## Application note

## STEVAL-ISA054V1, 100 W SMPS based on the STW9N150 Power MOSFET and UC3844B for industrial applications

## Introduction

This document introduces a solution for industrial power supplies. It takes advantage of the high voltage Power MOSFET, i.e. 1500 V breakdown voltage, to optimize the operation of the flyback converter based on the primary controller UC3844B.

The demonstration board has been designed and developed to address medium power applications. The board features two outputs, 24 V and 5 or 3.3 V (the latter sharing one output) and can deliver more than 100 W in total. The $5 / 3.3 \mathrm{~V}$ output is obtained by means of an integrated DC-DC converter based on L5970D, connected to the 24 V output, and adjustable by means of an external voltage divider.

The board is orderable with the order code "STEVAL-ISA054V1".
Figure 1. STEVAL-ISA054V1 board layout: components


Figure 2. STEVAL-ISA054V1 board layout: board layout and tracks


## Contents

1 Demonstration board description ..... 5
2 Specifics of the STW9N150 MOSFET ..... 9
3 Flyback transformer ..... 11
3.1 Transformer specifications ..... 12
4 DC-DC converter ..... 13
5 Primary and output waveforms ..... 14
5.1 Primary side waveforms ..... 14
5.2 Output side waveforms ..... 15
6 System time response at load variations ..... 17
7 Efficiency ..... 18
8 Bill of material ..... 19
9 Conclusion ..... 21
10 Revision history ..... 22

## List of tables

Table 1. Main specifications ..... 5
Table 2. Absolute maximum ratings ..... 9
Table 3. Electrical characteristics: on /off states ..... 9
Table 4. Electrical characteristics: dynamic ..... 10
Table 5. Switching times ..... 10
Table 6. Output voltage ..... 14
Table 7. STEVAL-ISA054V1: bill of materials ..... 19
Table 8. 1500 V power MOSFET product range ..... 21
Table 9. Document revision history ..... 22

## List of figures

Figure 1. STEVAL-ISA054V1 board layout: components . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1
Figure 2. STEVAL-ISA054V1 board layout: board layout and tracks . . . . . . . . . . . . . . . . . . . . . . . 1
Figure 3. Circuit schematic . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
Figure 4. Mechanical layout. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11
Figure 5. Electrical schematic . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 11
Figure 6. DC-DC converter . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13
Figure 7. Drain voltage (blue) and current (green) at 230 Vac, full load. . . . . . . . . . . . . . . . . . . . . 14
Figure 8. DC bus voltage at $180-265 \mathrm{Vac}_{\mathrm{rms}}$ input AC voltage range with 0.4 A fixed output current 15
Figure 9. 24 V output voltage spikes at full load . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 15
Figure 10. 24 V output voltage at start-up . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16
Figure 11. Output diode voltage (blue) and current (green) at 180 Vac input voltage, full load. . . . . . 16

Figure 13. 24 V DC output at load switching from 0.4 A to $4 \mathrm{~A} \ldots \ldots \ldots \ldots . \ldots \ldots . .$.
Figure 14. Efficiency at lout $=4 \mathrm{~A}$ for 24 Vdc output and lout2 $=1 \mathrm{~A}$ for 5 Vdc output $\ldots \ldots . . \ldots .18$
Figure 15. Efficiency at $\operatorname{Vin}=230 \operatorname{Vac}_{r m s} \ldots \ldots .$. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 18

## 1 Demonstration board description

The proposed board is based on a flyback converter and employs as primary switch the STW9N150, a $2.5 \Omega$, 8 A, 1500 V power MOSFET, which uses STMicroelectronics proprietary high voltage "mesh overlay" technology. Thanks to this technology, the switch features very low $R_{D S(o n)}$ per area, low gate charge and high switching performances. The device is available in a TO-247 package.

The demonstration board has been designed according to the specifications listed in table below.

