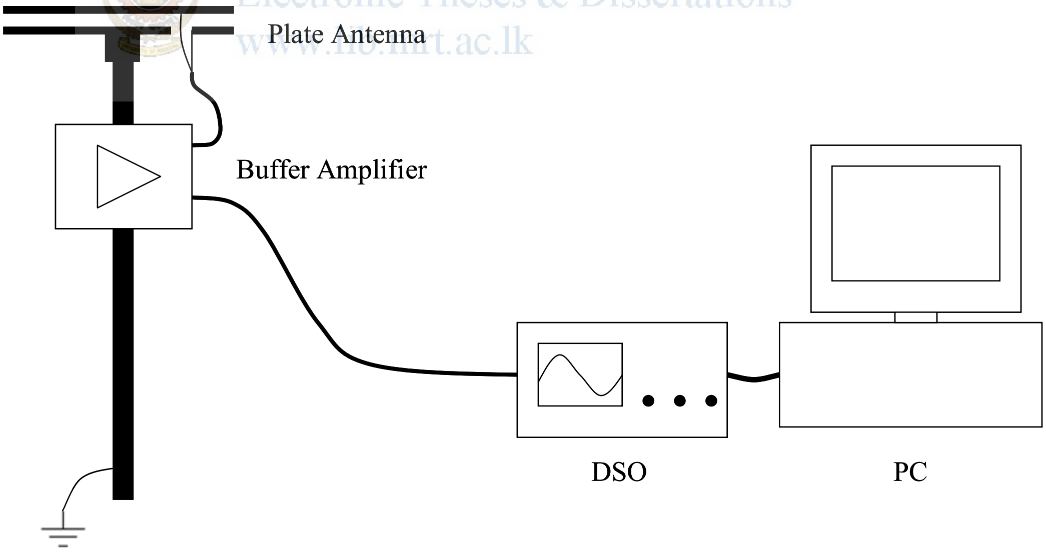
CHAPTER 3

FIELD MEASUREMENTS

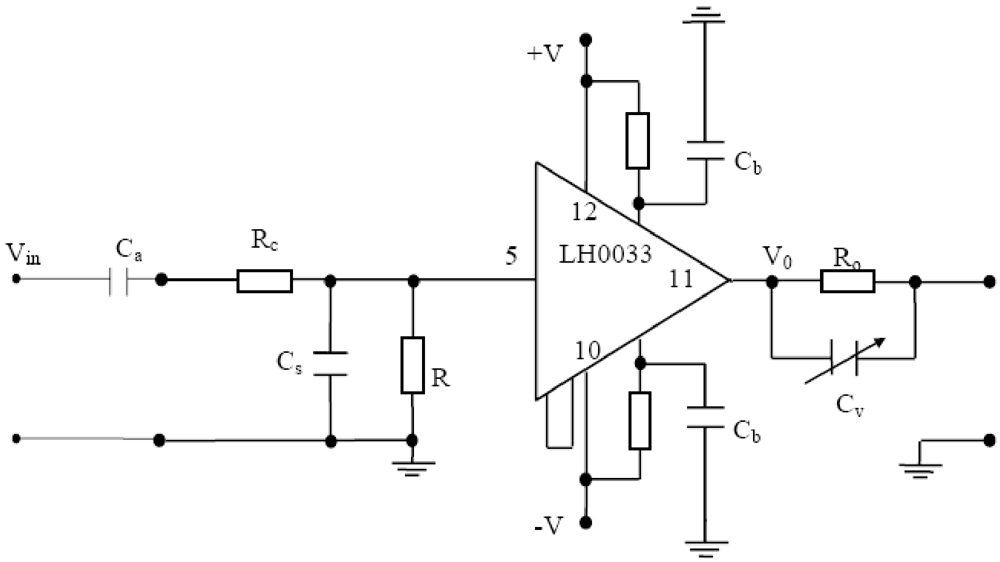
In order to verify the characteristics of static and dynamic environmental electric field variations during thunderstorms that were described in Chapter 2, some field measurements were taken. The apparatus used to observe electric field variation and the observations made will be discussed in this chapter.

