Design of the Ground Resistance Measuring System to the Earth-Noise

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ABSTRACT

Generally, grounding systems are responsible for the safe operation of a power system. Their performance guarantees equipment protection and personnel safety under condition of the limited ground potential rise and touch voltages as well as step voltages under ground fault conditions. Therefore, it is necessary to measure the ground resistance frequently for checking the performance of grounding system,

In this paper the ground resistance measuring system using digital signal processor and high-performance L-C resonant band pass filter is presented. The signal current magnitude for measuring ground resistance in this system is 10^{-1} [A] to 5×10^{-2} [A] and the current frequency is 30[Hz].

1. INTRODUCTION

Using of the power semiconductor applications aggravate to the power environment of power system. The communication applications and power electronic equipment request high quality power, but generate harmonics and noise. Because of these harmonic and noise, recent power environment become worse. This change of environment affect the power system, air and earth. Also each electronic application operated wrong and lessened the life.

Therefore, recent power system demand substitution technique. Especially, the grounding electric pole of power system corroded better than others power system for the reason of earth fault. Recently, automation system need the reliable ground ability and the maintenance of ground system.

But until now, the ground resistance measurement is gave a lookover.

The caustic of grounding electric pole result in ground ability damage, breakage of power system equipment and damage to person by the overvoltage. Grounding system of a generating station or a substation is designed with the prime objective of providing safety to personnel during an earth fault. Therefore, the grounding system need development and maintainment.

Generally, the design and ability analysis are calculated by conventional equation and software from physical condition of system. frequently, the calculated result of complex ground system can be a great error, thus must measure the ground resistance directly.

Therefore, the main purpose of this paper is exactly measurement and analysis of the earth-noise in the power system, and have objection to design new insensitive ground resistance measuring system to the earth-noise

2. Ground Resistance and The Noise of Earth

The definition of ground resistance is the DC ground resistance or ground resistance by high frequency current, steady-state ground resistance. The character of ground electric pole is ground resistance and ground impedance. The ground resistance of DC or low frequency band consist of ground wire, resistance of ground electric pole, surface of pole, resistance between pole-earth, resistance earth around pole.

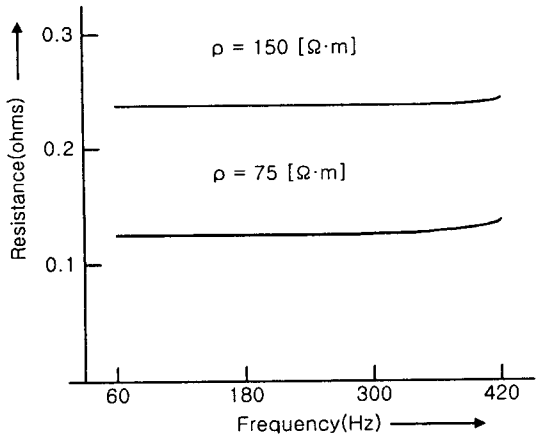


Fig. 1 Resistance vs. frequency of a 400[m]×400[m] ground mat

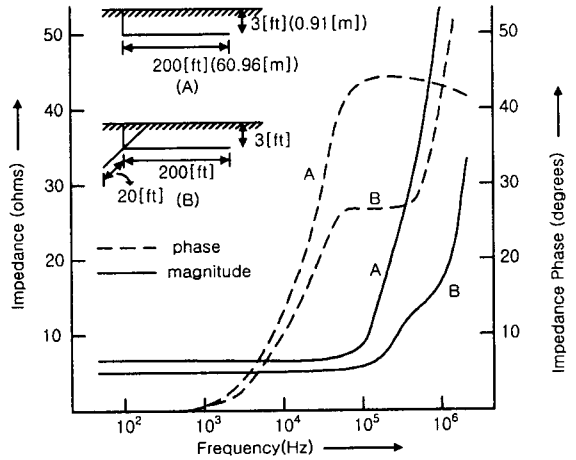


Fig. 2 Impedance vs. frequency of systems A and B

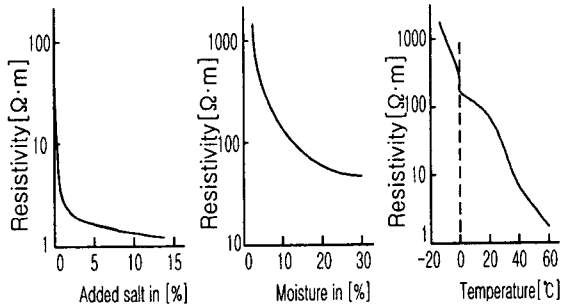


Fig. 3 Earth resistivity variations

(a) Salt (b) Moisture (c) Temperature

3. Design of Ground Resistance Measuring System

Figure 4 is the diagram of ground resistance measuring system to design. This system consists of CPU of DSP, current supply to the current contribution(C1, C2), current sensor, voltage sensor and interface.

