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by Lourens Brits

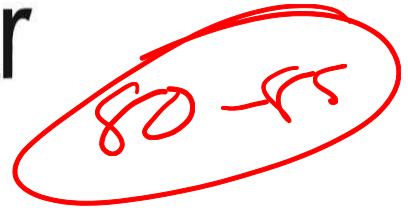
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Name : Lourens Brits
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- ① EXCELLENT RESEARCH AND SPEC
- ② DESIGN METHOD WAS EXPLAINED IN DETAIL.
- ③ COMPREHENSIVE TESTING
- ④ VALID CONCLUSIONS.
- ⑤ RESEARCH INTO ALTERNATIVE COMPONENTS COULD HAVE BEEN MORE EXTENSIVE.

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1. Executive Summary

The power supply design in this assignment was carried out in line with published theory. The design specifications were ascertained from the customer, after which decision had to be made whether a top down or bottom-up approach would be followed. Following research into both approaches, the bottom-up method was chosen, given that the output voltage and current required was the starting point and that all components were readily available.

A block diagram of the required power supply sections gave structure to the design. The power supply design was split into two halves, back-end and front end. The front end was concerned with a step-down transformer, voltage rectifier and smoothing capacitor and the back end with the voltage regulator, current boost transistor and associated heat management, and the load.

The voltage regulator was chosen, which required various calculations to be made to provide a starting point for the back-end simulation, which highlighted the need for a current boost Transistor as the regulator was limited to 150mA current output by design. The transistor heat management design required power dissipation calculations to be carried out which enabled a suitably sized heatsink to be chosen.

The back-end simulation was carried out using Multisim, where the calculated values were tuned to provide the correct output values. The circuit was subjected to various loads to ascertain the optimum load, which was indicated by a period of symmetry on the resultant load-voltage graph.

Once the back-end simulation was satisfactory the front-end design was carried out, with transformer turns ratio, rectifier requirements and smoothing capacitor sizing was carried out.

Further testing was carried out on the feasibility of incorporating over-voltage and reverse-polarity protection to the circuit.

Finally, once circuit analysis was complete a full conclusion was carried out.

2. Research Requirements and Compilation of the Specification

Following consultation with the customer the following power supply requirements were ascertained. The power supply needs to comply with industrial standards as it will be utilised to power a gas detector controller with stable 24V DC voltage.

The power supply will be mounted within a cabinet in a rack room, where constant ventilation is provided for the room itself, as well as within the cabinet. The customer specification does not require a specific mounting method, as long as the power supply is enclosed for safety reasons.

Mains supply voltage will be 110V AC, 60Hz supplied from a local area transformer, which supplies various components in the rack room.

An output current of 240mA will be required to run the gas detector and controller output signal to the distributed control system (DCS).

Further environmental aspects to take into considerations within the enclosure includes low levels of humidity and vibrations.

Finally, the customer requires the power supply to be manufactured in an ethical and sustainable manner, which should include designing for repair and reusability/recycling as well as ensuring compatibility with [BS EN 60079-22-2](#) "Explosive atmospheres. Gas detection. Selection, installation, use and maintenance of detectors for flammable gases or oxygen" (HSE, 2004).

Overall component costs need to be within £150.

3. Design Method, Choices and Calculations

The design of the regulator circuit needed to be carried out initially, which included calculating component values and simulation testing using Multisim, once the desired output voltage and current was achieved the input stage was designed utilising the ON semiconductor design handbook. The back end and front end of the power supply was subsequently combined to enable full circuit simulation and testing. Finally thermal management parameters will be calculated, with an appropriate heatsink chosen.

The basic block diagram of the components required to convert an AC mains supply to a regulated DC voltage is shown in figure 1.

In this case a step-down transformer with a determined turns ratio, is utilised to not only reduce the 110V AC applied to the primary windings to the required AC voltage on the secondary windings, but also as a means to isolate the rectifier circuit from the mains supply.

The rectifier converts the AC voltage into DC voltage utilising diodes which are arranged in the form of a bridge, where two diodes conduct during the positive half cycle and opposite two during the negative half-cycle, thereby producing a pulsating DC voltage which is not ripple free (Arrow, 2018).

The filter circuit is utilised to reduce the inherent ripple in the DC voltage produced by the rectifier circuit. This is achieved through the use of capacitors, inductors or a combination of both in most cases (Electronics, 2020).

