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Design of Power factor Correction Based Bridge-less Converter for Different Loads of SMPS

Ms. M. Sethu Madhavi[1], Ms. K. Poorna Sai[2], Ms. K. Tejaswini[3], Mr. M. Venkateswara Rao[4], Mr. K. Gokul Sai[5], Mr. L. Venkata Mahesh Babu[6], Dr. N. Samba Siva Rao[7]

UG Scholars, Department of Electrical & Electronics Engineering, NRI Institute of Technology, Agiripalli, Vijayawada, India[1,2,3,4,5]

Assistant Professor, Department of Electrical & Electronics Engineering, NRI Institute of Technology, Agiripalli, Vijayawada, India[6]

Professor and Head, Department of Electrical & Electronics Engineering, NRI Institute of Technology, Agiripalli, Vijayawada, India[7]

ABSTRACT: This project proposes a power-factor-corrected canonical switching cell (CSC) converter based switched-mode power supply for arc-welding applications. In the proposed system, CSC converter operating in discontinuous inductor current mode (DICM) is used to attain inherent power factor correction. The DICM operation substantially reduces the complexity of the control and effectively regulates the dc-link voltage. At the back end, a pulse width-modulated (PWM) isolated full bridge dc–dc converter is used to provide a high-frequency isolation, which is mandatory for the arc-welding process. A dual-loop control scheme is utilized to incorporate over current protection and to regulate dc voltage at the output making it suitable for arc-welding applications. Later the proposed converter is re modelled as bridgeless converter for better efficiency, less total harmonic distortion and multiple functionalities of the system. The performance of the proposed AWPS is examined in terms of power factor, total harmonic distortion of the supply current, efficiency, and output current limit over a wide range of line/load variations.

I. INTRODUCTION

A RC-welding is considered as one of the most principal ways of welding. However, the weld quality, technical and economic characteristics of arc-welding machine aremainly dependent on its power supply [1], [2]. There are twotypes of power supplies for arc-welding: arc-welding powersupply (AWPSs) with dc output; AWPS with ac output. Thefirst type provides constant polarity current and voltage, leadingto high arc stability and a smoother welding output as compared to the second one. Conversely, arc welding power supplyyields a combination of negative and positive current, whichworks satisfactorily mainly for welding aluminum or its alloysonly [3]. For decades, conventional dc AWPS employed an uncontrolled diode bridge rectifier (DBR) followed by a bulky dc-linkcapacitor at the front end and an inverter along with the rectifierfor ac–dc conversion at the load end. Figpresents the measured power quality (PQ) indices for the conventional dc AWPSincluding parameters like total harmonic distortion (THD) ofcurrent, power factor (PF), displacement power factor (DPF)at the input ac mains. As depicted from the obtained results,extremely low PF and large harmonic currents generated bythe conventional AWPS are prime issues as they can lead toincreased losses in the utility systems.

II. PROPOSED CONCEPT

In this project, a CSC converter is proposed as a front converter to deal with the PQ issues associated with an AWPS. Moreover, an effort has been put forward to incorporate overcurrent withstand capability in the proposed AWPS, which is very important for achieving high-quality weld. CSC converter allows one to overcome the shortcomings of aforementioned buck–boost converters by having a smaller number of input devices, non-pulsating input current, etc.

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Additionally, the DICM operation results in inherent PFC and fast dc-link voltage regulation using a single-loop voltage feedback controller. Besides, power switch is turned on at zero current and the freewheeling diode is turned off at zero current reducing the switching losses.

