3280 memory which is driven directly by the 8715 making data available within a couple of microseconds.

The Concurrent 3280 system design includes a number of features to enhance real-time processing. The four data disks have two dedicated controllers and two bus Interfaces (SELCH) to allow data to travel unimpeded to the data disks without interference from other disks users in the system. The digital tapes have the same configuration. High speed parallel interfaces are provided to support

data and file transfer to and from a second TDHS system and a TMDP (a general purpose Concurrent) system. Fairchild Weston designed the high speed interfaces (UDMAI) used to transfer the data into the Concurrent CVT and archiving buffers.

The system has two types of computer terminals, Tektronix 4236 graphic terminals and Concurrent 6312 alphanumeric terminals. The terminals are interfaced to the system using serial RS-232 lines set to the highest baudrate supported by the terminals; 38.4 kilobaud for the Tek and 19.2 kilobaud for the Concurrent. A video system is interfaced to the Concurrent using a parallel DMA channel which allows high speed transmission of data to the video system.

The software automatically adjusts to the terminal type allowing the user to perform all functions from any terminal on the system except for the obvious restriction that graphics can only be done on the Tek terminal. In addition, the second page of the Concurrent terminal is automatically used to locally store the Main Menu page eliminating the need to constantly send the Main Menu page to the terminal.

The telemetry front end interfaces are either RS-232 or parallel DMA depending on the particular unit's requirements. An interface is provided to get interrupts from the timing system into the 3280. Two interfaces are provided to get telemetry front end status into the 3280 (local/remote and search/lock).

SOFTWARE DESIGN

The TDHS system was designed in a manner consistent with systems provided by Fairchild Weston over the last few years. The user interfaces to the system via a Main Menu (Figure 1) which allows the selection of the desired function without knowing computer acronyms. Rather than breaking the menus into strictly logical screens the EMR horizontal menu approach incorporates what is normally the top two levels of the menu structure into the Main Menu. The menu items are grouped by related functions. The header for each group (File Maintenance, Acquisition, and Interactive Displays) is followed by the next lower level of functions. For instance, under Acquisition the user may select to: Compile TFE Load Files, Load the Telemetry Front End, Start/Stop Data Acquisition, etc. This menu approach greatly reduces menu paging and key strokes making the users's task simpler.

When the user initially logs onto the system he is asked for an access key in addition to the normal password. This key identifies to the TDHS software what functions on the Main Menu are available to this user. Those that he is allowed to perform are highlighted and those that he is not allowed to perform are displayed

in low intensity. For each account the TDHS manager can setup ten (10) different access keys to be assigned to different users. Each access key can be assigned one of four (4) authorization levels. Each of these authorization levels can be setup to allow or deny access to each of the Main Menu functions. The TDHS manager can easily restrict one user to display data only while allowing another user to access the full capabilities of the system.

FILE MAINTENANCE

The File Maintenance portion of the menu occupies the left half of the Main Menu screen. Selecting item one (1) will take the user into the Parameter Data Base subsystem. The next menu presented will allow the user to select from the following options:

- Database Edit
- Database Utilities
- Build Tag, DAC and Discrete Maps
- Print DAC Map
- Print Discrete Map
- Print Tag Map
- Print a specific Frame Map

The Parameter Database Edit facility allows the user to enter and modify all of the setup information for parameters in the telemetry link(s). This information is stored on a parameter basis and includes the position in the telemetry format, number conversion, compression, engineering unit conversion, scaling for DACs, and limit checking. Routing of a parameter to its various destinations (DACs, CVT, archiving, etc.) is also specified in the Parameter Database. The Database Utilities allow the user to query the database for specific information to be copied into another database or for printing to the system printer.

Once the user has built tag, DAC and discrete maps he can then print the individual maps to the system printer. The tag map is sorted by tag assignment and allows the user to identify duplicate tags and to verify specific tag assignments. The DAC map allows the user to review the assignment of parameters to the DACs driven from the 8715 Preprocessor. The discrete map provides the some capability for discretetes. The user can select to print a frame map for any link. This map is formatted with the frame word numbers going down the page while subframes go across the page. Each telemetry word/frame position contains the parameter name for the word/channel that resides at that frame position.

