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SHORT HISTORY OF EMC TECHNOLOGY APPLIED IN JAPANESE ANTARCTIC RESEARCH EXPEDITION (RESEARCH NOTE)

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On 14 January 1959, two helicopters, as the first flight of the 3rd Japanese Antarctic Research Expedition (JARE), landed at Syowa Station with the aim of attending a geoscientific research for the International Geophysical Year (IGY) after one year uninhabitance. They brought a great sensational news to the world that they found two living dogs without being fed during whole winter in Antarctica.

As a member of this expedition, I started the resumption work for the main power plant of this base. I participated in this party as a geoscientist, as well as an electric engineer. Soon, we set up a new diesel electric generator of 40 kW, 3-phase, 100 and 200 V. After finishing the mechanical set up on the engine mounts, I felt confused how to connect the center of star circuit to a grounding post. Because Syowa Station was built on a rock of very bad conductivity of eastern antarctic pre-Cambrian granuate (granite-gneiss). The rock conductivity in this area was approximately 10^{-6} S/m.

I had to change the circuit connection of generator output from star to delta in order to avoid the grounding problem, but this was just a beginning of a long struggle against very strong EMC (Electromagnetic Compatibility) obstruction in our Antarctic expedition. For example, when the HF communication radio transmitter of 1 kW output was keyed down, or the ionospheric bottom-side sounder (10 kW peak output, sweep frequency range from 0.5 MHz to 17 MHz) was turned on at every 15 min, recording data of high-sensitivity geophysical observation instruments in the base showed very strong electromagnetic interferences in their records under this comletely groundingless condition.

During the whole austral autumn of 1959, I had to work everyday to solve these interference ploblems by trial and error. Finally, we reached a tentative best solution, although several insufficiences still remained. Syowa Station was built on a small island named East Ongul Island. I extended 600 m long and one cm^2 cable from generator hut to the shore and terminated the cable with copper plate of 2 m by 1 m, which was sunk into the sea water after very hard work of thick ice boring. This grounding system is shown as the common mode grounding line in Fig. 1.

I once again changed the generator wiring from delta to star and connected the

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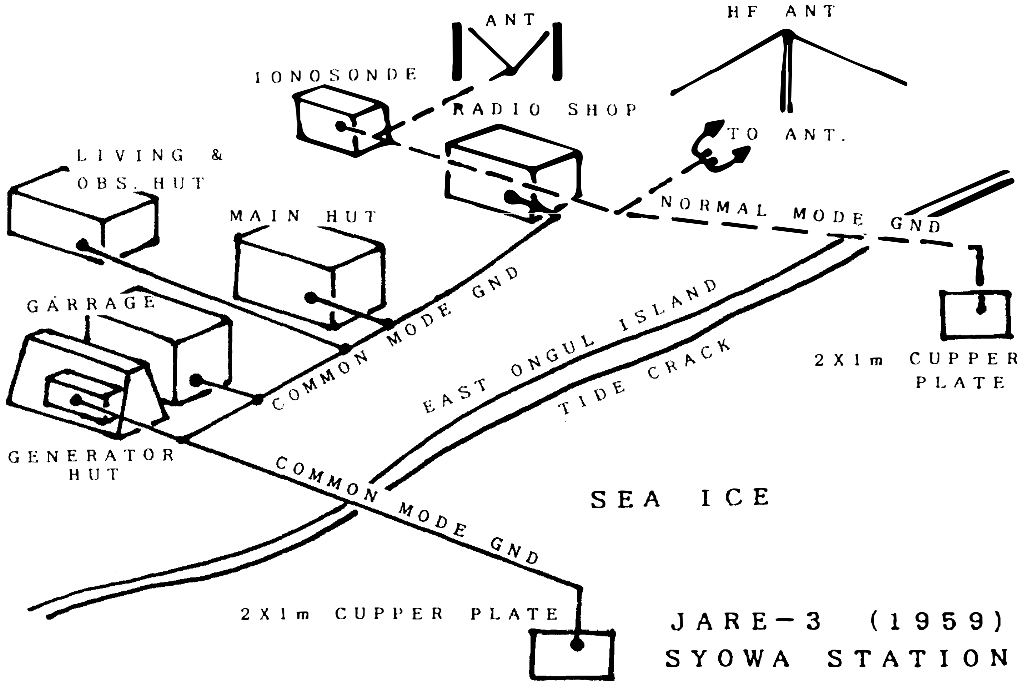

Fig. 1. The electrical grounding system at Syowa Station for JARE-3, in 1959. An example of the separation for Common mode and Normal mode grounding system.

center point of the star circuit to the grounding cable connected to the sea water. This grounding work, however, did not results in dramatic improvement to the interferences caused by radio transmitters. The interference level were reduced by about 6 to 10 dB, but considerable interferences still remained. Next, I extended the grounding cable from the generator hut to the radio communication hut and ionosphere observatory, and connected the ground terminals of the radio transmitter and the ionosonde to the grounding cable. We found that this arrangement gave no improvement to interference occurring in magnetometers and other sensitive instruments.

