Video Quality in Set-Top Box：

Improving Test Productivity While Retaining Quality Index

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ABSTRACT

The key performance index for a set-top box appears to be its video and audio quality. The video quality is benchmarked by many different types of video patterns. In this paper, we propose a Video Combination Technique (VCT) to integrate twenty-four video sources into a single one. Thus, the benefits of VCT include lower test complexity, lower test cycles and cost saving.

1: INTRODUCTIONS

Everyone knows what the video is – it is another definition for the television. Televisions have been around in our homes; it is an integral part of modern life.[24] What is the key performance index (KPI) of a digital home product? It appears to be its video quality.[4] The quality index contains amplitude, timing, linear distortion, nonlinear distortion and noise. The quality index covers all test items and the measurement. This paper discusses the test methodology of video quality. Since the video quality is benchmarked by many different types of video test patterns, how to simplify these complicated video sources will be an issue. We propose a Video Combination Technique (VCT) to simplify the video test pattern. The VCT combines twenty-four video sources into one. The VCT is now in patent pending. The benefits of VCT include lower test complexity, lower test cycles and cost saving. Thus, it improves the test productivity while retaining quality index.

2: VIDEO QUALITY INDEX

The overall of video quality is influenced at a number of index: amplitude, timing, linear distortion, nonlinear distortion and noise in Table 1.

3: PROBLEM STATEMENT

Broadcasters traditionally rely on test patterns and images to check the signal quality throughout the signal path. These various formats produce different signal degradation and so naturally require different test material.[6]

To measure these parameters, a series of video test signals are injected into the video transmission system.

Index	Description	Influence	How to measure
Amplitude	NTSC defines peak-to-peak amplitude 1 volt (140 IRE)	Too light or too dark	100 IRE white level
Timing	Horizontal and vertical synchronization pulse widths fall within specified limits	Picture breakup	Any composite signal
Linear Distortion	Caused by imperfect transfer characteristics in the signal path	Incorrect color saturation, color smearing, fuzzy vertical edges, brightness variation, flicker	12.5T sine-squared pulse with 3.58 MHz modulation, T rise time white bar, 18 us 100 IRE bar, window or field square wave
Nonlinear Distortion	Crosstalk and intermodulation effects between luminance and chrominance	High brightness areas colors not reproduced,	Modulated staircase, unmodulated 5 step staircase, modulated pedestal
Noise	Noise random or coherent from natural and man-made sources	Snowy, grainy, sparkles	Any line with constant level

Table 1 Video Quality Index

Then measure the response from the output of the transmission system with a video waveform monitor and a video chrominance vector scope.[3] Table 2 illustrates generic video source patterns. There are twenty-four patterns. Each video pattern on television is full screen. Each pattern is designed by their physical methodology to benchmark video performance. In Table 2, it shows the picture outlook and waveform.

4: OPERATION MODEL

As NTSC system has 525 scanning lines. Thus, each frame takes two vertical scans (fields), with the even and odd lines scanned on alternate fields as shown in Figure 1.[24]

