CountryLink CityRail **RailCorp**

Engineering & Projects Group
Chief Engineers' Division

Signals Type Approval

Certificate No: ★10/0603

Manufacturer: ----------	***Leonard Electronics Pty Ltd***
Supplier: --------------	***Leonard Electronics Pty Ltd***
Product Description: ------	***Dual Voltage Regulator 2x(12V, 1A) for level crossing applications.***
Approved For: -----------	***Use in level crossings installations in RailCorp Signals***
Restrictions or Limitations: --	***Nil***
Date of Issue: -----------	***10 October 2010***

Warwick Allison
Chief Engineer Signals & Control Systems

This approval is applicable to the item being used on RailCorp infrastructure in accordance with RailCorp installation standards and procedures. It makes no conclusions about the suitability for use under any other circumstances, and any reliance on the approval by any other organisation is done so entirely at that organisation's own risk.
Should changes be made to the equipment which alters its model number, performance characteristics or dimensions a new application for type approval must be made.

SIGNALLING TYPE APPROVAL SUMMARY	SIGNALS TYPE APPROVAL REGISTER No	*10/0603

ITEM	Dual Voltage Regulator 2x12V/1ADC
SUPPLIER	Leonard Electronics Pty Ltd.
MANUFACTURER	Leonard Electronics Pty Ltd.

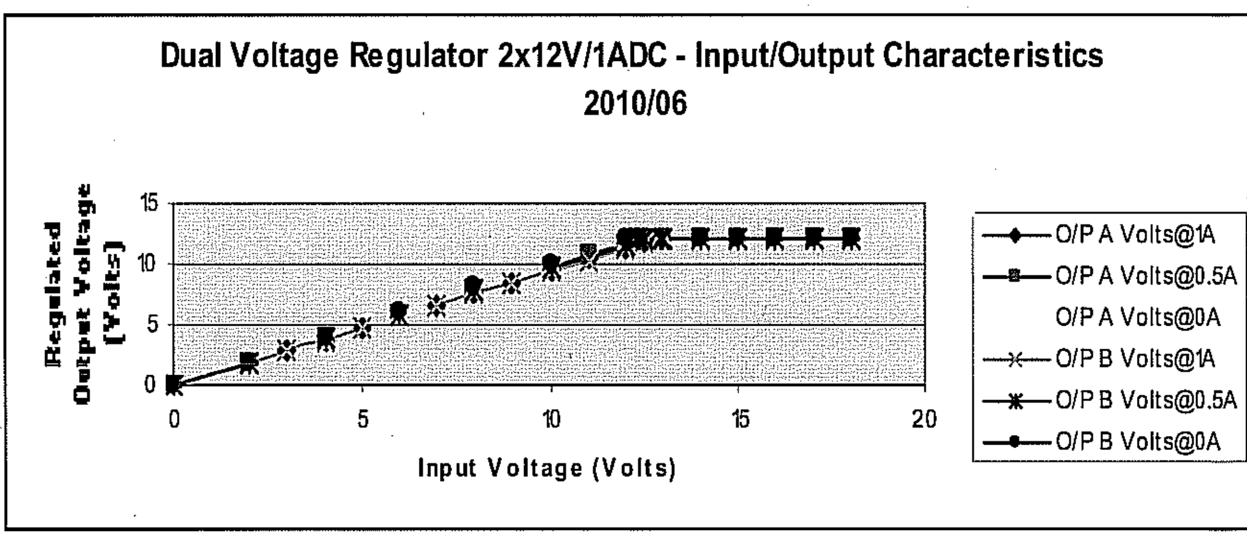
ITEM DESCRIPTION	Dual Voltage Regulator 2x12V/1ADC for level crossing applications.			
VERSION DATA				
RELEVANT SPECIFICATIONS	Signal Standard Specification SPG 1020 – DC Power Supplies for Signalling applications			
DEVELOPMENT STATUS	Commercial product	Manufactured to RailCorp Signalling specifications		
APPLICATION STATUS				

