# AN2001
# Application note

## VIPower: VIPer53 single output reference board 90 to 264 VAC input, 24W output

## Introduction

The VIPer53 combines an enhanced current mode PWM controller with a high voltage MDMesh Power Mosfet in the same package. VIPer53 is available in two different packages, DIP-8 and PowerSO-10. This reference board is an offline wide range power supply that incorporates VIPer53 and is set up for secondary regulation by driving the PWM controller through an optocoupler. The switching frequency is set at 100 kHz and the total output power is 24W.

- Switch mode general purpose power supply
- Current mode control with adjustable limitation
- 75% efficiency
- Output short circuit and overload protection
- Thermal shutdown protection
- Meets EN55022 class B EMI specification
- Blue Angel compliant

### Operating conditions

| Parameter | Limits |
|---|---|
| Input voltage range | 90 to 264Vac |
| Input Frequency | 100kHz |
| Output voltage | V=12V |
| Output power | 24W |
| Efficiency | 75% typical |
| Line regulation | +/- 0 |
| Load regulation | +/- 0.2% |
| Output ripple voltage | 15mVpp |
| EMI | EN55022 Class B |

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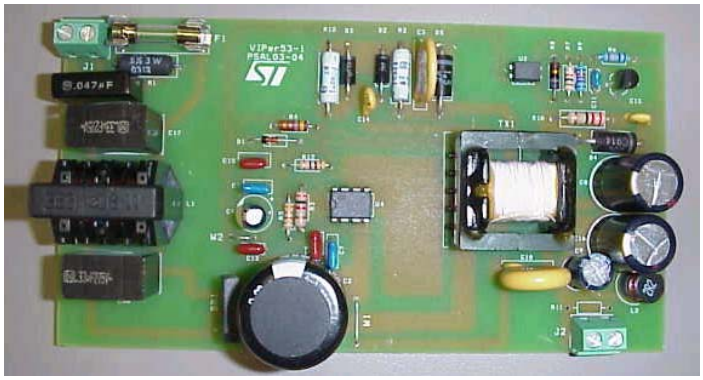
# 1 PCB lay-out

**Figure 1. Board layout (not in scale)**



# 2 Efficiency

*Figure 2.* and *Figure 3.* shows the two efficiency curves of the reference board. The measurements on *Figure 2.* are taken at the input voltage of 120Vac while the output load is varied from 0A to the full load of 2A. Meanwhile, *Figure 3.* shows the efficiency when the input voltage is varied from 90 to 264Vac while the output load is fixed at 2A.

**Figure 2. Efficiency vs. Iout**

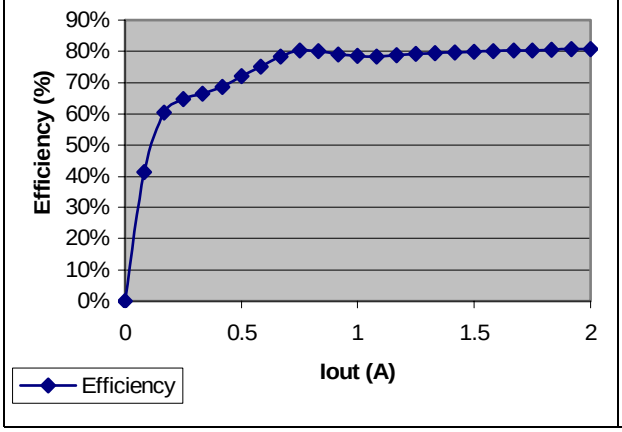
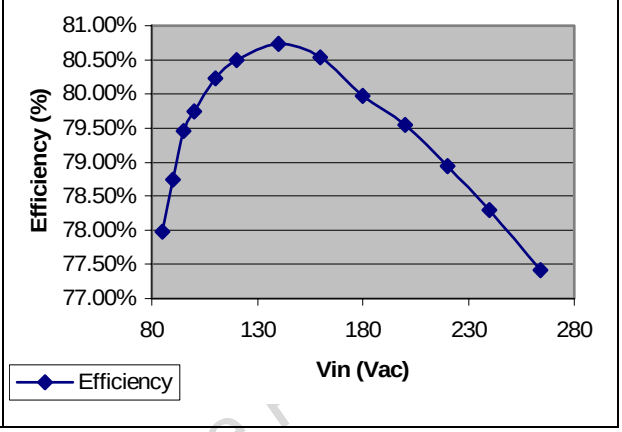



**Figure 3. Efficiency vs. Vin**



# 3 Load regulation

Vout is measured while the output load is varied from 0A to 2A at the nominal input voltage of 120Vac. *Figure 4.* shows the load regulation measured, which is 0.2%.

