

Troubleshooting and Analyzing Digital Video Signals with CaptureVu



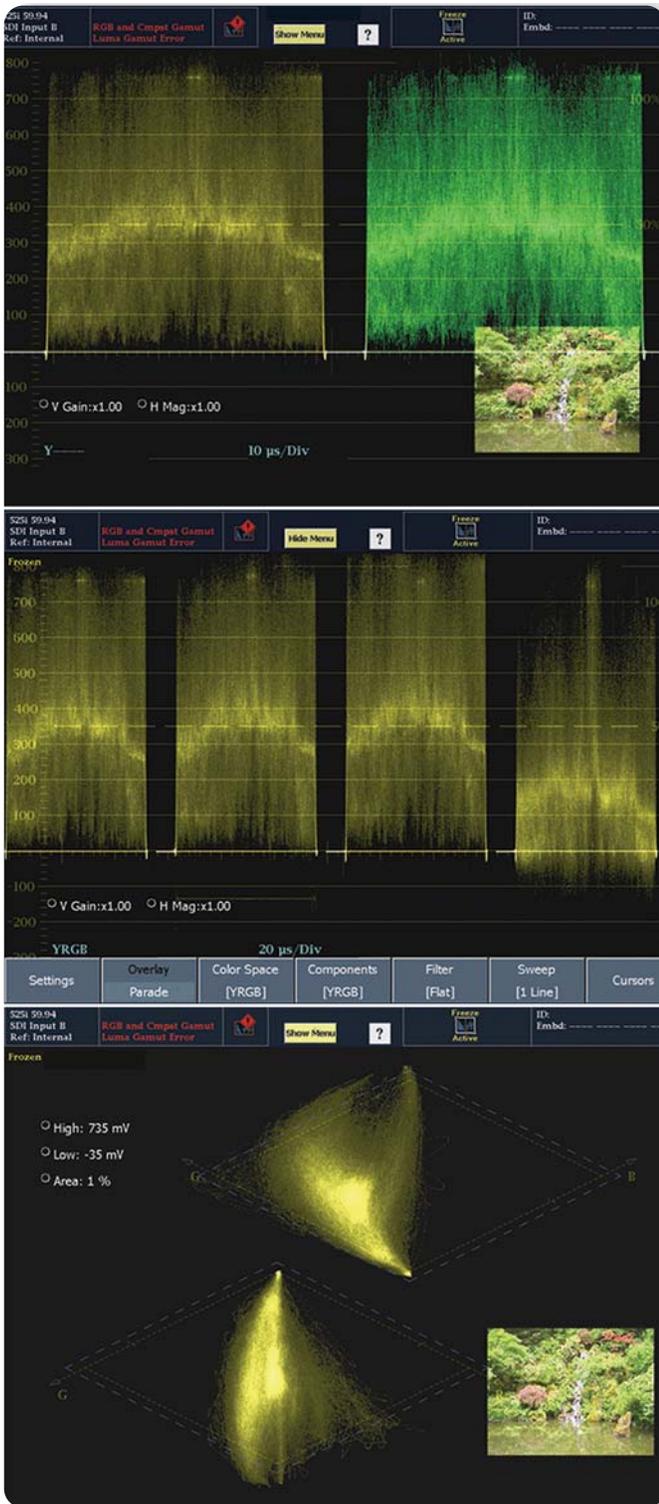
Digital video systems provide and maintain the quality of the image throughout the transmission path. However when digital video problems occur they often appear to happen randomly and can be the most difficult to isolate and diagnose. Murphy's Law states that "Anything that can go wrong will go wrong" and usually these problems occur when you least expect them and at the most inconvenient moment during testing or video production. There are mainly two types of video errors.

First, transmission of the digital signal in the physical layer can result in the receiver's inability to recover the clock and then recover the data. Video measurement equipment with the ability to view the Eye and Jitter displays of the signal can help in troubleshooting these types of problems. Further information can be provided on these measurement techniques within the Tektronix application note Physical Layer Testing of Serial Digital Signals (Literature Number 25W-19525).