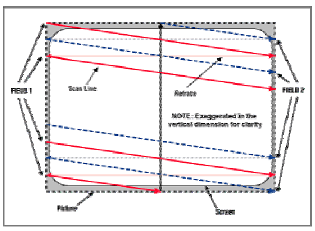


Figure 1 Television Interlaced Scanning

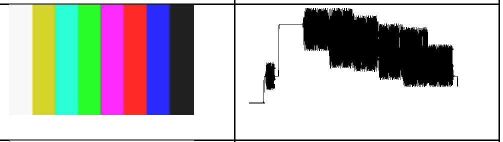
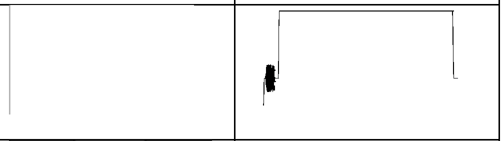
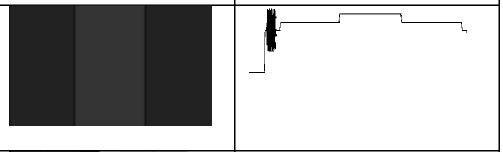
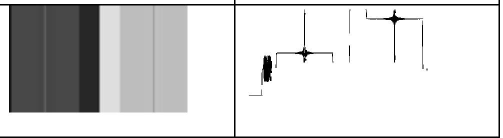
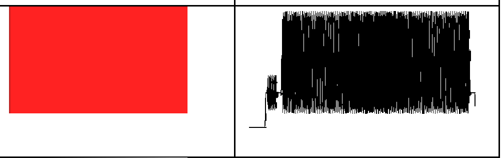
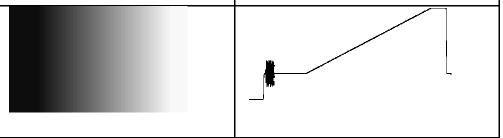
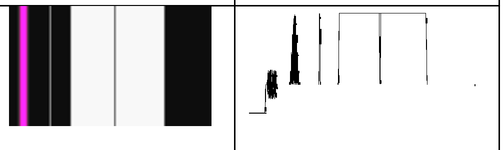
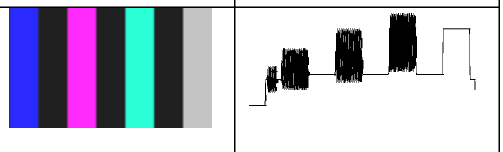
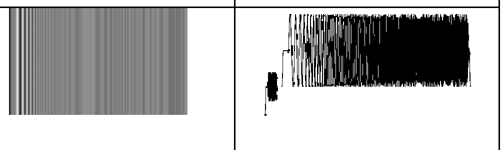
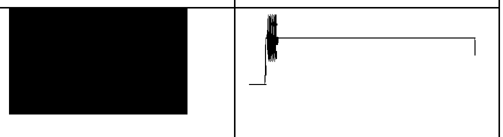
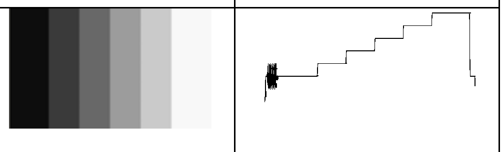
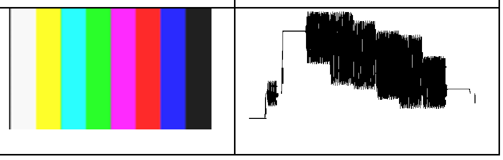
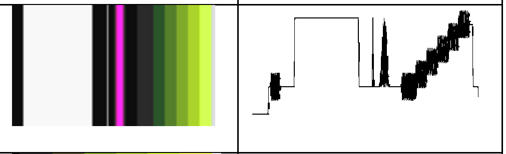
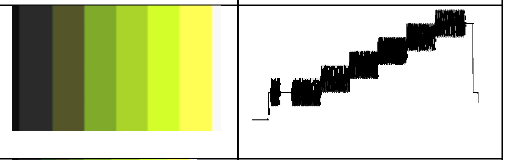
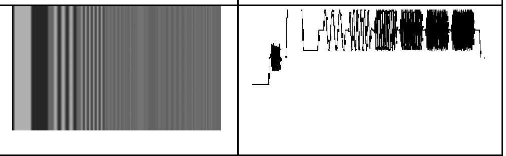
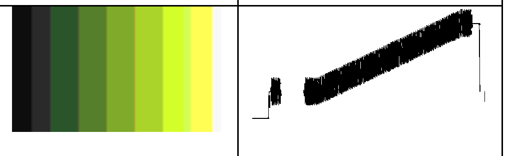
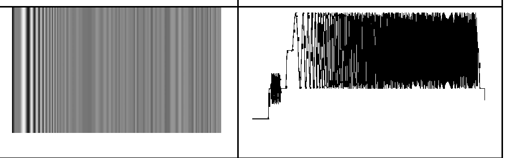
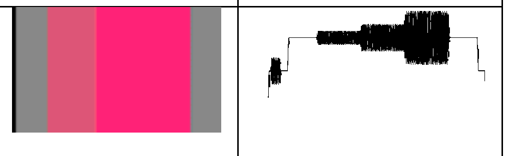
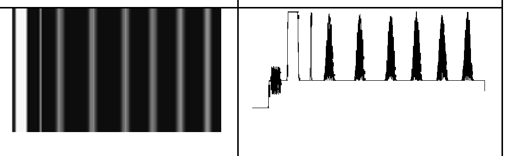
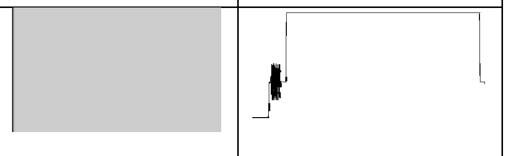
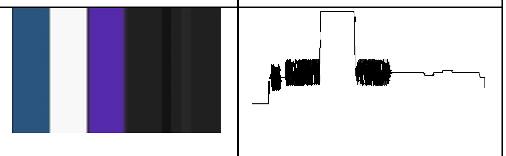
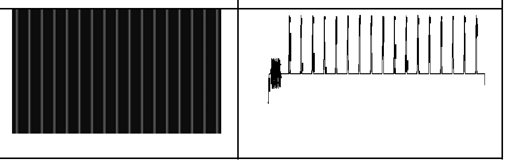
Name	Picture Outlook	Waveform
Color Bar 75%		
IRE100		
GreyWind		
Sin(x/x)		
RED100		
Ramp		
PulseBar		
RBB		
6MHzSweep		
IRE0		
5 Step		
ColorBar 100%		
FCC Composite		
N7 Composite		
Mod 5 Step		
Mod 10 Step		
Multi-burst		
Mod Ramp		
8MHz Sweep		
Mod Ped		
Multi-pulse		
Horzline		
IWQ		
Vertline		