Table 1. Main specifications

| Parameter | Value |
| :---: | :---: |
| Input voltage (CON1) | $400 \mathrm{~V}_{\text {acrms }} \pm 20 \%$ |
| Input voltage (CON2) | $180-265 \mathrm{Vacrms}$ |
| Input frequency | 50 Hz |
| Output 1 | 24 V at 4 A |
| Output 2 | 5 V at 1 A |
|  | 3.3 V at 1 A |
| Output power | 100 W |
| Safety | EN60950 |
| EMI | EN55014 |

The input section is provided with two connectors: CON1 for 400 Vac input voltage, and CON2 for 230 Vac input voltage. The output voltages are available on CON3 and CON4, with a shared ground between the two outputs, as shown in Figure 3.

The converter is controlled by the UC3844B, a primary controller for the flyback converter. The UC3844B controller provides the necessary features to implement off-line or DC-to-DC fixed-frequency current mode control schemes with a minimal number of external parts. The IC can control the power capability variations with the mains voltage by means of the feedforward line voltage. The IC also includes a disable function, an on-chip filter on the current sense pin, an error amplifier with a precise reference voltage for primary regulation and an effective two-level overcurrent protection.

The reflected voltage of the transformer has been set to 400 V , providing enough margin for the leakage inductance voltage spike, and a small RCD clamper circuit is used to limit excess voltage on the drain of the MOSFET.

During normal operation, the IC is powered by the auxiliary winding of the transformer via the D2 diode. The primary current is measured using the external sensing resistor (R23) for current mode operation.

The output voltage regulation is performed by a secondary feedback on the 24 V output. The feedback network consists of a programmable voltage reference (TL1431C), which drives an optocoupler that ensures the required insulation between the primary and secondary sections is met. The optotransistor drives the feedback pin (COMP) which controls the operation of the IC.

The flyback transformer is manufactured by Magnetica, and guarantees that the safety insulation is in accordance with the EN60950 low-voltage directive. Transformer specifications are detailed in Chapter 3.

Figure 3. Circuit schematic


The 5 V output is obtained from the 24 V output by means of an integrated power IC, the L5970D. The L5970D is a step-down monolithic power switching regulator with a switch current limit of 1 A , able to deliver up to 1 A DC current to the load depending on the application conditions. The output voltage can be adjusted by a voltage divider supplying either 3.3 V or 5 V . More detailed information on DC-DC conversion is introduced in Chapter 4.

The whole power supply has been realized on a single-side $35 \mu \mathrm{~m}$ PCB, whose total surface amounts to $176 \times 90 \mathrm{~mm}$.

## 2 Specifics of the STW9N150 MOSFET

Using the well-consolidated high voltage MESH OVERLAY™ process, STMicroelectronics has designed an advanced family of power MOSFETs with outstanding performances. The strengthened layout coupled with the company's proprietary-edge termination structure gives the lowest $\mathrm{R}_{\mathrm{DS}(o n)}$ per area, unrivalled gate charge and switching characteristics.

In particular, the proposed board employs as primary switch the STW9N150, a $1.8 \Omega$, 8 A, 1500 V power MOSFET. Table 2, 3, 4, and 5 show the characteristics of the MOSFET.

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
| :--- | :--- | :---: | :---: |
| $\mathrm{V}_{\mathrm{DS}}$ | Drain-source voltage $\left(\mathrm{V}_{\mathrm{GS}}=0\right)$ | 1500 | V |
| $\mathrm{~V}_{\mathrm{GS}}$ | Gate-source voltage | $\pm 30$ | V |
| $\mathrm{I}_{\mathrm{D}}$ | Drain current (continuous) at $\mathrm{T}_{\mathrm{C}}=25^{\circ} \mathrm{C}$ | 8 | A |
| $\mathrm{I}_{\mathrm{D}}$ | Drain current (continuous) at $\mathrm{T}_{\mathrm{C}}=100^{\circ} \mathrm{C}$ | 5 | A |
| $\mathrm{I}_{\mathrm{DM}}{ }^{(1)}$ | Drain current (pulsed) | 32 | A |
| $\mathrm{P}_{\mathrm{TOT}}$ | Total dissipation at $\mathrm{T}_{\mathrm{C}}=25^{\circ} \mathrm{C}$ | 320 | W |
|  | Derating factor | 2.56 | $\mathrm{~W} /{ }^{\circ} \mathrm{C}$ |
| $\mathrm{T}_{\mathrm{J}}$ | Operating junction temperature <br> $\mathrm{T}_{\text {stg }}$ | -55 to 150 | ${ }^{\circ} \mathrm{C}$ |