Current supply is equipment to send signal current in the earth. In this system, If the measured signal current is large, to be convinced detection of measuring signal in the earth-noise. But the equipment become bigger. Therefore measuring signal current is used small-current, this system is designed several ten mA~several hundred mA.

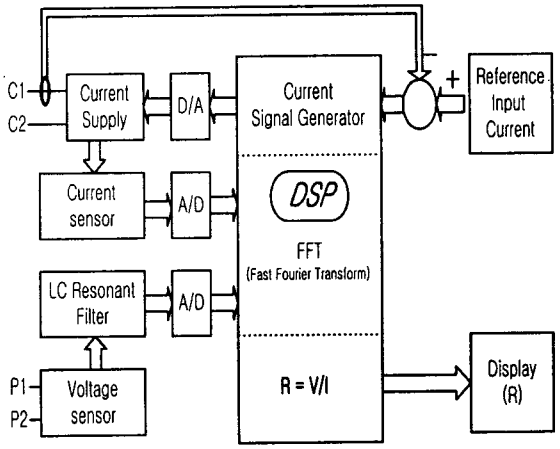


Fig. 4 The Block diagram of ground resistance measuring system

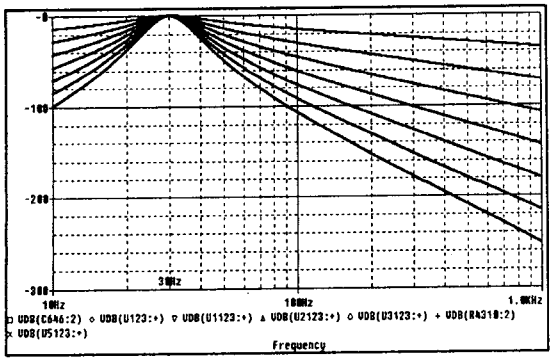
4. Design of Filter Circuit

4.1 Gain Character of Filter System

The gain character of filter system connected buffer have nature to find a total each unit filter character. Fig. 5 show gain of this filer system. The reduced scale is about 9.5, the case connected the 7-step the reduced scale is 67.0 dB. This filter ability is satisfied with condition.

The connected to 7-step bandwidth filter that has 30 [Hz] resonant frequency is satisfied with result that has the reduced sale 60 dB to the 60 [Hz].

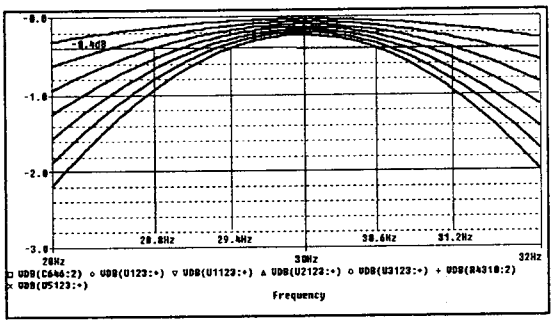
In this paper, we design the 7-step filter to consider the worst condition that the reduced scale is about 60 dB.



Attenuation[dB]							
Step	BP(1)	BP(2)	BP(3)	BP(4)	BP(5)	BP(6)	BP(7)
60[Hz]	-9.5	-19.05	-28.58	-38.10	-47.63	-57.15	-67.0
180[Hz]	-21	-42	-63	-83	-104	-125	-146
300[Hz]	-25	-51	-76	-101	-127	-153	-178
420[Hz]	-28	-57	-85	-113	-142	-170	-198

Fig. 5 The attenuation characteristic of cascaded type (LC resonant band pass filter with the buffer)

Fig. 6 shows bandwidth of filter system and the reduced character of resonant frequency.



Attenuation[dB]					
Frequency / Measuring point	29	29.5	30	30.5	31
Step 1	-0.10	-0.05	-0.03	-0.05	-0.10
Step 2	-0.20	-0.10	-0.07	-0.10	-0.20
Step 3	-0.30	-0.15	-0.10	-0.15	-0.30
Step 4	-0.41	-0.20	-0.13	-0.20	-0.40
Step 5	-0.51	-0.25	-0.17	-0.26	-0.50
Step 6	-0.61	-0.30	-0.20	-0.31	-0.60
Step 7	-0.71	-0.35	-0.23	-0.36	-0.71

Fig. 6 The attenuation characteristic of cascaded type (LC resonant band pass filter with the buffer)

4.2 Experimental Result

Table 1 shows measuring result of reduced scale to the 60[Hz] in each step of filter system that used to add 7-step LC resonant bandwidth filter circuit of the same character. Table 1 shows result of simulation and hardware system. The simulation result is 67 dB in the last step but hardware system result is about 62 dB for error of the electric parts.