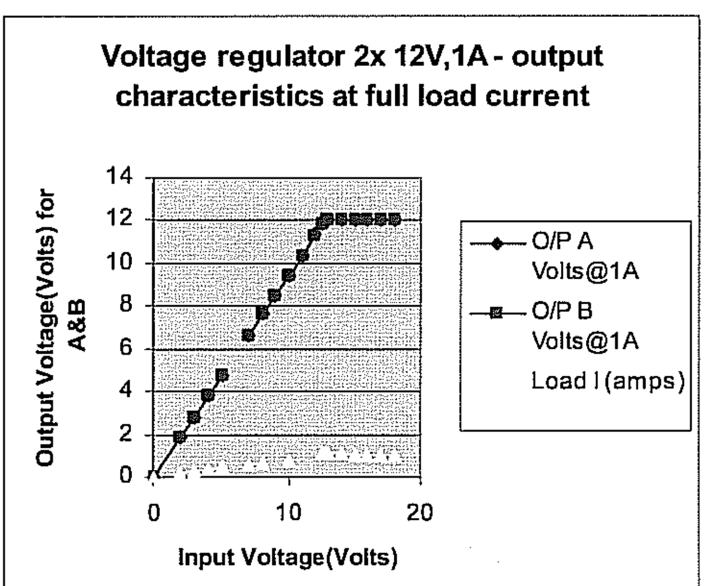
EVALUATION SUMMARY
Checked parameters of the regulator against the specified characteristics Tested samples at manufacturer's premises for input and output parameters. Checked heat dissipation

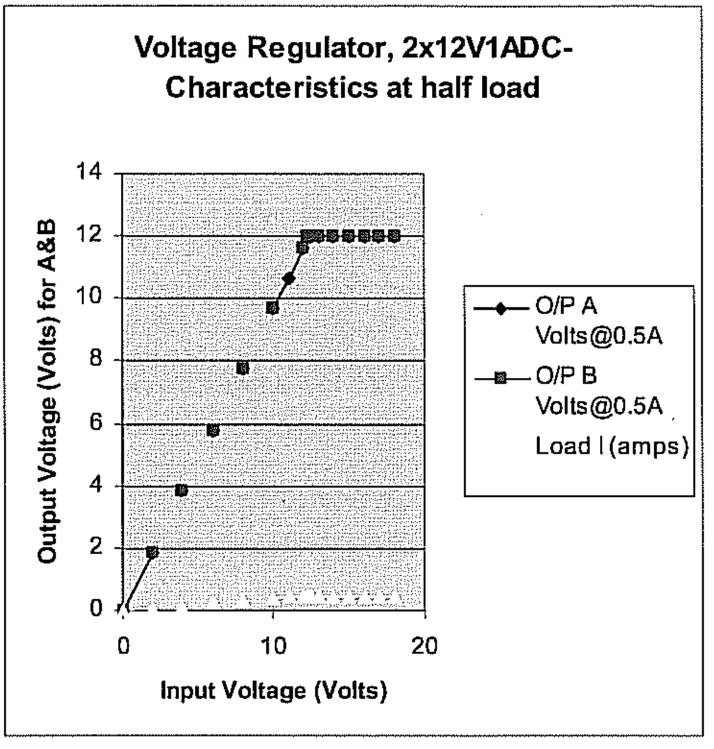
REPORT PREPARED BY	REVIEWED BY	APPROVED BY
Name: Siri Kamalasuriya	Name: Paul Szacsvay	Name: Warwick Allison
Position: Senior Engineer – Equipment & Interfaces	Position: Principal Engineer Signals Technology	Position: Chief Engineer Signals
Signature:	Signature:	Signature:
Date: 25/06/2010	Date: 13 October 2010	Date: 14-10-10