# 4 Line regulation

The line regulation is measured to be 0%. Here, the output load is kept at the full load of 2A while the input voltage is varied from 90 to 264V and the output voltage for the reference board remains regulated.

**Figure 4. Load regulation**

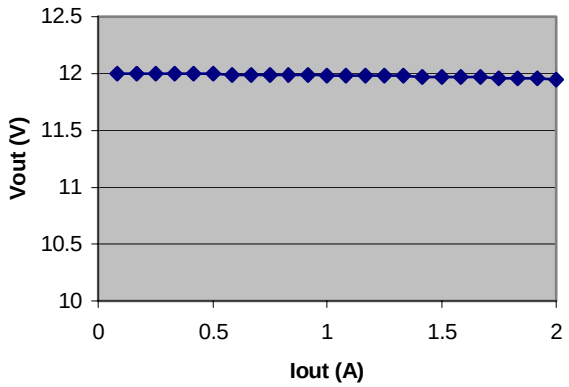
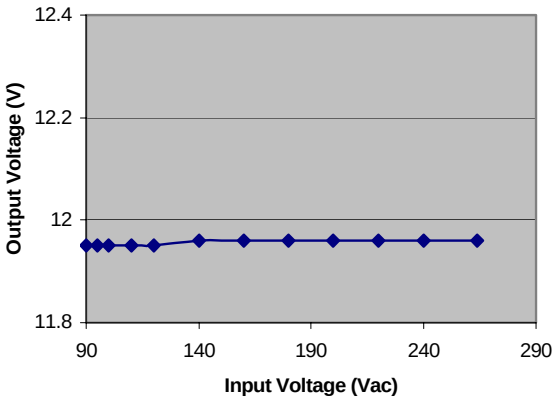



**Figure 5. Line regulation**



# 5 Transient response

**Figure 6. Transient response**

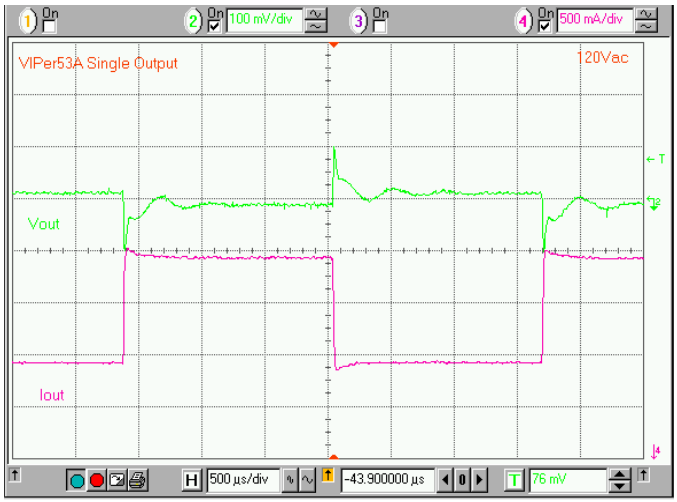



*Figure 6.* shows the transient load response as the output load is stepped from 1A to 2A (50% to 100% load) at the input voltage of 120Vac. The dynamic response is 80mV or 0.7% while the settling time is found to be 420µs.

# 6 Line and switching frequency ripple

*Figure 7.* and *Figure 8.* show the line and switching frequency ripple of the reference board measured at the input voltage of 120Vac and the output current is fixed at 2A.

