CHAPTER 4

DESIGN OF THE NEW LIGHTNING WARNING SYSTEM

In designing the lightning warning system, some observations and information from literature study were taken in to consideration. They are namely:

1. Crackle detected on an AM receiver
2. Rate of lightning strokes has a minimum of about one stroke per minute
3. Static electric field varies from about $100Vm^{-1}$ during fair weather conditions to about $10kVm^{-1}$ during a thunderstorm

Key aim of the design is to minimize the cost of the warning system as far as possible while keeping the level of protection up to the standard. A brief block diagram of the warning system is shown in Figure 4.1, which will be discussed in detail later in this chapter.

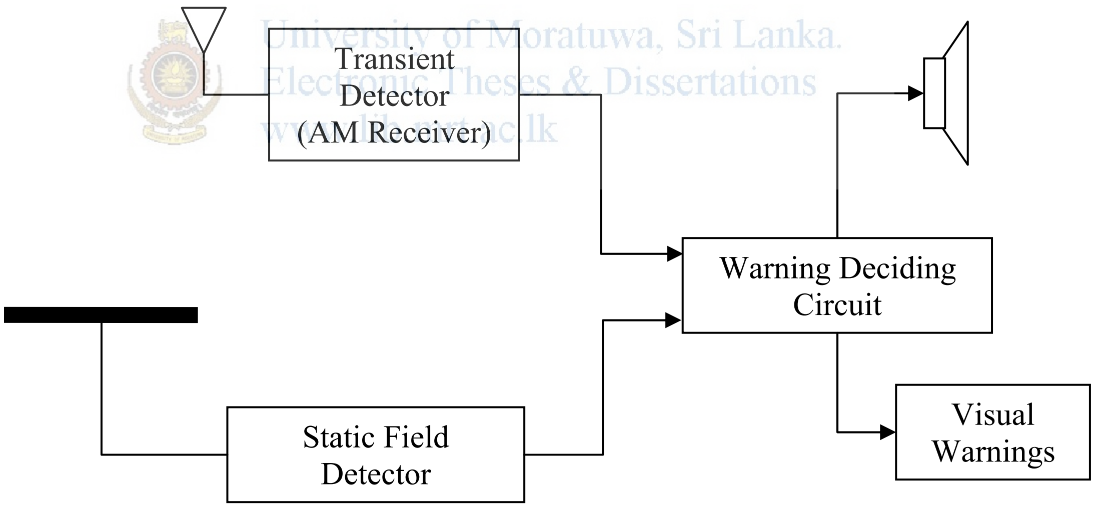

Figure 4.1 – Block diagram of the lightning warning system.

4.1 Transient Detector

An AM receiver is used to detect the transients due to lightning as it should not be exposed to direct lightning hence the risk is a minimum. A proper high amplitude noise (crackle) can be detected at the output of the AM receiver. The frequency of reception was selected to be close to 1600 kHz as the average noise around 1600 kHz was found to be less compared to other ranges according to observations made in the present study. Also the amount of radio noise emitted is higher in the range 300 kHz to 30 MHz according to literature.

One drawback of using an AM receiver to detect lightning transients is that it also detects switching transients. To eliminate detecting switching transients to a great extend, two methods were employed. They are:

1. Using a slower response so that switching transients that has a shorter period compared to transients due to lightning can be eliminated
2. Output of the transient detector is triggered only if at least two transients are detected in two minutes period (effectively at least one stroke per minute)

Block diagram of the transient detector is shown in Figure 4.2.

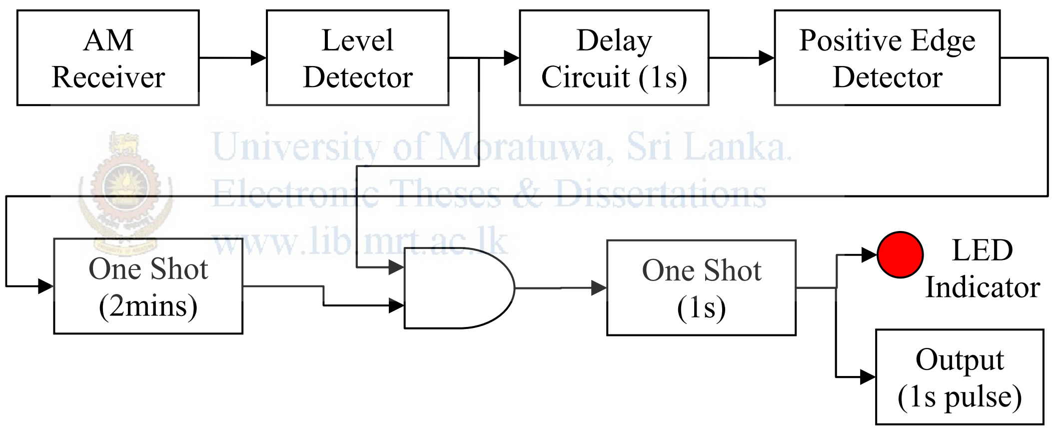

Figure 4.2 – Block diagram of the transient detector.

An advantage of the transient detector developed in the present work is that it, itself, can be used as a stand alone lightning warning device. It is designed to operate using four AA sized rechargeable batteries so that it can also be used as a hand held device. Once the batteries are fully charged, the device can be used for about two days. The device is functional even while charging batteries. When the transient detector is connected with the other units, it does not need batteries and it can be powered from the main supply. An explanation on the operation of the transient detector is given in the following sections. A photograph of the transient detector is shown in Figure 4.3.