Table 2 Video Sources Outlook and Waveform

The first one to 20 scanning lines are vertical blanking interval (VBI). VBI is not displayed by televisions. Figure 2 illustrates the logical of NTSC scanning standard, hence, the useful scanning lines start from 21 to 262 for odd field as summarized in Table 3.

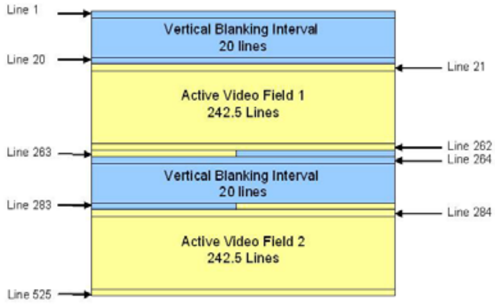


Figure 2 Details of NTSC Scanning Standard

There are twenty-four video sources to be implemented by video combination technique. Therefore, each specific pattern requires 10 scanning lines.

Each pattern scanning line = (262-21) / 24 = 10

	Lines	Useful Lines
Field 1 (Odd)	1 ~ 262	21 ~ 262
Field 2 (Even)	263 ~ 525	284 ~ 525

Table 3 NTSC System VCT Assignment

As there are so many video test patterns, the video combination technique is collecting 24 patterns into one video frame as shown in Figure 3.

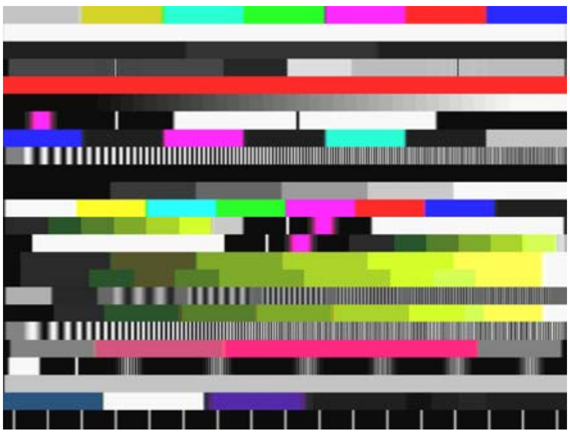


Figure 3 Video Combination Technique Pattern

The specific unique patterns are assigned as Table 4. Each unique video source has 10 scanning lines. There are 24 specific patterns totally. The 24 patterns can apply to all of the STB's video performance test requirements.

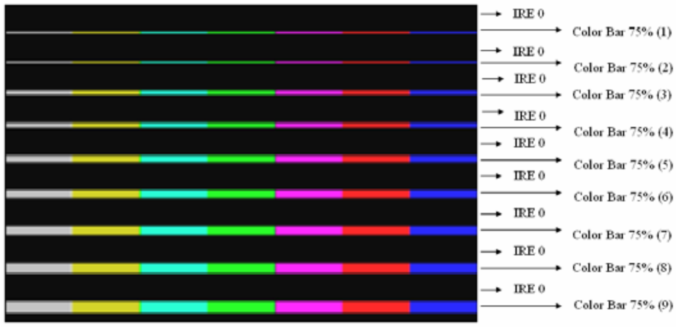


Figure 4 Guard Video Scanning Pattern

Each video contains 10 scanning lines logically. But the physically, we design a unique pattern as shown in Figure 4 to evaluate how many scanning lines are available. We do an evaluation pattern that only has IRE0 and color bar 75%. The scanning lines with color bar are from 1 to 9 group and step with 20 lines. The pattern passes through the digital broadcasting system. We normally use color bar pattern to evaluate the picture quality. Using video analyzer analysis the video quality then comes out the color vector result as shown in Table 5 and 6.