**Figure 7. Line frequency ripple**

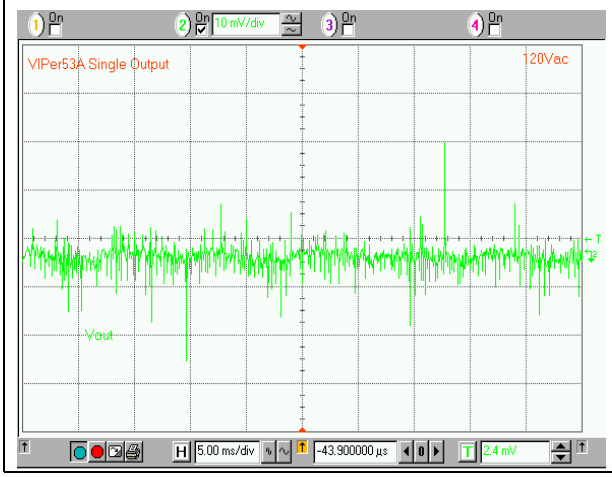
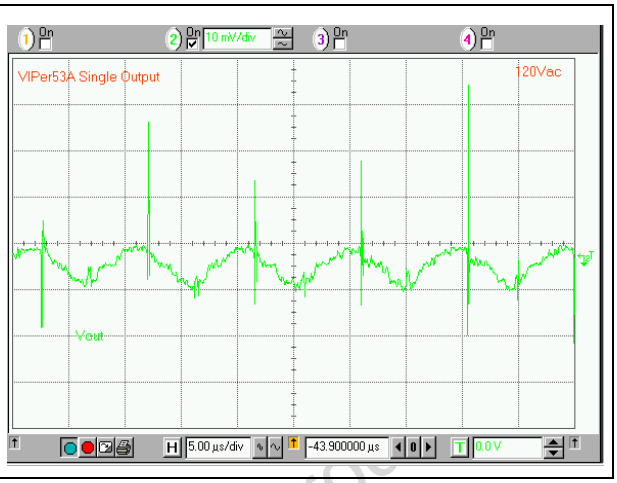



**Figure 8. Switching frequency ripple**

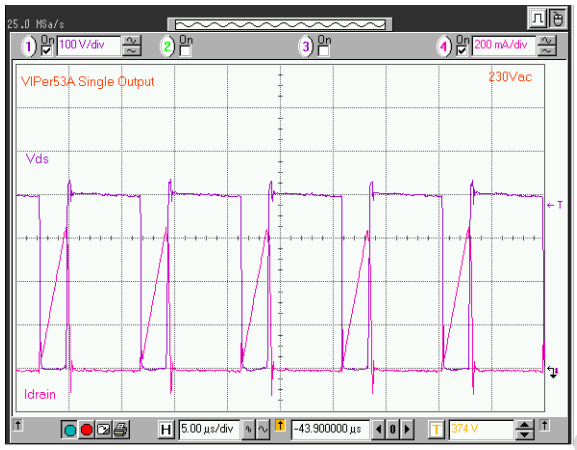



Both waveforms show a line frequency and switching frequency ripple of 10mVpp each.

# 7 Waveforms

*Figure 9.* shows the drain current and Vds at 230Vac full load. The converter is working in discontinuous mode as can be seen from the waveforms.

**Figure 9. $V_{ds}$ and drain current**



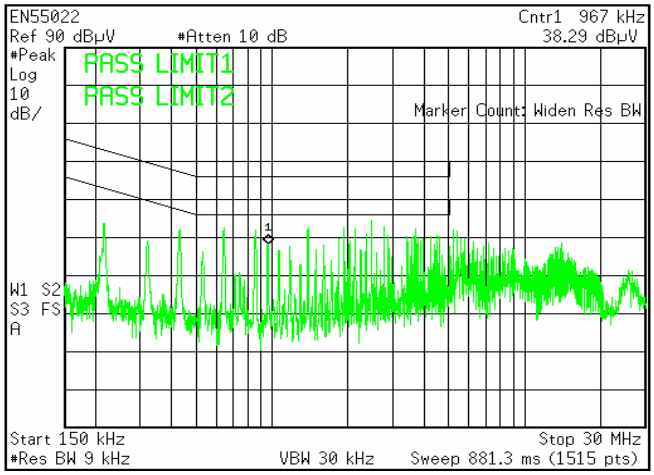
# 8 Blue Angel

The reference board consumes less than 1W total when working in stand-by burst mode at the input voltage of 120Vac. The measured input power consumption is 569mW with zero loads at the output.

Therefore, the board meets Blue Angel norm.