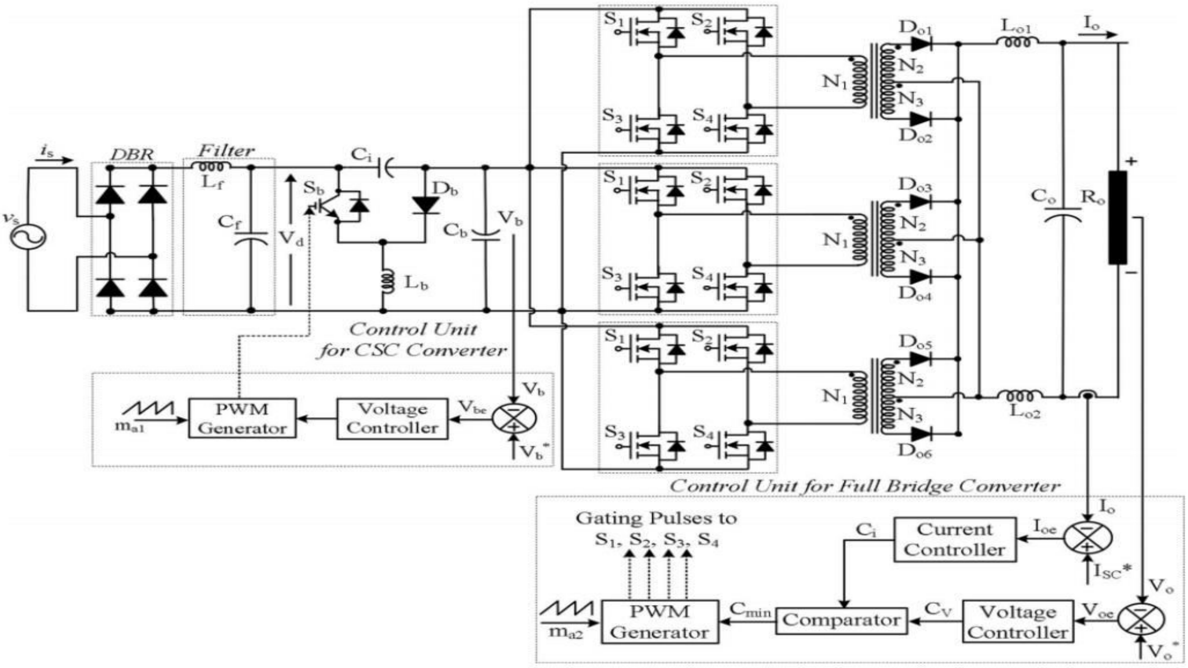

Fig-1: Configuration of CSC converter and isolated FB converter-based AWPS

The CSC converter is followed by full-bridge (FB) converters, which provide high frequency isolation desired for safe welding operation. The FB converters are used to emulate the conventional welding power supply. Three FB converter modules are connected in parallel to incorporate the power expandability feature depending on the current rating of the power supply. The major contribution of this paper is twofold: 1) inputPQ improvement by using CSC converter at the front end, and2) voltage regulation and overcurrent limiting at the output 31 end by using FB converters. The AWPSs that are currently available in the market are devoid of power factor correction and input PQ improvement. AWPS stands out as a special entity as compared.

CSC Converter-Based AWPS

The system configuration of the proposed PF-correctedAWPS is presented in Fig.2. In this section, the DBR is followed by CSC converter, which acts as a pre-regulator to achievePFC at the utility interface. The DICM operation of the CSCconverter minimizes the turn-on switching losses of the power switches and enhances the reverse recovery of the output diodes significantly. The CSC converter converts the rectified input ac mains voltage into an intermediate regulated dc voltage. The controlled output of the CSC converter is fed to the FB converters, which provide the desired dc arc voltage suitable for the welding load. The FB converters are designed to operate in continuous conduction mode (CCM). The proposed topologies designed taking into account the important properties of arcwelding process like constant output dc voltage, output dc arc currentregulation during overload, and reduced input current harmonics over wide line/load range. Individual control loops are designed for both the converters (CSC and FB) to optimize their functions. The efficient control of AWPS facilitates fast dynamic response, which enables to achieve high-quality weld.

