

1602826

by Sean Jones

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Executive summary

A job has been established to design a power supply unit for a consumer electronics device. This power supply needed to be designed, simulated to be able to evaluate the power supply. Research was first done to find the specification of the power supply. It was also researched in how to meet these specifications.

The power supply design started with the design of the regulator. This was done first as it is the output of the power supply and rest was made easily around this. The regulator performed very good giving very slight voltage change over a large span of load. The rest of the power supply was designed around this regulator including safety features to protect against overvoltage protection and short circuit protection.

the power supply was tested on multisim and compared against original specifications to ensure that it was an effective solution to the problem. The design proved very good giving a constant out put under a varying input voltage. All the components used would comply with the environmental concerns around the power supply making this design a very strong solution

ES should cover all sections and give a flavour of the entire report

Researching requirements and compilation of the specification

The customer has given a specification of the technical and environmental requirements of the power supply. The technical specification is in the table below. The input voltages have been given tolerances to meet voltage supply tolerance.

Technical specification	Value	Tolerance
V_{in}	240 VAC	+ 6% and - 6%
V_{out}	24 VDC	+/- 1% @ 240 Vin +/- 2.4% @ + 6% and - 6% 240 Vin
I_{out}	5A	+/- 5%
F_{in}	50Hz	N/A

An environmental specification is given as well as a technical one. This is the characteristics around the power supply that the circuitry will have to withstand during running. The first being ambient temperature around the power supply may vary from 15°C to 60°C. The atmosphere where the power supply will be susceptible to high vibrations so components that can handle this and component mounting methods must be considered. According to Manufacturing Tomorrow (2020) a method of reducing vibration damage could be to mount the PCB on dampers. The IP rating of the power supply needs to be IP67. According to IEC Standards (2004) this means it must protect against hazardous parts and dust whilst protecting against temporary submersion in water. The power supply must be compact and potable. This may be difficult as a 5A 24V power supply will have to use a high rating transformer which may be bulky and heavy compromising the size and weight of the power supply.

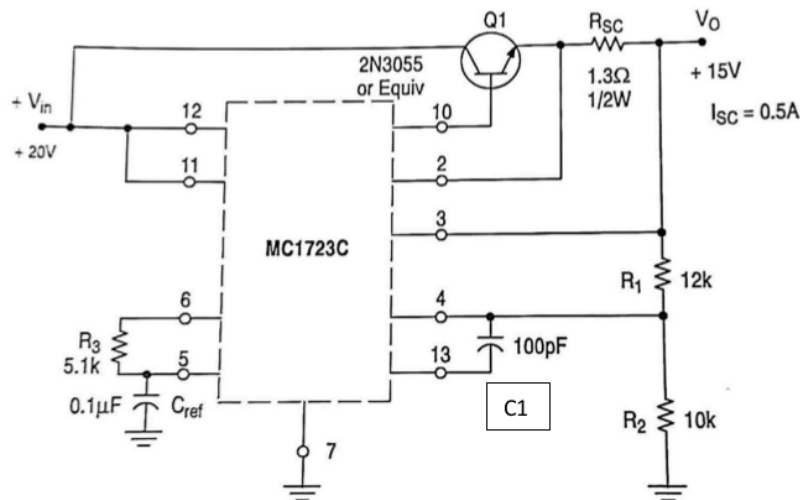
Design method, choices and calculations

A linear power supply will be designed. This type of power supply is simplistic design with a high-quality stabilized output when a varying input is present. This suits this application with the input having a 14V potential deviation with the output only having a 0.48V tolerance band.

This type of power supply has 4 main stages. The first is the transformer. This brings the voltage down to voltage slightly more than what's needed for the regulator. A rectifier is next in the circuit to turn the reduced AC into a DC. An electrolytic capacitor is then used to reduce ripple on the waveform to what the regulator accepts. The final and most important part is the regulator which gives the steady output.

*A block diagram here
would have been good*

The first part of the design is the regulator. According to On Semiconductor (2002) the MC1723C is a suitable chip for this application. In the normal configuration of the regulator the voltage can be achieved but the current cant. According to (Motorola, 1996) if used in the "NPN Boost Configuration" as shown in Figure 1 below the current can be achieved. The chip driving a transistor which amplifies the weak output voltage into something usable for this application. The voltage after the transistor is fed back into the chip with the voltage divider giving the chip the set point voltage for the output, this is how the linear regulator achieves its steady voltage output. For this reason, this chip is used in the design. The datasheet from Motorola (1996) for the MC1723C is found in the Annexe.



R2 Figure 1 MC 1723C chip (semiconductor, 2002)

With the regulator chip selected the relevant calculations can be made.

A low value of C_{ref} is for a low noise operation. The datasheet suggests a value between 0 & $0.1\mu F$

$$C_{ref} = 0.1\mu F$$

$R_1 + R_2$ is a chosen value which must be between $10K\Omega$ and $100K\Omega$ which is a design parameter taken from the datasheet.

$$R_1 + R_2 = 50K\Omega$$

$$R_2 = \frac{V_{ref}}{V_o} (R_1 + R_2)$$

V_{ref} is from the datasheet

$$R_2 = \frac{7}{24} (50 \times 10^3)$$

$$R_2 = 15K\Omega$$

According to On Semiconductor (2002) R_2 should be able to vary by 5% to allow the output to be set accurately. As this circuit is only being simulated the ratio between R_1 and R_2 will be adjusted on Multisim until correct voltage is given.

$$R_1 = (R_1 + R_2) - R_2$$

$$R_1 = (50K\Omega) - 15K\Omega$$

$$R_1 = 35K\Omega$$

$$R_3 = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_3 = \frac{35K\Omega \times 15K\Omega}{35K\Omega + 15K\Omega}$$

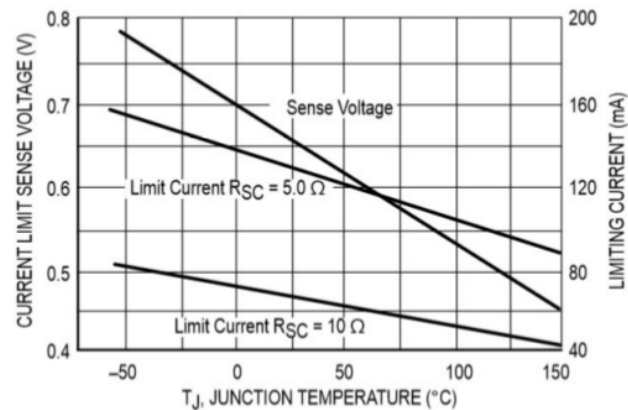
$$R_3 = 10.5 K\Omega$$

Which as a round number,

$$R_3 = 11 K\Omega$$

*Preferred
value*

The maximum current is determined by the R_{sc} value which is calculated below. According to Motorola (1996) the chip wants 0.6V dropped through this resistor so the resistance is worked out by dividing the required volt drop by the maximum required current. The chip has its own method of dealing with short circuit protection as when the volt drop goes above 0.6 V the chip will assume the current is higher than what the circuit was designed for and will reduce voltage and current proportionally to prevent damage. Figure 2 shows the relation between the current sensing and the limiting current.