# 9 EMI results

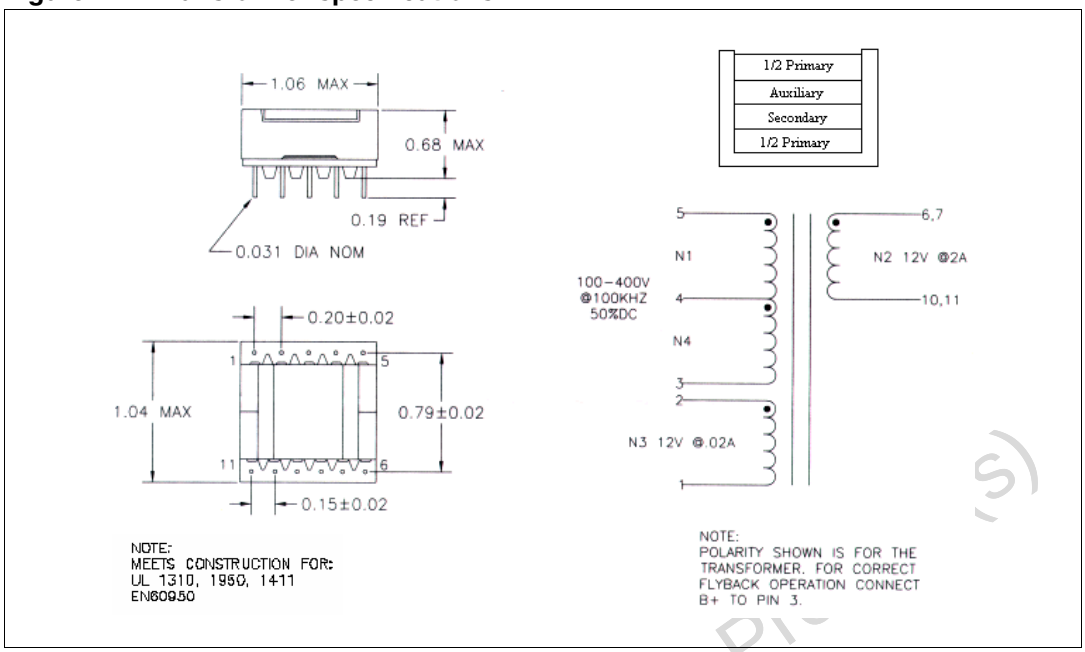
**Figure 10. EMI**




The reference board passes the EN55022 Class B EMI test as shown in *Figure 10.*

# 10 Transformer specification

**Figure 11. Transformer specifications**




The transformer is designed and manufactured by Cramer Coil and Transformer Co., Inc. The electrical characteristics of the transformer are as follows:

The electrical specifications of the transformer are as follow:

- Primary Inductance 1.10mH±10%
- Primary Leakage Inductance 6.4µH typical
- HIPOT (N1, N3, N4 tro N2) 4000VAC, 1sec
- DCR (N1/N4) 0.905 Ω typical
- DCR (N2) 0.020 Ω typical
- DCR (N3) 0.112 Ω typical
- Turns Ratio (N1/N4:N2) 1:0.121±3%
- Turns Ratio (N1/N4:N3) 1:0.121±3%

When VIPer53 is on, energy is stored in the primary winding of the transformer (pins 3-5). This energy is transferred to the auxiliary winding (pins 1-2), and to the output (6, 7-10, 11) when the VIPer53 is off. The auxiliary winding provides the bias voltage for the VIPer53 at pin 7 (Vdd).

# 11 Different output current and voltage capability

The standard voltage and current values for the reference board can be changed to deliver a different voltage and current value, with changes to the following components as detailed in *Table 1.*

**Table 1. Secondary component value to obtain different output voltage and current**

| Vout and Iout | T1 | R6 | R9 | C8, C16 | D4 |
|---|---|---|---|---|---|
| 5.0V 4.8A | CVP53-003 | 2.49kΩ 1% | 2.49kΩ 1% | 3300µF 10V | STPS1045 |
| 12V 2.0A | CVP53-001 | 3.48kΩ 1% | 13.3kΩ 1% | 1000µF 25V | BYW98-200 |
| 15V 1.6A | CVP53-004 | 2.94kΩ 1% | 14.7kΩ 1% | 1000µF 35V | BYW98-200 |
| 24V 1.0A | CVP53-005 | 1.50kΩ 1% | 13.0kΩ 1% | 470µF 50V | BYW98-200 |