Operation of Proposed CSC Converter-Based AWPS

The operating principle of both the converters is discussed in detail. The following assumptions are made to simplify the analysis of the proposed AWPS:

1) all semiconductor devices are considered to be ideal;
2) all semiconductor devices are considered to be ideal;
3) the capacitors Cb and Co are considered to be large enough to maintain the output voltages Vb and Vo as constants without any ripple during one switching period;

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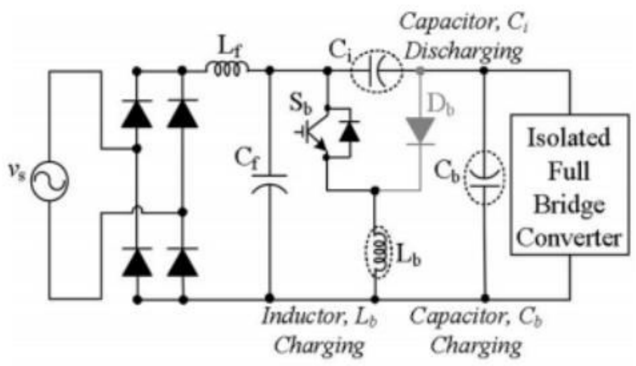
4) the supply voltage vs is considered to be a constant during one switching frequency (fs) cycle as fs >> f, the line frequency

Operating Modes of CSC Converter:
The operating principle of the CSC converter is analogous to the conventional Cuk converter although Cuk converter uses two inductors in place of a single inductor for the CSC converter. The operation of CSC converter is presented in Fig.2. The rectified output of the DBR is given to the CSC converter. For DICMoperation, there are three intermediate operating stages of theCSC converter for every switching cycle, which are describedas follows:

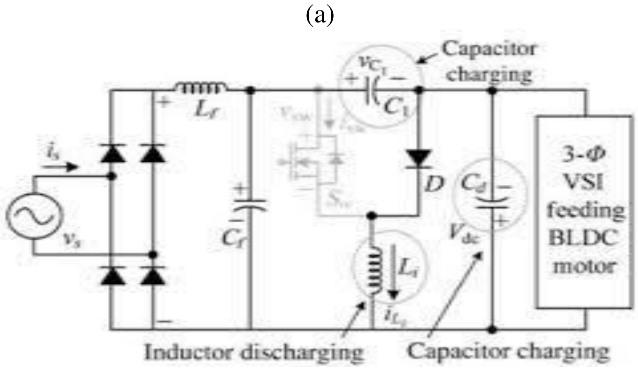
Stage I:
During this stage, the switch Sb conducts while thediode Db is reverse biased as shown in Fig.2(a). In this interval, the power is transferred from the supply as well as from the intermediate capacitor Ci to the inductor Lb as presented inFig.2(d). Therefore, the intermediate capacitor Ci discharges through the inductor Lb and dc-link capacitor Cb causing the voltage across the intermediate capacitor to decrease. The value of intermediate capacitor Ci must be large enough to maintain its voltage continuous during this period.

Stage II:
This stage begins when the switch is turned off leading to the conduction of diode Db. As shown in Fig.2(b), the energy stored in inductor Lb is released to intermediate capacitor Ci and dc-link capacitor Cb. Thus, the current through the inductor Lb starts decreasing while the voltage across the intermediate capacitor Ci begins to increase. The voltage across the dc-link capacitor Vb also continues to increase.

Stage III:
This stage is illustrated in Fig. 2(c). When the current through the inductor Lb becomes zero, the converter enters into DICM as shown in Fig.2(e). The intermediate capacitor Cicontinues to get charged from the supply. As the diode is reverse biased, Ib is provided by discharging of the dc-link capacitor Cb. Hence, the dc-link voltage decreases during this period. Theenergy transfer process for CSC converter during one completeswitching period is shown. The current through the inductor Lb remains zero until switch Sb is triggered again torestart the switching cycle as shown in Fig.2(d).