If the receiver is able to decode the serial digital signal, then there are a wide array of format protocols which need to be correctly formatted in order for the data stream to be processed correctly. Video monitoring and measurement equipment that can detect these error conditions within the video signal are essential tools in dealing with data format problems. Video measurement equipment can typically detect EAV (End of Active Video) and SAV (Start of Active Video) data errors along with incorrect Line Length and received CRC (Cyclic Redundancy Coding) errors. However once the engineer has determined these type of errors it maybe necessary to further analyze the data stream using the data list capabilities of the measurement instrument.

Troubleshooting and Analyzing Digital Video Signals with CaptureVu

► Application Note



► **Figure 1.** CaptureVu of WFM7100 showing image capture of RGB Gamut Error. Initially captured as a YPbPr waveform, the display can be reconstructed into YRGB or the Diamond display for further analysis.

The data rate of the digital signal can sometimes make it difficult to determine the specific data word causing the problem within the data stream. With the CaptureVu® capability available on the Tektronix WFM7100/6100, these instruments can capture and store a complete video frame to the internal memory when a specific type of error occurs.

The user can manually capture the video signal on the waveform monitor by entering the Capture mode of the instrument. There are two types of capture functions available within the waveform monitor.

- The capture “Trace” function allows the current waveform displays to be frozen on the screen and is basically a simple image capture of the current available display. In the waveform displays (waveform, vector, and gamut) the trace from the captured data appears in yellow. The captured trace can be viewed separately or can be compared to the trace of the live video signal. However, with a “frozen” trace or picture, the instrument cannot create a different display from the captured screen image. This captured data is basically a snapshot of the instrument at one moment in time.
- The CaptureVu mode allows the user to additionally select Buffer mode when a digital signal is applied to the instrument. CaptureVu stores the complete video frame of data within the instrument. This captured data stored within the buffer can then be used by the instrument to reconstruct any supported display.

For example, suppose the instrument captured a video frame containing an RGB Gamut error and initially presented the captured data in a waveform display configured in YPbPr parade mode. The user may want to view this captured data in a display configured for YRGB parade mode to see the component(s) with a gamut error. Simply changing the waveform display mode to YRGB parade causes the instrument to automatically create a new waveform display of the capture data in an YRGB parade, which can be compared to a display of the live signal in YRGB parade mode. Alternatively, the user could chose to analyze the gamut error using the Tektronix Diamond display. Selecting this display causes the instrument to create this entirely different view of the captured data as shown in Figure 1.

Trigger Types	Definition of Error
Lock Error	Indicates instrument lost lock to the input signal
EAV	Trigger on when the EAV timing reference signal differs from the expected value
SAV	Trigger on when the SAV timing reference signal differs from the expected value
HD Line Number Error	Triggers when the length of a video line differs from that expected for the detected video format.
HD Y CRC Error	Triggers when the encoded CRC for a line's Y (luma) samples differs from the calculated CRC.
HD C CRC Error	Triggers when the encoded CRC for a line's C (chrominance) samples differs from the calculated CRC.
HD Y ANC Checksum Error	Triggers when the encoded checksum in a Y (luma) ancillary data packet differs from the calculated checksum.
HD C ANC Checksum Error	Triggers when the encoded checksum in a C (chrominance) ancillary data packet differs from the calculated checksum.
Video Format Error	Triggers when the signal format detected on the selected video input differs from the configured Input Format or that the format detected differs from that indicated by the signal's SMPTE 352 payload identifier.
Luma Gamut Error	Triggers when the selected video input signal contains luma levels that violate the configured Luma gamut thresholds.
Composite Gamut Error	Triggers when the selected video input signal contains colors that violate the configured Arrowhead gamut thresholds.
RGB Gamut Error	Triggers when the selected video input signal contains colors that violate the configured Diamond gamut thresholds.
SD AP CRC Error	Triggers when encoded AP (active picture) CRC differs from the calculated CRC.
SD FF CRC Error	Triggers when encoded FF (full field) CRC differs from the calculated CRC.

