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Power factor controller used as DC–DC converter for photovoltaic sources

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Abstract

An active power factor controller (PFC) integrated circuit, normally used in AC circuits, has been used for DC-to-DC boost conversion with a stable output voltage for a variable DC input voltage as obtained from photovoltaic (PV) sources. The circuit described here uses a power factor controller MC 34262 to give approximately 400 V_{DC} output for an input variation from 90 to 280 V_{DC}. The maximum efficiency achieved was 98% at 450 W. Comparisons between AC and DC operations have been made.

Keywords: Photovoltaic; Solar energy; Lighting; Converter; PFC; SMPS

1. Introduction

Discontinuous mode DC–DC boost converters are well described in the literature [1]. Another type of converter, in a bridge configuration, has been used to stabilize varying DC input voltages [2]. This is a relatively complicated circuit and is used for high power requirements. A need was felt for a circuit for low and medium power applications. Literature survey showed that some manufacturers [3,4] provide integrated circuits for active AC power factor correction to be used as pre-converters in electronic ballasts and off-line power converter applications. Ref. [3] provides such a solution for an AC–DC power factor corrected pre-converter for a 450 W load, with an output voltage of 400 V_{DC}, using the integrated circuit MC 34262. For this kind of operation, the line AC voltage is first converted to a haversine, by full wave rectification, then chopped 10,000–20,000 times and processed to get the desired result. Since the haversine has a significant DC component, as shown in Eq. (1) [5], it stands to reason that the power factor controller (PFC) can work from a pure DC photovoltaic source also. The photovoltaic source has to charge a battery to provide a stable DC output to avoid instability in operation, since the PFC input current versus voltage characteristic has a negative slope. An experiment was therefore carried out, with a slight modification to the circuit, to determine the characteristics of the circuit and use it for lighting a 400 W HID lamp [6]. The modification was necessary to protect it from an accidental reversal of the DC source polarity, created by the PV charged battery, while keeping low the device dissipation losses.

The following equation shows the DC component ($I_m \times 2/\pi$) in the haversine current expression:

$$i = I_m \left[\frac{2}{\pi} - \frac{4}{\pi} \sum_{\substack{k=\text{even} \\ k \neq 0}} \frac{\cos k\omega t}{(k+1)(k-1)} \right], \tag{1}$$

where

$$I_m = \frac{E_m}{r_p + R_l}. \tag{2}$$

The quantities involved above are—E_m: peak AC voltage, R_l: load resistance, r_p: rectifier resistance, $\omega = 2\pi f$, f: frequency.

The circuit presented here was operated from both AC and DC inputs. A comparison is given below.

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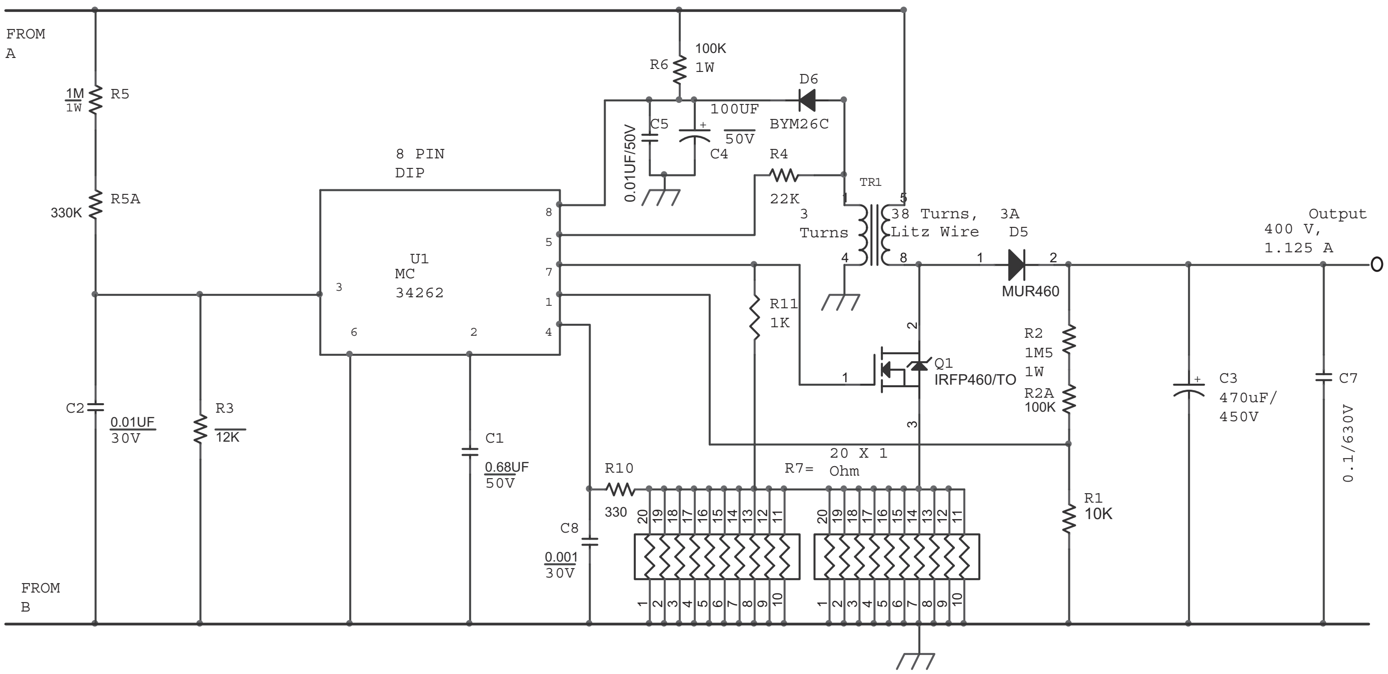