We didn't need this garph

Figure 2 Current limiting (Motorola, 1996)

$$R_{sc} = \frac{0.6V}{I_{sc}}$$

$$R_{sc} = \frac{0.6V}{5}$$

$$R_{sc} = 0.12\Omega; 1.0W$$

$$V_{in} \geq V_{out} + 2\phi + 3V$$

$$V_{in} \geq 24 + 1.2 + 3V$$

$$V_{in} \geq 28.2V$$

As 28.2 is the minimum value to run the chip for this application it will be rounded up to 30V

$$V_{in} = 30V$$

The values for the components are shown in the table below

<i>Component</i>	<i>Value</i>
<i>R1</i>	35k Ω
<i>R2</i>	15k Ω
<i>Rsc</i>	0.12 Ω ; 1.0W
<i>Cref</i>	0.1 μ F
<i>Vin</i>	30V
<i>Vout</i>	24V

The physical components that can be used for are now found from datasheets.

Starting with the transistor, the main characteristics of this device is it must be able to handle 5A through the collector, be able to be driven from 150 mAdc and be able to handle 24V. A suitable device found is the ON Semi 2N3055G NPN Transistor. The data sheet for this device is in the annexe. The main characteristics are in the table below, the data was obtained from (rs-online, 2020). the comparison for the technical data of the transistor values and the required show the 2N3055G is compatible for this.

	Transistor	Required
Maximum DC Collector Current	15A	5A
Maximum Collector Emitter Voltage	60V	24V
Maximum Operating Temperature	+200°C	+60°C
Minimum Operating Temperature	-65°C	+15°C
Maximum Collector Base Voltage	100	24V

C_{ref} and C1 will be a Wurth Elektronik 100nF Electrolytic Capacitor. The capacitance, maximum voltage and working temperature range match the application. The datasheet for this is in the annexe.

R1 is made of 2 resistors in series 1 fixed value and 1 potentiometer. The fixed value is 34KΩ and the potentiometer 2KΩ. the same principle goes for R2, the fixed value is 14KΩ and the potentiometer 2KΩ. the datasheets for these resistors are in the annexe. R3 uses the same range of resistors as R1 and R2.

The resistor for Rsc has to withstand more power than the rest so a different range must be used. The chosen resistor has a 3W power rating making it suited for the job. The datasheet is attached in the annexe.

That completes the regulator the next step is to look at the front end firstly starting with the amount of allowable ripple into the regulator. This requires information from the datasheet to have a voltage value for ripple

$$\text{Ripple Rejection} = \frac{\text{Ripple Out}}{\text{Ripple In}}$$

$$-74 \text{ dB} = \frac{1\text{mV}}{\text{Ripple In}}$$

$$\text{Ripple In} = \frac{1\text{mV}}{-74 \text{ dB}}$$

Convert -74dB into Volts

$$\begin{aligned} 74 &= 10^{\frac{-7}{20}} \\ &= 10^{\frac{1}{200 \times 10^{-6}}} \\ -74 &= 5V \end{aligned}$$

The maximum amount of ripple that can possibly enter the chip is 5V.

$$\text{Ripple} = 2.5V$$

$$V_m = V_{in} + 2V_{in}$$

$$V_m = 30 + 60$$

$$V_m = 45V$$

Maximum Ripple is 5V. to be safe of not having ripple on the output a 3V maximum ripple will be used instead.

$$rf = \frac{2.5}{2\sqrt{2} \cdot 30} \times 100$$

$$rf = 2.94\%$$

$$\omega CR_L = 20$$

Value taken from Graphs on in annexe.

$$\frac{V_C}{V_m} = \frac{30}{45} = 0.6$$

$$\frac{R_s}{R_l} = 20\% = 0.2$$

$$R_s = 0.2 \times R_l$$

$$R_l = \frac{V_C}{I_o}$$

$$R_s = 0.2 \times \frac{V_C}{I_o}$$

$$R_s = 0.2 \times \frac{30}{5}$$

$$R_s = 1.2\Omega$$

$$R_s = 0.2 \times \frac{V_C}{I_o}$$

$$C = \frac{20}{2\pi \times 50 \left(\frac{30}{5}\right)}$$

$$C = 10.6mF$$

The voltage going through the capacitor is up to 50v. the closest component to this on the market is a 10mF with a 50v maximum voltage. The datasheet for this component is in the annexe

Good, preferred value

The rectifier can now be calculated. The first part to be calculated is the current passing through each diode.

used

$$IF(avg) = I_o/2 = 2.5$$

$$\frac{R_s}{(2 \times R_l)} = 1.2$$

$$I_{rms} = 2A$$

The diode current graph in the annexe is used to obtain the values for the diode calculations.

$$\frac{IF(pk)}{IF(avg)} = 5.4$$

$$IF(peak) = 5.4 \times 2.5 = 13.5$$

$$PIV = 45$$

$$I_{surge} = \frac{Vm}{Rs + E_{sr}}$$

$$I_{surge} = \frac{45}{1.2}$$

$$I_{surge} = 37.5$$

A bridge rectifier is specified to save having 4 separate components. The bridge rectifier with suitable characteristics was found and is in the annexe.

The transformer is the final part of the circuit to be calculated.

$$Vs = \frac{VM + 2}{\sqrt{2}}$$

$$Vs = \frac{45 + 2}{\sqrt{2}}$$

$$Vs = 33.23$$

$$secondary\ resistance = 3.2\Omega$$

$$Va\ rating = 2 \times Vs \times I_{rms}$$

$$Va\ rating = 2 \times 33.23 \times 2$$

$$Va\ rating = 132.92VA$$

$$turns\ ratio = \frac{V_{in}}{V_{out}}$$

$$turns\ ratio = \frac{240}{33.23}$$

$$turns\ ratio \approx 7\ to\ 1\ ratio\ step\ down$$

The transformer required is shown in the annexe from (farnell, 2020). It hasn't got the exact turns ratio required to supply the bridge rectifier with 33.23 volts but is slightly higher so shouldn't affect the system as the chip can deal with a slightly higher input voltage.

A fuse will be placed before the AC supply on this system in case of a short on the transformer or following circuitry. A ZNR surge absorber could be used to protect components in the power supply in the instance of a power surge.

A heatsink maybe required for the regulator chip in this situation. A heatsink is used to disburse heat from the case and junction of a semiconductor device through a finned metal object which allows the surrounding air to absorb the heat. The chip works best at optimal temperatures given in the datasheet. It can be calculated what size heatsink if one is needed at all from these values. Figure 3 shows a semiconductor with a heat sink principle

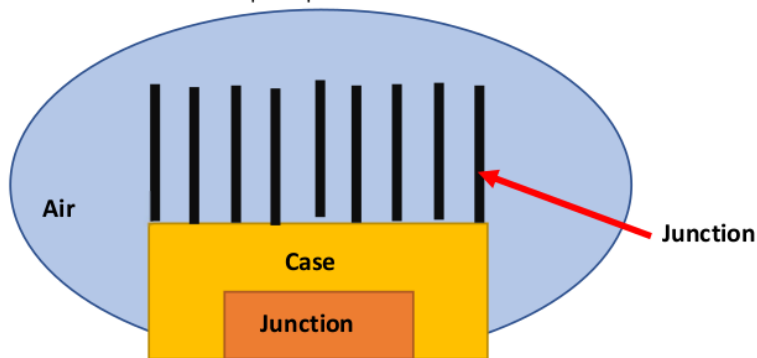


Figure 3 Heat sink principle

J = Junction

C = Case

S = Heat Sink

A = Atmosphere

The equation below is the relation between these elements of a heat Sink

$$\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA}$$

According to the datasheet

JC = 1.52 Thermal Resistance

According to On Semiconductors (2002)

$$\theta_{CS} = 15.1^{\circ}\text{C per W}$$

$$T_J = T_A + P_D \theta_{JA}$$

$$\theta_{JA} = \frac{T_J - T_A}{PD}$$

$$\theta_{SA} = \frac{T_J - T_A}{PD} - \theta_{JC} - \theta_{CS}$$

$$T_A = +60^{\circ}\text{C}$$

$$T_J = 200^{\circ}\text{C}$$

$$C_s = 0.1$$

$$\begin{aligned}\theta_{SA} &= \frac{200^{\circ}\text{C} - 60^{\circ}\text{C}}{30 \times 5} - 1.52 - 0.1 \\ &= -0.686^{\circ}\text{C per W}\end{aligned}$$

A heatsink is not needed for this application.

