A Study on response time measurement of FPD using statistical techniques of histogram

YEUN-WOO LEE [1], GI-CHANG PARK [2], SANG-DAE LEE [1],

Abstract

As FPD technology is getting improved, there are a lot of issues on signal processing and analysis, and its relative importance has been increasing day by day. In particular, response time sad in the evaluation item of FPD has been measured by oscilloscope. In this paper, we propose an effective measurement method of response time in FPD. The proposed method is to calculate the rising/ falling time by using statistical techniques of histogram and analyzing an energy distribution.

Ultimately, the method has proved the utility and reliability by comparison of oscilloscope

1. Introduction

Response time means time taking liquid crystals to be on/off. If voltage signals on outside change into on or off, liquid crystal is deformed by the signals. But it can't immediately react on account of viscosity of the liquid crystals and is postponed until reaching to steady state. The deformation characteristics of these liquid crystals present to optical characteristics and optically postponed time is called to response time. Response time is in proportion to viscosity of the liquid crystals and in inverse proportion to cell spaces. When electrical signals convert into on-to-off (or off-to-on), it is possible to measure the response time from transmittance characteristics for time. In particular, as technology of FPD is developing increasingly, there are a lot of the issues on signal management. So the relative importance has been increasing day by day.

Until now, there has been no active research for particularly regular methods and effective measurement methods on response time measurement. However, these have been recently paid much attention since the importance raised.

FPMS(Flat Panel Measurement System, FPMS) used in a number of industry fields has depended on simply filtering techniques (Digital Filter and Analog Filter etc,.) under the provision of VESA (Video Electronics Standards Association) standards. This method is using filtering techniques for panel's response signals. To obtain results that noise and ripple are low, high/low ripples have to be diminished, and then the response time is calculated. But by using filtering systems, Data's loss and response time delay occurs.

As compared to the value of oscilloscope, a number of errors on response time occur. In particular, when the response time for GTG (Gray to Gray) that level differences are very low is calculated, the values obtained as well as the errors are not acceptable to use as a measurement data.

In this paper, we propose algorithm in order to make data's loss minimum and obtain data of effective response time. The proposed method using histogram which is one of the statistical techniques is to extract an energy's distribution on the data obtained from a detector and define 0%~100% levels. Based on those, the response time is calculated.

Ultimately, the proposed method proves the utility and reliability by comparison of oscilloscope.

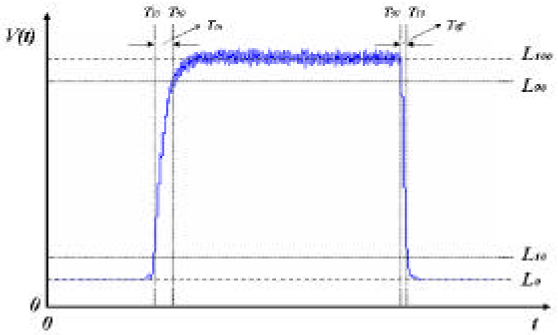
2. Principle

2.1 Response time calculation

Figure 1 shows result of response characteristics.

[1] SP-TECHNOLOGY CO., LTD, 2F KOSCOM(Korea Securities Computer Corporation) B-Dong, 1026-5 Hogye-Dong, Dongan-Ku, Anyang-City, Kyungki-Do, Korea 431-080. Phone(+82-31-477-8852), Fax(+82-31-477-8055), Email(luka75@sp-t.com)

[2] SAMSUNG ELECTRONICS CO., LTD.