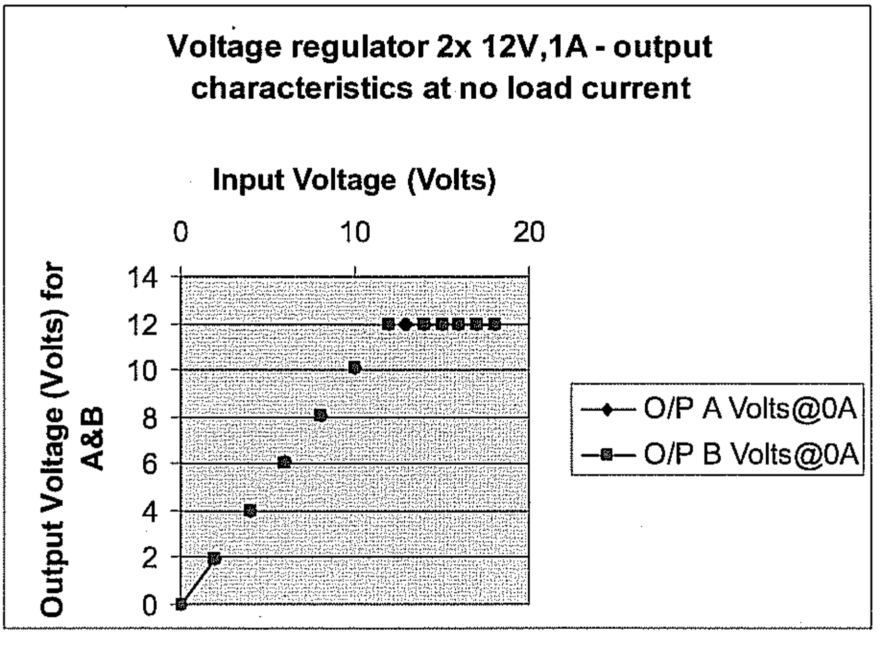
ITEM	RESULTS		STATUS
FORM & FIT			OK
APPLICATION DETAILS	For use in level crossing applications as some equipment needs 12V regulated supply. This dual voltage regulator is a revision to the previous 12V/1ADC voltage regulator with 4 outputs. For the convenience of maintenance, a disconnect terminal plug is used. This also provides mounting on a BRB rack with 1Q spacing. "Healthy status" green LED indication is incorporated for each Regulator. Black anodised		OK
FUNCTION			
DESIGN INSPECTION			
BENCH TESTS	Input output characteristics tested. See the attached for detailed test results Heat test at the rated voltage and at full load for over 30 minutes- the highest air temperature inside the unit in the vicinity of regulator was 30C above the ambient temperature.		OK
LIFE CYCLE			
MANUALS	N/A		
SERVICE HISTORY	Single 12V/1A regulator already in use.		OK
SERVICE TRIAL			OK
SUPPORT ANALYSIS	Spares	Available with Supplier	OK
	Supply	May be stocked in stores	OK
	Maintenance	May be Stocked in stores.	OK
QUALITY ANALYSIS	Design	Good	OK
	Manufacture		Satisfactory
	Materials		Satisfactory
SAFETY EVALUATION			OK
SOFTWARE / HARDWARE VALIDATION REVIEW	N/A		
RISK ANALYSIS	Safety	Touch proof terminals provides safety of maintenance personnel & system safety.	OK
	Function	Performs well	OK
	Reliability	Improved reliability	OK
MATTERS OUTSTANDING			

RESTRICTIONS ON APPLICATION
EVALUATION HISTORY & SIGNIFICANT ISSUES






Voltage Regulator, 2x12V1ADC-
Characteristics at half load
Output Voltage (Volts) for A&B
Input Voltage (Volts)
0
10
20
0
2
4
6
8
10
12
14
O/P A Volts@0.5A
O/P B Volts@0.5A
Load I (amps)


Voltage regulator 2x 12V,1A - output characteristics at no load current
Input Voltage (Volts)
0
10
20
Output Voltage (Volts) for A&B
0
2
4
6
8
10
12
14
O/P A Volts@0A
O/P B Volts@0A

Accurate power supplies using integrated voltage regulators

Len Stellema

The introduction of integrated voltage regulators was a boon for electronic engineers. Before that, regulated power supplies were rather complex, particularly if such a power supply had to be short-circuit proof.

