A Study of Electromagnetic Emission of 42"AC PDP Module

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Abstract

An EMI emission of 42" AC-PDP panel is studied in this paper. First, the EMI emission level is roughly estimated using both simple electric dipole type and magnetic dipole type radiator model. The value of current required for estimation has been obtained from Fourier Transform of the measured current in time domain. Second, we investigate which type of EMI radiation is dominant by FEM calculation of the wave impedance. The result shows that electric dipole type radiation is dominant EMI source.

I. Introduction

Flat panel display (FPD) has much more advantages in compact volume, high picture quality and high resolution than CRT. Among FPD's, plasma display panel (PDP) is a promising candidate in large size panel application since it has advantages of brightness, angle of vision, excellent resolution [1]. However, PDP system is causing electromagnetic interference (EMI) problem because it uses high voltage drive circuit and plasma that is formed by gas discharge to denote image. Thus, the electrode itself of display panel could be serious EMI source [2,3]. To solve EMI problem in PDP, an accurate EMI source model is essential. In this paper, the radiated emission level of 42" PDP has been calculated and compared using both electric dipole type and magnetic dipole type radiator model.

II. Measurement of Current through Electrodes

Fig. 1 shows two (X-Y) electrodes structure of 42" AC PDP module which utilized address display separated (ADS) driving scheme. Usually, TV field is divided by 8 subfields in ADS mode. Each subfield consists of reset, address, and sustain period. In this paper, the sustain period is selected to calculate the EMI emission level since main power is supplied in this period. During the sustain period, ac rectangular pulses of 170V with a frequency of ~200 kHz are supplied to the X-Y electrode, resulting in the horizontal current path as shown in Fig.1.

Fig.2 illustrates the measurement set-up. 42" PDP module was employed which has 480 XY electrodes. The X-Y current was measured by a current probe (Tektronix A6312) with a bandwidth of 100 MHz. Measured current data were stored with sampling rate of 5GS/s in digital oscilloscope (Tektronix TDS3054B). The measured current is shown in Fig.3.

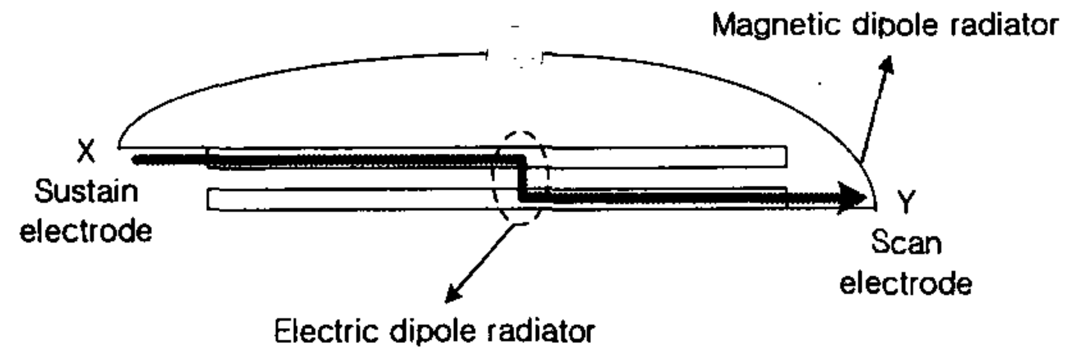


Fig. 1 Current path in sustain period (42" PDP)