Selecting Main Menu item two (2) allows the user to specify setup for the first PCM/AFS stream. For a PCM stream the user can specify setup parameters for the following functions:

- Bit Synchronizer
- Frame Synchronizer
- Parallel Data Formatter
- Time Code Formatter
- ID and Recycle Subframe Synchronizer Raw DACs and Discretes
- Asynchronous Frame Synchronizer

Main Menu selections three (3) through seven (7) allow the user to provide setup information for five (5) more PCM streams. When the user selects items eight (8) and nine (9) he can enter the setup for the PAM Synchronizer and its associated DACs. Main Menu selection ten (10) allows the user to specify setup information for six (6) Tunable Discriminators and four (4) Digital Discriminators. The tunable discriminators allow the system to recover PCM/FM, PAM/FM, telemetry receiver pre-detected data, or other wide band FM telemetry data. Each Digital Discriminator can process a full IRG multiplex of either Constant Bandwidth or Proportional Bandwidth.

Selecting item eleven (11) allows the user to choose which portions of the Calibration/Simulation system to setup. The system has two FM calibrators (one Constant Bandwidth and the other Proportional bandwidth) that can be setup. In addition, the system has four (4) EMR 8336 Simulators; three are used to simulate PCM data and the last is used to simulate PAM data. Each of the PCM simulators can have up to fifteen (15) screens of setup information. The PAM simulator can have up to sixteen (16) screens of setup information.

With these screens the user can place a value in every PCM word slot (random, count up or count down). In addition the user can elect to specify a unique value for sixty-four (64) mainframe or supercom and sixty-four (64) subcom or supersubcom channels. The user specified value can be one of the following:

- Constant
- Random values
- Count up or down
- Analog value
- Square waveform (user defined amplitude, offset, duration)
- Triangle waveform (user defined amplitude, offset, duration)
- Sawtooth waveform (user defined amplitude and offset)
- Sine wave (user defined amplitude and offset)

Calibration step one (user defined values and number of steps)
Calibration step two (user defined values and number of steps)
One of eight (8) user defined waveforms

Each of the eight (8) user defined waveforms can be assigned from one (1) to sixty-four (64) unique values.

Between items eleven (11) and twelve (12) is a double space. This signifies that the items below eleven (11) are the real-time host functions. The information on these menus can be changed prior to data acquisition and also after data acquisition begins. All functions can be turned on or off individually. Each function can also be executed at a user specified interval. The user specifies for each of the two printers from one (1) to seven (7) parameters to be printed. The high speed printer outputs a page at a time while the low speed printer outputs a line at a time. The user may select different intervals to send data to each printer. Each of the other functions allows the user to send from one (1) to thirty-two (32) parameters to the applicable destination: video graphics system, TMDP computer, other TDHS computer or the TEMPS 8715 Preprocessor. The video graphics system, as delivered by FWSI, supports an alphanumeric display of thirty-two (32) parameters updated at a maximum rate of twenty (20) times a second. Sending of data to the TEMPS Preprocessor requires the user to specify both the parameter to be sent out from the Concurrent host computer and which parameter processing path in the TEMPS is to be used to process the data. The Parameter Data Base is used to specify the processing details for data sent to TEMPS. The processing can include routing the data to DACs, CVT, archive device or to the TMDP computer.

Not only can the system send data to the second TDHS and the TMDP Concurrent, it can also receive data from both and deposit the data in the CVT. Once the data is in the CVT, it can be distributed by the real-time processes even back to the other TDHS and TMDP if desired. If the received data is sent to the 8715 Preprocessor it can be handled just like the telemetry data, including routing to DACs and to the archive device.

