Separating CEB and MCB mains lines, and reducing the unwanted coupling between them

We have known for years that the mains sidebands created by some electrical devices in the Mode Cleaner Building (MCB) are visible in the Magnetometers that are located in the Central Building (CEB); moreover some of these sidebands are also visible in the gravitational signal Hrec (see VIR-0247B-20 slides 19, 27 and following)

We also know that a magnetic probe placed over the 150 meters long vacuum pipe that connects the Mode Cleaner tower to the Injection tower measures all the side bands and anomalies coming from the MCB very well.

The suspect is that there is a flow of stray current in this tube, which produces magnetic fields in CEB and thus couples with Hrec. This problem could be due to the fact that the MCB and the CEB share the same low voltage 230Vac mains circuit. The HV to LV mains transformer is located in Technical Building 1; from here, two lines start towards the MCB and CEB buildings, each with three phases and the neutral wire (common).
There is also a general Protection Earth (PE) circuit that connects all three buildings together. Figure 1 shows a schematic of the electrical connection of the MCB, CEB and TB1.

Hypothesis:

- any imbalance in the three phases uses the neutral wire as a return for the unbalanced current.
- If there is a connection between the neutral and the Protective Earth (in addition to that foreseen in Technical Building 1), this return current will use all the "available low resistance connections" to return to the technical building.
- The Mode Cleaner pipe can actually be the lowest resistance path, chosen by the unbalanced current

Note that "a connection between the neutral and the Protective Earth" is not necessarily a physical galvanic connection: it could also be a capacitor used as a bypass in an Electro-Magnetic Compatibility (EMC) mains filter (see as example Figure 2).

Since it is practically impossible to find out all the possible connections between the neutral and the protective Earth, we had prepared two proposals to solve this problem:

1) interrupt the 150 meters long vacuum tube by inserting an insulating septum between some flanges

2) interrupt the neutral wire coming from the HV to LV mains transformer of the technical building, creating a new local neutral line inside the MCB building with the use of a "from triangle to star" insulating transformer.

While at the beginning we thought that the first action was the most feasible, later we realized that likely it would not have solved our problem. In fact, once put a septum of insulation between the flanges of the pipe, the leak current would likely follow an alternative path (e.g. other earthed metallic connections) from MCB to CEB frustrating the result. For this reason, we decided to test the second proposal using an old and oversized isolation transformer available on site (see it in Figure 3).

The test was completed between 7 and 8 July and the results are that ALL the noise signals that we know to be generated by the MCB HVAC system (the variable 50Hz sidebands from the heater and the glitches from the chillers) have disappeared from the MC pipe and, more important, from the CEB magnetometer. See the result in Figure 4. This solved the problem.

We therefore propose to use this solution as the definitive one, using a transformer of appropriate size (e.g. 80 kVA) positioned in the MCB cavity.

According to Massimo D'Andrea this solution is OK from the point of view of safety. Massimo is currently purchasing the transformer and the installation can be planned shortly.