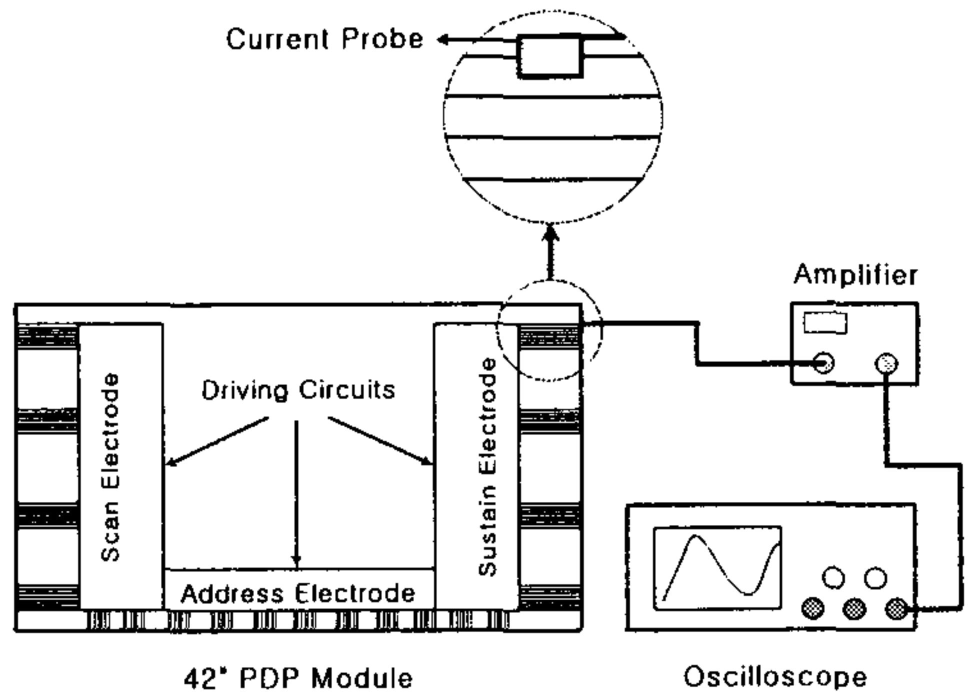


Fig. 2 Measurement setup

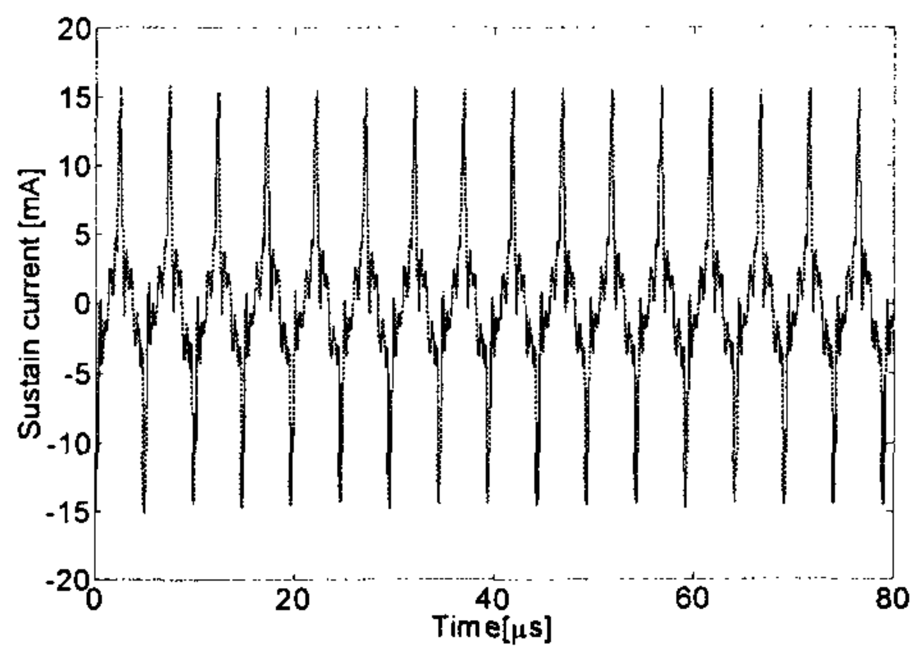
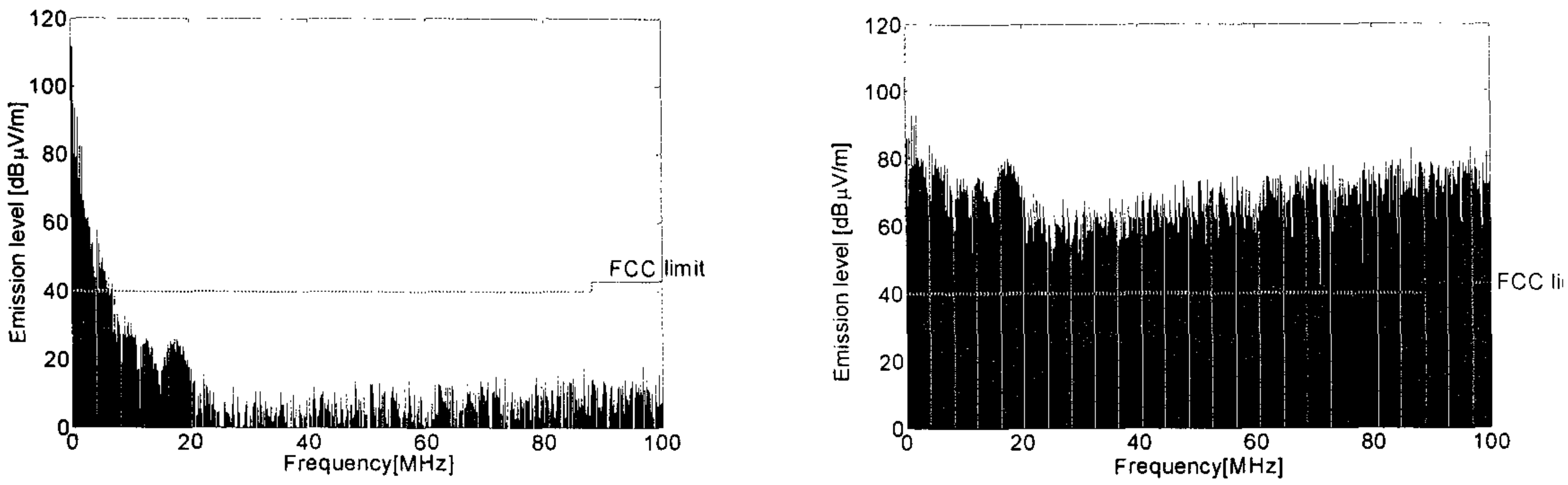