1. Pulse width limited by safe operating area.

Table 3. Electrical characteristics: on /off states

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathrm{V}_{(\mathrm{BR}) \mathrm{DSS}}$ | Drain source breakdown <br> voltage | $\mathrm{I}_{\mathrm{D}}=1 \mathrm{~mA}, \mathrm{~V}_{\mathrm{GS}}=0$ | 1500 |  |  | V |
| $\mathrm{I}_{\mathrm{DSS}}$ | Zero gate voltage drain <br> current $\left(\mathrm{V}_{\mathrm{GS}}=0\right)$ | $\mathrm{V}_{\mathrm{DS}}=\max$ rating <br> $\mathrm{V}_{\mathrm{DS}}=\max$ rating, <br> $\mathrm{T}_{\mathrm{C}}=125^{\circ} \mathrm{C}$ |  | 10 <br> 500 | $\mu \mathrm{A}$ <br> $\mu \mathrm{A}$ |  |
| $\mathrm{I}_{\mathrm{GSS}}$ | Gate-body leakage current <br> $\left(\mathrm{V}_{\mathrm{DS}}=0\right)$ | $\mathrm{V}_{\mathrm{GS}}= \pm 30 \mathrm{~V}$ |  |  | $\pm 100$ | nA |
| $\mathrm{V}_{\mathrm{GS}(\mathrm{th})}$ | Gate threshold voltage | $\mathrm{V}_{\mathrm{DS}}=\mathrm{V}_{\mathrm{GS}}, \mathrm{I}_{\mathrm{D}}=250 \mu \mathrm{~A}$ | 3 | 4 | 5 | V |
| $\mathrm{R}_{\mathrm{DS}(o n)}$ | Static drain source on <br> resistance | $\mathrm{V}_{\mathrm{GS}}=10 \mathrm{~V}, \mathrm{I}_{\mathrm{D}}=4 \mathrm{~A}$ |  | 1.8 | 2.5 | $\Omega$ |

Table 4. Electrical characteristics: dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{gfs}^{(1)}$ | Forward transconductance | $\mathrm{V}_{\mathrm{DS}}=15 \mathrm{~V}, \mathrm{I}_{\mathrm{D}}=4 \mathrm{~A}$ |  | 7.5 |  | S |
| Ciss <br> Coss <br> Crss | Input capacitance Output capacitance Reverse transfer capacitance | $\begin{aligned} & \mathrm{V}_{\mathrm{DS}}=25 \mathrm{~V}, \mathrm{f}=1 \mathrm{MHz}, \\ & \mathrm{~V}_{\mathrm{GS}}=0 \end{aligned}$ |  | $\begin{aligned} & 3255 \\ & 294 \\ & 22.4 \end{aligned}$ |  | pF <br> pF <br> pF |
| $\mathrm{C}_{\text {oss }}$ eq. | Equivalent output capacitance | $\mathrm{V}_{\mathrm{GS}}=0, \mathrm{~V}_{\mathrm{DS}}=0$ to 1200 V |  | 118 |  | pF |
| $\mathrm{R}_{\mathrm{g}}$ | Gate input resistance | $\mathrm{f}=1 \mathrm{MHz}$ gate DC Blas $=0$ <br> Test signal level $=20 \mathrm{mV}$ open drain |  | 2.4 |  | $\Omega$ |
| $\begin{aligned} & Q_{\mathrm{g}} \\ & \mathrm{Q}_{\mathrm{gs}} \\ & \mathrm{Q}_{\mathrm{gd}} \end{aligned}$ | Total gate charge <br> Gate-source charge <br> Gate-drain charge | $\begin{aligned} & \mathrm{V}_{\mathrm{DD}}=1200 \mathrm{~V}, \mathrm{I}_{\mathrm{D}}=8 \mathrm{~A}, \\ & \mathrm{~V}_{\mathrm{GS}}=10 \mathrm{~V} \end{aligned}$ |  | $\begin{aligned} & \hline 89.3 \\ & 15.8 \\ & 50.4 \end{aligned}$ |  | $\begin{aligned} & \mathrm{nC} \\ & \mathrm{nC} \\ & \mathrm{nC} \end{aligned}$ |