ACQUISITION

The Acquisition portion of the Main Menu allows the user to control the actual acquisition of data into the computer. The functions available under Acquisition include:

Logging Device Select
Link Select

- Compile TFE Load Files
- Load Telemetry Front End
- Select Cal/Sim Input (Deselect)
- Load Real-Time Processes (Unload)
- Start Data Acquisition (Stop)
- Monitor Data Acquisition

The operator uses the Logging Device Select (Item 17) to control the data archiving function. Figure 2 is an example of this menu. The user can activate or disable the archiving. One of the key features of the TDHS system is its ability to store data at high rates. This is accomplished by using a number of features designed into the system. First, the data buffers for disk are extremely large, 168 kilobytes. Second, the user can request the software to write data to two devices alternating the incoming buffers between the two. In this mode the system is capable of storing 1.6 megabytes of data per second to disk (where six (6) bytes make a data sample). In addition, the user may select to store sixteen (16) bit data (where four (4) bytes make a data sample) increasing the number of samples per second stored to 400 k. The user may also select continuous data logging where the user switches packs or tape reels after the first set is filled. This allows for data archiving runs that have more data than can fit on a pair of devices.

The TDHS system supports a logical to physical link concept via Main Menu item eighteen (18). During File Maintenance the user specifies the TFE setup and Preprocessor setup without selecting the actual physical hardware which will handle the data. The Link Select menu (Figure 3) allows the user to associate a specific logical telemetry stream with specific hardware. The user also activates or deactivates the hardware links to select those of interest for the upcoming data acquisition run. This menu also allows the user to select which calibrators and simulators will be used.

Selecting Main Menu item nineteen (19) commands the software to compile the telemetry front end load files required to support the links as specified on the Link Select menu. The software scans the Parameter Data Base for the required Preprocessor programming. It also picks up the requested telemetry front end setups and builds files that will load the TFE quickly. Once the compile has been done once, it need not be done again unless some setup parameter changes. The user may now load the telemetry front end by typing the menu item number twenty (20). The software loads the required telemetry units in parallel, whenever possible, to reduce the operator wait time to the minimum. One last step is required to prepare for acquiring data, the real-time processes must be loaded into memory (Main Menu item twenty-two (22)).

Data is acquired into the Concurrent by typing a twenty-three (23) or by an interrupt from the time code indicating that a tape search has found the start time. Data will automatically be routed to the appropriate destinations. Typing a twenty-three (23) again or a stop Interrupt from the time code will stop data acquisition. During data acquisition the operator can monitor the status of data archiving and the other real-time processes by typing a twenty-four (24). Figure 4 shows the Monitor Data Acquisition screen. Note that the incoming data buffers are counted as well as the outgoing buffers. The user can also see the percentage full for the disk(s) as they are filled.

One of the more interesting features of the TDHS software is the Select/Deselect Cal/Sim Input (Main Menu item 21). When this feature is selected, the software automatically switches the input source for the PCM bit synchronizers and the PAM inputs from the data input to the simulator input. In addition the software loads the calibrators and simulators that have been activated on the Link Select menu. Selecting Main Menu item 21 a second time switches the input sources back to data.

REAL-TIME INTERACTIVE DISPLAYS

In addition to the display of data on strip charts and on the Video Graphic System, the TDHS has two types of Concurrent based real-time displays. First, the user can look at data with an alphanumeric display. This display allows the user to look at up to thirty-two (32) parameters simultaneously. The user can put the parameters where he wishes within the two columns of sixteen (16) parameters on the screen. The EU Converted data will be displayed in floating point notation. Integer data is displayed in decimal, hexadecimal, octal or binary as selected by the user. Discrete data which is a portion of a telemetry word can be identified to the Parameter Data Base as an individual parameter made up of from one (1) to five (5) bits. The user can assign a name for each state of the discrete. For instance a single bit discrete can be named GEAR UP (value is zero) and GEAR DN (value is one). The display software will then automatically extract the appropriate bits and display the discrete parameter state. While viewing the data the user can interactively change the parameters being viewed.

The other real-time display is graphical. The user can elect to display from one (1) to six (6) parameters of data against time. Once the plot fills the screen it will begin scrolling from right to left adding new data to the right of the screen as it arrives. The user can specify the display rate and length of time, in seconds, that the data stays on the screen before scrolling off the left edge. As in the alphanumeric display the user can change the parameters being displayed interactively while viewing the data.