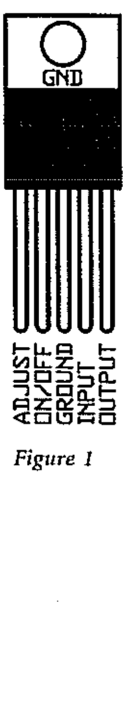


Figure 1

An integrated circuit voltage regulator, however, is very inexpensive, has a very small footprint and is short-circuit proof. Its output current is limited and when the temperature becomes too high, the thermal shutdown circuit takes over to prevent the IC from overheating.

Unfortunately, IC voltage regulators are not very accurate.

This article will show that it is possible to add components to a suitable regulator to make a device, the output voltage of which is very stable. As an example, a regulator that produces +12 V at 1 A will be used.

The IC type LM2941CT is being used, which is in many ways similar to the LM317T but has some advantages:

The LM2942CT is a so-called low dropout voltage regulator and can source an output current of 1 A when the difference between input and output voltage is as low as 0.7 V, over a temperature range of -40 to +120 °C.

Because the dropout voltage is so low, a power supply using the LM2941CT can be very efficient.

Because the dropout voltage is much lower than that of an LM317T, the heatsinks to be used can be smaller or the IC can run cooler or the ambient temperature can be higher.

The adjust current is so low that it can be ignored in calculations.

The on/off pin can be used to switch the IC off. If not used, this pin is connected to ground.

The IC is protected against reverse input voltage connection.

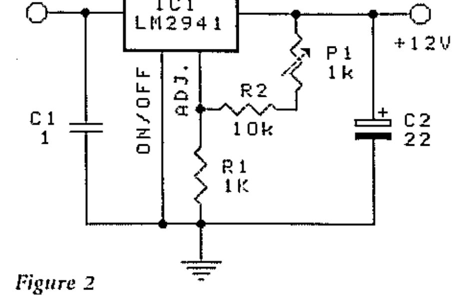


Figure 2

A built-in diode between input and output prevents the output voltage from becoming higher than the input voltage to prevent damaging the IC.

Figure 2 shows a circuit diagram in which the IC is used. The voltage at the adjust terminal is typically 1.275 V, but can vary from unit to unit and over a range from -40 to +120 °C, from 1.211 to 1.339 V.

Ideally, the trimming potentiometer should be set to 12 V for the average input voltage and the average output current after the regulator has warmed up.

The output voltage $V_o=V_b$ (R+R2+P1)/R1. When it is set to 12 V, with an output current of 0.5 A and an input voltage of 14.5 V, it will normally never deviate more than 1%, when the input voltage varies between 12.7 or 16 V and output current to 5 mA or 1 A.

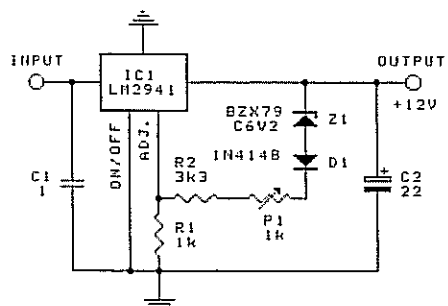


Figure 3

In this and the following circuits the heatsinks have a temperature coefficient of 10°/W, all resistors have a temperature coefficient of 50 ppm/°C, the circuit is mounted on a horizontally placed veroboard and the voltage regulator IC1 is mounted upright.

If trimpot P1 and resistor R2 are replaced by a constant voltage source of 12-1.275=10.725 V, the output will change the same amount as the voltage on the adjust pin so the stability of the output is a factor 12/1.275=9.4 or better.

A small step in this direction is shown in Figure 3. Here the 10 k resistor is replaced by a 3.3 k type in series with a 6.2 V zener and a diode.