Fig. 1. Circuit diagram of the power factor controller.

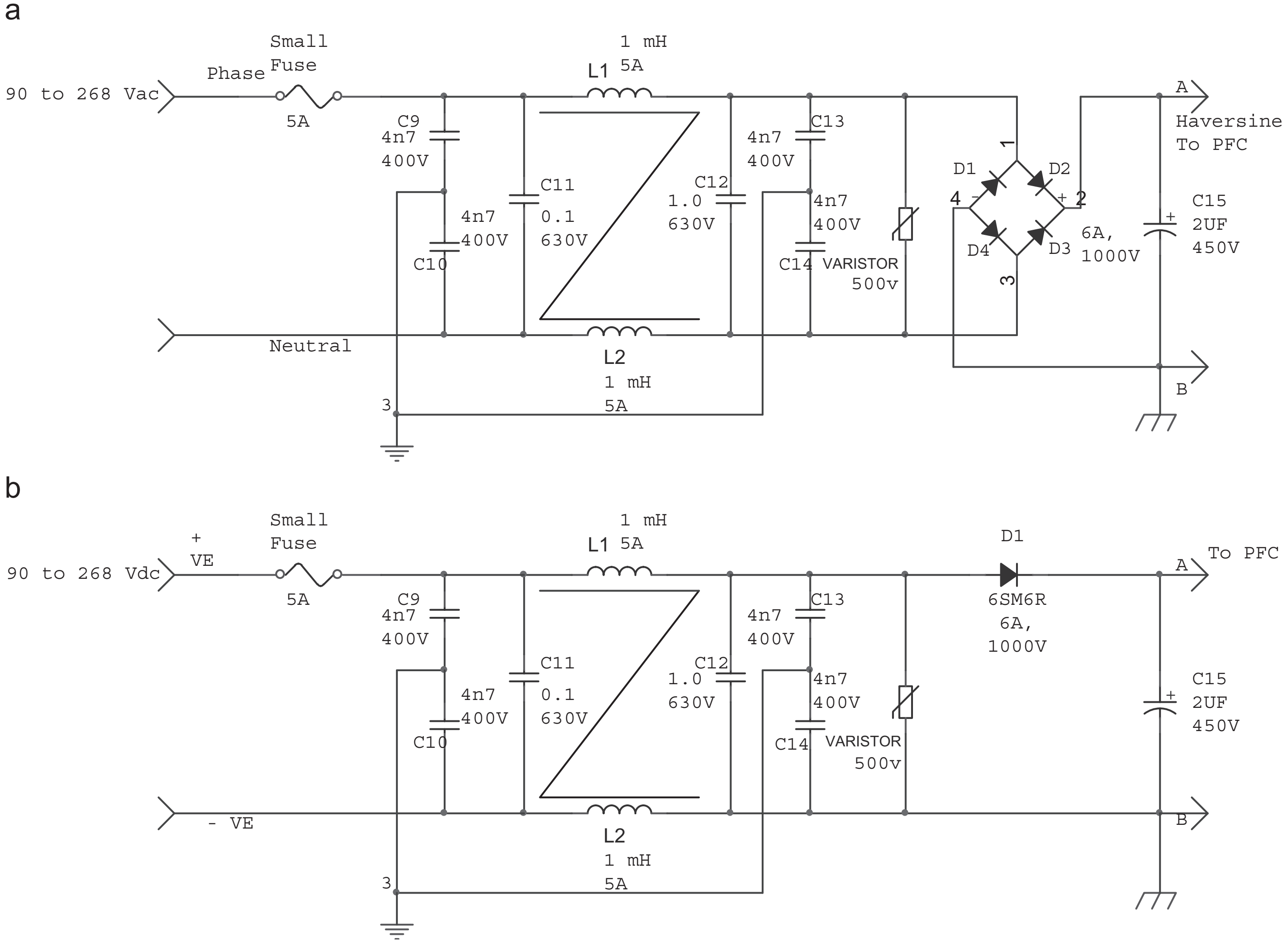

Fig. 2. (a) Rectifier and EMI filter for the PFC for AC operation. (b) Rectifier and EMI filter for the PFC for DC operation.