	Line @Field 1	Name
1	21 ~ 30	Bar 75
2	31 ~ 40	IRE 100
3	41 ~ 50	GreyWIND
4	51 ~ 60	Sin(x/x)
5	61 ~ 70	Red 100
6	71 ~ 80	Ramp
7	81 ~ 90	Pulse Bar
8	91 ~ 100	RBB
9	101 ~ 110	6MHz Sweep
10	111 ~ 120	IRE 0
11	121 ~ 130	5 Step
12	131 ~ 140	Bar 100
13	141 ~ 150	FCC Comp
14	151 ~ 160	N7 Comp
15	161 ~ 170	Mod 5 Step
16	171 ~ 180	Mod 10 Step
17	181 ~ 190	Multi Burst
18	191 ~ 200	Mod Ped
19	201 ~ 210	8MHz Sweep
20	211 ~ 220	Mod Red
21	221 ~ 230	Multi Pulse
22	231 ~ 240	Horizontal Line
23	241 ~ 250	IWQ
24	251 ~ 262	Vertical Line

Table 4 VCT Pattern Arrangement

Table 5 describes the guard video scanning line result of group 9. The color vector of good video quality must locate on square for each vertex, so table 5 means that the top two and the bottom two scanning lines in group 9 are not good.

Table 6 summarizes the result for nine groups. We come out our observation and found that video test failed for groups with very few scanning lines (e.g. 1 and 2) because all the scanning lines are bad. After Group 7, the video source has at least 5 scanning lines of good quality. We defined the scanning line space that can have bad quality in a video source as the "Guard Video Scanning Line". Based on the test result, each video source should have at least two scanning lines on its top and bottom boundary.

Scanning Line	Color Vector Measurement Result	
Line 246~254 (Group 9)	Line246  Fail	Line 247  Fail
	Line 248  Pass	Line 249  Pass
	Line 250  Pass	Line 251  Pass
	Line 252  Pass	Line 253  Fail
	Line 254  Fail	

Table 5 Scanning Line Color Vector Performance

Scanning Line	Color Vector Measurement Result
Line42 (Group 1)	4 **(F)**
Line64 ~ 65 (Group 2)	64 65 **(F)** **(F)**
Line87 ~ 89 (Group 3)	87 88 89 **(F)** P **(F)**
Line111~114 (Group 4)	111 112 113 114 **(F)** P **(F)** **(F)**
Line136~140 (Group 5)	136 137 138 139 140 **(F)** **(F)** P **(F)** **(F)**
Line162~167 (Group 6)	162 163 164 165 166 167 **(F)** **(F)** P P P **(F)**
Line189~195 (Group 7)	189 190 191 192 193 194 195 **(F)** P P P P P **(F)**
Line217~224 (Group 8)	217 218 219 220 221 222 223 224 **(F)** P P P P P **(F)** **(F)**
Line246~254 (Group 9)	246 247 248 249 250 251 252 253 254 **(F)** **(F)** P P P P P **(F)** **(F)**

Table 6 Scanning Line Performance of nine groups, where "P" means Pass, while "F" means Fail.

4: CONCLUSIONS

As the generic video test methodology is to display the source in turns. Our approach VCT shows the pattern one time and at least 24 patterns per frame. The benefit of VCT will save time for 24 times less than the one of traditional methodology. The operation complexity is also lower than generic one.

If we estimate the shipping quantity is one million per year and use six kinds of video sources for test cases, the operation costs two NT dollars per minute. Therefore, the generic method costs twelve million NT dollars. And the VCT approach costs two million NT dollars. As a result, the VCT approach could save up to ten million NT dollars per year.

The concept of guard video improves the accuracy of video measurement. Due to broadcasting system, it is essential to choose video compression standard. The side effect of MPEG compression downgrades the VCT performance between the adjacent patterns. While the pattern of VCT is over ten scanning lines, we choose the center scanning line of each pattern. Hence, the performance of video quality is reliable and improve the test productivity while retaining quality index.

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