[Figure 1] Response time calculation

Each mean of the figure 1 is shown as follows

T : *Time*

V(t) : *Voltage level (or luminance level)*

L_{100} : *Voltage level in On conditions*

L_0 : *Voltage level in Off conditions*

L_{90} : *Voltage level on 90% points*

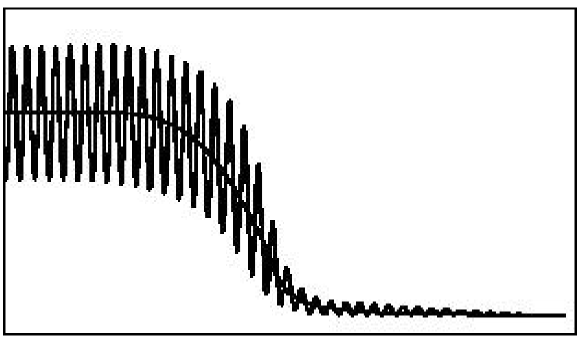
L_{10} : *Voltage level on 10% points*

T_{on} : *Time taking* T_{10} *to* T_{90} *(Turn On Time)*

T_{off} : *Time taking* T_{90} *to* T_{10} *(Turn Off Time)*

In here, it is *Rising Time*(T_{on}) = T_{90} - T_{10}, *Falling Time*(T_{off}) = T_{10} - T_{90}. Also in points between each data, a linear interpolation method is used, and this is used in order to manage a data bounded. Precisely on noise or rippling data, 100% level generally is defined to peak, and the section could be created very highly by noise etc. Therefore, the linear interpolation method or several filtering techniques are used because of necessity to get rid of ripple and noise.

Figure 2 is the proposed method of Moving Window Average Filtering.



[Figure 2] Moving Window Average Filtering (VESA)

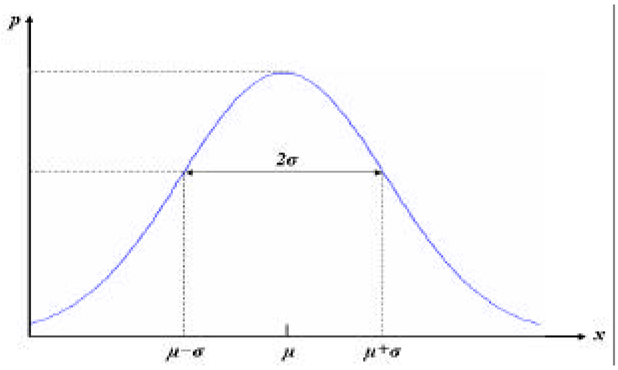
In case of figure2, results which ripple deviation is small could be extraordinary, but it is possible to obtain a loss of data by filtering and impossible to apply to results that ripple deviation are large. The results can be confirmed through comparison with oscilloscope.

It could be a weakness of all digital filters and is possible to manage, so it is necessary to exactly analyze the sections, because ripple deviation in the methods also is not uniform.

2.2 Histogram

Histogram is a figure and a table made by analyzing frequency on size and ranges through distribution of data. Generally, histogram is applied to a number of fields such as statistics, probability and image processing.

The figure 3 shows a normal or a Gaussian probability distribution function and, a result described by the function is called a normal distribution.



[Figure 3] basic form of a normal distribution curve

As the above figure, a normal probability function is the function having a double of parameters. One is µ which shows an average of the result and, the other is s which shows standard deviation. In normal probability distribution, peak is generally a average µ and, width of the curve or spread is determined by s. Sometimes, variation is used to describe spread of the curve and, variation is presented as a square of standard deviation s.

The normal probability function is shown as the below formula 1.

$$p(x) = \frac{1}{s\sqrt{2p}} e^{-(x-m)^2/2s^2} \qquad \text{(Formula 1)}$$

In addition, it is impossible to find out standard deviations or average values but possible to presume from experiment data. A presumption of the average μ is indicated in $\bar{x}$ and a formula calculating $\bar{x}$ is same as a formula calculating μ. This is shown as the below formula 2.

$$\hat{m} = \bar{x} = \frac{1}{n}\sum_{j=1}^{n} x_j = \frac{1}{n}(x_1 + x_2 + x_3 + \ldots + x_n) \quad \text{(Formula 2)}$$

In here, n becomes coefficient of data x_1, x_2, …, x_n. And it is possible to find out the standard deviation s as the below formula 3, using the values.

$$s = \sqrt{\frac{\sum_{j=1}^{n}(x_j - \bar{x})^2}{n-1}} \quad \text{(Formula 3)}$$