(a)



(b)

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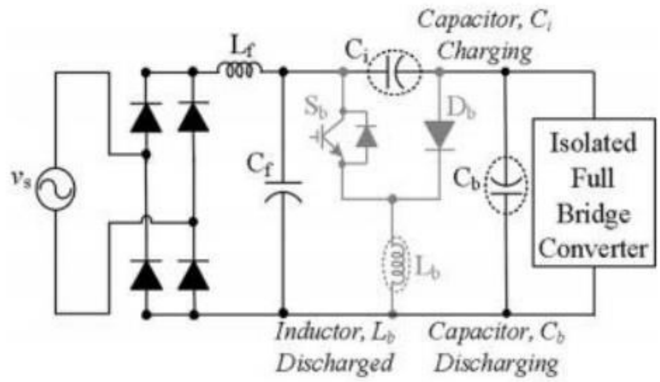
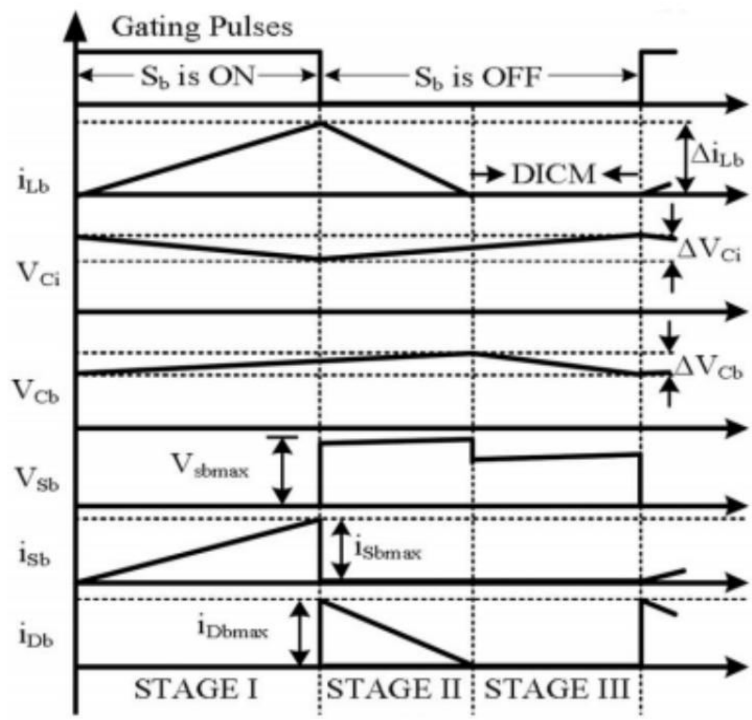


(c)



(d)

Fig.2. Operation of CSC converter: (a) Stage I, (b) Stage II, (c) Stage III, (d) waveforms during one switching period

Operating Modes of FB Converter

The controlled output of CSC converter is fed to the FB buck converter to step down the dc-link voltage to the desired level. Three FB converters are connected in parallel so that device rating can be reduced and also scaling up the power rating is easy. Referring to Fig.3, the FB converters operate in CCMwhose operating stages are described as follows:

Stage I:

This stage is initiated when the switches S1 and S4are turned on and the dc-link voltage Vb is applied across the primary winding of the high-frequency transformers (HFTs) as shown in Fig. 3(a). The diodes Do1, Do3, and Do5 become forward biased, and the energy is stored in the output inductorsLo1 and Lo2. This results in an increased inductor current while the output filter capacitor Co discharges through the welding load.

Stage II:

During this stage, S1, S2, S3, and S4 are switched off while all the output diodes (Do1, Do2, Do3, Do4, Do5, and Do6)

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freewheel the energy stored in the output inductors Lo1 and Lo2. This stage is presented in Fig.3(b). The inductors release its stored energy to the output capacitor Co and welding load; thus, the output inductor current starts decreasing linearly.