1. Pulsed: Pulse duration $=300 \mu \mathrm{~s}$, duty cycle $1.5 \%$

Table 5. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{d}(\mathrm{on})}$ | Turn-on delay time |  |  | 41 |  | ns |
| $\mathrm{t}_{\mathrm{r}}$ | Rise time | $\mathrm{V}_{\mathrm{DD}}=750 \mathrm{~V}, \mathrm{I}_{\mathrm{D}}=4 \mathrm{~A}$ |  | 14.7 |  | ns |
| $\mathrm{t}_{\mathrm{d} \text { (off) }}$ | Turn-off delay time | $\mathrm{R}_{\mathrm{G}}=4.7 \Omega, \mathrm{~V}_{\mathrm{GS}}=10 \mathrm{~V}$ |  | 86 | ns |  |
| $\mathrm{t}_{\mathrm{f}}$ | Fall time |  |  | 52 |  | ns |

## 3 Flyback transformer

Figure 4 and Figure 5 show the electrical and mechanical specifications of the transformer. Section 3.1 lists the technical specifications for the transformer.

Figure 4. Mechanical layout


Figure 5. Electrical schematic


### 3.1 Transformer specifications

- Inductance: (at $1 \mathrm{kHz}, 20 \mathrm{deg} \mathrm{C}$ )
- Primary (pin 2-5): $2.25 \mathrm{mH}+/-15 \%$
- Auxiliary (pin 6-7): $3.3 \mu \mathrm{H}+/-15 \%$
- Secondary (pin 13,12-9,10): $9 \mu \mathrm{H}+/-15 \%$
- Resistance: (at 20 deg C)
- Primary (pin 2-5): $0.8 \mathrm{~m} \Omega$ max
- Auxiliary (pin 6-7): $45 \mathrm{~m} \Omega$ max
- Secondary (pin 12-9): $13 \mathrm{~m} \Omega$ max
- Secondary (pin 13-10): $15 \mathrm{~m} \Omega \max$
- Transformer ratio: (at $10 \mathrm{kHz}, 20 \mathrm{deg} \mathrm{C}$ )
- Terminals 2-5 / 6-7: 28 +/-5 \%
- Terminals 2-5 / 13-9: $16+/-5 \%$
- Terminals 2-5 / 12-10: $16+/-5 \%$
- Inductance losses: (pin 2-5, 6-7-9-10-12-13 at 10 kHz, Ta 20 deg. C): $1 \%$ NOM
- Parasitic capacitance: (pin 2-5 at $650 \mathrm{kHz}, \mathrm{Ta} 20 \mathrm{deg}$. C): 26 pF NOM
- Saturation current: (pin 2-5 at 0.35T Bsat, Ta 20 deg. C): 1.5 Ap max
- Working current: (pin 2-5 at Pmax 103 W, F 70 kHz , Ta 20 deg. C): 1.2 Ap max
- Working frequency: (at Pmax $103 \mathrm{~W}, 70 \mathrm{kHz}, \mathrm{Ta} 20 \mathrm{deg}$. C): 70 kHz nom
- Temperature: (at Pmax 103 W ): $-10 /+40$ deg C
- Primary/Secondary isolation: (at 50 Hz , time 2", Ta 20 deg. C): 4000 V
- Dimensions max: $40 \times 28 \mathrm{~mm}$, h 45 mm
- Weight: ~ 68 g .