Shame :)

Testing, results and analysis

The regulator is simulated on multisim. This is to be sure that this part of the circuit works before being combined with the rest of the power supply. A similar chip is used as the Multisim doesn't have the MC1723C. all the components original calculated values are used to start with. Figure 4 shows the regulator circuit being simulated. The output values are not good on this test with the voltage being 0.9 volts too low. The current value is in proportion the load on the output.

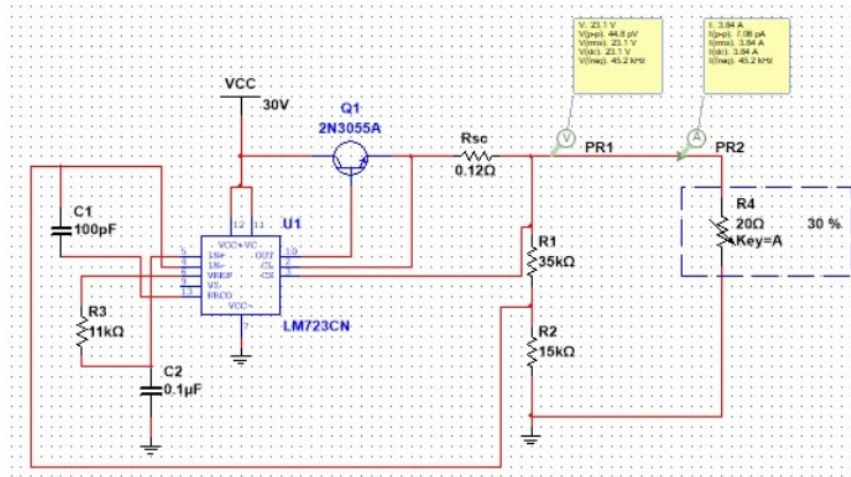


Figure 4 regulator calculated values

The ratio between R1 and R2 are altered to make a more accurate output voltage from this regulator. This is shown in Figure 5.

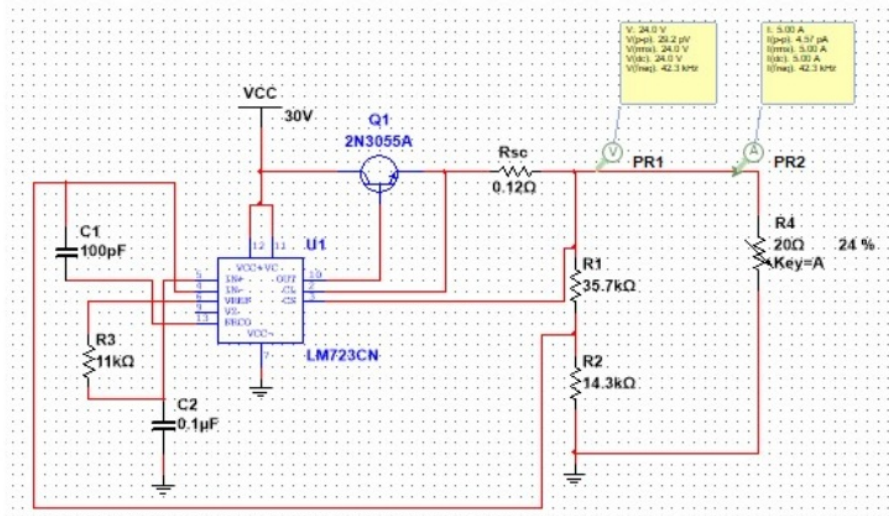


Figure 5 regulator revised values

The altered values of R1 and R2 have given a very accurate output voltage of 24.0 Volts. The load resistance was also altered to find where the current was at maximum before the regulating chip starts to limit the current output in short circuit protection. The current and voltage were recorded at 0.1Ω intervals of load resistance. These results were placed on a graph to be analysed. Graph is shown in Figure 6

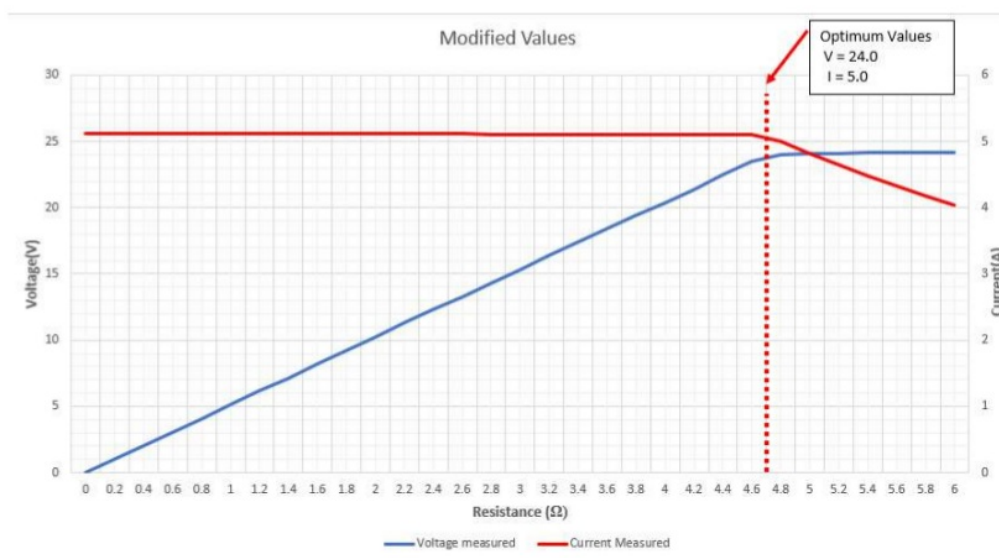


Figure 6 graph showing load resistance vs current and voltage

The graph shows the current remains at 5 A in a short circuit situation but the voltage is reduced to 0 meaning no current would really be flowing. This may be a simulation error. The lowest load resistance this power supply can be used in effectively is 4.7Ω . after this the current reduces as its just not required to pull that much current at them loads.

To prove the high stabilisation of the output voltage over a large span of load resistance, a $1k\Omega$ resistor was placed on the output of the regulator which is 200 times more the load data being recorded on the graph. Figure 7 shows the regulator behaviour during this. The voltage has risen only 0.2 volts which is within the specification.