After many trial-and-error steps, I put a new sea ground plane into another ice-hole, which was separated by 400 m from the common mode grounding point for the power plant, and extended this new grounding cable to new radio hut and ionosphere observatory. Finally, I connected the grounding post of RF antenna circuits to this grounding cable. A dramatic improvement was achieved. Today, this grounding system, which was separated from the common mode grounding line, is called as normal mode grounding line as shown in Fig. 1.

After my work on the grounding problem in the third expedition, later Japanese Antarctic Research Expeditions did not try any further action in the field of EMC technique. In 1976, I returned to Syowa Station as the leader of the 17th Japanese Antarctic Research Expedition, I faced again another new interference problem during the construction of an inland station. We had a plan to extend the upper atmosphere observation network around Syowa Station. As a part of this network, we selected a new observation site located at 300 km southeast of Syowa Station.

We called this as "Mizuho" Station. This site was used as ice boring base since 1973, three years before our arrival.

The Mizuho Station is built on the snow surface of the antarctic ice sheet with a thickness of 2200 m. The electrical characteristics of the ice sheet was as follows:

Dielectric constant: 1.05 at the surface and 3.8–3.95 at the depth of 150 m to bottom of the ice sheet.

Conductivity: 10^{-7} S/m or less.

Inside structure: Polycrystalline with high pressure air cells. This situation is quite similar to the grounding condition in satellites in the space. We set a diesel engine generator in a hole of an ice tunnel. The depth of the hole became deeper and deeper year by year with new snow accumulation.

After rebuilding the base, we must solve two large difficulties. The first one is an unbelievably great natural electrostatic charging and discharging phenomenon. The meteorological condition of Mizuho Station was as follows:

Temperature: $-20°$C in summer and -50 to $-60°$C in winter.

Relative Humidity: 1 to 6% (water vapor) throughout the year.

Wind velocity: Between 10 m/s to 30 m/s from SE.

The noise level of electrostatic charge started and quickly increased to overscale receivers "S" meter and finally made a strong electric discharge sound somewhere like a lightning strike. And the noise level returned to a quiet value, but the level increased again soon thereafter. We found that the noise showed a good synchronization to snow cloud packet drifting. Outside the base, there was always the katabatic wind of 10 to 30 m/s, and very dry tiny snow powders were carried by this wind. Gusty wind brought a mass of snow cloud, producing a large amount of electric charge carried with this gusty wind. Electrostatic noise started to increase with the approaching of a snow cloud and continued to increase during the passing of strong drifting snow mass until a discharging took place like a lightning strike. During the passing of the drifting snow, strong discharges took place several times, and the noise stopped in a short period just after the pass over of snow clouds.

In order to reduce electrostatic charge up, we tried to bury all metallic materials completely under the snow surface. By this method, we obtained a perfectly successful result in decreasing the electrostatic charge noise. If a tiny portion of metallic material was exposed to outside the snow surface, strong electrostatic charging and discharging would come back quickly. So, we buried all metallic materials including HF and riometer antennas under the snow surface, and the all-sky camera and exhaust pipe of the generator are covered by a thick plastic board.

The second difficulty was the ground system in the base. When the key down of radio transmitter (50 W) took place, all the observation equipments and high sensitive electronic facilities went into heavy interferenced conditions. The power cable between the generator and the observation cabines ran beside and across the wall of cabins. All the equipments were connected to this power cable through the capacitive coupling. We connected grounding points of all the equipments and machines with a thick power cable, and this cable was extended about 40 m, where