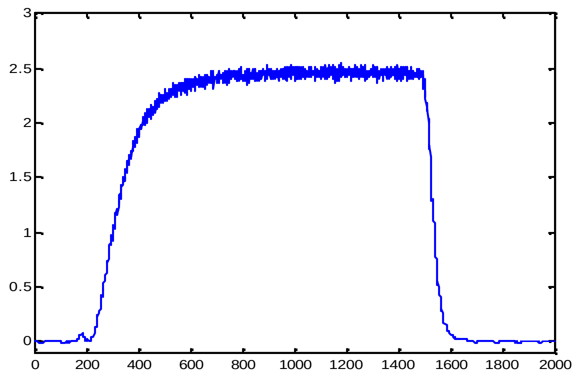
Therefore, s^2 could be shown as the below formula 4.

$$\hat{s}^2 = s^2 = \frac{1}{n-1}\sum_{j=1}^{n}(x_j - \bar{x})^2 \quad \text{(Formula 4)}$$

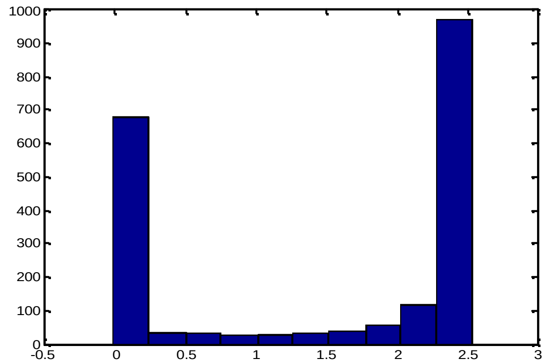
3. Results

In order to prove the utility of the proposed method, we performed response time measurement, applying histogram techniques on LCD panel. In addition, the utility and reliability on the proposed measurement method have been proved by data comparison with oscilloscope through a real time.

Figure 4 shows a sampling data for 0 to 255 (gray level) which was obtained from analog signal.

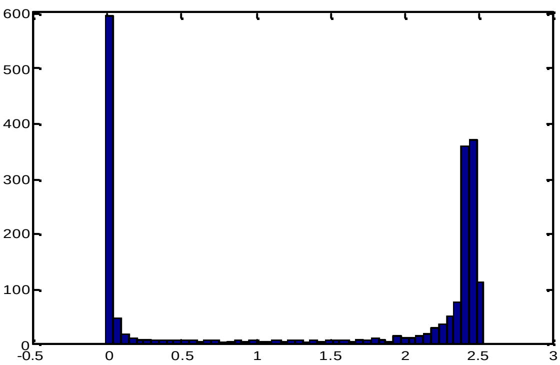


[Figure 4] Sampling data

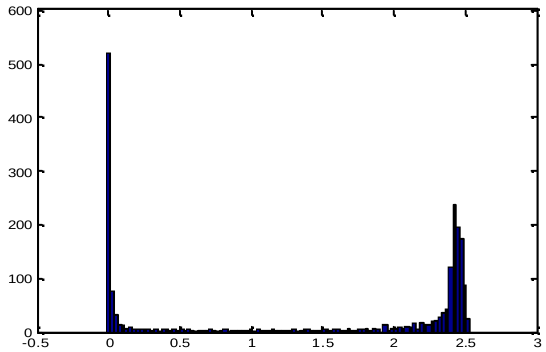


[Figure 5] Energy distribution on the figure 3 (Interval: 10)

In here, sampled data could be energy distribution because the data is luminance level and could analyze the distribution through using histogram. Energy distribution on the figure 4 is like the figure 5. In here, x axis is luminance level of a sampled data and, y axis is a data distribution coefficient of each luminance level. On the distribution, energy is dominant on 0% level and 100% level, and this means that it is possible to extract a representative value on each level. Also when extracting a representative value on each level (0%, 100%), it is possible to find a representative value more subdivided through creating interval of histogram. Figure 5, 6, 7 is shown as examples for interval 10, 50, 100. In this paper, interval = 100 is used.