Fig. 3 Current of one sustain electrode during sustain period



(a) (b)

Fig. 4 Calculated Emission level (a) Dipole antenna (l=0.001m, r=3m, $\theta=\pi/2$), (b) Loop antenna (a=0.5280m, r=3m, $\theta=\pi/2$)

III. EMI Emission Model

As shown in Fig.1, there are two kinds of radiators, that is, electric dipole type and magnetic dipole type radiator during sustain period because discharge occurs cross two electrodes. The crossed section could be considered as electric dipole radiator. Since the total current pass forms a closed loop, the current carrying two electrodes could be considered as magnetic dipole radiator. Then, the emission level of electric dipole radiation can be calculated by the following equations [4].

$$E_r = \eta_0 \frac{I(k) l \cos\theta}{2\pi r^2}\left[1+\frac{1}{jkr}\right][V/m] \quad (1)$$

$$E_\theta = j\eta_0 \frac{kI(k) l \sin\theta}{4\pi r}\left[1+\frac{1}{jkr}-\frac{1}{(kr)^2}\right][V/m] \quad (2)$$

where $k = \omega\sqrt{\varepsilon_0 \mu_0}$

Note that the size of l is determined by one cell's size[5]. The current spectrum of I(k) has been obtained from Fourier Transform of the measured data in Fig.3. Then, the expected emission level at the distance of 3 m is shown in Fig.4(a). It is assumed that each cell and electrode line has no phase difference since the distance between cells and electrodes is much smaller than wave length. In the similar way, the emission level of magnetic dipole radiation can be calculated by the following equations [4].

$$E_\phi = \eta_0 \frac{(ka)^2 I(k) \sin\theta}{4r}\left[1+\frac{1}{jkr}\right][V/m] \quad (3)$$

Note that the radius of a is approximated by 42" PDP panel size. Then, the expected emission level at the distance of 3m is shown in Fig.4(b).

IV. Wave impedance of EMI Emission using FEM Simulation

To investigate which type of EMI radiation is dominant in the structure shown in Fig 1., the wave impedance of radiated field has been calculated using finite element method (FEM) simulator. First, the capacitance of a gap in Fig.1 should be determined to calculate the wave impedance. Fig. 5 shows one cell structure of PDP and its circuit model. The total capacitance of C during discharge is given by

$$C = C_g + \frac{C_d}{2} \quad (4)$$

where C_g and C_d are the capacitance between two strips and between one strip and shorted ground. Note that discharge makes the shorted ground.