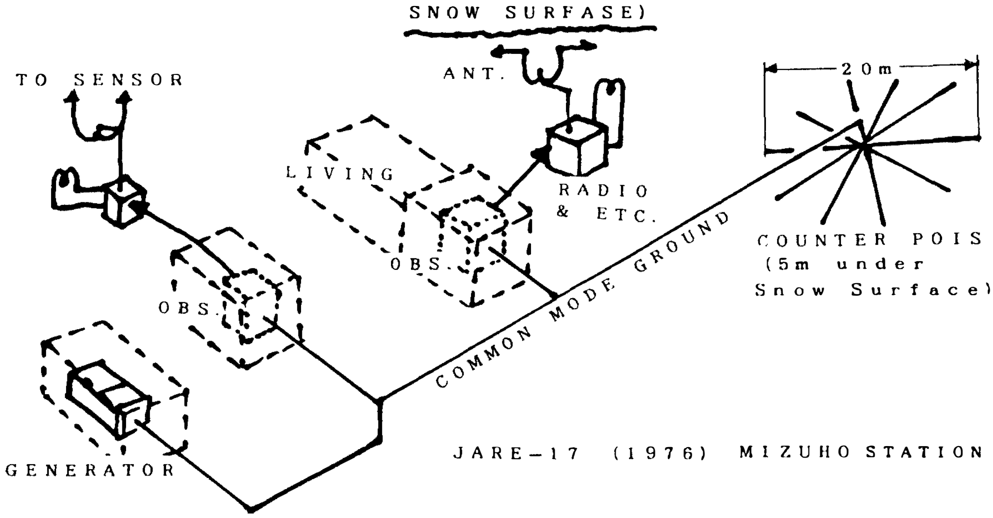

Fig. 2. The electrical grounding system at Mizuho Station for JARE-17, in 1976. An example of a typical grounding system in free space by one point ground.

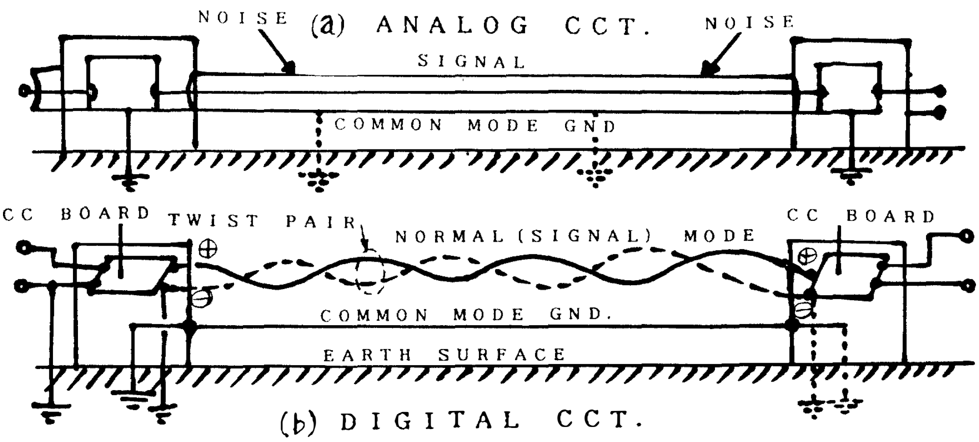

Fig. 3. Modern grounding systems for (a) analog circuits, and for (b) digital circuits.

we built a counter-poise consisted of 20 radial wires of 20 m long. This counter-poise was set at 5 m under the snow surface. After the setting of the counter-poise, we connected common mode grounding cable to the center of the counter-poise as shown in Fig. 2. This counter-poise type grounding system worked perfectly in eliminating all the natural and man-made noises in our base. This counter-poise could work as both common mode and normal mode ground. The RF system, their antennas and sensors were also connected to this ground as one point grounding and we obtained very satisfactory results.

In order to eliminate peculiar strong interferences in digital circuits, which have been developed in the last 10 years, the grounding technique has advanced very much in recent years. In the modern EMC technology, the recommended way to eliminate DC on-off signal in digital system is the separation of the grounding between power lines and equipment bodies. The former is called as "common mode grounding" and the later as "normal mode", or "signal mode grounding", as shown in Fig. 3. It must be noted here with this figure that the cold end of the normal mode must be separated from the common mode grounding. In the case of digital circuits, "twisted pair" circuit is usually used to eliminate the leaky field generated by the DC impulse current in this circuit.

When we were faced with strong interference at Syowa Station in the third expedition in 1959, the results of our improvements were very similar to the modern system. Of course, we had never know this new technique at that time. I applied this grounding technique later in the design of rocket and satellite instrumentation, after returning from the Antarctic. And I have obtained several cases of noise and interference reduction techniques in the rocket, balloon, and satellite experiments in Japan. The last 30 years of experiences in grounding and noise interference reductions are still of great use my EMC technique until today.

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