Letrika
Driving innovation

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SOLAR MICRO INVERTER 260

System concept description

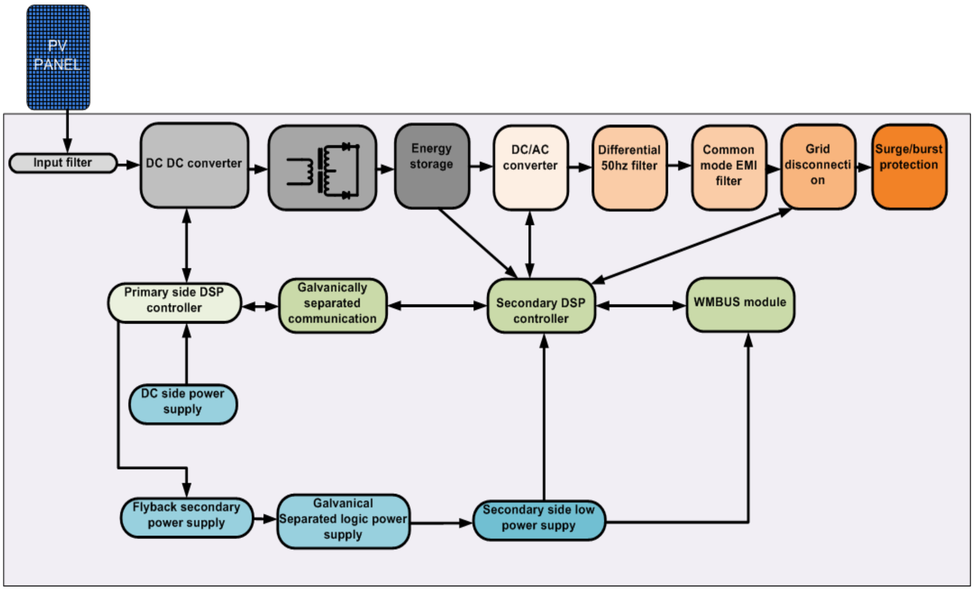
Letrika solar micro inverter 260 is designed with clear targets:

-uncompromised lifetime design by using electrolytic capacitors free design
-very low PV panel current ripple with extremely precise MPPT algorithm
-environmental protection IP67 with completely potted electronics (poliuretane compound)
-aluminum DIE casted enclosure for high mechanical strength
-galvanic separation between PV panel and grid
-power factor regulation capability
-dual DSP controllers design for increased safety and precise MPPT and grid control
-Open Source Linux based communication gateway with embedded web server

Below block schematics shows internal micro inverter architecture.

Complete energy storage is done on foil capacitors on high voltage, 400V side. This, so called two stage architecture is more expensive then single stage architecture and have normally lower efficiency due to higher number of power components, but have advantage of very low current ripple on PV panel, increasing panel efficiency and lifetime. Additional advantage is composed by use of long lifetime foil capacitors, which have at least 10 times longer lifetime then any comparable electrolytic capacitor.

Control section is constructed around two DSP controllers, one controlling primary side DC/DC converter, second controlling DC/AC section and communication through WMBUS wireless link. Two controllers communicate through galvanic separated channel and exchange regulation data every 100usek. In addition, there are two small safety microcontrollers that are supervising both main DSPs.