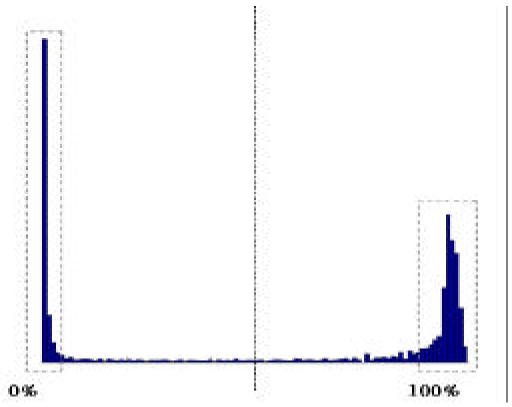


[Figure 6] Interval : 50



[Figure 7] Interval : 100

As the figure 8, the data analyzed by histogram obtains the representative values from levels (or values) which energy distribution is dominant on 0%, 100% levels. In this paper, representative values of 0%level is defined from maximum peak value between 0 to 49 range, and representative values of 100% level is defined from maximum peak value between 50 to 100 range for total 101 levels which have 0 to 100 range as shown in the figure 8.



[Figure 8] Analysis on sections

Figure 9 is PMT sensor used in the experiment of this paper. Basic models of the sensor and the oscilloscope used in the experiment are as Table1 and 2.

[Figure 9] PMT Sensor

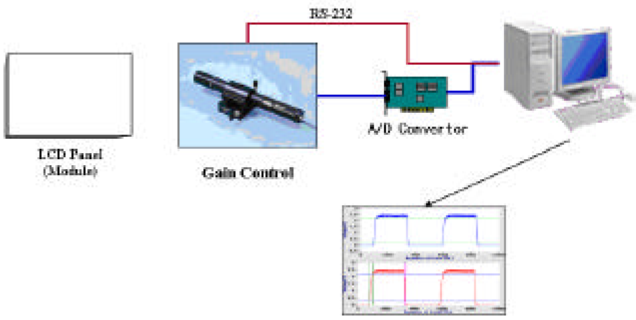
[Table 1] PMT Sensor Spec.

List	Specification
Supply Voltages	+5vdc (micro controller), ±12vdc (PMT)
Analog Output Impedance	50 Ohms
Analog Output Bandwidth	20 kHz
Rise Time	11 μs
PMT Photo Cathode Type	Bi-Alkali
PMT Spectral Response	Hamamatsu 400K curve
Focal Distance	~26" (66 cm) nominal
Aperture	1/8°
Spot Size at Focal Distance	0.060" (1.5 mm)
Warm Up Time	1 hour for real measurements

[Table 2] Oscilloscope Spec.

Model	Bandwidth	Max Sampling (S/s)
TDS3052B (2 CH)	500MHz	5 GS/s

Figure 10 is composition of this experiment. Response time is defined by using the proposed algorithm, after received signals from panel and done A/D conversion.



[Figure 10] Composition of test system

Figure 3 is what was compared with the measured data by using the proposed method and oscilloscope. Response time measured by using the proposed method is almost same as values measured by using oscilloscope. This means that it is possible to obtain an accurate value without using oscilloscope when response time is measured. And it is the most important to select an appropriate detector for an accurate value.

[Table 3] Measured values of response time and measured values of oscilloscope

Test No.	Our's		Oscilloscope	
	Rising	Falling	Rising	Falling
Test 1	6.4	7.1	6.0	7.1
Test 2	6.0	6.7	6.4	6.9
Test 3	6.3	5.1	6.1	5.8
Test 4	6.6	4.0	6.8	4.1
Test 5	6.0	6.1	5.9	6.0
Test 6	6.1	6.6	6.3	6.8
Test 7	6.2	6.2	6.8	6.9
Test 8	6.0	5.1	6.4	5.3
Test 9	6.0	3.8	6.6	3.8
Test 10	5.6	6.7	5.9	6.8

LCD used in this experiment has been measured by randomly selecting general panels.

In the experiment result, the proposed method has differences depending on which detector is used. But any detector is used; response time is almost same as oscilloscope. Without using oscilloscope, response time can be effectively measured by using algorithm proposed in this paper.

4. Conclusions

We have reported the effective method on response time measurement of FPD by statistical techniques of histogram.

The proposed method analyzes the energy distribution or data distribution, and then finds accurate 0% and 100% level for sampled data or acquired data on a real time.

This means that it is possible to measure effectively response time without using digital filter and reduce calculation time. We have proved the utility and reliability through comparison of oscilloscope.

5. References

[1] Video Electronics Standards Association., Version 2.0.

[2] MATLAB for Engineering Applications., By W. Palm.

[3] Advanced Engineering Mathematics., ERWIN KREYSZIG.