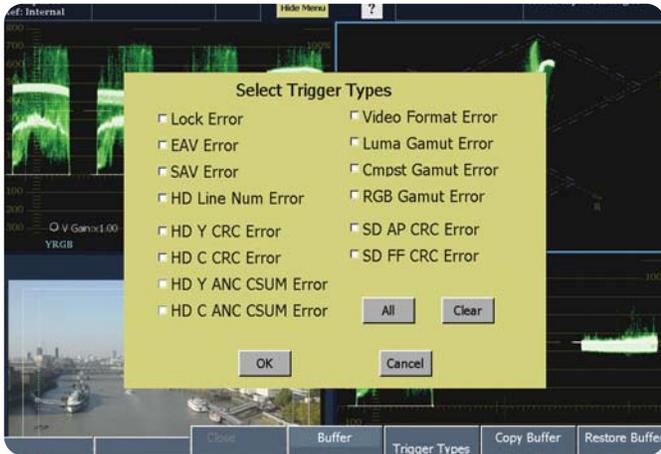
► **Table 1.** *Trigger types.*

Another ability of CaptureVu is to be able to select an automatic trigger event based on a one or more video error

conditions shown in Table 1. These trigger conditions cover a range of errors in SDI signal formats or video levels.

Troubleshooting and Analyzing Digital Video Signals with CaptureVu

► Application Note



► **Figure 2.** WFM7100 trigger types.

The instrument can be configured with a variety of Trigger Type selections as shown in Figure 2 that are available in the Settings sub-menu of main Capture menu. The users can select any number of supported trigger types. After configuring the trigger menu, the user sets the instrument to “Run” mode and the instrument watches for the first occurrence of an error that matches any of the selected trigger types. When an error occurs, the waveform monitor captures the video frame containing the error and stores this in internal memory. The automatic trigger functions then allows the user to view this capture data in any of the waveform displays.



► **Figure 3.** Front panel USB.

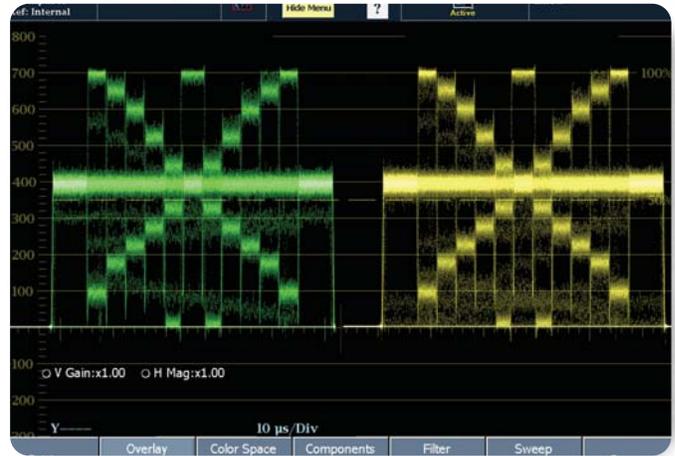
Using the USB port on the instrument's front panel, users can store the data from the captured video frame on a USB memory stick as shown in Figure 3. In the Settings menu of Capture, one of the configurations is to “Copy the Buffer to USB.” Selecting this allows the user to name the file and then store it to a USB memory stick. Once stored, they can transfer the captured data back to the same instrument, or a different instrument, at a later date. This capability can be used in a variety of ways:



► **Figure 4.** Camera alignment setup.

For instance, an engineer in the field can capture a video frame containing an error and share this with a colleague in their testing facility. The engineer at the testing facility can then restore the captured data to another waveform monitor and use it to troubleshoot the problem.