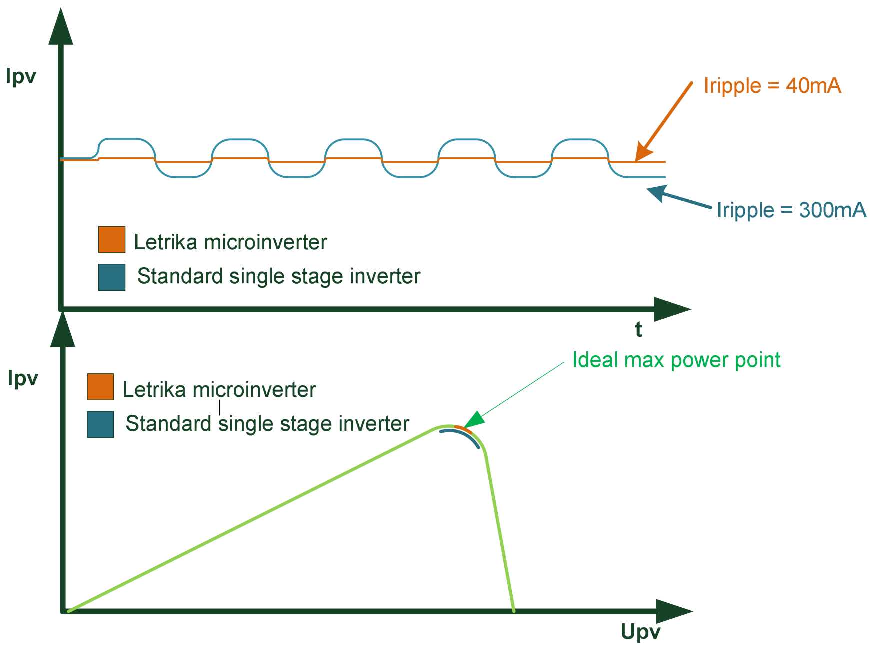


This architecture, although seems complicated, makes some nice features described above with clear results in:

-**MPPT tracking precision**

Due to current ripple on PV panel, caused by 100 or 120Hz grid load transferred to PV panel side, actual maximum power point is oscillating around ideal point. Higher the current ripple, lower MPPT tracking precision.

The influence is clearly shown in bellow graphs. Note, that the current ripple influence changes with PV panel MPPT curve, more the curve is sharp, biggest is the influence.



-Reactive power control capability (power factor regulation)

Reactive power capability in renewable energy generators was overlooked for many years. That was a logical consequence of low market penetration of those products. But since share of renewable sources is increasing, also impact of their power converters to grid performance is becoming more and more important.

Already from early days, big conventional power stations works as voltage, frequency, power factor regulators, otherwise, the grid would collapse. Big renewable power inverters have been equipped with power factor regulation capability since few decades ago, but smaller inverters are still operating mainly on fixed power factor.

Main reason for this gap is lack of standardization of small renewable plants since their impact to the grid was considered negligible. This was true in past, but now, number of micro plants is growing and their impact to grid quality must be considered.

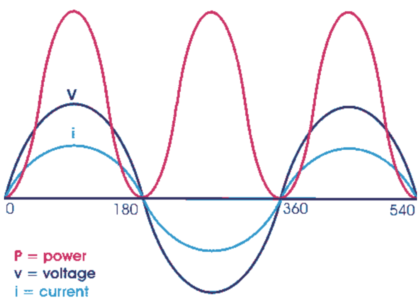
Some sort of grid frequency regulation is incorporated into all inverters as real power limitation when grid frequency is increasing, but, to be able to regulate grid voltage, inverters must be able to produce reactive power. In addition, inverters with reactive power capability can help as power factor compensators, since the power produced can be either inductive or capacitive.

Many of the grid problems faced today are direct consequence of overlooked importance of reactive power capability. Grid over-voltages are typical example, since they are caused by overload of real energy in the network. Another example are overheated and saturate power transformers.

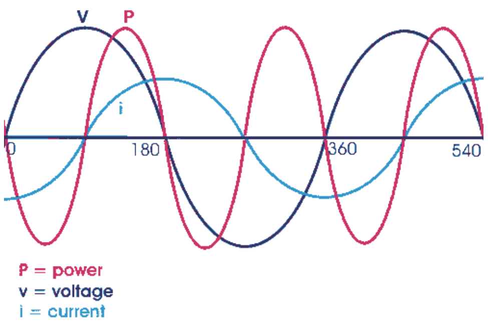
Due to these facts, more and more countries and standardization bodies will request power factor capability for micro-grids in the future. Some already impose reactive power capability to all inverters installed on grid, even the smallest one, and more will follow.

Letrika inverter is completely prepared for these trends. Reactive and real power are independently regulated. Inverter can produce 125Var on 260W real power, meaning power factor of +/-0.9. Inverter is capable of generating 250Var of reactive power, but the real power is of course limited.