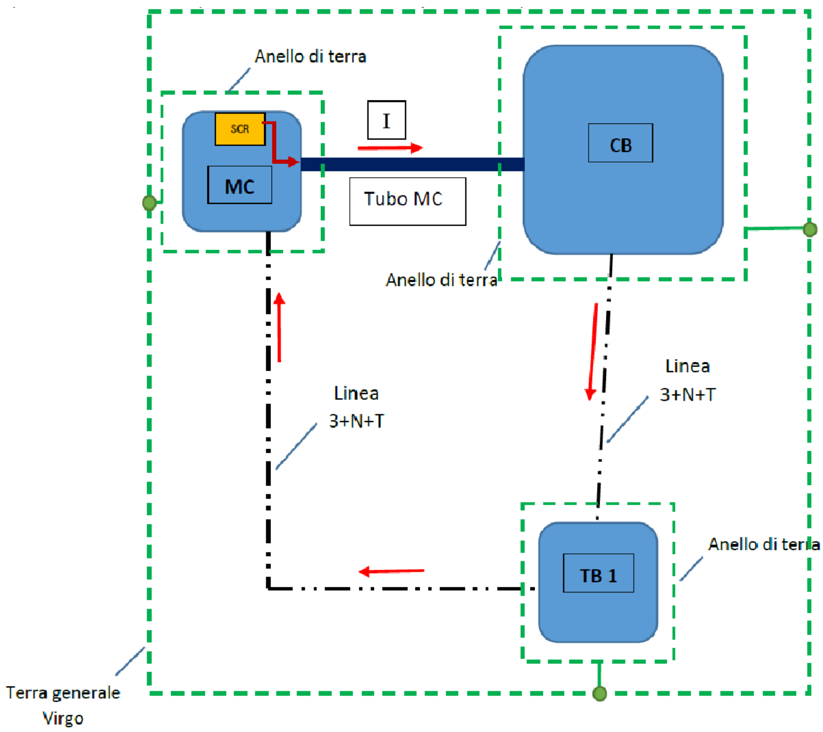
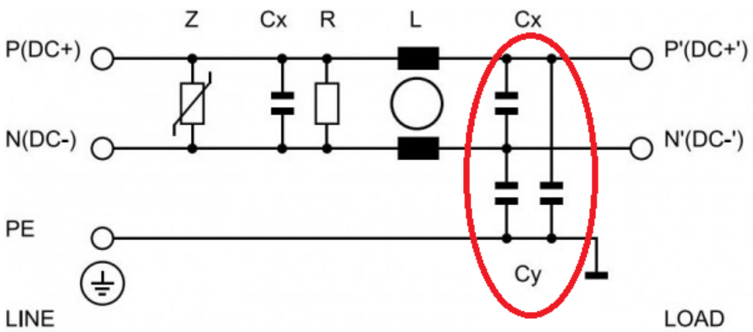


Fig.1: TB1, CEB and MCB electrical connections



Filter	Current ratings at 50ºC (40º) A	Leakage current[†] (480V/50Hz) mA	Power loss W	Component values/phase ∑L mH	∑Cx µF	∑Cy µF	R1 MΩ	R2 MΩ	Connections input	Connections output		Weight kg
FN 258 - 7 / ??	7 (8)	18.0	9	4.5	4	1.5	1.5	0.68	/29	/07	/29	1.1
FN 258 - 16 / ??	16 (18)	20.0	20	3.0	5.9	1.5	1.5	0.68	/29	/07	/29	1.7
FN 258 - 30 / ??	30 (34)	26.5	19	2.0	6.6	2.2	1.5	0.68	/33	/07	/33	1.8
FN 258 - 42 / ??	42 (47)	28.2	30	1.5	6.6	2.3	1.5	0.68	/33	/07	/33	2.8
FN 258 - 55 / ??	55 (62)	28.2	31	1.1	6.6	2.3	1.5	0.68	/34	/07	/34	3.1
FN 258 - 75 / ??	75 (85)	28.2	23	0.9	6.6	2.3	1.5	0.68	/34	-	/34	4
FN 258 - 100 / ??	100 (113)	28.2	41	0.9	6.6	2.3	1.5	0.68	/35	-	/35	5.5
FN 258 - 130 / ??	130 (145)	32.8	50	0.6	11	2.3	1.5	0.68	/35	-	/35	7.5
FN 258 - 180 / ??	180 (204)	32.8	68	0.13	11	2.3	1.5	0.68	/40	/07	/40	11
FN 258 - 250 / ??	250 (280)	32.8	75	0.13	26.4	2.3	1.5	0.68	/40	/07	/40	12

† Max. leakage under normal circumstances. Note: if two phases are interrupted, worst case leakage current could reach 5.6 times higher levels. Filters with lower leakage current (P [3.5mA] and L [0.8mA] types) are available on request.