Then, the cell structure can be considered as a coplanar transmission line. If the characteristic impedance of Z_0 and the propagation of β are known, the total capacitance can be found by the following equations

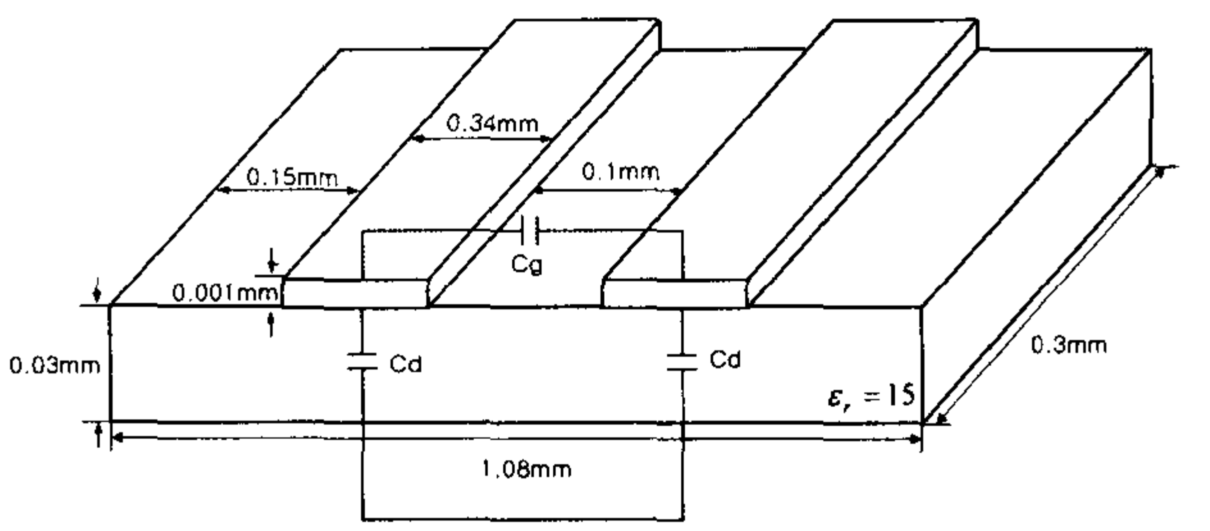


Fig. 5 One cell structure and its capacitance

Table. 1 Measured and simulated capacitance of one PDP cell

	Measured *C* [pF]	Calculated *C* [pF]
200 [KHz]	0.0202	0.0204
1 [MHz]	0.0202	0.0192
10 [MHz]	0.0202	0.0193
100 [MHz]	0.0202	0.0193

$$C = \frac{1}{Z_0 v_p} = \frac{\beta}{Z_0 \omega} [F/m] \quad (5)$$

where Z_0 and β calculated by FEM simulation.

The calculated capacitances with the frequency are listed in Table. 1. Also, the capacitance has been determined from the voltage across the cell during discharge. Since the waveform of voltage and current is measured, the capacitance can be determined from I = Cdv/dt. The measured and simulated values show a good agreement.

To calculate the wave impedance of one electrode line as shown in Fig.1 using FEM simulator, one electrode is reconfigured as shown in Fig.6. In this configuration, the electrode is replaced by circular wire with the radius of 0.3 mm and the gap is also replaced by a simple gap with a capacitance of 0.02 pF. The gap size is simply determined by $C = \varepsilon_0 S/d$.

Fig. 7 shows the calculated wave impedance with the distance from the radiator at the frequency of 50 MHz. It shows that the wave impedance decreases with the distance and converges to 377Ω. To compare, the wave impedance of electric dipole and magnetic dipole are plotted in Fig.7.

As seen in Fig.7, the wave impedance of one electrode line with a gap is quite similar to that of electric dipole type. This indicates that electric dipole type radiation is dominant EMI source.

V. Conclusion

The EMI emission level of 42" AC-PDP module has been roughly estimated and compared using both electric dipole type and magnetic dipole type radiator model. The current spectrum which is needed in the calculation has been obtained from Fourier Transform of the measured data in time domain during sustain period. We investigate which type of EMI radiation is dominant by FEM calculation of the wave impedance. The result shows that electric dipole type radiation is dominant EMI source.