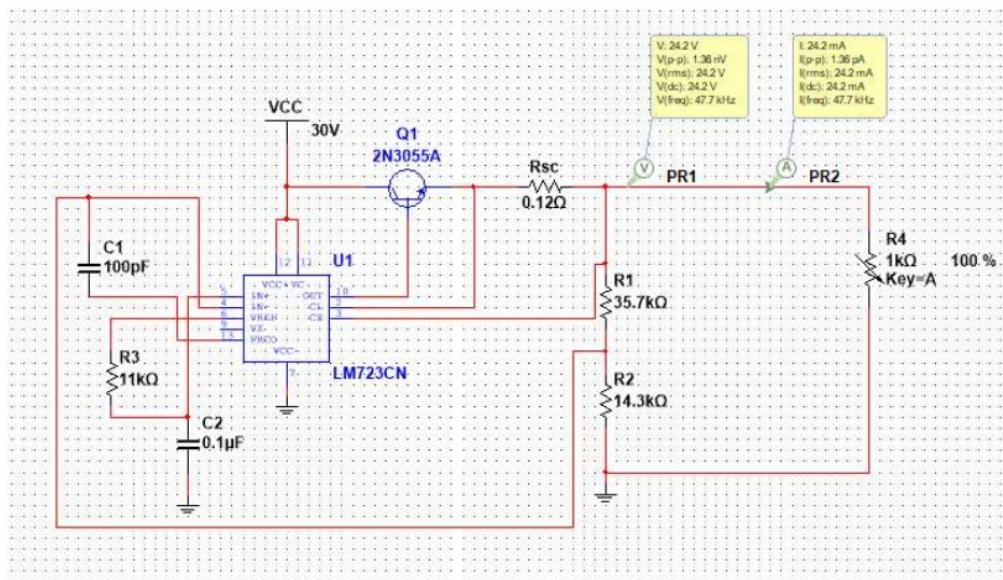


Figure 7 regulator at very low load

The next part of testing is to turn the regulator into a sub circuit on multisim and create the entire power supply to have a full function test. Figure 8 shows this. A 240VAC 50Hz supply is added to the circuit for testing. An oscilloscope is used to compare the different stages of the power supply rectification and regulation.

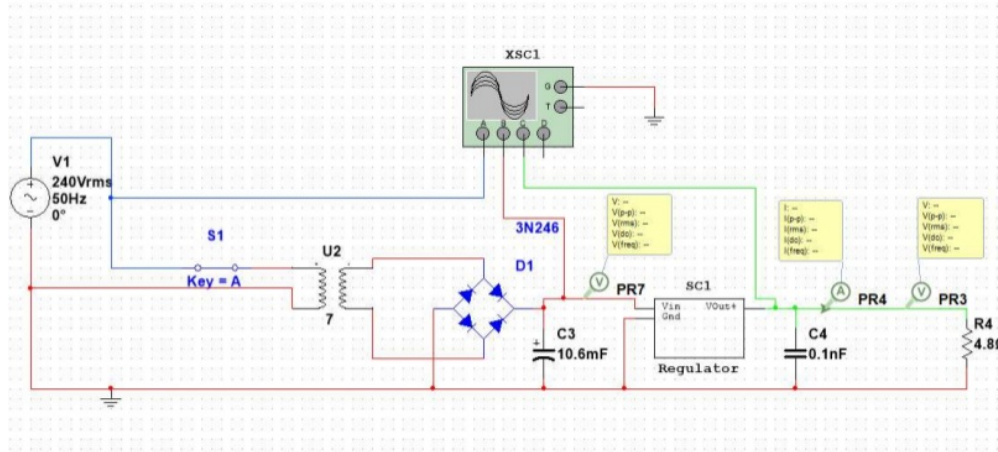


Figure 8 final power supply circuit

The circuit was testing under maximum load of 4.8Ω the output of the power supply was 24.0 Volts at 5.0 A. the voltage coming into the regulator was 31.4V with a 2.41V ripple. Figure 9 shows the oscilloscope results. its clearly visible how well the regulator performs here with dead flat DC output at 24VDC.



Figure 9 power supply stages comparison

The specification states that the regulator must work within certain tolerances of input voltage whilst maintaining a quality output. The minimum and maximum V_{in} values were simulated on the power supply the check that the specification is met with this design. Figure 10 shows the power supply running at maximum rated input voltage.

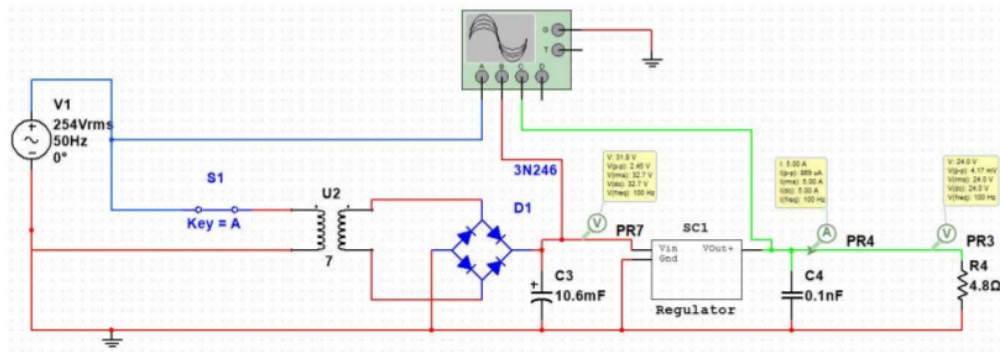


Figure 10 power supply tested at maximum input voltage

This hardly effects the powers supplies performance with the same output voltage and current but the regulators input voltage being slightly increased which isn't important as its within the range from original calculations.

Figure 11 shows the circuit under the minimum input voltage. The input voltage to the regulator is dropped to 26.6 where it had to be above 28.8 in the calculation to maintain a 24.0V output. The out come of this has reduced the output to 23.1 V. This is still within the specification but can be improved.

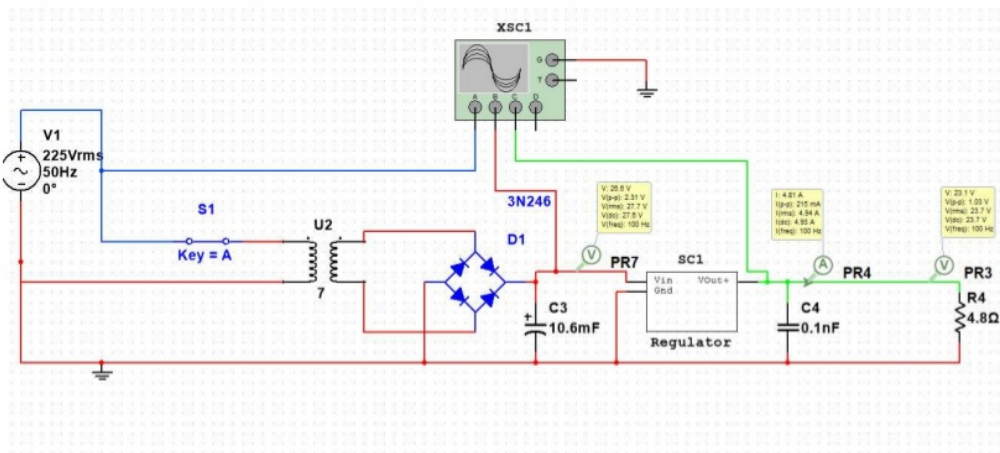


Figure 11 power supply tested at minimum input voltage

Conclusions

The specification was a good starting point for designing the power supply. This put the major fundamentals of the design upfront as certain voltages and current ratings allow the use of certain chips to be used. This also allowed the power supply to be designed with British and international standards in mind to involve maximum health and safety from the device.

