A MONITORING SYSTEM FOR GRID-CONNECTED PV PLANTS

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Abstract – The growing diffusion of small grid-connected PV plants in households has generated the need of easy-to-use monitoring systems, particularly looking at people that want to be informed quickly and easily on the contribution of their plant to the family energy balance.

Embedded monitoring systems that inverter manufacturers usually propose are undoubtedly quite effective on a technical point of view, but often they require a PC to fully exploit their performances. Furthermore, they are focused on the PV plant and not on the dwelling electric system.

For these reasons, CESI has recently developed a system aimed to perform an easy monitoring of the AC behaviour of single-phase grid connected PV plants.

The monitoring system is totally independent from the equipment which composes the PV plant (PV modules and inverter) and its configuration (single inverter or multi-inverter). Furthermore, it has been conceived for an easy operation and so its technology is based on a touch-screen 8" monitor, with an interface fully understandable also by people that are not very familiar with electric and energy concepts.

The system is composed by a grid analyser that measures AC voltage, PV power, loads power and the power exchanged with the grid, along with a "smart" terminal with a 8" colour touch-screen. The software application has been developed on a PC platform.

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1. GENERAL ARCHITECTURE OF THE MONITORING SYSTEM

The aim of the project was to develop a system which could perform the monitoring of PV plants connected to LV grid, giving the possibility to display the main electric values relevant for the photovoltaic plant as well as for the home plant.

The system has been studied for single-phase (230 V) systems preferably located in homes, whose maximum power is often comparable with the maximum power supply obtainable from the electric company. In a situation like this it is useful to measure and keep track of the following quantities:

➢ **Power and energy produced by the PV plant**

➢ **Power and energy to the internal loads**

➢ **Power and energy taken or delivered to the public grid**

Furthermore, on the basis of experiences and from an analysis of the needs of PV producers, the following characteristics have been considered as particularly important:

➢ **Easy to use**

➢ **Easy to install**

➢ **Effectiveness in data representation**

➢ **Flexibility of use**

➢ **Cost not too high**

The system is composed by a grid analyser for data collection and a "smart" device with a 8" screen for memorisation and displaying. Neither keyboard or mouse are needed because the "smart" device has a "touch-screen" interface.
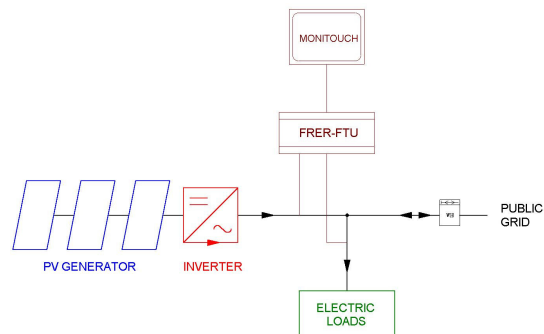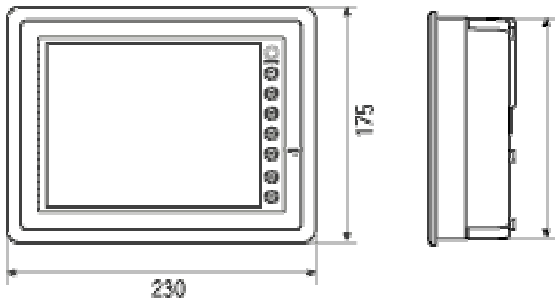
2. HARDWARE CONFIGURATION OF THE MONITORING SYSTEM

The monitoring system has been conceived for having only a minimal interaction with the existing electric energy distribution plant and to be used also "by a child" in a totally safe way.

The electric diagram is shown in the following drawing.
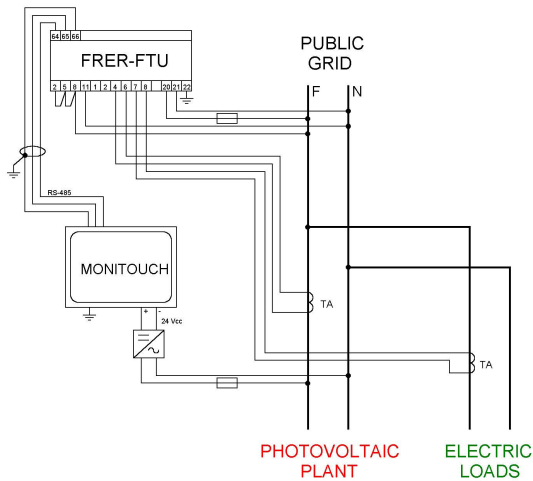
The 8" smart screen may be placed in the most suitable spot of the home.

