A LITTLE PIECE OF SOUTH AFRICAN HISTORY

When I sent Wernich a database with a line in which the conductors were spaced several kilo metres apart, it triggered a reminder of a significant event. In 1966 or thereabout, Eskom, the South African Government and the Portuguese Government decided to build the Cabora Bassa power station on the Zambezi river and send the power to near Pretoria. The only possibility was to send the power by high voltage direct current because the route length of over 2000 km was in excess of one quarter wave length at 50 Hz, thus precluding conventional a.c. transmission. High voltage d.c. rectifier/inverter systems require communication to set the inverter firing angles. The maximum allowable transit delay for the communication signals is 30 ms. For reasons of security against high winds, it was decided to set the + and - conductors on separate towers 1.5 km apart, each having a quad bundle with a steel ground wire at the top of the tower.

A consortium consisting of Brown Boveri and AEG and others decided to tender for the job. I was asked to visit the planning engineers in Zurich and to take my then, rudimentary PLC program, with me. The problem at hand was to decide how to obtain reliable communication over that distance with a maximum transit delay of 30 ms. This turned out to be the most fascinating debate of my career. We considered the following possibilities:

Microwave: Ruled out because the route was primitive bush with no power supply for the many repeaters which would be required.

Satellite: Ruled out because of cost, primitive technology and transit delay (700 ms or so).

Tropo Scatter: Maximum range 300 km and too unreliable.

Short Wave: Fade problems, lack of reliability and security.

Coax Cable: This was feasible. A telephone cable between Canada and England had been in operation since 1957 with the repeaters every 10 km being fed by a d.c. current. Ruled out because the cost would have exceeded that of the high voltage system.

Apart from a few wild suggestions which were not tenable it turned to be power line carrier or nothing. (Optical fibre would have been put inside the steel ground wire had it been the present but optical fibres were then in their infancy and repeaters had to be spaced every 100 metres). And this is where I came in.

We ran the system on my program and it was no go. The conductors were so far apart that there were two decoupled modes, basically ground mode attenuation. The signal was totally lost within about 10 km. This almost scuppered the project. However I then suggested that the ground wire should be insulated from all the towers by a single disc insulator. The integrity of the ground would be maintained by having line traps at each end of the long line in the ground wires and coupling would then be between the lone phase conductor and ground wire. I was not prepared for the eruption that followed my suggestion. The high voltage engineers absolutely refused to isolate the ground wire from the towers. Finally I said “if you don’t you don’t have a contract!” The consortium decided to go ahead and plan the d.c. line accordingly.

None of the other big players - Siemens, ASEA, English Electric and General Electric believed my calculations and refused to tender. The coupling ratio of voltage was interesting - it was 1 unit on the ground conductor and 0.3 units on the phase conductor. This puzzled people quite a bit until I pointed out that because of the high degree of asymmetry between ground conductor impedance and phase conductor impedance, this ensured that the current vector was (1 -1) which minimized the ground current.

We refined the calculation to take into account the distributed capacitance of the ground conductor due to the insulating disc. This causes resonance when the frequency is such that the tower spacing is one half wavelength (in this case about 350 kHz).

I had long forgotten the saga, had emigrated to Canada in 1974 when early in 1975 I had a call from Walter Senn, the Brown Boveri PLC head, inviting me to spend two weeks holiday all expenses paid for by Brown Boveri in Zurich. When I asked why he said “to say thank you”. He had just returned from South Africa where he commissioned the PLC telecommunication link. The maximum error in attenuation from 50 to 400 kHz between my program and his measurements was less than 2 dB. Even the resonance at 350 kHz matched. This made me quite famous in the PLC world. Up to that time it was invariably inferred that I “cooked” my input data to match field test results. This time I was “clean” - the measurements were done almost 9 years after the calculations!

Just before I made my presentation at Stellenbosch we had made a tour of South Africa including a trip to the Game Reserve. Somewhere near Punda Maria we saw one of the two bi-poles and stopped for a photograph and here it is. I was however critical of the design which is very ugly and adds to the cost. The transmission engineers who knew nothing about fields insisted on having the conductors vertically above each other giving the tower a rather “crane” like look. This was unnecessary but my advice had been disregarded. No matter.

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