## 4 DC-DC converter

Figure 6 shows the schematic of the converter. The device uses an internal P-channel DMOS transistor, with a typical $R_{\mathrm{DS}(o n)}$ of $250 \mathrm{~m} \Omega$ as switching element to avoid the use of a bootstrap capacitor, and guarantees high efficiency. An internal oscillator fixes the switching frequency at 250 kHz to minimize the size of the external components. The power IC features several protections, such as a pulse-by-pulse current limit with the internal frequency modulation aimed to an effective constant current short-circuit protection, feedback disconnection and thermal shutdown. Finally, it can be synchronized using a dedicated pin as well as inhibited for reduced stand-by power consumption and time sequence operations.

Figure 6. DC-DC converter


## 5 Primary and output waveforms

### 5.1 Primary side waveforms

All measurements have been performed at ambient temperature (about $25^{\circ} \mathrm{C}$ ), with the input voltage in the range of $180 \mathrm{Vac}_{\mathrm{rms}}$ to $265 \mathrm{Vac}_{\mathrm{rms}}$. The output voltage measurements during normal operation at no load and full load are listed in Table 6.

Table 6. Output voltage

| Vinrms | 24 V output | 5 V output | 3.3 V output |
| :---: | :---: | :---: | :---: |
|  | No load $\rightarrow 24.09 \mathrm{~V}$ | No load $\rightarrow 4.928 \mathrm{~V}$ | No load $\rightarrow 3.293 \mathrm{~V}$ |
| 180-265 Vacrms | Full load $\rightarrow 24.079 \mathrm{~V}$ <br> Max voltage spike $\rightarrow 510 \mathrm{mV}$ | Full load $\rightarrow 4.932 \mathrm{~V}$ <br> Max voltage spike $\rightarrow 490 \mathrm{mV}$ | Full load $\rightarrow 3.295 \mathrm{~V}$ <br> Max voltage spike $\rightarrow 320 \mathrm{mV}$ |

Figure 7. Drain voltage (blue) and current (green) at 230 Vac, full load


Figure 8 shows the DC bus voltage at input AC voltage variations. The load current is fixed on a $1 / 10$ value of the maximum output current.

Figure 8. DC bus voltage at $\mathbf{1 8 0}-265 \mathrm{Vac}_{\text {rms }}$ input AC voltage range with 0.4 A fixed output current


### 5.2 Output side waveforms

Figure below shows the output voltage ripple for a 24 V output at full load. The output voltage ripple has been minimized by choosing output capacitors with a very low ESR and high ripple current. The spikes have a peak-to-peak amplitude smaller than 510 mV . An additional LC filter has been introduced after the first output capacitor bank in order to reduce the voltage ripple and large voltage spike.

Figure 9. 24 V output voltage spikes at full load


Figure 10 shows the 24 V output voltage time response at start-up.
Figure 10. 24 V output voltage at start-up


Figure 11 shows the output voltage and current for diode STPS20120CFP. The green waveform is the current flowing through the diode and the blue waveform is the voltage across the diode.

Figure 11. Output diode voltage (blue) and current (green) at 180 Vac input voltage, full load


## 6 System time response at load variations

Some tests have been done varying the load current, switching between the maximum and minimum values and vice versa. Figure 12 shows the output overshoot after current load switching from 4 A to 0.4 A , with a response time of 30 ms .

Figure 12. 24 V DC output at load switching from 4 A to 0.4 A


Figure 13 shows the output overshoot after current load switching from 0.4 A to 4 A , with a response time of 30 ms .