All diodes and base-emitter junctions of transistors have a temperature coefficient very close to -2mV/°C, and 6.2 V zener diodes have

a positive temperature coefficient which partly compensate for the negative temperature coefficient of the diode.

The temperature coefficient of 10 combinations of BZX79C6V2 zener diodes and 1N4148 diodes were measured.

The voltage across the combinations ranged from 6.76 to 6.85 and the temperature coefficient from 0.08 to 0.41 mV/°C at 1 mA.

The values are slightly worse at 2 mA. The dynamic resistance of a 6.2 V zener goes up sharply if the current goes below 1 mA, so 1 mA should be chosen as the zener current.

The output voltage variation is now 4.1 times the adjust voltage variation. So the output stability has improved by a factor of 2.3, just by adding two very inexpensive components.

This circuit will provide an even more stable output, if used to produce 9 or 10 V.

It may appear that for an output of 12 V, it would be better to use a 9.1 V zener diode, but this zener has a temperature coefficient of typically +6 mV/°C.

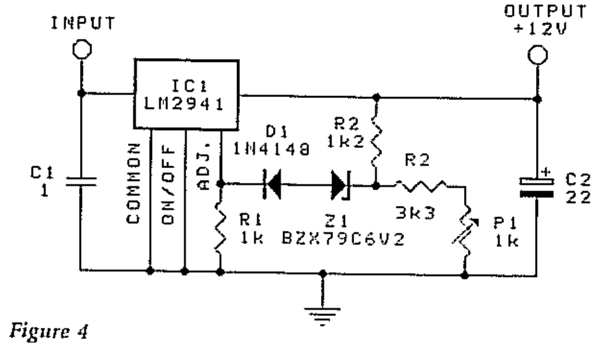


Figure 4

By reducing the resistance value of the combination of resistor R2 and trimpot P1 to 1.2 k and bleeding excessive current to earth (see Figure 4), the accuracy is made a factor 6.4 higher than that of the circuit of Figure 2.

So the output voltage will be between 11.98 and 12.02 plus a maximum 0.5 mV/°C.

In the Figure 5 circuit, the adjust pin is connected to the output via a shunt regulator, which has a temperature coefficient of maximum 100ppm/°C.

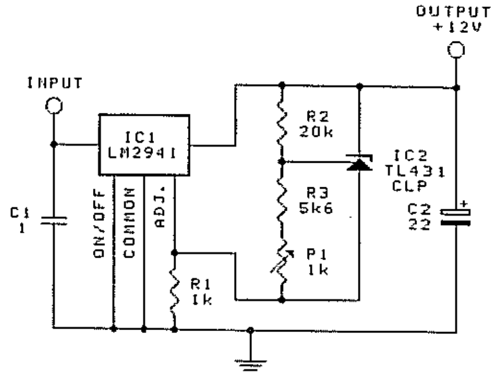


Figure 5

The stability of the circuit is a factor 9.4 better than that of the circuit shown in Figure 2. The measured temperature coefficient of one circuit with randomly selected components was 0.9 mV/°C.

The circuit shown in Figure 6 is a big improvement, because a change in the output is amplified by the transistor. The temperature coefficient of the base-emitter connection of the transistor is partly compensated for by that of the zener.

In the tested circuit, the zener used was the worst of the 10 diode and zener diode combinations tested. It was glued to the flat side of the transistor to ensure that the temperatures were equal.

The distance between the zener diode-transistor combination and the 10 °C/W heat sink was 20 mm. When the output current is 1 A and the input voltage is changed from 12.7 to 16, the output voltage does not change initially but after an hour the output voltage is less than 3 mV higher.

When the input voltage is 16 and the output current is changed from 0 to 1 A, the output voltage increases less than 3 mV after an hour. The measured temperature coefficient of this voltage regulator is 0.56 mV/°C.