Stage III:
Analogous to Stage I, switch pair S2 and S3 conducts to transfer the energy to output inductors, as shown inFig.3(c). Diodes Do1, Do3, and Do5 remain open during this interval. However, the output capacitor Co discharges through the welding load.

Stage IV:
Likewise, Stages II and IV are similar, as shown in Fig.3(d), as none of the switch pairs conduct, and again the output rectifier diodes (Do1, Do2, Do3, Do4, Do5, and Do6) act as freewheeling diodes. The output inductors release their stored energy charging the output capacitor Co. This stage terminateswhen the switches S1 and S4 are switched on again and the operating modes repeat in each switching cycle.

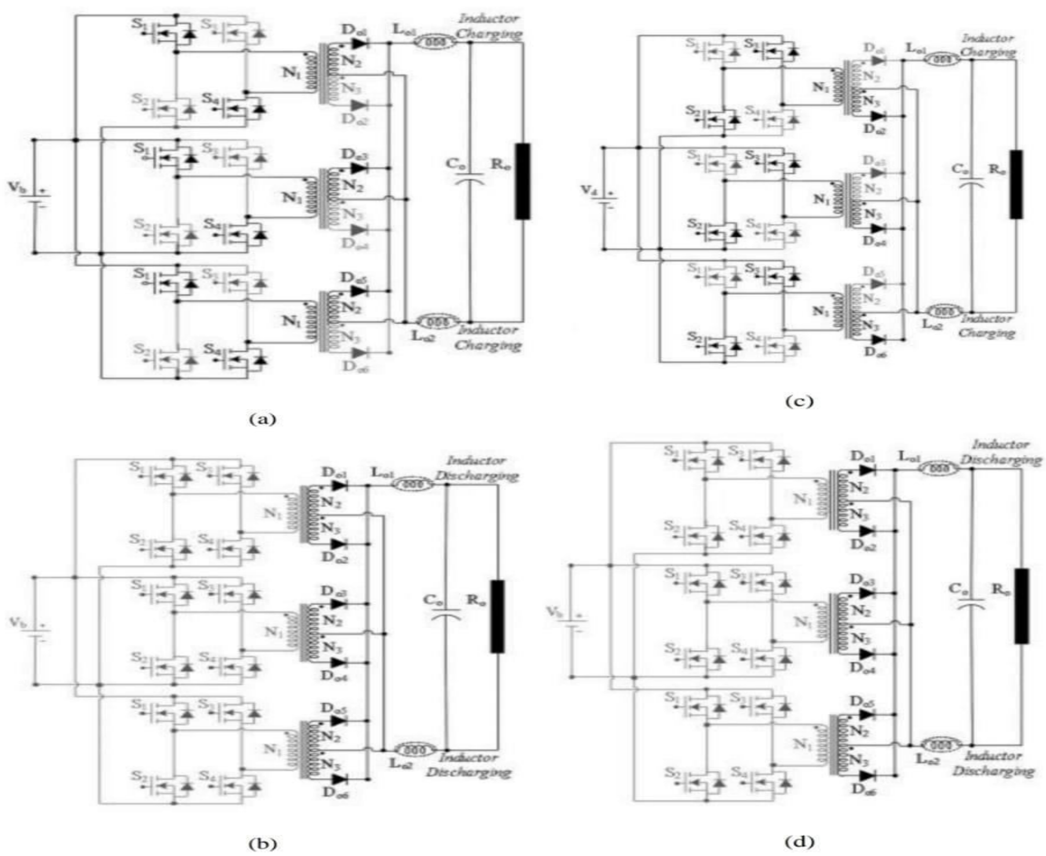

Fig 3 Operation of FB buck converter: (a) Stage I, (b) Stage II, (c) Stage III, and (d) Stage IV.