Figure 13. 24 V DC output at load switching from 0.4 A to 4 A


## 7 Efficiency

Figure 14 shows the ratio pout/pin as a function of the input AC voltage. The input voltage range is between 180 V and 265 Vrms . The output load current is fixed at 4 A for 24 Vdc out and 1 A for 5 Vdc out. The maximum efficiency is about $82 \%$ and is reached with an input voltage of $230 \mathrm{Vac}_{\mathrm{rms}}$.

Figure 14. Efficiency at $\mathrm{I}_{\mathrm{out} 1}=4 \mathrm{~A}$ for 24 Vdc output and $\mathrm{I}_{\mathrm{out} 2}=1 \mathrm{~A}$ for 5 Vdc output


Figure 15 shows the ratio of pout/pin depending on the output current variation. The current range is between 0.5 A and 4 A for a 24 V output. The input AC voltage is fixed at 230 Vac $_{\text {rms }}$.

Figure 15. Efficiency at Vin $=230 \mathrm{~V}_{\text {acrms }}$


## 8 Bill of material

Table 7. STEVAL-ISA054V1: bill of materials

| Reference | Part / value | Tecnology information |
| :---: | :---: | :---: |
| Cin | $10 \mu \mathrm{~F}, 25 \mathrm{~V}$ ceramic | Monolithic ceramic capacitors |
| Cout | 470 FF, 10 V -ZL series | Aluminium electrolityc capacitors |
| Co1,Co2,Co3,Co4,C16 | $560 \mu \mathrm{~F}, 35 \mathrm{~V}$-ZL series | Aluminium electrolityc capacitors |
| C2 | $68 \mu \mathrm{~F}, 450$ V-MXC series | Aluminium electrolityc capacitors |
| C3 | $330 \mu \mathrm{~F}, 25 \mathrm{~V}$ | Electrolytic capacitors |
| C4 | 2.2 nF, 1600 V R73 KP series | FILM-FOIL polypropylene capacitors |
| C5 | $68 \mu \mathrm{~F}, 450$ V-MXC series | Aluminium electrolityc capacitors |
| C6 | 100 nF | SMD mult.ceramic capacitors |
| C7 | 22 nF | SMD mult.ceramic capacitors. |
| C8 | 220 pF, 5\% | SMD mult.ceramic capacitors |
| C9 | 1 nF , K | Ceramic capacitors |
| C10 | $1 \mathrm{nF}, \mathrm{K}$ | COG ceramic capacitors |
| C12,C13 | $47 \mathrm{nF}, \mathrm{X} 2660$ Vac | Multi-layer metallized capacitors |
| C14 | 10 nF | Ceramic capacitors |
| C15 | 2.2 nF, Y1 | Y1 capacitor |
| D2 | 1N4148 | Ultrafast $100 \mathrm{~mA}-75 \mathrm{~V}$ diode |
| D3,D5 | STTH108 | Turboswitch diode STMicroelectronics |
| D6,D9,D10,D11 | 1N4007 | RECTIFIER 1 A-1000 V |
| D7 | STPS2L25U | Schottky diode 2 A-25 V STMicroelectronics |
| D8 | STPS20120CFP | Schottky diode 20 A-120 V STMicroelectronics |
| F1 | FUSE, 2 A $6.3 \times 32$ | Fuse |
| J2 | CON3, 24 V | Power connector |
| J3 | CON1, 400 Vac | Power connector |
| J4 | CON2, 230 Vac | Power connector |
| J5 | CON4, 3.3/5 V | Power connector |
| L1 | $28 \mathrm{mH}, 2 \mathrm{~A}$ | EMI filter |
| L2,L3,L5 | $1 \mathrm{mH}, 2 \mathrm{~A}$ | Line inductor |
| L4 | $33 \mu \mathrm{H}, 2 \mathrm{~A}$ | Inductor |
| L6 | $10 \mu \mathrm{H}, 4 \mathrm{~A}$ | Filter inductor |
| Q5 | STW9N150 | HV power MOSFET 1500 V STMicroelectronics |