As a second example, an operator aligning cameras for the next production can use CaptureVu to compare and analyze the output of different cameras. Normally the camera is aligned by using a camera test chart as shown in Figure 4 and making measurements of the signal on a waveform monitor. Once the alignment is complete, the operator can use CaptureVu to make a manual capture of



► **Figure 5.** Capture from a known good camera for comparison.

the video signal as shown in Figure 5. This saved data can be used as a “golden reference” for aligning other cameras by matching the displays of the live signal from a different camera to displays of the captured data from the reference camera. Because CaptureVu creates the display from the raw video data, operators can compare the cameras outputs on various waveform, vector, gamut and picture displays. Further by saving the data to a USB memory stick operators can compare the alignment of the camera over time to see any degrades as the camera ages or changing conditions within the studio.

Troubleshooting and Analyzing Digital Video Signals with CaptureVu

► Application Note

Typically once the instrument is powered down, the saved information from the capture could be lost. However the ability to save and recall the saved data from a USB memory stick into the instrument or another instrument allows for operators to compare data over a period of time or allows the operator to save and send the data to an engineer or editor for further analysis or comparison. This can help considerably in explaining a variety of different phenomenon which maybe observed during production.

In troubleshooting and design applications, engineers can use this capture capability to diagnose video format errors. Usually these types of errors happen intermittently and can be difficult to isolate within the video signal. Engineers can configure the waveform monitor to watch for and capture the video frame containing the error. When the instrument detects and captures a frame, it records the capture time within the error log. The data can then be saved to the memory stick and the user can re-arm the instrument to wait for the next error. With this approach, engineers can then see if these errors happen at regular intervals when changes are made within the video source by switching devices or other systems within the video signal path.

Once the engineer has captured sufficient data for further analysis to a USB memory stick he can then probe this data further on a PC. The captured data contains a full video frame that includes the ancillary and active picture data. The instrument uses a proprietary format to save this captured data to the USB memory stick. Tektronix has developed a utility program that can read and format the captured data in a variety of ways:

0. A simple CSV file containing the raw Cb,Y,Cr,Y* samples in the capture data. The file is not directly suitable for importing into a spreadsheet program but could be used as a raw text file input for a user-developed application program.
1. A CSV file optimized for spreadsheet applications. This file can be imported into a spreadsheet program to allow the user to search through the data. The spreadsheet application formats the data suitably for each cell and includes individual sample and line numbers.
2. A *.PIC file used by the Tektronix TG700 test signal generator. With this format, the capture data can be transferred directly to the generator as a full frame picture. This *.PIC file contains only the active picture data for the TG700. The TG700 module inserts the ancillary and blanking data

This utility program is available on the Tektronix website.

To use this utility, the engineer inserts the USB memory stick into the computer and opens the appropriate drive letter for the device. When the data is saved to the USB stick a folder is created on the drive, for example WFM7100_CapBuffer. Within this directory there will be a selection of *.CAP files that have been saved to the memory of the device. These files can be saved to the computer and then the Capture utility can be used to extract the data in to an appropriate format. The user would select the data format (0, 1, or 2), enter the name of the capture file the utility is to process, and then the name of a file to store the converted data on the PC.

USB Capture Filename: bars.cap
Header Version: 1
Captured – 18:15:03 UTC Mar 31, 2006
Frame Count: 1
Events at Trigger:
0 EAV Error
0 SAV Error
0 Line Number Error
0 Luma CRC Error
0 Chroma CRC Error
0 Luma Checksum Error
0 Chroma Checksum Error
0 Signal Lock Error
0 Active Picture CRC Error
0 Full Field CRC Error
0 Video Standard Error
1 Luma Out of Gamut Error
1 Composite Out of Gamut Error
1 RGB Out of Gamut Error
1 Manual Trigger
Video Format: 1080i_59.94
Total Lines: 1125
Active Lines: 1080
Total Luma Samples per Line: 2200
Active Luma Samples per Line: 1920

► **Table 2.** Header format.

