

## BMB-ISE Automation Systems

### Product line: ROPEWAY PLANTS

#### A sun-powered funicular in Livorno

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1

The funicular railway climbing from Livorno to Montenero and to the sanctuary bearing the same name has recently undergone a very special maintenance activity.

The funicular is 656m long with a difference in height of 111m, each car can carry 40 people and the maximum slope is 18,4%. The plant is provided with an intermediate station and it has a capacity of 560 passengers per hour, about

250.000 passengers yearly.

This funicular was built in 1907 and modernized in 1979 (48KW motor), when the property was transferred from a private company to a public body. Since then the plant has been updated every 10 years on the occasion of the general overhauls.

During the last decennial overhaul, besides other minor activities, the event recorder (black box) has been replaced and installed

in a Personal Computer while the rescue group has been modified displacing the old Diesel motor with a D.C. motor.

The most important modification, and the main subject of this article, involved the electrical power supply system, now based on the prevailing use of sun energy.

The company Ansaldo Sistemi Industriali BMB-ISE Automation Systems participated in all these activities with the co-operation of Poma Italia for the mechanical and engineering matters. The photovoltaic field has been designed and developed by the company SEI (Sistemi Elettrici Integrati) in Prato.

The photovoltaic field has been installed on the service building, located in the middle of a wide parking-place, about 0,5km far from Montenero and from the uphill station of the funicular.

348 sun panels have been placed on the roof of this building, each measuring

1. The Montenero's funicular
2. The service building in the the parking place with the roof covered with sun panels

2





1

130x80cm, gathered in 29 lines, each consisting of 12 panels; the lines are divided into two sectors of 12 and 17 lines respectively. Each panel generates 100 watts at 25 volts, thus obtaining a total production of 24,8KW. The expected yearly production of electric power ranges from 40 to 50MWh.

The power of the voltaic field is transferred to the electrical power network through an inverter with sinusoidal waveform to power the funicular, while the energy surplus, if any, is given to ENEL (Italian National Energy Organization).



3

The fares for the power transferred to ENEL or drawn from the public network are exactly the same because the supply contract does not exceed 20KW (the medium voltage room will be removed and the space used to position the batteries).

The main drive of the winch is the existing D.C. motor and relevant static thyristor converter.

In parallel to this power system now there is also a dc/dc full-chopper converter powered by a lead-acid stationary storage battery, made of 67 series-connected cells with rated voltage of 400V and capacity of 300Ah lasting ten hours. The battery is dimensioned for a 2-hour continuous operation in absence of network voltage (17 trips). During this time the current can be

1. The winch
2. Bank of batteries
3. Control desk with monitors



2

delivered for the general plant services and to move the cars also in the most unfavorable condition, that is to say with load always going uphill.

In case of network failure, the plant speed is reduced according to the voltage obtainable from the battery: this voltage will be 320V at the end of the discharge phase.

The battery is kept charged by means of a bi-directional thyristor converter that correctly manages the power flux from and to the network and always assures the best voltage level of the battery for a good plant operation. In such a way the power returned by the plant when it is loaded downhill is regenerated and stored in the battery. The photovoltaic field is parallel connected to the electrical network.

A chopper group provided between the photovoltaic field and the battery allows modulating the energy

delivered from the photovoltaic field to the battery at constant current, thus allowing the plant to run when the sunlight is present and the network voltage is failing.

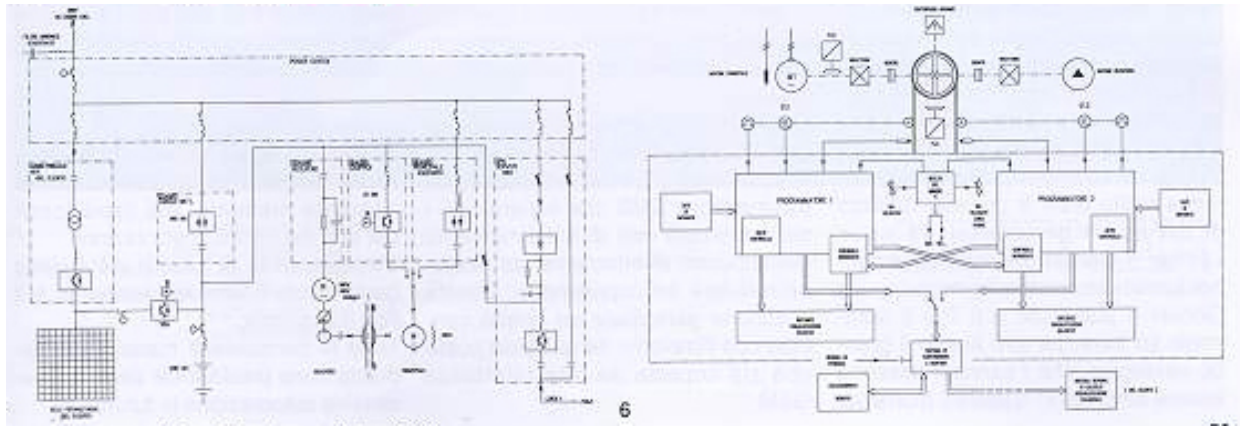
In this emergency condition it is necessary a manual enabling of the system, while the passage from a supply system to the other one is completely automatic and not

perceptible in all the other cases.

Of course, there is also an UPS set (emergency power generating set drawing the electric energy from the battery and generating a three-phase voltage) that delivers the voltage to the line services (downhill station and plant lighting included).

With these substantial modifications the

Montenero's funicular has reached the aim of ATL (Livorno's public transport company) of "zero emission". The solutions implemented in this funicular are considered interesting for small-power plants, awaiting a more detailed estimation of the advantages of the zero-emission.



1. System block diagram