**Figure 12. PC board top legend (not in scale)**

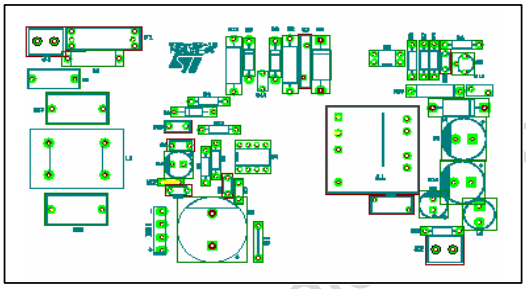


**Figure 13. PC board bottom copper (not in scale)**

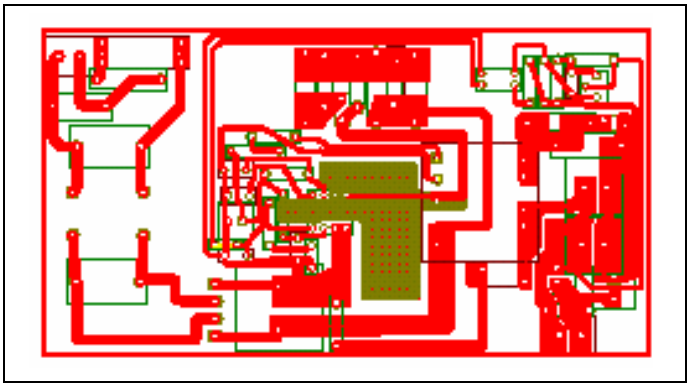




**Table 2. Component list**

| Quantity | Reference | Description |
|---|---|---|
| 1 | BR1 | KBP210GDI bridge rectifier |
| 1 | C1 | 0.047µF 250V boxcap |
| 1 | C2 | 68µF/400V electrolytic |