3.1 Apparatus Used

A flat plate antenna of which the capacitance to ground 58 pF and the physical height 1.88 m was used to sense the vertical electric field. The antenna was fed to a Digital Storage Oscilloscope (DSO) through a buffer amplifier (an operational amplifier and RC circuit which acts as an active integrator). Then the DSO was connected to a personal computer to upload the data. Diagram of the apparatus and the schematic of the buffer amplifier are shown in Figure 3.1.



(a)



(b)

Figure 3.1 – (a) Diagram of the apparatus (b) Schematic of the buffer amplifier [17].

The decay time constant of the antenna system is determined by the product *R(Ca+Cs)*. The expression for the output voltage is given by equation 3.1 [17] as,

$$V_{in}(s) = V_o(s)\,\frac{C_s}{C_s + C_a}\,\frac{s}{s + \dfrac{1}{R(C_a + C_s)}} \qquad \textbf{(3.1)}$$

where $V_{in}(s) = E(s)\, h_{eff}$

$s = j\omega$

$V_{in}(s)$: The induced voltage in the flat plate antenna (in Laplace domain)

$E(s)$: Electric field in the absence of the antenna (in Laplace domain)

h_{eff} : Effective height of the antenna

$V_o(s)$: The output voltage of the amplifier (in Laplace domain)

C_a : Antenna capacitance

C_s : Parallel capacitance connected to the amplifier

R : Parallel resistance connected to the amplifier

In order to measure the electric field without distortion, $1/R(C_s+C_a) << |s|$ or in other words, the decay time constant of the system, $R(C_s+C_a) >> \tau$, where τ is the slowest time component of the signal to be measured.

Two time constant values were used to measure dynamic field variation and static field variation. Time constant was set to 20ms for measuring dynamic field variations and it was set to 1min to measure static field variations.

The apparatus was placed within the premises of the University of Moratuwa, close to the Department of Electronic & Telecommunication Engineering. Some observations made will be discussed in the next section.

3.2 Observations of the Field Measurements

In the section some of the observations made in the field study will be discussed.

3.2.1 Static Electric Field Variation

Environmental static electric field showed almost no change and had a low value under fair weather conditions. An observation made on static electric field is shown in Figure 3.2.

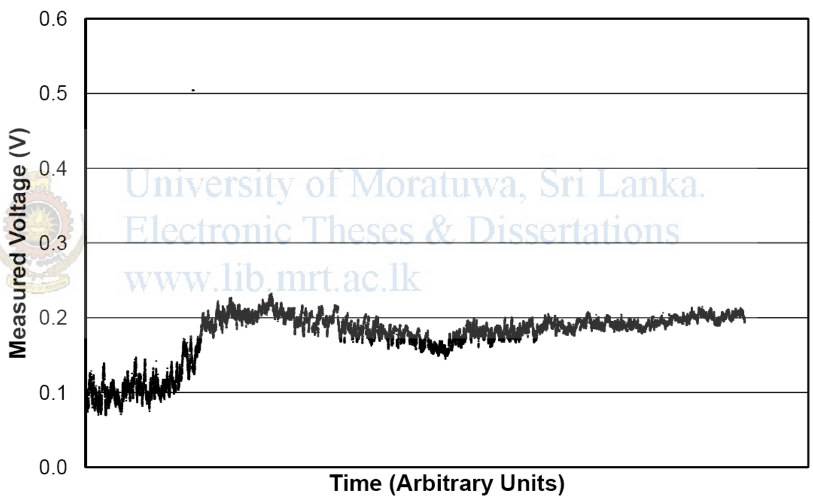


Figure 3.2 – Static field variation observed on 10th August 2004.