Starting the design of the power supply at the regulator worked effectively as the range of chips are a lot smaller than the range of most other components so choosing a chip and making everything else fit around it is a much more efficient method of design. The rest of the power supply was easily designed from here as the components were generic. Looking at component datasheets helped find the relevant components with the correct characteristics.

The method of calculating if the regulators chip needed a heat sink worked well and was found out that a heatsink was unnecessary

The testing was very affective. The Multisim simulation allowed quick and simple trial and error of different values on the regulator to obtain the correct output voltage. The variable resistor function made it very quick to change the load resistance of the regulator to record to regulators behaviour over span of load resistances. The regulator performed very well when the correct values of R1 and R2 were used. When testing the entire power supply circuit, the simulation software wasn't working correctly when an inline fuse was being used on the supply. When this fuse was removed for simulation purposes the circuit worked perfectly.

All components used in the design were compliant for the temperature range from the spec. the finished circuit would be placed into an IP67 rated enclosure with suitable external connectors used to meet the specification. The system met all technical requirements from the spec within a tight tolerance.

It would be recommended to increase the input voltage to regulator in order to make better use of the power supply. Even though the output voltage was within the specification tolerances it could have had exactly 24.0V if the regulators input voltage was 2 volts greater which would have been archivable without affecting the behaviour when the power supply is being used on the maximum input voltage.

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Voltage Regulator

VOLTAGE REGULATOR

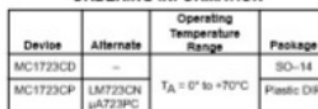
- Output Voltage Adjustable from 2.0 Vdc to 37 Vdc
- Output Current to 150 mAdc Without External Pass Transistors
- 0.01% Line and 0.03% Load Regulation
- Adjustable Short Circuit Protection



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ORDERING INFORMATION



$$V_O = 7 \left(\frac{R_1 + R_2}{R_2} \right) I_{SC} = \frac{V_{sense}}{R_{SC}} = \frac{0.66}{R_{SC}} \text{ at } T_J = +25^\circ\text{C}$$

For best results $10 \text{ k} < R_2 < 100 \text{ k}$
 For minimum drift $R_3 = R_1 \parallel R_2$

MC1723C

MAXIMUM RATINGS (T_A = +25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Pulse Voltage from V _{CC} to V _{EE} (50 ms)	V _{I(p)}	50	V _{pk}
Continuous Voltage from V _{CC} to V _{EE}	V _I	40	V _{dc}
Input-Output Voltage Differential	V _I -V _O	40	V _{dc}
Maximum Output Current	I _L	150	mA _{dc}
Current from V _{ref}	I _{ref}	15	mA _{dc}
Current from V _Z	I _Z	25	mA
Voltage Between Noninverting Input and V _{EE}	V _{ie}	8.0	V _{dc}
Differential Input Voltage	V _{id}	±5.0	V _{dc}
Power Dissipation and Thermal Characteristics T _A = +25°C Derate above T _A = +25°C Thermal Resistance, Junction-to-Air	P _D 1/θ _{JA} θ _{JA}	1.25 10 100	W mW/°C °C/W
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +175	°C
Operating Ambient Temperature Range	T _A	0 to +70	°C

ELECTRICAL CHARACTERISTICS (T_A = +25°C, V_{IN} 12 V_{dc}, V_O = 5.0 V_{dc}, I_L = 1.0 mA_{dc}, R_{SC} = 0, C₁ = 100 pF, C_{ref} = 0 and divider impedance as seen by the error amplifier < 10 kΩ connected as shown in Figure 2, unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
Input Voltage Range	V _I	9.5	—	40	V _{dc}
Output Voltage Range	V _O	2.0	—	37	V _{dc}
Input-Output Voltage Differential	V _I -V _O	3.0	—	38	V _{dc}
Reference Voltage	V _{ref}	6.80	7.15	7.50	V _{dc}
Standby Current Drain (I _L = 0, V _{IN} = 30 V)	I _{IB}	—	2.3	4.0	mA _{dc}
Output Noise Voltage (f = 100 Hz to 10 kHz) C _{ref} = 0 C _{ref} = 5.0 μF	V _n	— —	20 2.5	— —	μV(RMS)
Average Temperature Coefficient of Output Voltage (T _{low} < T _A < T _{high})	TCV _O	—	0.003	0.015	%/°C
Line Regulation (T _A = 25°C) { 12 V < V _{IN} < 15 V 12 V < V _{IN} < 40 V (T _{low} < T _A < T _{high}) 12 V < V _{IN} < 15 V	Reg _{line}	— — —	0.01 0.1 —	0.1 0.5 0.3	% V _O
Load Regulation (1.0 mA < I _L < 50 mA) T _A = 25°C T _{low} < T _A < T _{high}	Reg _{load}	— —	0.03 —	0.2 0.6	% V _O
Ripple Rejection (f = 50 Hz to 10 kHz) C _{ref} = 0 C _{ref} = 5.0 μF	RR	— —	74 86	— —	dB
Short Circuit Current Limit (R _{SC} = 10 Ω, V _O = 0)	I _{SC}	—	65	—	mA _{dc}
Long Term Stability	ΔV _O /t	—	0.1	—	%/1000 Hr.

NOTE: T_{low} to T_{high} = 0° to +70°C

2N3055(NPN), MJ2955(PNP)

Preferred Device

Complementary Silicon Power Transistors

Complementary silicon power transistors are designed for general-purpose switching and amplifier applications.

Features

- DC Current Gain – $h_{FE} = 20-70$ @ $I_C = 4$ Adc
- Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 1.1$ Vdc (Max) @ $I_C = 4$ Adc
- Excellent Safe Operating Area
- Pb-Free Packages are Available*

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current	I_B	7	Adc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate Above 25°C	P_D	115 0.657	W W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

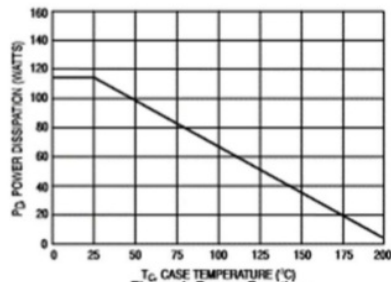


Figure 1. Power Derating

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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December, 2005 – Rev. 6

1



ON Semiconductor®

<http://onsemi.com>

15 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON 60 VOLTS, 115 WATTS



TO-204AA (TO-3)
CASE 1-07
STYLE 1

MARKING DIAGRAM



xxxx55 = Device Code
xxxx = 2N30 or MJ20
G = Pb-Free Package
A = Location Code
YY = Year
WW = Work Week
MEX = Country of Origin

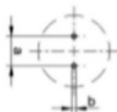
ORDERING INFORMATION

Device	Package	Shipping
2N3055	TO-204AA	100 Units / Tray
2N3055G	TO-204AA (Pb-Free)	100 Units / Tray
MJ2955	TO-204AA	100 Units / Tray
MJ2955G	TO-204AA (Pb-Free)	100 Units / Tray

Preferred devices are recommended choices for future use and best overall value.