Formatting the data using mode “0” allows the data to be formatted for use by text editing programs. The data is structured in terms of the samples Cb, Y, Cr, Y* on each line. This can lead to a large number of lines within the file depending on the format and the text editor must be able to process all the lines of data present within the file. Some programs limit the number of lines that the application can actually process. This type of file can be used for importing of the data into a specific application program developed by the engineer. For instance an application could take the raw data and convert the active video image into a picture file format.

When the user selects option “1” of the Capture utility program, the data is formatted so that it can be imported into a spreadsheet application using a *.CSV extension. The spreadsheet data appears in the Cb, Y, Cr, Y* order with line number and sample indication present. In order to format the sample data correctly within the spreadsheet application an “x” precedes each actual hex value. Additionally, a header provides information on when the captured occurred, the triggered error types present within the captured data and the format of the video signal. In the example shown in Table 2, the signal was a 1080i_59.94 format, containing an active picture area of 1920x1080. This header information provides information on whether the data was captured by a specific automatic trigger event or a manual capture by the user. In this case, a manual trigger was performed and Composite, Luma and RGB gamut errors are present within the capture.

Troubleshooting and Analyzing Digital Video Signals with CaptureVu

► Application Note

Line/Sample	Cb+000	Yc+000	Cr+001	Y+001	Cb+002	Yc+002	Cr+003	Y+003	Cb+004	Yc+004	Cr+005
0001/1924	x204	x204	x200	x200	x2f7	x2bb	x1e8	x23c	x000	x040	x3ff
0001/2024	x1e6	x040	x10d	x040	x218	x040	x1c8	x040	x206	x040	x140
0001/2124	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0024	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0124	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0224	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0324	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0424	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0524	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0624	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0724	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0824	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/0924	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1024	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1124	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1224	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1324	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1424	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1524	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1624	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1724	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200
0001/1824	x200	x040	x200	x040	x200	x040	x200	x040	x200	x040	x200

► **Table 3.** Example of part of spreadsheet file.

Engineers can use a variety of utilities within the spreadsheet program to sort or search through the data, or develop a Visual Basic program to search and format the data in a variety of ways. For instance, engineers can use the Find function of the spreadsheet application to search for a specific data value for instance such as “x3FF.”

Typically engineers may wish to find all occurrences of the SAV and EAV values. These values are denoted by a sequence x3FF, x000, x000. A simple Find and formatting of the cells will be able to find all x3FF and x000 values within the spreadsheet but typically will not be able to identify them in sequence. For instance, ancillary data is formatted as x000, x3FF, x3FF and these values will also be found by doing a simple search.

In order to do a more complete search of the sequential sequence of EAV/SAV or ANC a simple Macro program can be written to search through the spreadsheet.

Appendix A show a sample Visual Basic program that could be used to find the EAV and SAV values within the spreadsheet and format these cells in bold text and color the cell background to make the easily identifiable within the data. Using these types of tools, engineers can determine if an ancillary data sequence generated by a particular video device contains an error introduced by an error in the device code or operation.

The third option “2” is to convert the captured data into a *.PIC file format. This format allows the data to be sent to a Tektronix TG700 Test Signal Generator (TSG) and be used as a test signal. This function can be used by an engineer who may have discovered a specific video sequence or type of image that can stress the device under test (DUT). Using CaptureVu, the engineer can capture a frame of this video signal and store it to the USB memory device. The captured file (*.CAP) can be converted into a frame picture suitable for downloading into the Tektronix TG700 (*.PIC). The TG700 test signal generator can also be configured to move the frame picture horizontally and vertically to create motion and allow the engineer to observe any artifacts created by the device. By converting the captured video frame into a test signal, the engineer now has a know source of video data which can be applied to the DUT to compare the DUT output signal with the original test signal.

Often, engineers apply a test signal to the device under test (DUT) and perform measurements of the signal output from the device. With CaptureVu, an engineer can capture the video frame of a test signal such as color bars directly into the waveform monitor and then apply the test signal from the generator through the DUT and compare with the live output of the DUT to the captured test signal to identify differences. The data from both the test signal and the captured DUT output can be saved to USB memory.