Finally, the voltage regulator circuit enables a stable unvaried DC voltage to be produced across the load, regardless of variations in line voltage or current. This is achieved through the use of Zener diodes, transistors or more commonly, integrated circuits, depending on application. IC voltage regulators provide a means of achieving a steady DC voltage at a very low cost with easy implementation (Laughton & Warne, 2003).

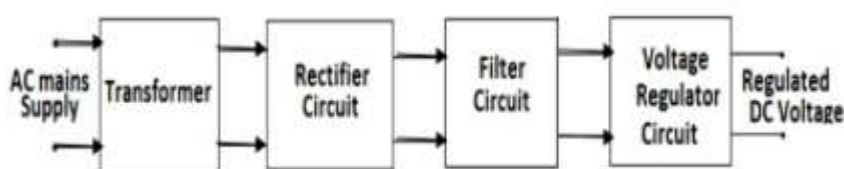


Figure 1 - Power Supply Block Diagram (Electronics, 2020)

The design method is further elaborated upon below.

3.1 Regulator Design

The Motorola MC1723C voltage regulator was chosen due to availability, cost and due to the fact that it has been proven to be reliable. The adjustable output voltage range of 2VDC to 37VDC was deemed to be most suitable. The maximum output current of 150mA DC was less than required, but could be increased through the use of external pass NPN transistors, to achieve the desired output of 240mA.

Figure 2 shows the LM1723C diagram, which was configured to produce a stable, positive 24v DC output. $V_{CC} -$ pin was grounded, with the $V_{CC} +$ positive and V_C pins joined the initial voltage supply line, where $V_{CC} -$ & $V_{CC} +$ is the supply to the chip an V_C the supply to the transistor.

