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A transistorized lightning stroke counter

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ABSTRACT. A battery powered transistorized lightning stroke counter which can record lightning strokes to ground was developed. This counter is sensitive to positive pulses within a frequency band of 100 to 2500 Hz and has threshhold levels from 10-100 volts which can be set by an attenuator. The minimum duration between successive pulses which can be counted is 0·5 sec. It weighs about 4 kg and its dimensions are 150 mm × 150 mm × 175 mm.

1. Introduction

Lightning strokes, in particular, ground strokes are of great interest to power system engineers, because of the transient over-voltages they produce on power systems. Collection of data regarding the frequency of occurrence of ground strokes in any given area is of utmost importance for economic design of transmission lines and other equipment

The requirements of a lightning stroke counter are — (1) The counter must be simple in circuitry and operation so as to minimize cost and maintenance; (2) The counter must be inexpensive so that a reasonably large number can be installed to collect significant data over a wide area in a relatively short time; (3) The counter installation must be independent of an external power supply; (4) It must count the strokes to earth within a certain definite area and (5) It must be possible to regulate or alter the range, for example 10 to 15 km corresponding to the audibility of lightning or 45 to 50 km in order to be able to obtain mean value over a large area.

2. Present state

Several types of counters are available for recording of lightning flashes (*see* Ref.). However, these do not discriminate between cloud to cloud and cloud to ground strokes, but record all the strokes in the range of the counter. The well known and commonly used counter for registering of majority of ground strokes is the ERA counter (Golde 1966) which uses a cold cathode thyratron. The power supply is 180 volts taken from batteries. But the cold cathode thyratrons and high voltage batteries are not as yet manufactured in India, and are also very expensive.

Barham (1965) has also designed a transistorized counter. The special feature of the circuit is a 3-volt mercury battery used as a reference voltage in the first transistor circuit. The sensitivity is fixed at 5 V/m and cannot be varied. The circuit used is more complicated.

3. The new lightning stroke counter

Fig. 1 gives the block diagram of the lightning stroke counter. The change in the field intensity due to the lightning stroke induces a voltage pulse in the aerial which is fed to the counter. The pulse passes through a band pass filter with the pass band in the range of 100 to 2500 Hz between 3 db points. The filter with the low pass band is used to provide the discrimination between cloud to cloud and cloud to ground strokes. The output from the filter passes through an attenuator and drives a monostable multivibrator which gives a rectangular pulse of a certain duration. The output of the multivibrator drives a counter driver. The counter is of electromechanical type and registers one count for each pulse from the multivibrator.

4. Circuit description

Realization of the required characteristics with low power consumption and good temperature stability are the factors considered most important in the circuit design. A brief discription of the different stages is given in the following paragraphs. The circuit diagram is given in Fig. 2.

4.1. *Filter Circuit* — The filter circuit consists of a resistence-capacitance filter with a pass-band from 100 to 2500 Hz. The filter is terminated by a potentiometer which is used as an attenuator of the pulse passing to the next stage. Setting of this potentiometer determines the sensitivity of the counter.