These two files can then be compared by various utilities to find differences between the test signals and the DUT.

Additionally the TG700 software utility FrameGen (available from the Tektronix website www.tek.com) can be used to read the PIC file data and either view the image or save the image as a BMP picture file format.

Conclusion

The new CaptureVu function on the WFM7100 and WFM6100 provides a useful tool to assist engineers and operator maintain the video quality of their digital system. By enabling a capture of the complete frame of the video signal the operator can compare different video signals against the captured reference. In digital video systems engineers can find it difficult to troubleshoot this high speed digital data as a momentary error occurs within the signal. By using trigger capture the video signal data can be frozen in time and can be analyzed in detail by the engineer either on the waveform monitor or by using the capture utility to translate the data into a spreadsheet application. This can aid in the troubleshooting of digital video signals and help in reducing Murphy's Law.

Appendix A

Visual Basic Macro

```
Sub ANCFormatCells()  
,  
  
'ANCFormatCells Macro  
'Tektronix, Inc Sample Program  
'Ancillary Data search for EAV and SAV sequence  
  
'Set Variables to be used in program  
    Dim CountCol As Integer  
    Dim CountRow As Integer  
    Dim Count1 As Integer  
    Dim Count2 As Integer  
    Dim Count3 As Integer  
    Dim Count4 As Integer  
    Dim LastValRow As Integer  
  
'Set Initial values of variables  
'Initial value of start of search for row and columns  
    CountCol = 4  
    CountRow = 31  
  
'Last Value of Column for 525 signal format: Default  
    LastValRow = 4754  
  
'Initial value of start of search for row and columns for  
Standard Definition formats  
    Count1 = 1  
    Count2 = 2  
    Count3 = 3  
    Count4 = 4  
  
'Check for High Definition formats 1080 or 720 in cell  
position (25, A)  
'If High Definition format then search in Y and C data  
samples  
'Format count to search Y and C samples separately  
If Cells(25, 1) = "Total Lines: 1125" Or Cells(25, 1) =  
"Total Lines: 750." Then  
    Count1 = 2  
    Count2 = 4  
    Count3 = 6  
    Count4 = 8  
End If  
  
'If High Definition 1080 format then last row is cell 30405  
If Cells(25, 1) = "Total Lines: 1125." Then  
    LastValRow = 30405  
End If
```

```
'If High Definition 720 format then last row of cells 12780
  If Cells(25, 1) = "Total Lines: 750." Then
    LastValRow = 12780
  End If
```

```
'If Standard Definition format 625 then last row of cells is
5655
  If Cells(25, 1) = "Total Lines: 625." Then
    LastValRow = 5655
  End If
```

```
'Start search from Column 3 to 199 for all formats
  For CountCol = 3 To 199
```

```
'Start search from Row 31 to LastValRow assigned by
cell(25,1) value
  For CountRow = 31 To LastValRow
```

```
'Search for Ancillary Data
'If the sequence of cells is x000, x3ff, x3ff then format the
cells Font to Bold
'Select Interior color of cells to be Yellow
```

```
  If Cells(CountRow, CountCol).Value = "x000" And
  Cells(CountRow, CountCol + Count1).Value = "x3ff" And
  Cells(CountRow, CountCol + Count2).Value = "x3ff" Then
    Cells(CountRow, CountCol). Select
      With Selection.Font
        .Name = "Arial"
        .FontStyle = "Bold"
        .Size = 10
      End With
```

```
      With Selection.Interior
        .ColorIndex = 27
      End With
```

```
    Cells(CountRow, CountCol + Count1). Select
      With Selection.Font
        .Name = "Arial"
        .FontStyle = "Bold"
        .Size = 10
      End With
```

Troubleshooting and Analyzing Digital Video Signals with CaptureVu

► Application Note

With Selection.Interior

.ColorIndex = 27

End With

Cells(CountRow, CountCol + Count2). Select

With Selection.Font

.Name = "Arial"