Publication Order Number:
2N3055/D

B Recommended hole pattern: [mm]



C Schematic:



D1 Electrical Properties:

Properties	Test conditions	Value	Unit	Tol.
Capacitance	0.25V, 120Hz	0.1	μF	$\pm 20\%$
Rated voltage		50	V (DC)	max.
Leakage current	after 1 min.	3.0	μA	max.
Discharge factor	120 Hz	10	%	typ.
Surge current	120V @ 60/50°C	1.3	mA	max.



E General information:

Aluminum Electrolytic Capacitors	35°C, <45% RH
Storage Conditions	-40°C to +105°C
Operating Temperature	2000 h @ +105°C, 50 V DC
Lead-free	20°C, 33% RH for not specified differently
Test conditions of Electrical Properties	
see	
III according to	separate documentation

D = 0.5	5.0
P = 0.5	2.0
$\Gamma \pm 1$	11.0
ϵ	1.5
$\text{Pr} \theta \pm 0.02$	0.5
a	2.0
b	0.8

1.0	2014-11-11	SSR	PGK					
REV	DATE	BY	CHECKED					

DESCRIPTION	WCAP-AT65 Aluminum Electrolytic Capacitors	
QMR. NO.	860020672001	
	 COMPLIANT ROHS & WEEE EUROPEAN ELECTRONICS	SEE M4
SIZE 5.0 X 11.0		

[illegible]

Type R Series

Type R Series



The resistive element comprises a thin film of nickel-chrome alloy deposited onto a high thermal conductivity ceramic substrate. Metal end caps are laser fitted to the element prior to spinning to value. Tinned copper lead wires are welded to the end caps and the components are then coated. One coat of photoresist is followed by three coats of epoxy resin. All resistors are tested for value and tolerance.

Key Features

- Precision metal film resistors with tolerance to 0.1% and temperature coefficients to 10ppm.
- Metal film resistors have excellent stability under load and severe environmental conditions. They exhibit very low noise current and voltage coefficients. Precision metal film resistors are particularly suitable in all applications where long-term stability is important.

Characteristics - Electrical

	YH8	EH8	CH8	YH1	EH1	CH1	YH2	EH2	CH2
Rated Power @ 70 °C (W)	0.125			0.25			0.5		
Resistance Range (ohms) Min	5.0H			10H			10H		
Max	5.0K			1M0			1M0		
Tolerance (%)				0.1	0.25	0.5			
Code Letter				B	C	D			
Temperature Coefficient (ppm/°C)	± 15	± 25	± 50	± 15	± 25	± 50	± 15	± 25	± 50
Selection Series				136					
Limiting Element Voltage - Nominal (V)	250			250			250		
Maximum Overload Voltage (V)	400			500			700		
Operating Temperature Range (°C)				-55 to +150					
Dielectric Strength (V)				500					
Insulation Resistance Min Dry (Mohms)				10,000					
Voltage Coefficient Max (ppm/V)				5					

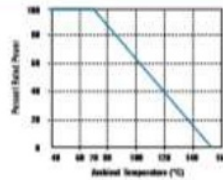
Dimensions



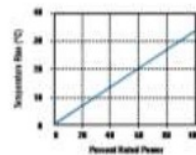
Style	L*	B	d mm
H8	3.3 ± 0.1	1.7 ± 0.2	0.45
H1	6.3 ± 0.3	2.3 ± 0.2	0.6
H2	9.5 ± 0.5	3.5 ± 0.5	0.6

* Length is measured in accordance with IEC 294

Derating Curve



Surface Temperature Vs Load

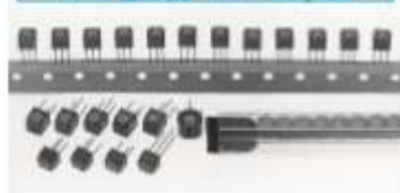


豊富な種類で選べるローコスト汎用タイプ

1回転型サーメットリマ SINGLE TURN CERMET TRIMMERS

CT-6

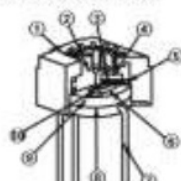
RoHS 指令対応 RoHS compliant



■特長 FEATURES

- RoHS 指令対応
- 汎用タイプ
- 14 種類の豊富なバリエーション
- 密閉型
- RoHS compliant
- Various configurations to choose from
- Wide variety (14 types)
- "O" ring sealed and washable

内部構造図 INTERNAL STRUCTURE



番号 Part name	材料 Material	特性 Characteristic
① ハウジング Housing	PBT (ポリブチレンテレフタレート) Polybutyleneterephthalate	UL94V-0
② ロータ Rotor		
③ ワイパ (調整子) Wiper	合金 Metal alloy	—
④ シム Rubber cushion	シリコンゴム Silicone rubber	
⑤ Oリング "O" ring	シリコンゴム Silicone rubber	UL94H
⑥ 抵抗体 Resistive element	RuO ₂ サーメット RuO ₂ cermet	
⑦ 端子 Terminal pin	銅、Snめっき Copper, Sn-plated	—
⑧ 接着剤 Adhesive	エポキシ Epoxy	UL94V-0
⑨ ベースエレメント Base element	セラミック Ceramic	
⑩ 電極 Electrode	Ag-Pd サーメット Ag-Pd cermet	—

■型式表示 PART NUMBER DESIGNATION



※ご注文に際しては、型式一覧表をご確認ください。
Please refer to the LIST OF PART NUMBERS when placing orders.

Figure 8-5. Root-Mean-Square Ripple Voltage for Capacitor-Input Circuits

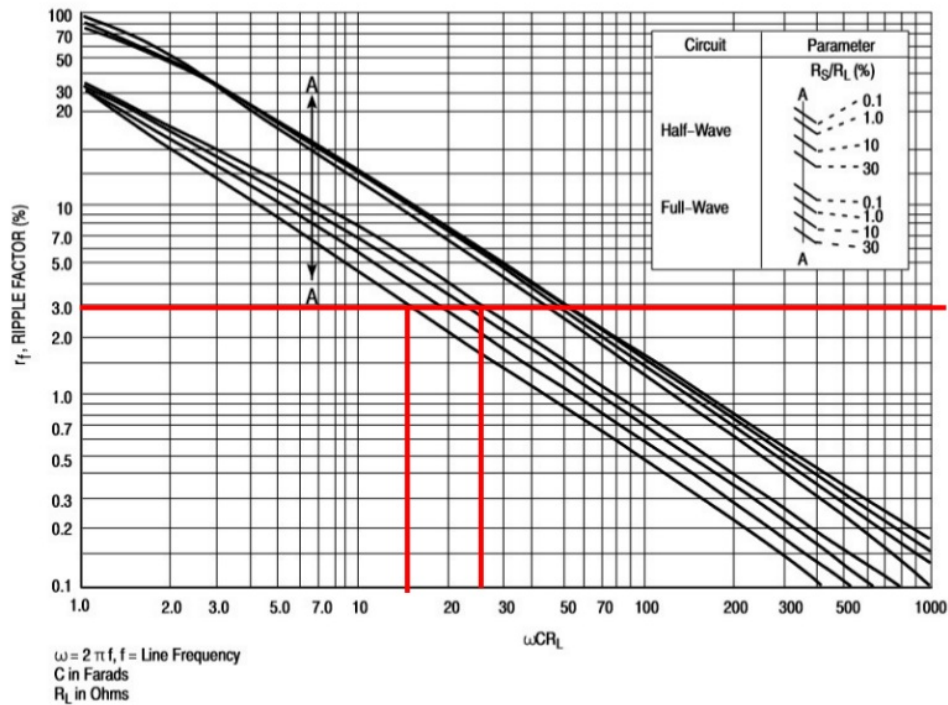


Figure 8-3. Relation of Applied Alternating Peak Voltage to Direct Output Voltage in Full-Wave Capacitor-Input Circuits