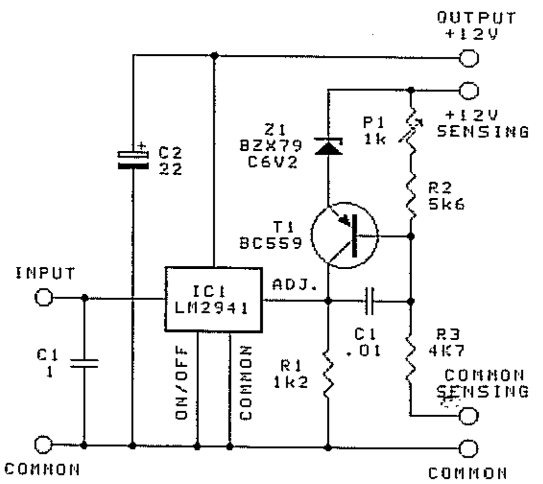


Figure 6

To avoid degradation of the performance caused by wire resistance, the sensing inputs are directly connected to the load. This is called the four-wire system.

In the circuit shown in Figure 7, an operational amplifier is used. Its high gain and very low temperature coefficient, together with the low temperature coefficient of the voltage reference LT1029CZ (nominal 20 ppm/°C or 0.014mV/°C), makes it a very high performance regulated power supply.

The temperature coefficient measured on one sample was about 0.025 mV/°C. When the output current changes from 0 to 1 A, the output voltage changes less than 0.1 mV initially, but when the voltage regulator warms up, more.

The largest change occurs when the input voltage and current changes from 12.7 V/0 A to 17 V/1 A. After half an hour the output is about 0.4 mV lower.

When a cardboard shield is placed between the voltage reference and the voltage regulator the change is about 0.3 mV and without a shield, and with a 6 °C/W heatsink instead of a 10 °C/W heatsink, also 0.3 mV.

When resistors R4 and R5 (in Figure 9, R5 and R6) and the voltage reference Z1 are connected to the PCB via thin 6 cm long wires, the change is only about 0.1 mV.