ANALYSIS INTERACTIVE DISPLAYS

The TDHS system allows the user to view stored data immediately after data archiving to disk has been completed. The operator need only MARK the disk on to the operating system and the users can now begin reviewing the data. The data needs no reformatting or copying from other devices. Again the user has his choice of an alphanumeric or graphic display. The alphanumeric display works very similar to real-time where the data is displayed in two sixteen (16) parameter columns. The user selects the time slice that he wishes to see and the parameters to be displayed. The software will present the data in the same formats as in real-time but the user is guaranteed to see all samples of the channels displayed. Using the numeric keys the user can speed up or slow down the rate the data is sent to the screen. The user can go backward or forward through the data by using the up and down arrow keys.

The analysis graphic display works in a manner different than real-time. The user selects the time slice of interest and the parameters to be displayed. The software will then retrieve the required data and plot it, filling the screen. The plot will not scroll but the user can view the next segment of data with a single key stroke or request a different time slice. The analysis graphic software offers cross plots of parameter versus parameter in addition to plots of data versus time. Other features of the analysis graphic program include the ability to send up to seven (7) parameters to the line printer to be printed in a tabular format. The program also allows the user to search the telemetry data for user specified events. Some of the events supported include:

- Value greater than user limit
- Value less than user limit
- Value equal to user variable
- Change greater than user limit

The user may search for one (1) to four (4) events simultaneously. The software will report the time in the data file where the user requested event occurred.

UTILITIES

The TDHS has a number of utilities which are not available through the menu system. One set of utilities allows the user to transmit and receive files from the other TDHS and from the TMDP. A second set of utilities allow the reading and writing of ASCII files on digital tapes not conforming to the Concurrent OS/32 file formats.

The largest set of utilities allow users to create 8715 Preprocessor algorithms. Some of these utilities are provided on a personal computer. With these utilities the user can change or create algorithms and compile and link them for use in the 8715. In addition a program automatically updates the Parameter Database menus and the 8715 compiler to recognize the new or changed algorithm. Another program allows the user to build algorithm chains for his specific needs. Again the database software and 8715 compiler software will recognize the new processing chain.

The last utility copies telemetry data from digital tape to disk for use by the analysis software.

CONCLUSION

The complete Concurrent TDHS system, which is expected to become fully operational in early 1990, will increase WSMR's capability to meet higher data rate requirements involved in multiple weapon system testing, increase the overall system reliability to support real-time missions, reduce response time to project personnel for their data analysis and decision making, and allow expansion to incorporate advancing technology.

TDHS MAIN MENU		account name	dd-mmm-yy hh:mm:ss
<p>FILE MAINTENANCE</p> <p>1 = PARAMETER DATABASE 2 = PCM_A (AFS_A) SETUP 3 = PCM_B (AFS_B) SETUP 4 = PCM_C (AFS_C) SETUP 5 = PCM_D (AFS_D) SETUP 6 = PCM_E (AFS_E) SETUP 7 = PCM_F (AFS_F) SETUP 8 = PAM_A SETUP 9 = PAM_B SETUP 10 = FM SETUP 11 = CALIBRATION/SIMULATION</p> <p>12 = DATA TO LINE PRINTERS 13 = DATA TO TEMPS 14 = DATA TO VGS 15 = DATA TO TMDP 16 = DATA TO TDHS</p>	<p>ACQUISITION</p> <p>17 = LOGGING DEVICE SELECT 18 = LINK SELECT 19 = COMPILE TFE LOAD FILES 20 = LOAD TELEMETRY FRONT END 21 = SELECT CAL/SIM INPUT 22 = LOAD REAL-TIME PROCESSES 23 = START DATA ACQUISITION 24 = MONITOR DATA ACQUISITION</p>		
	<p>INTERACTIVE DISPLAY</p> <p>25 = REAL-TIME ALPHA DISPLAY 26 = REAL-TIME GRAPHIC DISPLAY 27 = ANALYSIS ALPHA DISPLAY 28 = ANALYSIS GRAPHIC DISPLAY</p>		
	<p>LO = LOG OFF SYSTEM EX = EXIT TO OS/32</p>		

ENTER MENU ITEM NUMBER:

Figure 1 TDHS Main Menu

LOGGING DEVICE SELECT account name dd-mon-yy hh:mm

DATA LOGGING	= ACTIVE		
NUMBER OF SIMULTANEOUS DEVICES	= 2		
CONTINUOUS DATA LOGGING (2ND SET ACTIVE)	= YES		
FILENAME (DISK)	= TELDATA		
BITS PER DATAWORD	= 32		
LOG TO (DISK OR MAGTAPE)	= DISK		
	VOLUME	DISK	MAGTAPE
FIRST SET:			
CURRENT DEVICE 1	DAT1	DKC1:	MTA0:
CURRENT DEVICE 2	DAT2	DKD0:	MTB0:
SECOND SET:			
NEXT DEVICE 1	DAT3	DKD0:	MTA1:
NEXT DEVICE 2	DAT4	DKC1:	MTB1:

CTRL-keys: D=DELETE, P=PRINT, U=CANCEL, W=REFRESH SCREEN, Z=TERMINATE
SELECT (TEXT, TAB, >, <)

Figure 2 Logging Device Select Menu

LINK SELECT account name dd-mmm-yy hh:mm:ss

— FM EQUIPMENT —	H/W LINKS	STREAM ASSIGNMENTS
8470 DIG. DISC. 1 = INACTIVE	PCM 1 = INACTIVE	PCM 1 = PCM_A
8470 DIG. DISC. 2 = INACTIVE	PCM 2 = INACTIVE	PCM 2 = PCM_B
8470 DIG. DISC. 3 = INACTIVE	PCM 3 = INACTIVE	PCM 3 = PCM_C
8470 DIG. DISC. 4 = INACTIVE	PCM 4 = INACTIVE	PCM 4 = PCM_D
410 TUNABLE DISC. 1 = INACTIVE	PCM 5 = INACTIVE	PCM 5 = PCM_E
410 TUNABLE DISC. 2 = INACTIVE	PCM 6 = INACTIVE	PCM 6 = PCM_F
410 TUNABLE DISC. 3 = INACTIVE		
410 TUNABLE DISC. 4 = INACTIVE	AFS 1 = INACTIVE	AFS 1 = AFS_A
410 TUNABLE DISC. 5 = INACTIVE	AFS 2 = INACTIVE	AFS 2 = AFS_B
410 TUNABLE DISC. 6 = INACTIVE	AFS 3 = INACTIVE	AFS 3 = AFS_C
	AFS 4 = INACTIVE	AFS 4 = AFS_D
	AFS 5 = INACTIVE	AFS 5 = AFS_E
	AFS 6 = INACTIVE	AFS 6 = AFS_F
— CAL/SIM. EQUIPMENT —		
PCM SIMULATOR 1 = INACTIVE	PAM 1 = INACTIVE	PAM 1 = PAM_A
PCM SIMULATOR 2 = INACTIVE	PAM 2 = INACTIVE	PAM 2 = PAM_B
PCM SIMULATOR 3 = INACTIVE		
PAM SIMULATOR 1 = INACTIVE		
4080 CALIBRATOR 1 = INACTIVE		
4080 CALIBRATOR 2 = INACTIVE		

CTRL-keys: D=DELETE, P=PRINT, U=CANCEL, W=REFRESH SCREEN, Z=TERMINATE
SELECT (TEXT, TAB, >, <)

Figure 3 Link Select Menu

REAL-TIME DATA MONITOR		account name		27-APR-88 15:55:45	
<u>DATA ACQUISITION STATUS</u> INACTIVE			<u>LOGGING STATUS</u> UNLOADED		
<u>INPUT BUFFER COUNT</u>	<u>LOGGED BUFFER COUNT</u>	<u>DROPPED BUFFER COUNT</u>	<u>LOGGING ERRORS COUNT</u>	<u>CURRENT LOG DEVICE SET</u>	<u>NEXT LOG DEVICE SET</u>
235	2147	1	1	DKC1: 14% DKC0: 14%	DKC0: DKC1:
<u>DATA TO L/S LP</u>	<u>DATA TO H/S LP</u>	<u>DATA TO TEMPS</u>	<u>DATA TO VGS</u>	<u>DATA TO TMDP</u>	<u>DATA TO TDHS</u>
UNLOADED	UNLOADED	UNLOADED	UNLOADED	UNLOADED	UNLOADED
PRESS "RETURN" TO EXIT DISPLAY					

Figure 4 Real-time Data Monitor Display