.FontStyle = "Bold"

.Size = 10

End With

With Selection.Interior

.ColorIndex = 27

End With

Cells(CountRow, CountCol + Count3). Select

With Selection.Font

.Name = "Arial"

.FontStyle = "Bold"

.Size = 10

End With

With Selection.Interior

.ColorIndex = 27

End With

End If

'Search for End of Active Video and Start of Active Video

Data sequence

'If the sequence of cells is x3ff, x000, x000 then format the
cells Font to Bold

'Select Interior color of cells to be Light Blue

If Cells(CountRow, CountCol).Value = "x3ff" And

Cells(CountRow, CountCol + Count1).Value = "x000" And

Cells(CountRow, CountCol + Count2).Value = "x000." Then

Cells(CountRow, CountCol).Select

With Selection.Font

.Name = "Arial"

.FontStyle = "Bold"

.Size = 10

End With

With Selection.Interior

.ColorIndex = 24

End With

```
Cells(CountRow, CountCol + Count1). Select  
With Selection.Font  
.Name = "Arial"  
.FontStyle = "Bold"  
.Size = 10  
End With
```

```
With Selection.Interior
```

```
.ColorIndex = 24
```

```
End With
```

```
Cells(CountRow, CountCol + Count2). Select
```

```
With Selection.Font
```

```
.Name = "Arial"
```

```
.FontStyle = "Bold"
```

```
.Size = 10
```

```
End With
```

```
With Selection.Interior
```

```
.ColorIndex = 24
```

```
End With
```

```
Cells(CountRow, CountCol + Count3). Select
```

```
With Selection.Font
```

```
.Name = "Arial"
```

```
.FontStyle = "Bold"
```

```
.Size = 10
```

```
End With
```

```
With Selection.Interior
```

```
.ColorIndex = 24
```

```
End With
```

```
End If
```

```
'Search Next Row
```

```
Next CountRow
```

```
'Search Next Column
```

```
Next CountCol
```

```
'When Search Complete End Macro
```

```
End Sub
```

This simple macro could be adapted to search for a variety of data sequences that can be found within the digital data stream.

Troubleshooting and Analyzing Digital Video Signals with CaptureVu

► Application Note

Notes

Notes

Contact Tektronix:

ASEAN / Australasia (65) 6356 3900
Austria +41 52 675 3777
Balkan, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium 07 81 60166
Brazil & South America (11) 40669400
Canada 1 (800) 661-5625
Central East Europe, Ukraine and the Baltics +41 52 675 3777
Central Europe & Greece +41 52 675 3777
Denmark +45 80 88 1401
Finland +41 52 675 3777
France +33 (0) 1 69 86 81 81
Germany +49 (221) 94 77 400
Hong Kong (852) 2585-6688
India (91) 80-22275577
Italy +39 (02) 25086 1
Japan 81 (3) 6714-3010
Luxembourg +44 (0) 1344 392400
Mexico, Central America & Caribbean 52 (55) 5424700
Middle East, Asia and North Africa +41 52 675 3777
The Netherlands 090 02 021797
Norway 800 16098
People's Republic of China 86 (10) 6235 1230
Poland +41 52 675 3777
Portugal 80 08 12370
Republic of Korea 82 (2) 528-5299
Russia & CIS +7 (495) 7484900
South Africa +27 11 254 8360
Spain (+34) 901 988 054
Sweden 020 08 80371
Switzerland +41 52 675 3777
Taiwan 886 (2) 2722-9622
United Kingdom & Eire +44 (0) 1344 392400
USA 1 (800) 426-2200

For other areas contact Tektronix, Inc. at: 1 (503) 627-7111

Updated 15 September 2006

For Further Information

Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tektronix.com



Copyright © 2006, Tektronix. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks or registered trademarks of their respective companies.

10/06 DV/WOW

25W-19524-1