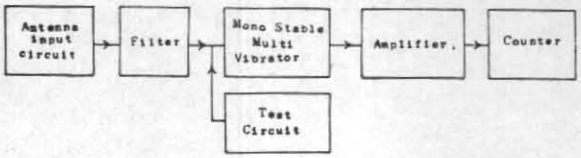

Fig. 1. Block diagram of the lightning stroke counter

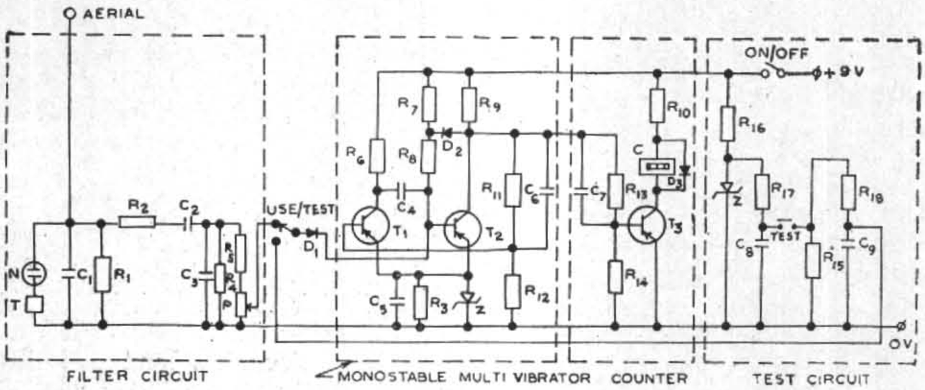

Fig. 2. Lightning Counter Circuit

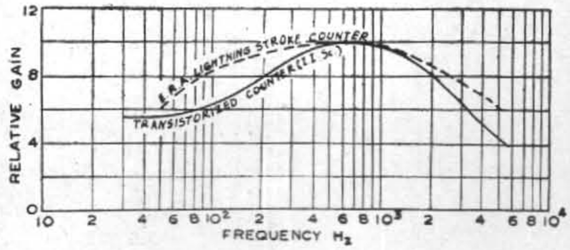

Fig. 3. Filter characteristics

4.2. *Multivibrator* — A conventional emitter coupled monostable multivibrator has been used to generate a rectangular pulse of 0·5 second duration whenever a short pulse due to a lightning stroke appears at the aerial terminal. The period of the pulse output of the multivibrator is chosen so that the counter will definitely operate in this period, and also the period is large enough so that multiple strokes are counted as one stroke. Bruce (1941) has given the statistical results of multiple strokes collected by various investigators where it is seen that the time interval between multiple strokes for 98 per cent of the strokes is 0·5 sec. The duration of 0·5 sec was also found to be sufficient for reliable operation of the counter near the end of life of the battery. Hence, a pulse duration of 0·5 sec is chosen. A zener reference bias is used between the emitter junction of the transistors to ground so that for 10 per cent change in battery voltage the emitter junction voltage will remain unaltered. This will ensure the stability of the calibration. The output of the monostable multivibrator drives the counter amplifier which energizes the electro-mechanical relay and registers a count for every pulse due to a lightning stroke.

4.3. *Test Circuit* — The test circuit consists of resistances and capacitances connected so that when the push button S_2 is pressed a condenser discharges into an R-C circuit thus generating a positive pulse. This pulse when applied to the base of the normally conducting transistor, (T_2 of Fig. 2) causes the multivibrator to operate. The working of the instrument can thus be checked.

5. Characteristic of the counter

5.1. *Sensitivity* — The sensitivity of the counter is defined as the field strength in volts per metre that actuates the counter. This field strength is the voltage required at the aerial to actuate the counter divided by the height of the aerial in metres. The sensitivity is adjustable in the range of 2-20 V/m. A sensitivity of 5 V/m recommended by CIGRE (Muller-Hillebrand — *See* Ref.) is used for measurement of lightning strokes in the field.

The sensitivity calibration is done by the method suggested in Chan's (1967) report using low voltage impulses. The amplitude of the output of the calibrating pulse generator equals the product of the sensitivity of the counter in V/m and the aerial height in metres. To calibrate the instrument for any sensitivity, pulses of corresponding magnitude are applied with the sensitivity control advanced fully clockwise and backed off in gradual steps. A certain critical setting is found such that the counter operates reliably for each impulse. This setting gives the calibration for the sensitivity, X V/m. This is repeated to obtain various calibration points in the range of 2-20 V/m.

5.2. *Range of the counter* — In view of the amplitude variations of the lightning strokes the range of the counter must be defined somewhat arbitrarily in statistical terms. Horner (1960) has defined the effective range of the counter as the range within which the actual number of strokes occurring to ground over a long period is equal to the number counted. The range of the counter depends on the sensitivity setting of the counter. For a counter with 25 V/m sensitivity the counting range is tentatively determined as 11-12·5 km by Muller-Hillebrand (1960).

5.3. *Spurious response* — A lightning stroke counter is subjected to spurious response, because of the statistical nature of the occurrence of lightning storkes in its intensity and occurrence of intense strokes between clouds in the vicinity of the counter station can actuate the counter, and a few weak strokes to ground near the extreme values of the range of the counter can be missed. Spurious response is reduced in this counter by the provision of the sharp cut-off filter. Another problem is the run away of the counter. When the ambient temperature is high the counter may oscillate and may give a high value of reading even when there are no thunderstorms. The attendant of the counter station should notice all such discripencies and get the counter checked.

6. Conclusion

By and large, the transistorized counter answers most of the requirements set down earlier and is particularly suited to Indian conditions.

This type of counter has been in use at this Institute for about three years and has given satisfactory performance. Plans are underway to produce the counters in large numbers to meet the demand of the various regional electricity boards in India.

Acknowledgement

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