Mechanical data

Current	-7	-16	-30	-42	-55	-75	-100	-130	-180	-250	Tol.* mm
A	255	305	335	329		329	379 ± 1.5	439 ± 1.5	438 ± 1.5	478 ± 1.5	±1
B	126 ± 0.8	142 ± 0.8	150 ± 1	185 ± 1		220		240			±1.5
C	50	55	60	70	80	80	90 ± 0.8	110 ± 0.8			±0.6
D	225 ± 0.8	275 ± 0.8	305	300		300	350 ± 1.2	400 ± 1.2		440 ± 1.2	±1
E	240	290	320	314		314	364	414	413	453	±0.5
F	25	30	35	45	55	55	65	80			±0.3
G	6.5										±0.2
H	300		400	500					500		±15
J	1 ± 0.1			1.5				3	4		±0.2
L	9			12					15		±1
O	M5			M6			M10				–
P	AWG 16	AWG 14	AWG 10	AWG 8	AWG 6				50mm²	70mm²	–

All dimensions in mm; 1 inch = 25.4mm

* Measurements share this common tolerance unless otherwise stated

Electrical schematic

See table for component values

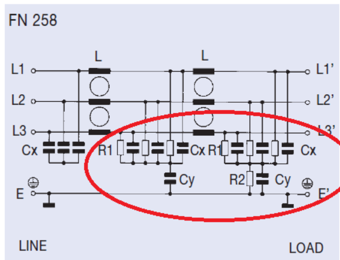


Fig.2: example of EMC filters with capacitors between Neutral and P.E.

Fig.3: the available old insulation transformer used for the test

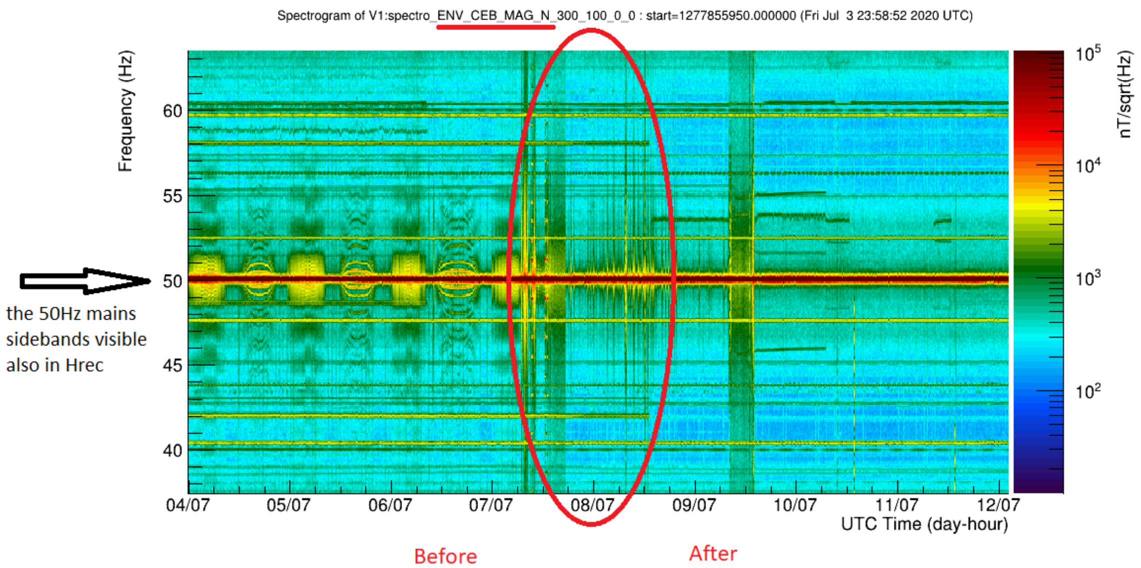


Fig. 4: the effect of the insulation transformer insertion as seen by the CEB magnetometer