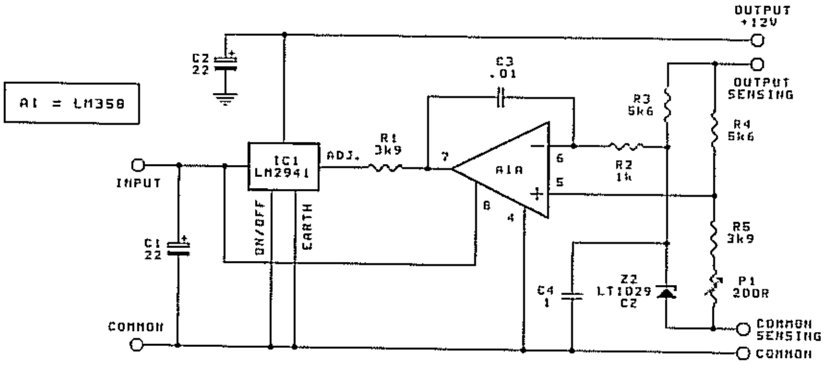


Figure 7

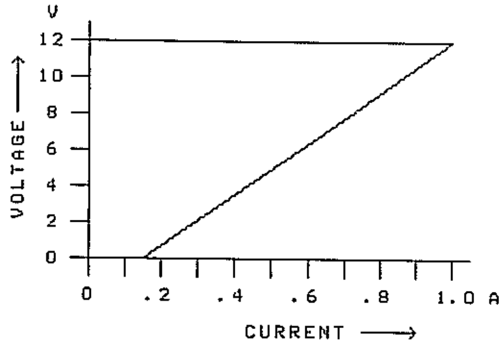


Figure 8

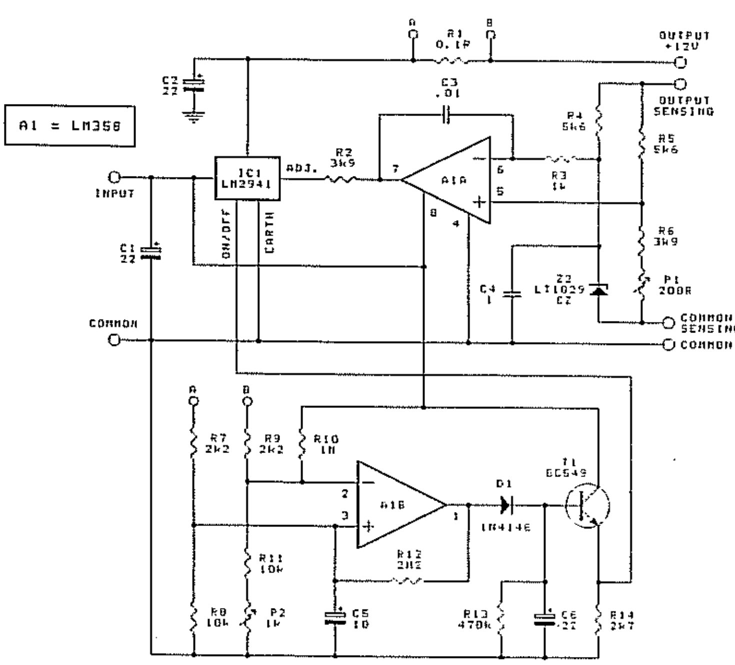


Figure 9

This is because the voltage regulator heats up the PCB, which in turn heats up the components.

It is suggested that the two resistors, the voltage reference and perhaps the operational amplifier as well as capacitor C3 are fitted on a separate board or that the voltage regulator is fitted on a separate board.

Thermal conduction and radiation between the voltage regulator and the component should be avoided.

The changes in output voltage were measured using a very accurate 4½-digit multimeter, set to 2 VDC, in series with a very accurate voltage reference of between 10 and 14.

To increase the stability, it is possible to use a voltage reference of a higher grade, such as an LT1029ACZ and resistors with a temperature coefficient of 20 or 10 ppm/°C for resistors R4 and R5 (R5 and R6 in Figure 9).

A voltage regulator which is short-circuit proof with a stable output has now been created. However, it does not protect the load.

If, for example, it is connected to a printed circuit board, which has a short between +12 V and common, the current that flows through this short may be well above 2 A. In most cases this will cause tracks to burn.

An ideal way to limit the short-circuit current is to use a fold-back overload protection system, see Figure 8. As long as the resistance of the load is above 12 Ω, the output voltage is 12 but if the resistance decreases, the output current as well as the output voltage decreases.

If the output is shorted, the current is only 150 mA.

Unfortunately, the voltage of IC voltage regulators cannot be controlled down to a few volts. Instead the on/off pin of the regulator is used to switch it off, when the output current exceeds the allowed current level.

Trimming potentiometer P2 is set to switch the power supply off when the output current is above 1 A. When the output current is increased to above this figure, the voltage between points A and B is higher than 100 mV.

The voltage on the non-investing input of amplifier A1B is then higher than the voltage on the inverting input.

The output of the op amp is then high, and consequently the voltage on the on/off terminal is high, switching the regulator off. The output voltage will then become zero, and so will the voltages on points A and B.

A small current through resistor R10 makes the non-inverting input of the amplifier more positive than the inverting input and consequently the output of the op amp goes low.

Capacitor C6 will then discharge slowly, until the regulator switches on. If the output current is still too high, capacitor C6 will charge in milliseconds and the output transistor T1 will go high, switching the regulator off.

When the output current is reduced to below 1A, the output of op amp A1B goes low, diode D1 is reverse biased and capacitor C6 discharges.

After about five seconds, the regulator is switched back on. But if the output current is not reduced, the regulator will be on for about 300 milliseconds, every five seconds, if the overload is only marginal and 30 milliseconds if the output is short circuited.

The measured stability of the regulators shown in Figures 7 and 9 are identical. In the tests, the same voltage reference was used.

Leonard Electronics Pty Ltd
leonard-e@bigpond.com