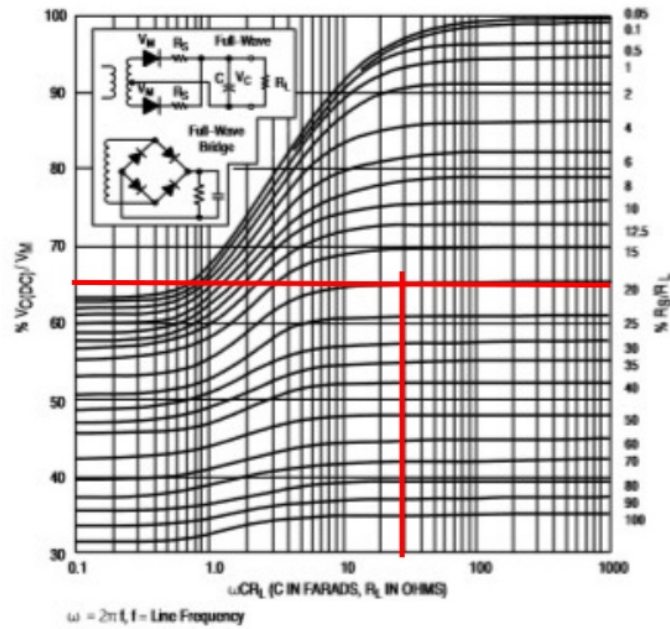
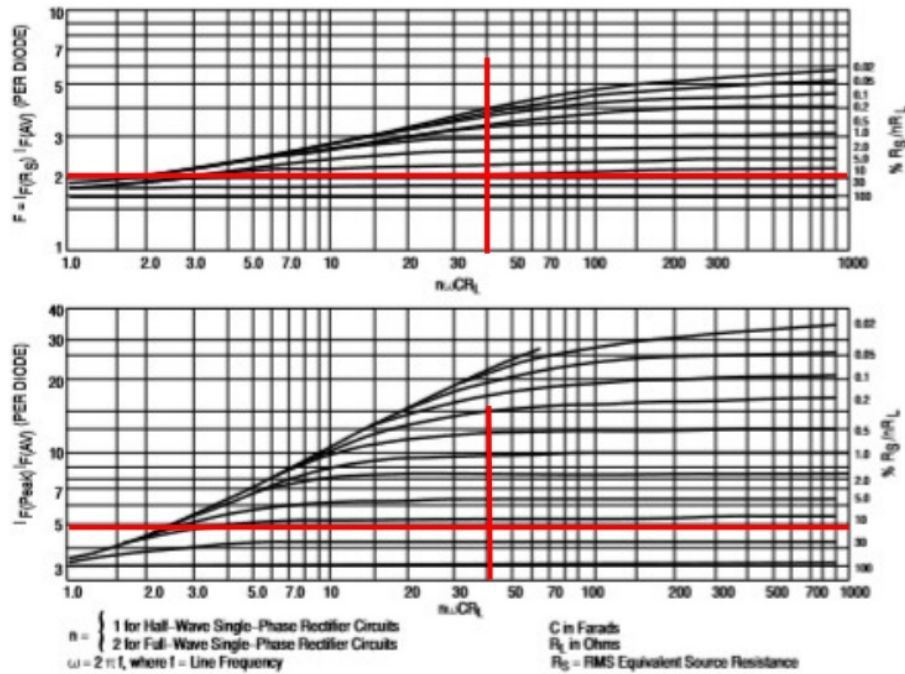


Figure 8-4. Relation of RMS and Peak-to-Average Diode Current in Capacitor-Input Circuits





Datasheet

ENGLISH

1000µF 50 V dc, Through Hole Aluminium Electrolytic Capacitor

RS Stock number [711-1532](#)



Specifications:

Item	Performance Characteristics																																																																														
Operating Temperature Range	-40 to +105°C	-25 to +105°C																																																																													
Rated Voltage Range	6.3 to 100 VDC	160 to 450 VDC																																																																													
Capacitance Tolerance	±20%/120Hz, +20%																																																																														
Leakage Current (×20%)	10V ~ 100V DC	0.5 (nC/mA/h)																																																																													
	160V ~ 450V DC	0.5 (nC/mA/h)																																																																													
	I: Leakage current (nA) C: Rated Capacitance (µF) V: Working Voltage (V) After 1 minute, whichever is greater measured, with rated working voltage applied																																																																														
Dissipation Factor (120Hz, 20 °C)	<table><tr><th>10V</th><th>6.3</th><th>10</th><th>16</th><th>25</th><th>35</th><th>50</th><th>63</th><th>100</th><th>160</th><th>250</th><th>350</th><th>450</th><th>450</th></tr><tr><td>0.25</td><td>0.20</td><td>0.18</td><td>0.16</td><td>0.14</td><td>0.12</td><td>0.10</td><td>0.10</td><td>0.10</td><td>0.10</td><td>0.10</td><td>0.10</td><td>0.10</td><td>0.10</td></tr></table> For capacitance exceeding 1000µF add 0.01 per increment of 1000µF		10V	6.3	10	16	25	35	50	63	100	160	250	350	450	450	0.25	0.20	0.18	0.16	0.14	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10																																																	
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Temperature Characteristics (Ta=θ)	<table><tr><th>10V</th><th>6.3</th><th>10</th><th>16</th><th>25</th><th>35</th><th>50</th><th>63</th><th>100</th><th>160</th><th>250</th><th>350</th><th>450</th><th>450</th></tr><tr><td>Impedance</td><td colspan="13"><table><tr><th>-25°C to 20°C</th><td>4</td><td>3</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>3</td><td>3</td><td>3</td><td>3</td></tr><tr><th>-40°C to 20°C</th><td>3</td><td>3</td><td>4</td><td>3</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td></tr></table></td></tr><tr><td colspan="14">Impedance ratio of 1.05kΩ</td></tr></table> <table><tr><td rowspan="3">Load Test</td><td colspan="2">Test conditions Duration time : 60~6000hrs 90~250 1000hrs Ambient temperature: +105°C Applied voltage: Rated DC working voltage After test requirements: ±20% After test requirements: ±20% of the initial measured value Dissipation Factor : <200% of the initial specified value Leakage current : <The initial specified value</td></tr><tr><td colspan="2">Test conditions Duration time : 600hrs Ambient temperature: +105°C Applied voltage: None After test requirements at +20°C: Same limits as Load Test. Pre-treatment for measurements shall be conducted after application of DC working voltage for 30 minutes.</td></tr><tr><td colspan="2">Shelf Test</td></tr></table>		10V	6.3	10	16	25	35	50	63	100	160	250	350	450	450	Impedance	<table><tr><th>-25°C to 20°C</th><td>4</td><td>3</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>3</td><td>3</td><td>3</td><td>3</td></tr><tr><th>-40°C to 20°C</th><td>3</td><td>3</td><td>4</td><td>3</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td></tr></table>													-25°C to 20°C	4	3	2	2	2	2	2	2	2	3	3	3	3	-40°C to 20°C	3	3	4	3	2	2	2	2	2	-	-	-	-	Impedance ratio of 1.05kΩ														Load Test	Test conditions Duration time : 60~6000hrs 90~250 1000hrs Ambient temperature: +105°C Applied voltage: Rated DC working voltage After test requirements: ±20% After test requirements: ±20% of the initial measured value Dissipation Factor : <200% of the initial specified value Leakage current : <The initial specified value		Test conditions Duration time : 600hrs Ambient temperature: +105°C Applied voltage: None After test requirements at +20°C: Same limits as Load Test. Pre-treatment for measurements shall be conducted after application of DC working voltage for 30 minutes.		Shelf Test	
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RS, Professionally Approved Products, gives you professional quality parts across all products categories. Our range has been testified by engineers as having comparable quality to that of the leading brands without paying a premium price.