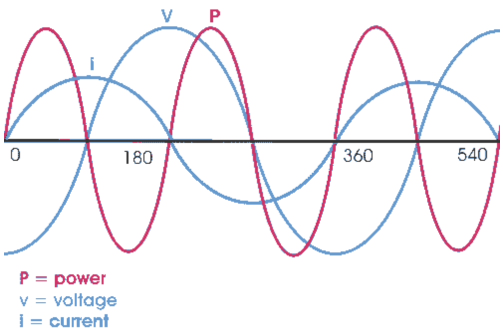
What the power factor means and how it is reflected on the grid is described in bellow figures:



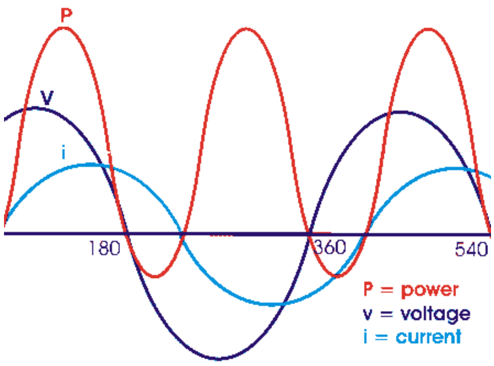
Current is in phase with grid voltage. This is typical diagram for resistive load.



Purely inductive power. Current is lagging 90° behind the voltage. Power oscillates at twice of grid frequency. Average power in this case is 0, since there is no useful work possible.



Purely capacitive power. Now the voltage is lagging behind the current. As for inductive reactive power, also here, the useful power is 0.



Between two extremes, any combination between real and reactive power is possible. The amount of reactive power is changed with angle between voltage and current.

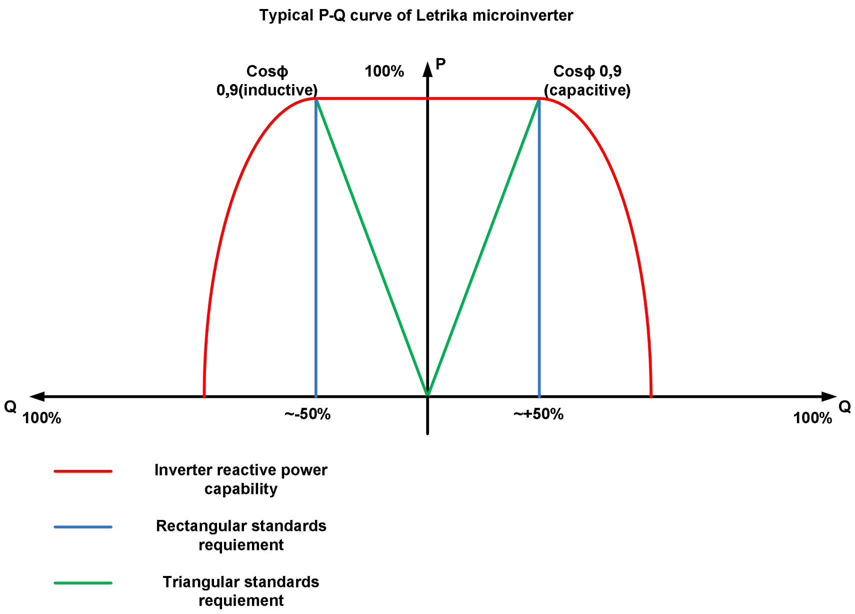
However, from the elementary description and true regulation of the power factor there are some steps to perform in inverter design that influence the inverter costs and size:

-Real time control of the power factor requires calculations intensive vector control algorithm, imposing use of very fast digital signal processors.
-Power magnetics must be overdesigned in order to be able to handle increment power during maximum inductive power factor.
-Dynamic regulation of power factor (e.g. CEI0-20 standard) is a very challenging task even for big inverters.
-Power capacitors must be overdesigned to allow maximum capacitive power factor.

But all this come with advantage, that we can actively control grid voltage and contribute to higher grid stability.

Some of the examples on how the power factor can be used for automatic grid stabilization are given below:

Typical dynamic power factor requirement



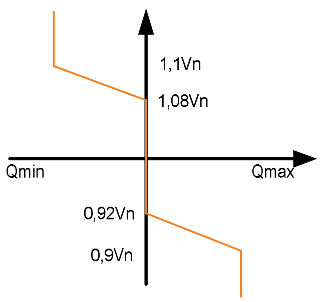
Red line describes inverter reactive power capability. It can be deduced that the inverter can keep real power at nominal level down/up to power factor of 0.9, than the real power will be decreased.