Environmental static electric field showed extremely high values before thunderstorms and during thunderstorms. A typical observation is shown in Figure 3.3 with the starting time of lightning (by visual observation).

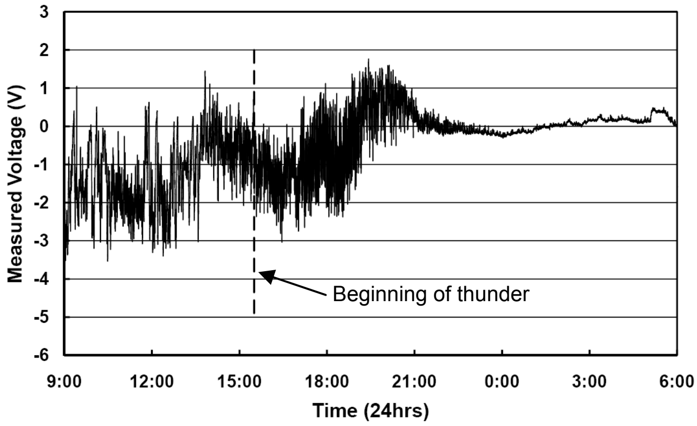


Figure 3.3 – Static field variation observed on 22nd October 2004.

3.2.2 Dynamic Electric Field Variation

Some of the transient voltages observed during a thunderstorm are shown in Figure 3.4.

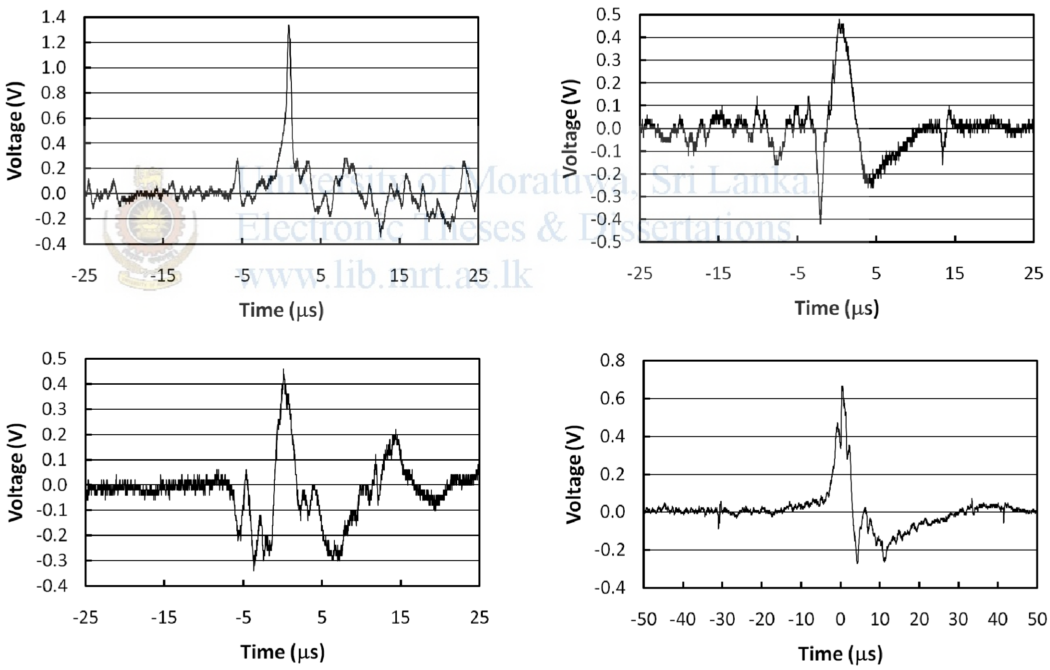
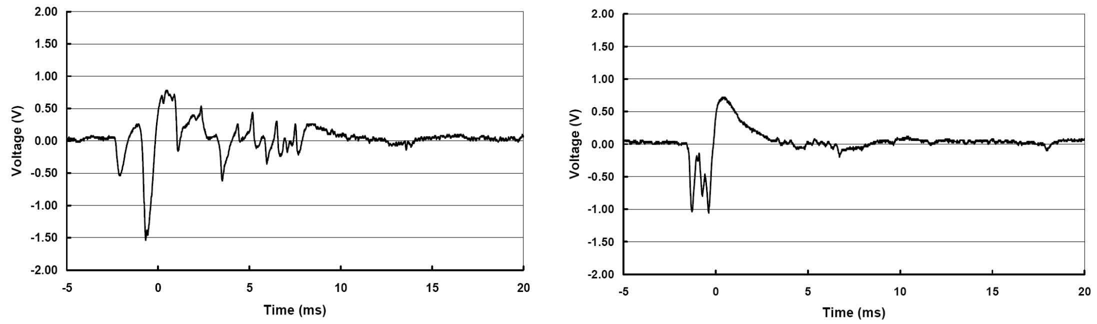