Electric components may be lodged in a simple panel suitable for domestic plants along with normal switches and protections.

The following figure shows the prototype built at CESI and now located in the photovoltaic experimental area.

However, this simple equipment reproduces completely the electric panel and the screen that may be installed in a house or apartment.

3 SOFTWARE CONFIGURATION OF THE MONITORING SYSTEM

The monitoring system has been programmed on a PC by using a special language provided by the builder of the 8" smart screen.
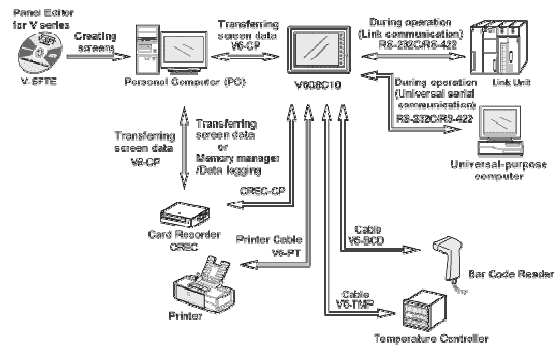
The communication protocol between the smart screen and the data collector is the MODBUS standard.

The smart screen may provide further expansions and system improvements because it may communicate with many peripherals (see the figure taken from technical manuals).

The software has been developed with the aim to provide a very simple interface to the user and so it is

possible the representation of instantaneous values as well as past trends by means of diagrams, tables and histograms.

Data sampling is made at 1 minute interval by the data collector; every 15 minutes the system performs an average of valid samples and records the result in the internal memory of the system.

Software development criteria that have been adopted, assure a good management of the 640 480 pixel screen with 128 colours and a limited RAM (16 kb).

The system developed by CESI gives the possibility to manage the following pages and their associated functions:
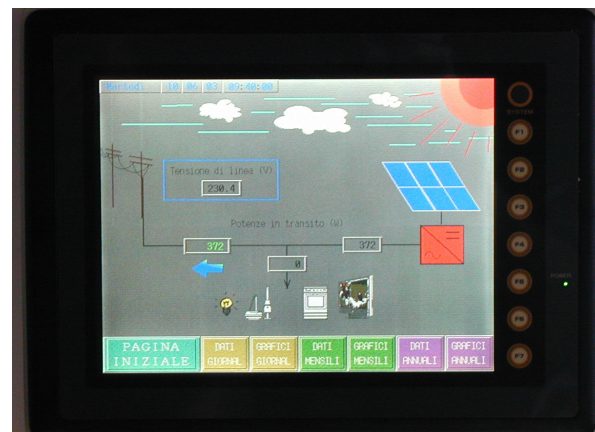
- Initial page

- Plant layout with instantaneous values of line voltage and power flows

- Set-up page for date and time, protected by a password entry page

- 4 Pages which show 15-minutes values of line voltage, energy from PV, energy to loads and energy exchanged with the public grid (24 hours)

- 4 Pages which show daily values of line voltage, energy from PV, energy to loads and energy exchanged with the public grid (28, 30 or 31 days)

- 4 Pages which show monthly values of line voltage, energy from PV, energy to loads and energy exchanged with the public grid (12 months)

- 4 Pages with a bar graph which show 15-minutes trends of line voltage, energy from PV, energy to loads and energy exchanged with the public grid (24 hours)

- 4 Pages with a bar graph which show daily trends of line voltage, energy from PV, energy to loads and energy exchanged with the public grid (28, 30 or 31 days)

- 4 Pages with a bar graph which show monthly trends of line voltage, energy from PV, energy to loads and energy exchanged with the public grid (12 months)

- A page, with up to 8 sub-pages, useful for swift annotations and drawings

- Several pages which contain short descriptions and photos of photovoltaic buildings in the world

4. OPERATION OF THE MONITORING SYSTEM

4.1 Initial page

4.2 Plant's layout with istantaneous values of line voltage and power flows

4.3 Electric panel

4.4 PV power generated – bar graph

4.5 Line voltage bar graph

4.6 Set-up page: User acknowledgment