www.vishay.com

VS-KBPC1, VS-KBPC6 Series

Vishay Semiconductors

Single Phase Rectifier Bridge, 3 A, 6 A



D-72

FEATURES

- Suitable for printed circuit board or chassis mounting
- Compact construction
- High surge current capability
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT

DESCRIPTION

The VS-KBPC series of single phase rectifier bridge consists of four silicon junctions connected as a full bridge. These devices are intended for general use in industrial and consumer equipment.

PRODUCT SUMMARY

I_{OAV}	3.0 A to 6.0 A
V_{RRM}	50 V to 1000 V
Package	D-72
Circuit	Single phase bridge

MAJOR RATINGS AND CHARACTERISTICS

SYMBOL	CHARACTERISTICS	VALUES KBPC1	VALUES KBPC6	UNITS
I_O		3	6	A
I_{RMS}	50 Hz	50	125	A
	60 Hz	55	137	
P_T	50 Hz	12.5	78	A's
	60 Hz	11.4	71	
V_{RRM}	Range	50 to 1000		V
T_J		-40 to 150		°C

ELECTRICAL SPECIFICATIONS

VOLTAGE RATINGS

PART NUMBER	V_{RRM} MAXIMUM REPETITIVE PEAK REVERSE VOLTAGE V	V_{RRM} MAXIMUM NON-REPETITIVE PEAK REVERSE VOLTAGE V	V_{RRMS} MAXIMUM RECOMMENDED RMS SUPPLY VOLTAGE V
VS-KBPC1005	50	50	20
VS-KBPC102	200	200	80
VS-KBPC104	400	400	125
VS-KBPC106	600	600	250
VS-KBPC108	800	800	380
VS-KBPC110	1000	1000	500
VS-KBPC6005	50	50	20
VS-KBPC602	200	200	80
VS-KBPC604	400	400	125
VS-KBPC606	600	600	250
VS-KBPC608	800	800	380
VS-KBPC610	1000	1000	500

Revised: 04-Apr-14

1

Document Number: 93585

For technical questions within your region: DiodesAmericas@vishay.com, DiodesAsia@vishay.com, DiodesEurope@vishay.com
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ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT www.vishay.com/doc?91000

Transformers Chassis Mounting

pro-POWER

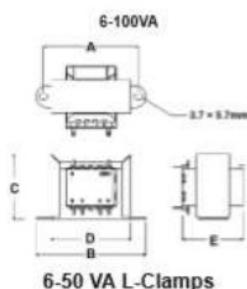


Features:

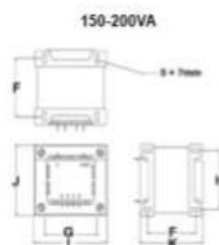
- Single 230V primary winding
- Double section imperial bobbin
- 6 to 200VA power, 50/60Hz
- Temperature class B (130°C)
- Dielectric strength 3,750Vrms
- Manufactured and tested in accordance with EN60950 and EN61558

Specifications:

Max. Winding Temperature	: 55°C
Overall Insulation Rating	: >50MΩ (at 500V, 20°C)
Flash Test (isolation test)	: Primary/Secondary/Lamination 2.4kVrms
Winding Wire	: Polyurethane coated IEC317 Grade 1
Tape	: 3M No 56 or 3M No 1350Y Thermosetting
Core	: 400/50
Finish	: Ultimeg 3.72 Clear



VA Rating	Reg % 2	A ±1	B ±1	C ±1	D ±1	E ±1	Weight
6	24	55	65	37	45	36	170g
12	16	74	90	50	60	45	390g
20	12	74	90	50	60	52	530g
50	9	94	106	65	79	58	985g



VA Rating	Reg % 2	F ±1	H ±1	I ±1	J ±1	K ±1	Weight
100	10	45	57	89	75	65	1,550g
150	9	62	63	88	74	78	2,100g
200	8	68	72	102	85	85	2,750g

Dimensions : Millimetres

www.element14.com
www.farnell.com
www.newark.com
www.cpc.co.uk

pro-POWER

1602826

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

64/100

PAGE 1

PAGE 2

PAGE 3

Text Comment. ES should cover all sections and give a flavour of the entire report

PAGE 4

PAGE 5

Text Comment. A block diagram here would have been good

PAGE 6

Text Comment. Preferred value

PAGE 7

Text Comment. We didn't need this garph

PAGE 8

PAGE 9

PAGE 10

Text Comment. Good, preferred value used.

PAGE 11

PAGE 12

Text Comment. Shame :)

Text Comment. Research on real components that meet the spec was needed and a shopping showing sources and prices would have finished the design.

GRADING FORM: CSG-RUBIC

RESEARCH-INFORMED LITERATURE



Research on real components that meet the spec was needed and a shopping showing sources and prices would have finished the design. There was little evidence of further reading and research and although there was a short reference list there was no evidence of any in-text referencing. Your references list relied on a small selection of mainly inappropriate and non-authoritative sources.

3

KNOWLEDGE AND UNDERSTANDING



The knowledge and understanding of the subject demonstrated by this assignment was reasonably extensive. There were very few gaps in your knowledge of the basic principles and your understanding of the higher level concepts was demonstrated to a limited degree. You have demonstrated some critical understanding of the main concepts and expanded your knowledge beyond that contained in the course notes, however your explanations need to be more detailed and written with a greater emphasis on critical evaluation rather than description.

22

ANALYSIS



Your explanation of the design process was good and the conclusions showed that you can interpret quantitative and qualitative data, although this was often descriptive. You could have evaluated the results in more detail and specified whether they concurred with theory suggesting reasons for any discrepancies. You have however demonstrated good analytical skills and your approach to the task was logical. Arguments made in the conclusions were mostly valid and demonstrated a good understanding of the topic. Further work – in your conclusion, you should relate the results to the original specification.

18

PRACTICAL APPLICATION AND DEP.



Your application of practical skills for this task was generally very good. You used the resources appropriately when designing the circuit and you used appropriate options for testing and evaluating the circuit performance. You managed to design an effective circuit that functioned within the specification and achieved this by only asking for assistance when appropriate thus demonstrating some advanced problem solving skills. Your results were comprehensive and allowed for a detailed conclusion to be attempted.

14

SKILLS FOR PROFESSIONAL PRAC.

Your written report was generally well written in a



coherent and fluent manner that contained most of the required detail, although it lacked the depth of explanation required in places. Avoid the use of photographs and/or scans of written notes.