Figure 4.3 – Transient detector.

4.1.1 AM Receiver

This is an ordinary AM receiver which is an envelope detector tuned to a frequency around 1600 kHz. Response time of the output circuitry of the receiver has increased by putting a high value capacitor to its output to eliminate responding to switching transients.

4.1.2 Level Detector

Level detector is used for noise cancellation. It triggers the rest of the circuit if the output of the AM receiver increases beyond the set value. Reducing the set value will increase the false alarm probability while increasing it, will reduce the detectability of transients.

4.1.3 Warning Indicator Circuit

The rest of the circuit is designed in such a way that when more than two transients are detected within two minutes (effectively more than one lightning stroke per minute), 1s pulse is released at the output. LED also goes “ON” during that period. Output will not trigger if the number of lightning strokes per minute is less than one because of the 1s delay circuit and 2min one-shot. Also, it will not trigger for a single stroke because of the 1s delay circuit.

4.2 Static Electric Field Detector

The static field detector consists of a charge sense antenna, a 60 Hz notch filter, a self-zeroing integrator, a signal limiter and a zero adjustment.

The charge-sense antenna is a large plate antenna. The charge induced on the plate antenna is then sent to the self-zeroing integrator through a 60Hz notch filter which filters off any noise induced on the plate from ac main supply. The circuit works with a 12V single supply. The front end of the circuit, the notch filter, is biased at 6V instead of 0V so that the output, when no high charge is present, will be close to 6V. The integrator has a very slow response time and hence it does not response to fast change of charges. The zero adjustment can be used to adjust the output back to 6V if there are any changes due to leakage. Sensitivity of the device can be increased by increasing the size of the charge-sense antenna.

The static field detector should be kept in a place which is not directly exposed to lightning to reduce the risk of getting struck by lightning. At the same time, it should not be kept in a well shielded place so that the change of static field will not be detected. A large opening, like a large window, a balcony or an open veranda would be an ideal place to keep the unit. It should be mentioned that the charge-sense antenna should not be touching anything. Also it should not be wet; otherwise, the charge induced on the antenna would be discharged to earth.

A picture of the static field detector is shown in Figure 4.4. Some readings taken using the static field detector are discussed in the following section.

(a) (b)

Figure 4.4 – (a) Static electric field detector (b) A proper placement of the static field detector.

4.3 Warning Deciding Circuit

Warning deciding circuit is the rear end of the warning system. This circuit derives the final warnings. The warning is released in three levels.

- If and only if the output of the static field detector goes away from its normal value, *i.e.* 6V, more than a certain amount, then the Green LED goes ON for 30 seconds. This alarm informs people that there is a possibility of a thunderstorm in few hours time.
- If the output of the static field detector goes away from its normal value, *i.e.* 6V, more than a certain amount, and the transient detector detects EM bursts at a rate greater that 2 bursts per minute then the Yellow LED goes ON with an audible alarm at the same time for 30 seconds. This alarm informs people that there is a possibility of a thunderstorm in about 20 minutes time.
- If the output of the static field detector goes away from its normal value, *i.e.* 6V, more than a certain amount, and the transient detector detects EM bursts at a rate greater that 5 bursts per minute then the Red LED goes ON with an audible alarm at the same time for 30 seconds. This alarm informs people that the thunderstorm is active and they should take precautionary action immediately.

The block diagram of the decision making circuit is shown in Figure 4.5.

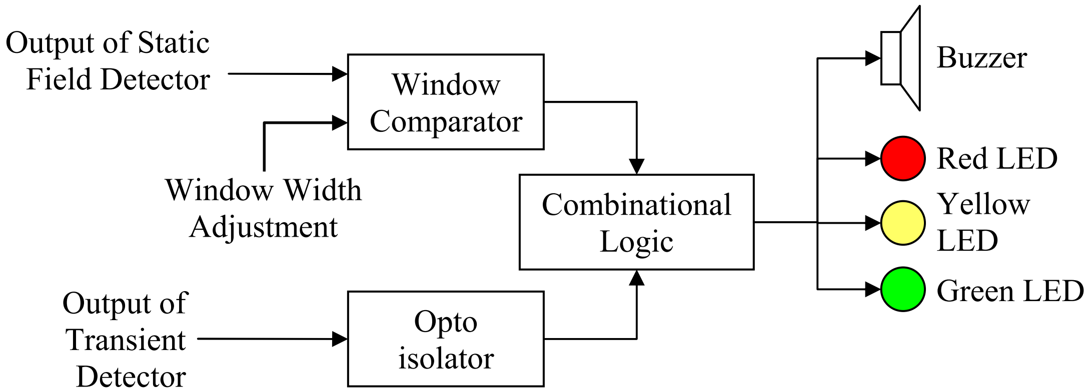

Figure 4.5 – Block diagram of the warning deciding circuit.

By the "Window Width Adjustment", an upper voltage and a lower voltage can be set such that when the output voltage of the static field detector goes beyond the upper voltage or when it goes below the lower voltage, the output of the widow comparator will be high. This adjustment helps to tune the system to suit the place in which it is located. The warning deciding circuit and the main power supply are implanted in the same unit and a photograph of it is shown in Figure 4.6.

Figure 4.6 – Unit containing warning deciding circuit and main power supply.