Blue line is typical requirement for fixed power factor. Power factor is kept constant during complete excursion of real power.

Green line shows power factor that change dynamically with real power.

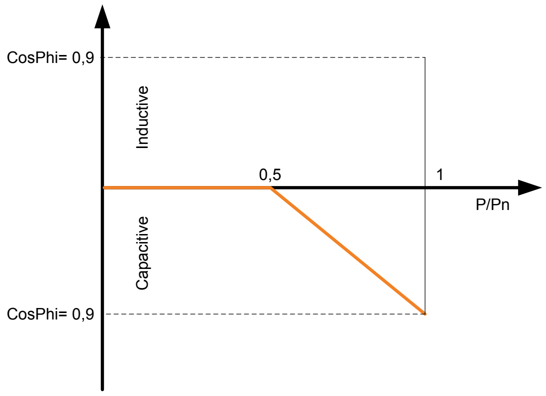
In addition to this simple requirements there are more demanding ones, for example:

CEI0-20 standard (voltage versus Q):



Power factor is linearly changed from minimum to maximum when grid voltage reaches predefined levels.

CEI0-20 standard (P/Pn versus Q):



Power factor is kept fixed until 50% of nominal power is reached, then power factor change toward maximum linearly up to nominal power.

All above and more functions are already implemented in Letrika micro inverter allowing grid operators more control over grid stability on micro grids.
Not to mention new standards will make use of power factor mandatory in all generating devices connected to the grid.
Grid improvement has been proven on many critical installations, where exclusive use of Letrika micro inverters completely avoided overvoltage transients on the grid.

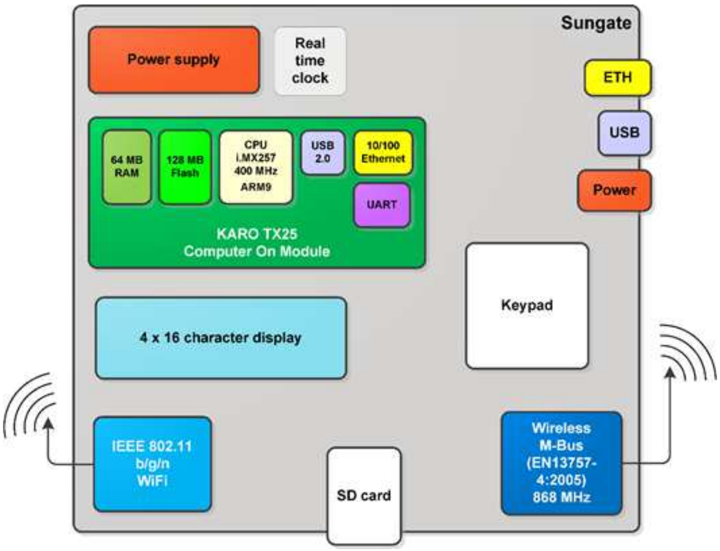
Communication Gateway description

Communication Gateway is a device that communicates with micro inverters via WMBUS communications, store the data into internal memory and retransmit data through multiple information channels.

<u>Communication Gateway key features are:</u>

-Embedded Linux operating system running on 400 Mhz ARM core processor
-up to 32Gbytes SD card for data storage.
-4 X 20 lines LCD display and keyboard for limited direct access to gateway functions.
-embedded web server (no need to have external cloud server to access inverters).
-868 Mhz WMBUS communication.
-IEEE 802.11Standard Wireless communication.
-Ethernet line.
-USB OTG connector.
-Real time clock.
-Additional features includes possibility to export data to cloud servers through desired protocols.
-Skilled customers are allowed to access open source software used in gateway (except WMBUS protocol with inverters).

Simplified Gateway architecture is presented below:



Letrika communication gateway differs from other micro inverters gateways in embedded Linux operating system, which allow virtual any software/drivers written for this operating system to be used on our gateway. Even more, software from gateway can be easily ported to Raspberry PI and other Linux based systems.

Another important feature is embedded web server. Embedded means that web pages are inside gateway and there is no need for external cloud server to access the micro inverters from internet.

Anyway, if client desires, communication gateway is capable of exporting data through different internet protocols, allowing client cloud servers to be customized.