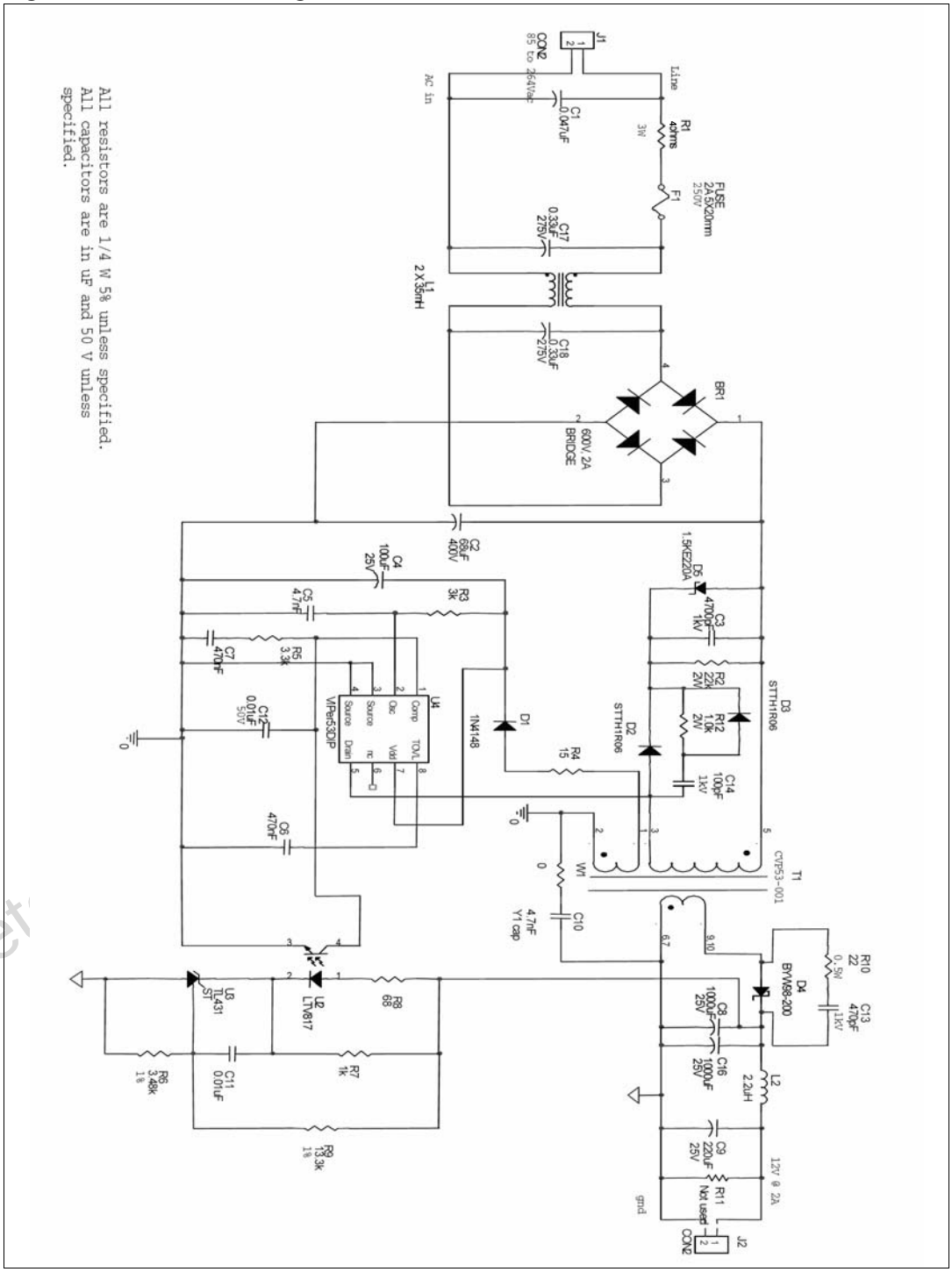
**Table 2. Component list**

| Quantity | Reference | Description |
|---|---|---|
| 1 | C3 | 4700pF 1kV ceramic |
| 1 | C4 | 100µF/25V electrolytic |
| 1 | C5 | 4.7nF 50V polyester |
| 2 | C6, C7 | 470nF 50V ceramic |
| 2 | C8, C16 | 1000µF/25V electrolytic |
| 1 | C9 | 220µF/25V electrolytic |
| 1 | C10 | 4.7nF/250V Y1 cap |
| 2 | C11, C12 | 0.01µF 50V ceramic |
| 1 | C13 | 470pF/1kV ceramic |
| 1 | C14 | 100pF/1kV ceramic |
| 1 | C15 | Not used |
| 2 | C17, C18 | 0.33µF/250V boxcap |
| 1 | L1 | Panasonic 35mH common-mode line choke |
| 1 | L2 | Coilcraft 2.2µH inductor |
| 1 | T1 | Cramer Coil CVP53-001 |
| 1 | R1 | 4Ω 5% 3W Wire wound |
| 1 | R2 | 22kΩ 5% 2W resistor |
| 1 | R3 | 3kΩ 5% 0.5W resistor |
| 1 | R4 | 15Ω 5% 0.25W resistor |
| 1 | R5 | 3.3kΩ 5% 0.25W resistor |
| 1 | R6 | 3.48kΩ 1% 0.25W resistor |
| 1 | R7 | 1kΩ 5% 0.25W resistor |
| 1 | R8 | 68Ω 5% 0.25W resistor |
| 1 | R9 | 13.3kΩ1% 0.25W resistor |
| 1 | R10 | 22Ω 5% 0.5W resistor |
| 1 | R12 | 1kΩ 5% 2W resistor |
| 1 | R13 | Not used |
| 1 | D1 | 1N4148 |
| 2 | D2, D3 | STMicroelectronics STTH1R06 |
| 1 | D4 | STMicroelectronics BYW98-200 |
| 1 | D5 | STMicroelectronics 1.5KE220A transil |
| 1 | U2 | H11A817A or LTV817A optocoupler |
| 1 | U3 | STMicroelectronics TL431 |
| 1 | U4 | STMicroelectronics VIPer53DIP |

**Table 2. Component list**

| Quantity | Reference | Description |
|---|---|---|
| 2 | W1, W2 | Jumper wire |
| 2 | J1, J2 | Connectors |

**Figure 14. Schematic diagram**



# 12 Revision history

**Table 3. Revision history**

| Date | Revision | Changes |
|---|---|---|
| 16-Jul-2004 | 1 | First issue |
| 12-Sep-2006 | 2 | - New template<br>- Component list value modified<br>- Schematic diagram modified |