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III. MATLAB/SIMULINK RESULTS

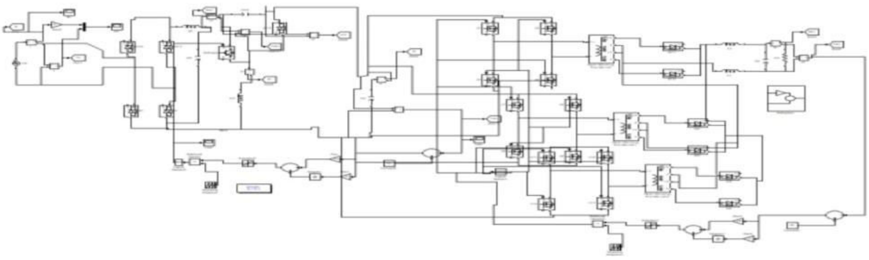

Figure shows the Simulation model of CSC converter and isolated FB converter based AWPS

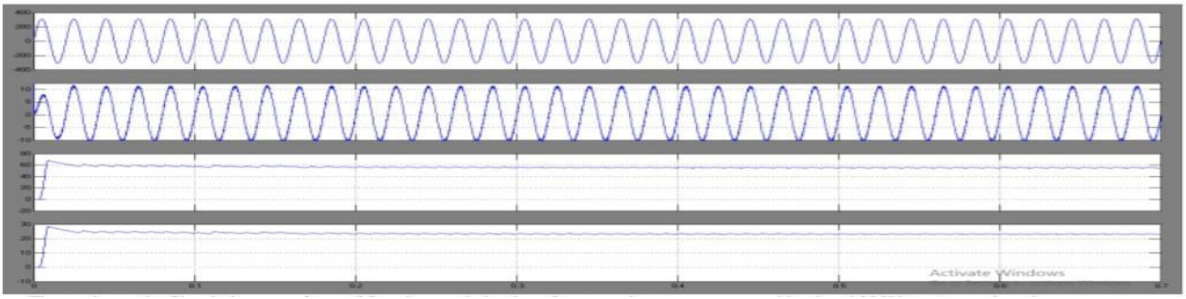

Figure shows the Simulation waveform of Steady state behavior of proposed converter at rated load and 220V (rms) supply voltage, source voltage, source current, output voltage and output current.

