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IMPROVED SENSITIVITY IN GROUNDING SEARCH SYSTEM USING TV SIGNAL FOR PHASE REFERENCE

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ABSTRACT: Grounding search systems need improved sensitivity to search more effectively for grounding routes. The proposed method changes the phase reference signal source from the search signal to a TV signal. A minimum signal level of 17 dBuV at the antenna terminal is needed to obtain the phase reference. Experimentation using the new system demonstrated an improvement of 40 dB in the minimum detectable level , and the phase measurement deviation improved from ±18 degrees to ±8 degrees.

1. INTRODUCTION

Grounding systems are necessary to protect equipment in buildings from electromagnetic noise such as lightning surges and over-voltage caused by AC power lines. A particularly strong relation exists between appropriate grounding system design and reduced incidence of malfunctions from these noises. IEC and ITU-T have published specifications governing grounding systems for effective protection of equipment[1],[2]. A grounding system that uses a ground riser has been applied to a telecommunications building[3].

However, applying these grounding systems to actual buildings is difficult, because buildings do not usually contain grounding wires and no data exist on grounding routes.

We had previously developed agrounding route search system for more efficient building protection [4]. This system uses both the amplitude and the phase data of the search signal to search for a route. It obtains the phase reference from the phase reference signal, which is overlapped with, and has a higher frequency than the search signal. The sensitivity of the system is limited by the level at which the phase reference signal can be detected, which depends on the difference in frequency between the search signal and the phase reference signal. We focused on studying these values for their importance in improving searching efficiency.

Here, we propose a new system for seeking grounding routes that improves the sensitivity and accuracy of phase measurement. The signal for the phase reference, the configuration of the system, the results of measuring the sensitivity, and the accuracy of the phase measurement are also described.

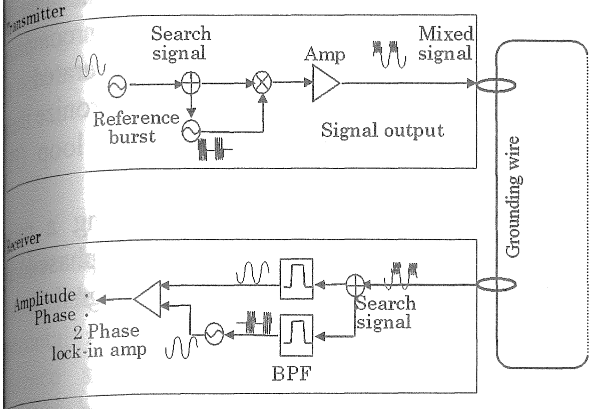

Fig. 1 Block diagram of our previous grounding route search system

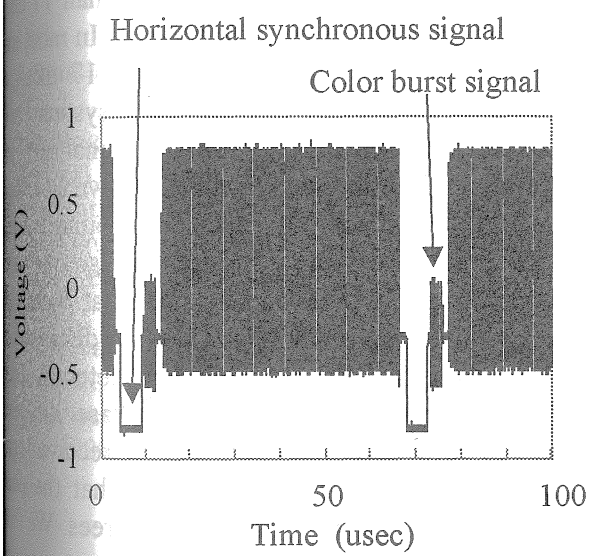

Fig. 2 NTSC signal

Table 1 Measurement of TV signal

Place	Terminal Voltage (dBuV)
A Open air	64
B Inside room near window	47
C Inside room 1	35
D Inside room 2	27
E Under ground room 1	25
F Under ground room 2	22

2. SIGNAL FOR PHASE SEARCH

Figure 1 is a block diagram of our previously developed system [4]. The phase reference signal, which uses a burst waveform, is overlapped with the search signal. The signals are separated by a band filter (BPF) and the phase reference signal is generated from the burst signal. To ensure sufficiently high sensitivity, the search signal is detected using a lock-in amplifier. However, the lock-in amplifier cannot be used to detect the phase reference. The sensitivity of the system is limited to the phase reference level that can be detected.

We investigated new phase reference sources, apart from the search signal, to improve its sensitivity. We examined four sources -- the AC mains wave, TV signal, Ground Positioning System (GPS) wave, and Long Range Navigation (LORAN) wave -- for possible application to the system. The phase of the AC mains wave changes according to the type of load, and the GPS and LORAN waves cannot detect signals within a building. Therefore we selected the TV signal for phase reference because it can be detected in most areas of a building.

Table 1 presents the results of measuring the TV signal. A dipole antenna was used as the receiving antenna of the system, and the output terminal level of the antenna was measured for the six environments listed. The level detected was higher than 22 dBuV.

Figure 2 depicts the NTSC signal waveform. For the phase reference signal we used a horizontal synchronous TV signal with a frequency of 15.7345264 kHz and a permissible deviation within 0.003% .