Table 7. STEVAL-ISA054V1: bill of materials

| Reference | Part / value | Tecnology information |
| :---: | :---: | :---: |
| Q6 | 2SD882 | NPN medium power transistor STMicroelectronics |
| Q7 | 2SB772 | PNP medium power transistor STMicroelectronics |
| RT1 | NTC - 10 | NTC thermistor |
| R1, R17 | 330 k , 2 W | Resistor |
| R2,R4,R7,R9 | $1 \mathrm{M} \Omega, 1 / 4 \mathrm{~W}$ | SMD resistor |
| R3 | 10 | Resistor |
| R5 | $91 \mathrm{k} \Omega$, 1\% | SMD resistor |
| R6 | $2.2 \mathrm{k} \Omega$, 1\% | SMD resistor |
| R8 | $1 \mathrm{k} \Omega$ | SMD resistor |
| R19 | $1 \mathrm{k} \Omega$ | Resistor |
| R10 | $4.7 \mathrm{k} \Omega$ | SMD resistor |
| R12 | $4.7 \mathrm{k} \Omega$ | SMD resistor |
| R11 | $56 \mathrm{k} \Omega$ | SMD resistor |
| R13 | $47 \mathrm{k} \Omega$, 3 W | Metal oxide film resistor |
| R14 | $10 \mathrm{k} \Omega$, 1\% | SMD resistor |
| R15 | $3.3 \mathrm{k} \Omega$, 1\% | SMD resistor |
| R16 | 5.6 k $\Omega$, 1\% | SMD resistor |
| R18 | 15 k, 1\% | Resistor |
| R20 | $24 \mathrm{k} \Omega, 1 \%$ | SMD resistor |
| R23 | 0.68 | Metal oxide sensing resistor |
| R26 | $1 \mathrm{k} \Omega$ | Resistor |
| R27 | 27 | Resistor |
| R28 | 12 | Resistor |
| R29 | 12 | Resistor |
| SW1 | SW1 | Jumper |
| T5 | Transformer | Transformer |
| U1 | UC3844B | Current mode Flyback controller STMicroelectronics |
| U2 | L5970D | Integrated DC-DC converter STMicroelectronics |
| U3 | TL1431C | Shunt regulator - STMIcroelectronics |
| U4 | PC817 | Optocoupler |
|  | HEAT SINK, 4.7 K/W | Heat sink |

www.BDTIC.com/ST

## 9 Conclusion

This document introduces a complete solution for an auxiliary power supply in a typical industrial application. The board has been fully characterized, showing good performance in all test conditions, confirming the suitability of the proposed solution for industrial applications. The STW9N150 described in this document belongs to ST's 1500 V power MOSFET series (see Table 8) that has been specifically created to satisfy the growing demand in the industrial market for very high voltage power MOSFETs.

Table 8. 1500 V power MOSFET product range

| P/N | BVdss [V] | $\mathbf{R}_{\mathbf{D S}(\mathbf{o n )}}$ at $\mathbf{1 0} \mathbf{V}[\Omega]$ | ID[A] | Package |
| :---: | :---: | :---: | :---: | :---: |
| STW9N150 | 1500 | 2.5 | 8.0 | TO-247 |
| STFW4N150 |  | 7 | 4.0 | TO-3PF |
| STW4N150 |  |  | 4.0 | TO-247 |
| STP4N150 |  | 9 | 4.0 | TO-220 |
| STFW3N150 |  |  | 2.5 | TO-3PF |
| STW3N150 |  |  | 2.5 | TO-247 |
| STP3N150 |  |  | 2.5 | TO-220 |

## 10 Revision history

Table 9. Document revision history

| Date | Revision | Changes |  |
| :---: | :---: | :--- | :--- |
| 24-Sep-2009 | 1 | Initial release. |  |

## Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.
Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.
Information in this document supersedes and replaces all information previously supplied.
The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.
© 2009 STMicroelectronics - All rights reserved

STMicroelectronics group of companies
Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