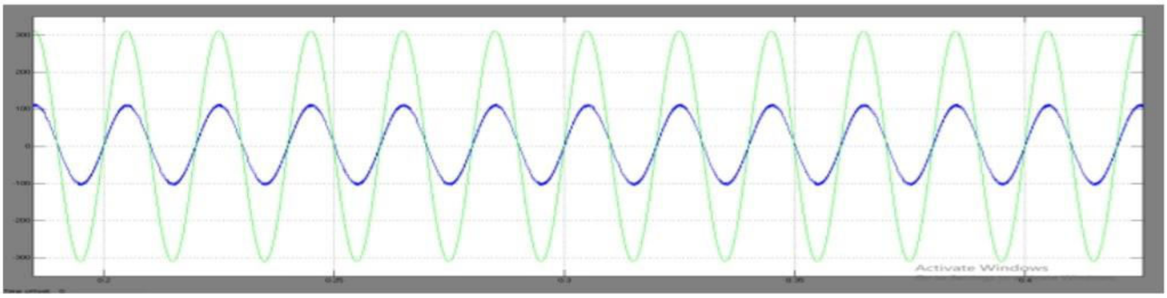

Figure shows the Simulation waveform of Input voltage and current

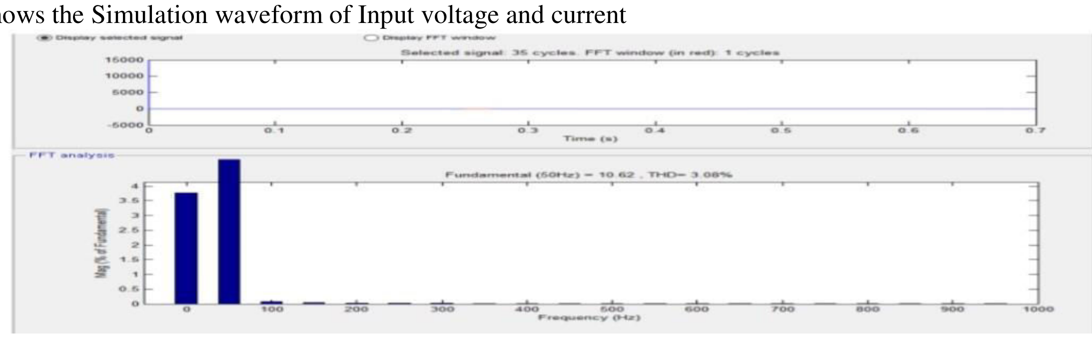

Figure shows the THD of source current with CSC converter

IV. CONCLUSION

The proposed circuit topology is a good solution as it offers excellent PFC features at the front end while the FB converter provides output isolation along with the over-current and startup protection. The component count has also reduced by integrating two power conversion stages. The quality of weld is enhanced by controlling the output side parameters to regulate the heat and mass input to the weld pool. Furthermore, it can be inferred from the obtained results

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that the proposed BL converter-based system has provided robustness and fast response. It is evident from the obtained results that the THD of the AC mains current is well below 5%. The PF has also remained close to unity making it suitable for wide-range of line/load operations. In all, it can be concluded that the proposed BL converter-based topology conforms to the requirements of the SMPS and THD less than the CSC converter.

Future Scope:

1. The proposed concept uses closed-loop control of Canonical switching cell converter for pulses, a PI controller is used for error compensation, here we can replace PI controller with Fuzzy Logic Controller to reduce response time then power quality also improved.
2. The Project applied to AWPS and also SMPS applications, this type of converters also we can apply for industrial applications where power quality or power factor is the major problem in those areas.

REFERENCES

[1] J.-M. Wang and S.-T. Wu, “A novel inverter for arc welding machines,” IEEE Trans. Ind. Electron., vol. 62, no. 3, pp. 1431–1439, Mar. 2015.

[2] J.-M. Wang, S.-T. Wu, S.-C. Yen, and H.-J. Chiu, “A simple inverter forarc-welding machines with current doubler rectifier,” IEEE Trans. Ind.Electron., vol. 58, no. 11, pp. 5278–5281, Nov. 2011.

[3] K. Weman, Welding Process Handbook. Cambridge, MA, USA: Woodhead, 2003, pp. 13–5.

[4] Limits for Harmonic Current Emissions, International Electro Technical Commission Standard 61000-3-2, 2004.

[5] B. Singh, B.N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, andD. P. Kothari, “A review of single-phase improved power quality AC–DC converters,” IEEE Trans. Ind. Electron., vol. 50, no. 5, pp. 962–981,Oct. 2003.

