Novel Ćuk-Buck MPPT Battery Charger for Standalone PV-Inverter Applications

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Abstract – *The theme of this paper is a novel MPPT converter for battery charger. The converter combines both ćuk and buck converters topologies to extract maximum power from photovoltaic arrays while supplying a controlled constant current/voltage to the battery simultaneously. The new topology uses two control signals instead of one control signal; one for maximum power point tracking, another for battery charger control providing constant current/voltage to the battery. The Advantage of this converter is to exploit the maximum power of the PV array avoiding battery damage caused by variable MPPT voltage. As a matter of fact, the tracking voltage that tracks the maximum power is variable according to weather irradiation conditions. However, batteries need constant voltage and current for charging to avoid the damage and to extend its lifetime. Therefore, it is reliable to combine the battery charger control and the maximum power exploitation using two control signals simultaneously. The real-time implementation of the ćuk-buck converter was carried in TMS320F28335 DSP. A 4kW prototype system was built and four 12V 100Ah batteries were used. The effectiveness of the proposed converter was tested in both simulation and experiment in various operating conditions. The experiment results verified that the PV power obtained of the two control signal converter was exploited better than that of one control signal and that battery's full charging state was reached in a relatively short time.*

***Keywords**: Battery Charger, Maximum-Power-Point Tracker (MPPT), Voltage and Current Control, Photovoltaic (PV).*

Nomenclature

S_1	MPPT switch
S_2	Battery charger switch
S_3-S_4	Inverter switches
S_B	Boost converter switch
L_1-L_3	Ćuk-buck converter inductors
L_4	Boost converter inductor
L_5-L_6	Output filter inductors
C_1	MPPT capacitor
C_2	Battery charger capacitor
C_x	Coupling capacitor
D_1	MPPT diode
D_2	Battery charger diode
V_{PV}	PV array voltage
t_{on}	Switch on time
t_{off}	Switch off time
ΔI	Current difference in a specific inductor
V_{c1}	Voltage applied on C_1
D	MPPT duty cycle
T	Time period
V_x	Voltage applied on coupling capacitor
V_B	Battery voltage
δ	Battery charger duty cycle
C	Battery charge
$\delta_{(k)}$	The current duty ratio
$\delta_{(k-1)}$	The previous duty ratio
$\Delta\delta$	Duty ration perturbation step size
V_{REF}	Reference voltage of ćuk-buck converter
$SOC\%$	State of charge percentage
C_L	Output filter capacitor
L_L	Load inductance
R_L	Load resistance

I. Introduction

Solar power has increased the attention for its significant potential in solving future energy problems and the foreseen severe shortage of energy sources [1]-[6]. Photovoltaic (PV) inverter systems can be either stand-alone or grid-connected system. Grid-connected systems are used to reduce utility power [7]-[9], whereas standalone ones provide the required power without the use of utility [10]-[12]. Furthermore, standalone systems dispense with the grid, so they need batteries that store the energy to supply load when the solar-energy production is low.

Storage batteries need a deep cycle to discharge a significant amount of the stored energy. The commonest deep-cycle battery is nickel-cadmium through it costs more than does lead-acid battery. Valve-regulated lead-acid (VRLA) battery has been widely used in PV applications recently. It is low-cost, maintenance-free, and considered the most recyclable among batteries [13]. For long battery life, a charge controller preventing

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