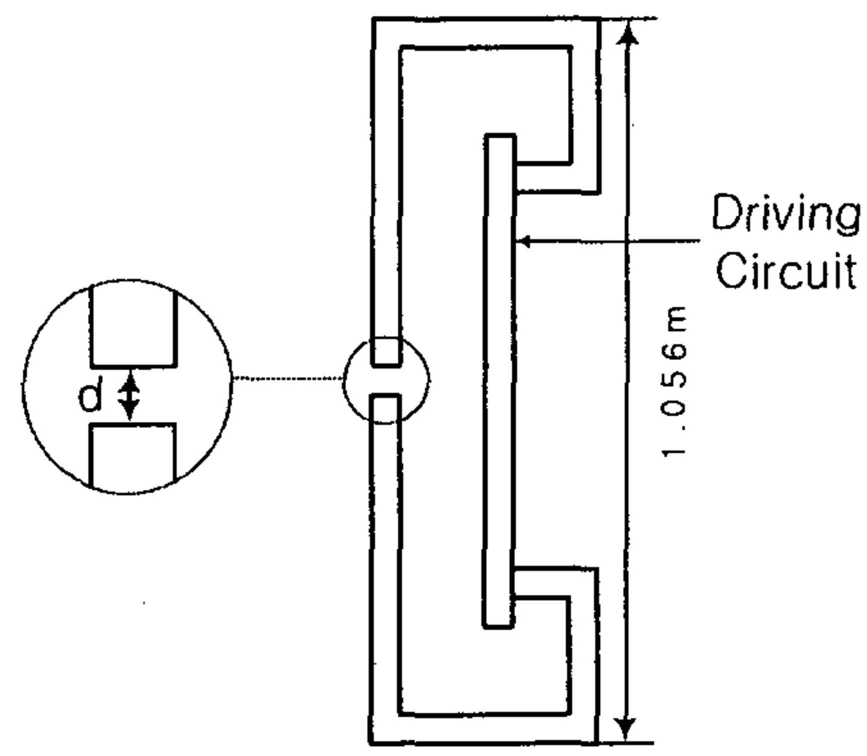


Fig. 6 Reconfigured one electrode line

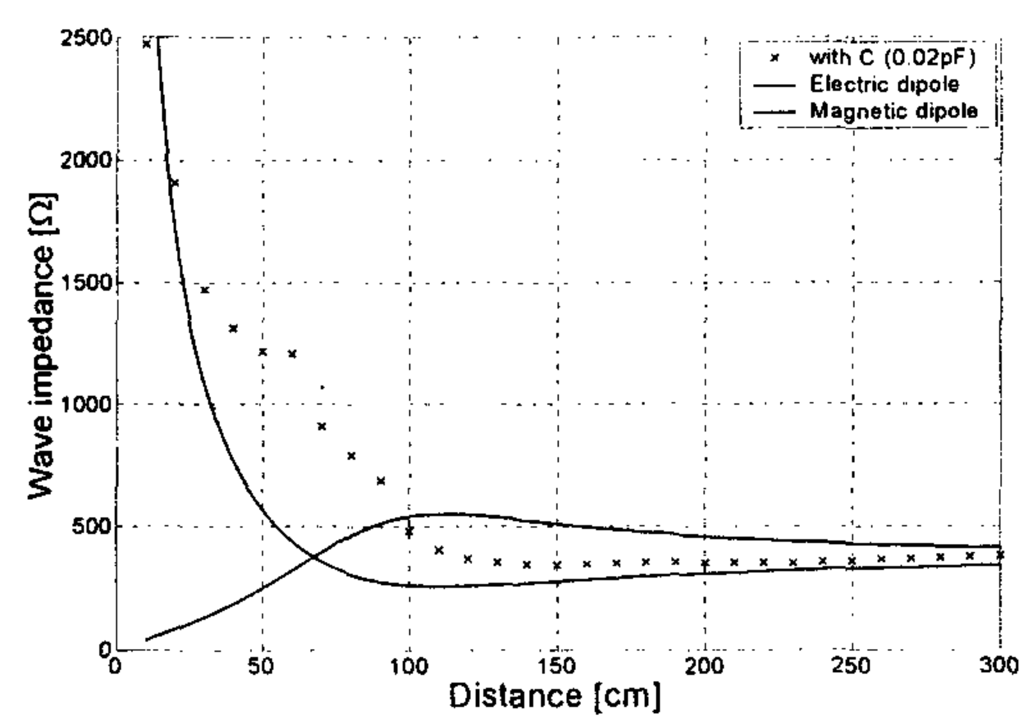


Fig. 7 Wave impedance of electric dipole, magnetic dipole and EMI source model (f=50MHz).

References

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