3. CONFIGURATION

A block diagram of the new grounding route search system is shown in Fig. 3. The received TV signal was amplified and detected by the TV receiver. The horizontal synchronous signal was separated from the base-band TV signal using a low pass filter (LPF) its a

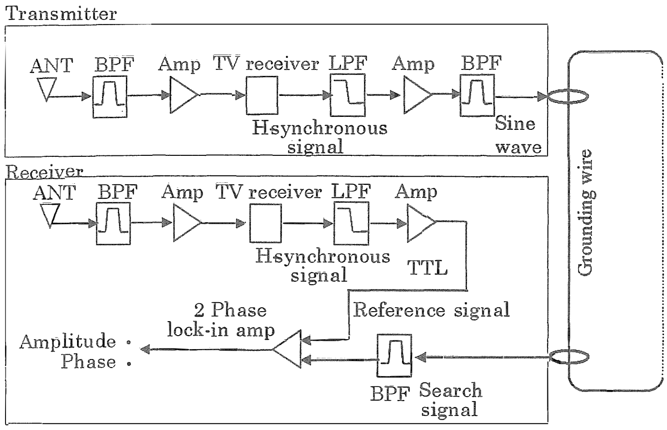

Fig. 3 Block diagram of the proposed system.

Table. 2 Relation between TV signal and generation of reference signal.

Input voltage (dBuV)	Reference signal
37.7	○
26.9	○
16.8	○
6.00	×
-3.83	×

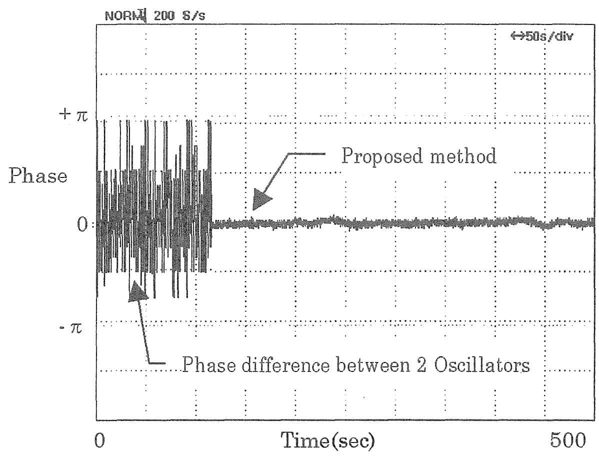

Fig. 4 Phase Deviation.

cut-off frequency of 40 kHz. The LPF was used to reduce the phase deviation caused by the filter. The reference signal was generated using a comparator and a TTL type reference signal was generated.

A search signal was generated to synchronize the the reference signal, using a phased-lock loop (PLL) circuit with a crystal oscillator.

The search signal was detected using a narrow band pass filter (BPF) and two-phase-lock-in amplifiers synchronizing the reference signal.

4. PERFORMANCE

We fabricated the new grounding route search system and evaluated its performance.

The relationship between the antenna termination voltage and the output of reference signal is summarized in Table 2. A level higher than 17 dBuV was needed to obtain a reference signal. In most areas the level of the TV wave was above 17 dBuV, as shown in Table 1. This means that the system can be used in most areas, because the TV signal level was sufficiently higher than this level, as shown in Table 1.

A deviation in phase difference was found between the source and the receive signal. The source signal was injected into a cable and measured at point 10 m away. The level of the TV signal was 26 dBuV for the signal generator and 47 dBuV for the detector. These results are shown in Fig. 4. The phase difference between the source signal and the receive signal was less than 8 degrees. This means that the phase difference improved from 36 to 16 degrees. We think that the phase difference in this system may be generated by the TV receiver, because many non-linear devices and BPFs are used in this receiver.

The sensitivity of the system was measured using the experimental setup shown in Fig. 5. A white noise of 200 Hz to 40 kHz and the search signal were applied directly to the receiving unit of the system. In the experiment, the level of white noise was 64 dBuV at 1 kHz. We changed the ratio of the search signal to the noise level. The measurement results are shown in Fig. 6. The system reported in Ref. 4 is used for comparison. For that system, the search signal should exceed the noise level by more than 15 dB. The proposed system, however, was able to detect a search signal at levels below 25 dB. This means that the new system improved the sensitivity by about 40 dB.

5. CONCLUSION

We have developed a new grounding route search system with improved sensitivity and precision. A TV horizontal synchronous signal is used as the new reference signal. The new system improves the sensitivity by 40 dB and reduces the phase detection error from 36 down to 16 degrees.

In future work we hope to reduce the phase detection error still more.

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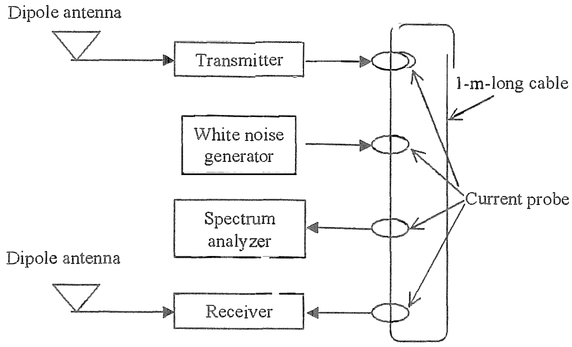

Fig. 5 Measurement setup.