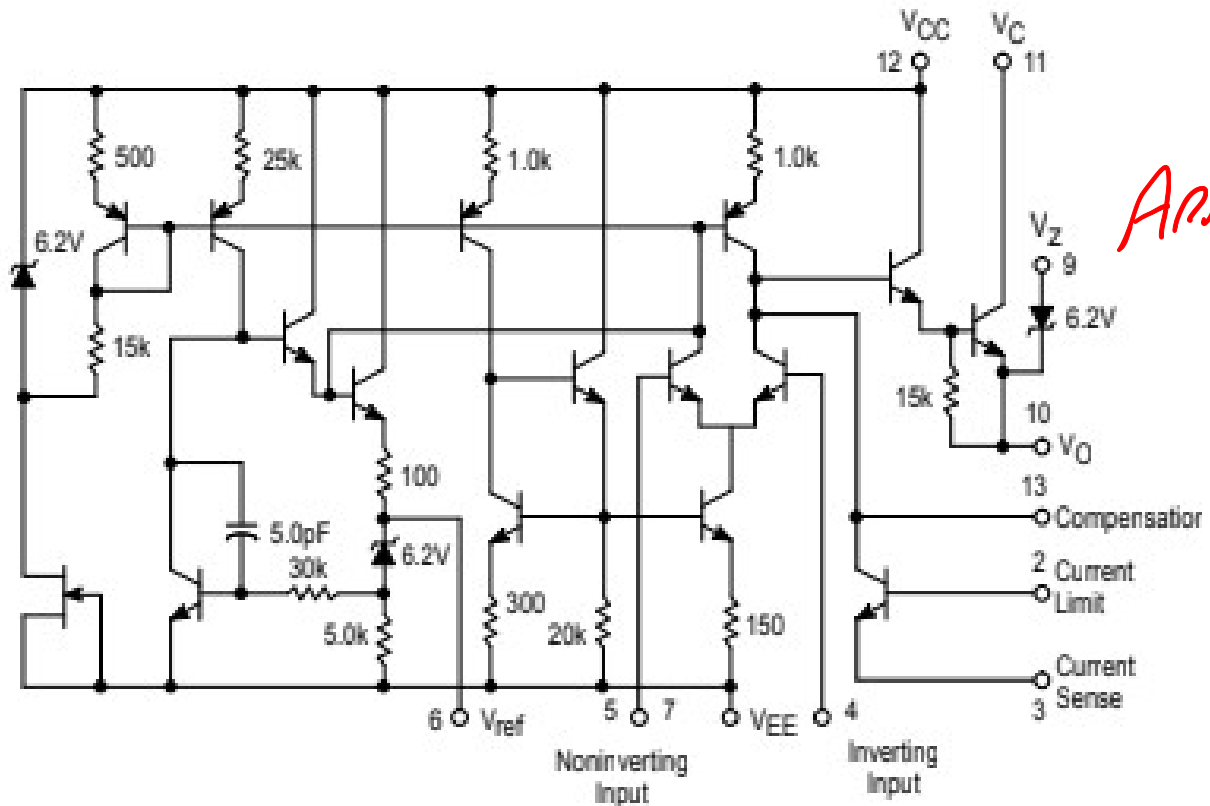


Figure 2 - Motorola MC1723C Schematic (Motorola, 2005)

The initial simulated circuit of the regulator was constructed using Multisim software, as seen in figure 4, with the configuration reflecting the current boost connection diagram shown in figure 3.

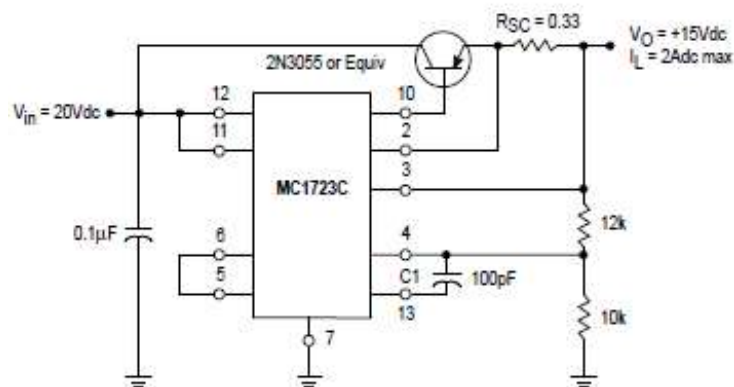


Figure 3 - NPN Current Boost Configuration (Motorola, 2005)

The 2N3055 NPN silicone power transistor is utilised as its operating ranges are deemed to be sufficient to achieve the desired output current. The datasheet can be seen in appendix figure 1.

The LM1723C has a current limiting feature incorporated in its design, where the R_{sc} voltage drop is monitored, which is proportional to current. The current is limited once the voltage drop across R_{sc} is equal to the base-emitter ON voltage, at which point an internal transistor starts conducting, which diverts base current away from the pass transistor. This method is known as constant current limiting (ON Semiconductor, 2002).

Appendix figure 2 shows the constant current limiting configuration, where Q2 is the external pass transistor, Q1 is the IC internal drive transistor and Q3 is the switching transistor, utilised to reduce the pass transistor (Q2) drive current (ON Semiconductor, 2002).

As seen in figure 4, C2 capacitor and R_{sc2} Resistor is connected in parallel with the frequency compensation pin and the current limited output value. This compensation technique is referred to as Miller compensation and is utilised to reduce op-amp instability (ON Semiconductor, 2002).

Figure 4 shows the simulated circuit, where component values were calculated to achieve a starting point, after which manual adjustments to component values needed to be made.