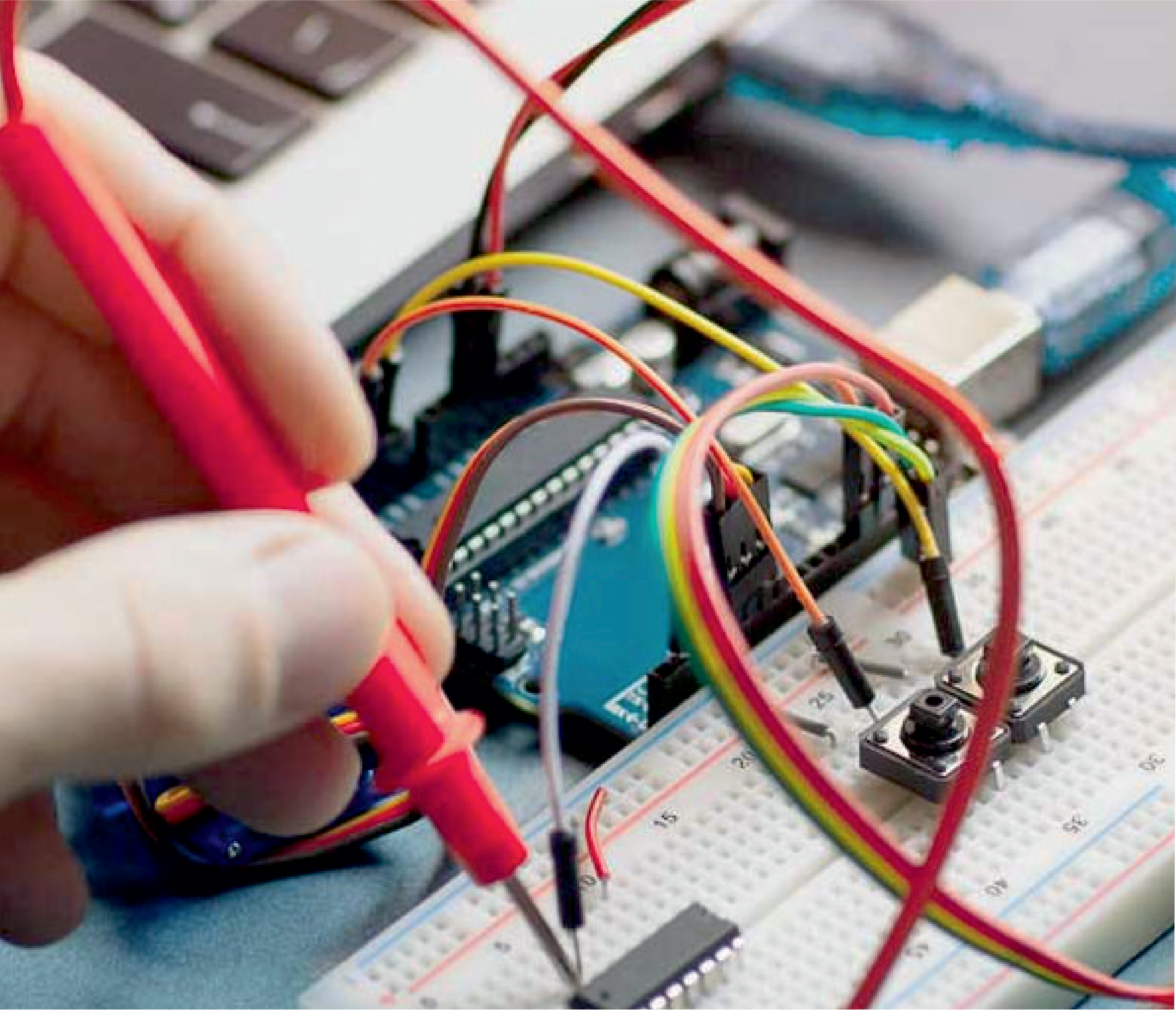
[6] M. M. Jovanovic and J. Yungtaek, “State-of-the-art, single-phase, active power-factor correction techniques for high-power applications—An overview,” IEEE Trans. Ind. Electron., vol. 52, no. 3, pp. 701–708, Jun.2005.

[7] O. Gracia, J. A. Cobos, R. Prieto, and J. Uceda, “Single phase power factor correction: A survey,” IEEE Trans. Power Electron., vol. 18, no. 3, pp. 749–755, May 2003.

[8] R. Casanueva, F. J. Azcondo, F. J. Diaaz, and C. Branas, “TIG welding ´machines,” IEEE Ind. Appl. Mag., vol. 17, no. 5, pp. 53–58, Sep./Oct.2011.

[9] C. Klumpner and M. Corbridge, “A two-stage power converter for welding applications with increased efficiency and reduced filtering,” in Proc. IEEEInt. Symp. Ind. Electron., 2008, pp. 251–256.

[10] V. Grigore and J. Kyyra, “High power factor rectifier based on buck converter operating in discontinuous capacitor voltage mode,” IEEE Trans.Power Electron., vol. 15, no. 6, pp. 1241– 1249, Nov. 2000.



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