Fig. 7 show real hardware system by LC resonant bandwidth filter (resonant frequency = 30 [Hz]) that added 7-step. It shows the reduced character of the last step (Input signal 20.6[V], Output signal 16.5[mV] - reduced scale is 61.9 dB)

Table 1 The attenuation characteristic classified by BPs at the cascaded filter system (at 60[Hz])

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Simulation	-9.5dB	-19.1dB	-28.6dB	-38.1dB	-47.6dB	-57.2dB	-67.0dB
Actual circuit	-9.1dB	-18.0dB	-26.9dB	-35.9dB	-43.7dB	-53.0dB	-61.9dB

Fig. 8 represents the reduced character to the last step (Input signal 2.08[V], Output signal 2.01[V]), reduced scale is about 3.3[%]. But this reduced scale can be decreased by the control equipment of ground measuring system.

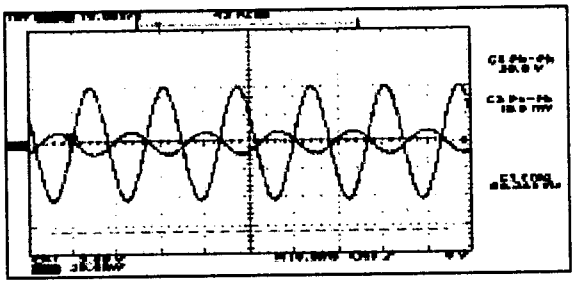


Fig. 7 The attenuation characteristic of proposed filter circuit (7step) at 60[Hz]

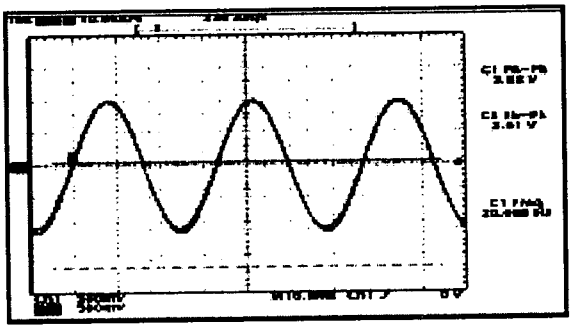


Fig. 8 The attenuation characteristic of proposed filter circuit (7step) at 30Hz

5. CONCLUSION

In this paper the ground resistance measuring system using digital signal processor and high-performance L-C resonant band pass filter is presented. The signal current magnitude for measuring ground resistance in this system is 10^{-1} [A] to 5×10^{-2} [A] and the current frequency is 30[Hz].

The proposed low signal current has the advantages that the electric facilities on power service do not influenced by this signal current.

Also, it is possible that the proposed ground resistance measuring system is implemented small, because of the low capacity of power supply part. However, this current has a defect that ground potential caused by the current is low. Thus, high performance filter is necessary to detect the low ground potential by the current above and to eliminate the noises in the earth.

Therefore the proposed system is composed of the high performance analog filter and FFT by digital signal processor.

But, the analog filter system required the high performance characteristic, which provides the attenuation characteristic of 60dB within narrow bandwidth to eliminate the noises(60[Hz]) and to detect the original signal(30[Hz]) implied by the proposed system.

Passive or active filters, except LC resonant filter, cannot realize this steep attenuation characteristic of the filter required in this system. However, it is very difficult that the required LC resonant filter with high steep attenuation is implemented because of the problem of selecting the small inductor with correct specifications in this system.

In this connection in order to overcome the problem mentioned above new filter, which has band pass filter characteristic with high steep attenuation, is proposed using GIC(Generalized Impedance Converter) circuit. GIC circuit confirms the significient solution the can offer correct LC resonant filter design method required in this paper specification.

To satisfy the filter specification that attenuation is 60dB between 30[Hz] and 60[Hz], we designed the 7-steps cascaded LC resonant band pass filter that this filter simulated inductor by GIC circuits

The attenuation characteristic of designed cascaded band pass filter is 67dB between 30[Hz] and 60[Hz] by simulation and then take the attenuation characteristic of 62dB at the proposed hardware.

Although the designed LC resonant filter with GIC circuit operates the full efficient performance with respect to measuring the grounding potential, there is difficulty to eleminate the noise perfectly which is very higher amplitude then that of the current signal injected to the earth in designed system.

In the presence of high reliable grounding measurement system, dual methods are adoped. The first one is LC resonant filter with GIC circuit described above. The last is DFT algorithm method operated in digital signal processor. DFT algorithm provids very efficient outputs which are the current signal injected to the earth and the voltage signal caused by ground potential essential to measure the ground resistance.

In order to verify the designed grounding measurement system feasibility, two comparision verifications, which are the ground resistance measurements using the designed system on power service and off power service, are carrid out for the same substaion.

Thc test results of ground resistance are equal values(1.2[Ω]) and for this reason, the insentivity of proposed ground resistance measuring system for noise is verified.

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