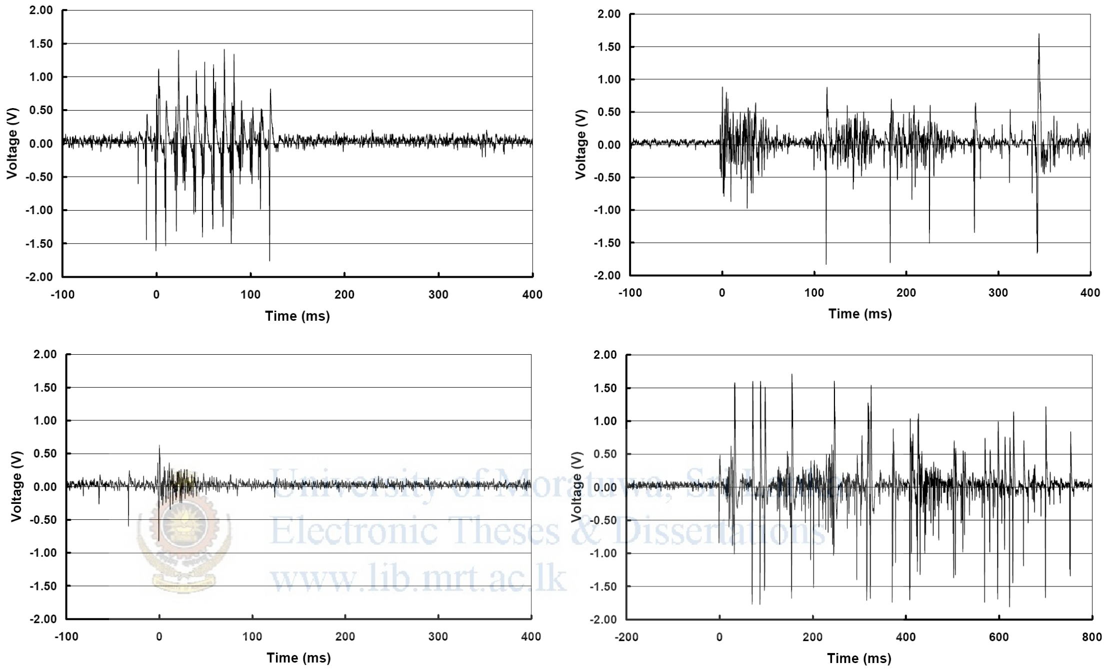
Figure 3.4 – Transient voltages observed during four different lightning strokes.

3.2.3 Radio Frequency Noise

A crackle can be heard on an AM receiver with each and every lightning stroke. Switching transients are also observed as crackles but in a shorter period of time with respect to the time period of a crackle due to lightning strokes. Figure 3.5 shows waveform of crackle received due to a lightning stroke and waveform of crackle received due to a switching transient.



(a)



(b)

Figure 3.5 – (a) Some waveforms of crackle due to switching transient

(b) Some waveforms of crackle due to lightning.