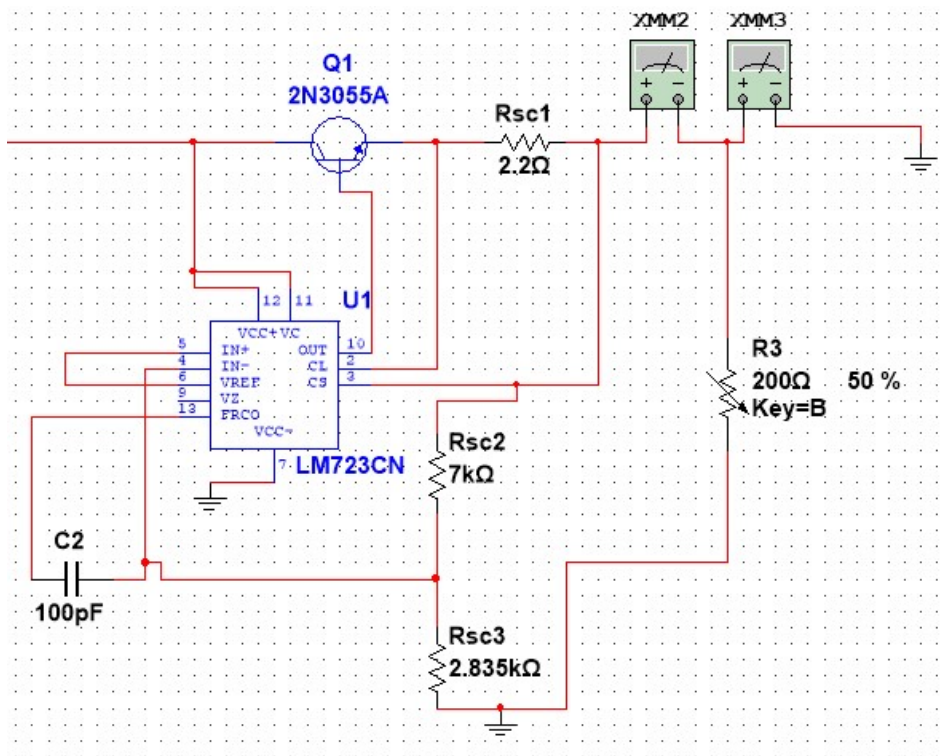


Figure 4 – Initial Simulated Regulator Circuit

3.2 Regulator Design – Component Calculations

The following calculations were made, in line with the regulator design manual, for the values of C_{Ref} , R_1 , R_2 , R_3 & R_{SC}

C_{Ref} given as 0.1μF for low noise application

$R_2 = \frac{7.0V}{V_0}(R_1 + R_2)$ where $R_1 + R_2$ are given as $10k\Omega$ & $V_{Ref} = 7.0V$ a characteristic of the chip, stated on the datasheet.

$$R_2 = \frac{7.0V}{24V}(10k) = 2.92k\Omega \text{ where the closest preferred value is } 3k\Omega.$$

$$R_2 = 3k\Omega$$

$$R_1 = 10k - R_2$$

$$R_1 = 10k - 3k = 7k$$

$$R_{SC} = \frac{0.6V}{I_{SC}} = \frac{0.6V}{240 \times 10^{-3}} \text{ Where } I_{SC} \text{ is the desired output current.}$$

$$R_{SC} = 2.5\Omega$$

R_3 will be utilised as a variable simulated load

Input Voltage:

$$V_{in} = V_o + 2\phi + 5V$$

$$V_{in} = V_o + (2 \times V_{BE}) + 5V \text{ where } V_{BE} \text{ are transistor losses.}$$

$$V_{in} = 24 + (2 \times 0.6) + 5V$$

$$V_{in} = 30.2V$$

Appendix figure 3 shows the simulated regulator circuit utilising the calculated component values, from this is it clear to see that further tuning of the component values will be needed to achieve the desired output values.

The output voltage & current is $23V$ & $23.7nA$, respectively, with small adjustments on R_{sc} , R_1 & R_2 these values are expected to increase in line with design requirements and will be elaborated upon in section 4.

3.3 Front End Design

The input section of the power supply is designed in reverse order to ensure the correct regulator input voltage is achieved. The following calculations have been carried out in line with published guidance.

3.3.1 V_m (Maximum No-load Output Voltage).

$V_m = V_{in} + \frac{1}{2}V_{in} = 30.2V + 15.1V = 45.3V$ This is the minimum voltage that would need to be applied to the capacitor from the front end.

3.3.2 Ripple Factor (R_f)

To calculate the ripple factor (R_f), clarity is needed on the following;

V_{in} (Regulator input voltage) can also be referred to as V_c , which is the smoothing capacitor output.

The datasheet states that the V_{ripple} (ripple voltage p-p under no-load) is 3v.

The minimum capacitor values can now be calculated to ensure sufficient ripple attenuation;

$$R_f = \frac{V_{Ripple(pp)}}{2\sqrt{2}(V_{DC})} \times 100\%$$

$$R_f = \frac{3V}{2\sqrt{2}(30.2)} \times 100\% = 3.51\%$$

Now that the R_f value has been calculated, a Schade curve can be used to ascertain a suitable value for ωCR_L for a full wave rectifier. Figure 5 shows the method followed, where the calculated ripple factor value is plotted on the y-axis & ωCR_L on the x-axis. The parameter key in the top left corner indicates which parameters to use for full wave circuits.

As shown in figure 5, the ripple factor is plotted at 3.5%, with the corresponding x-axis value (ωCR_L) range being 15 – 25. The average ωCR_L value of 20 will be used.

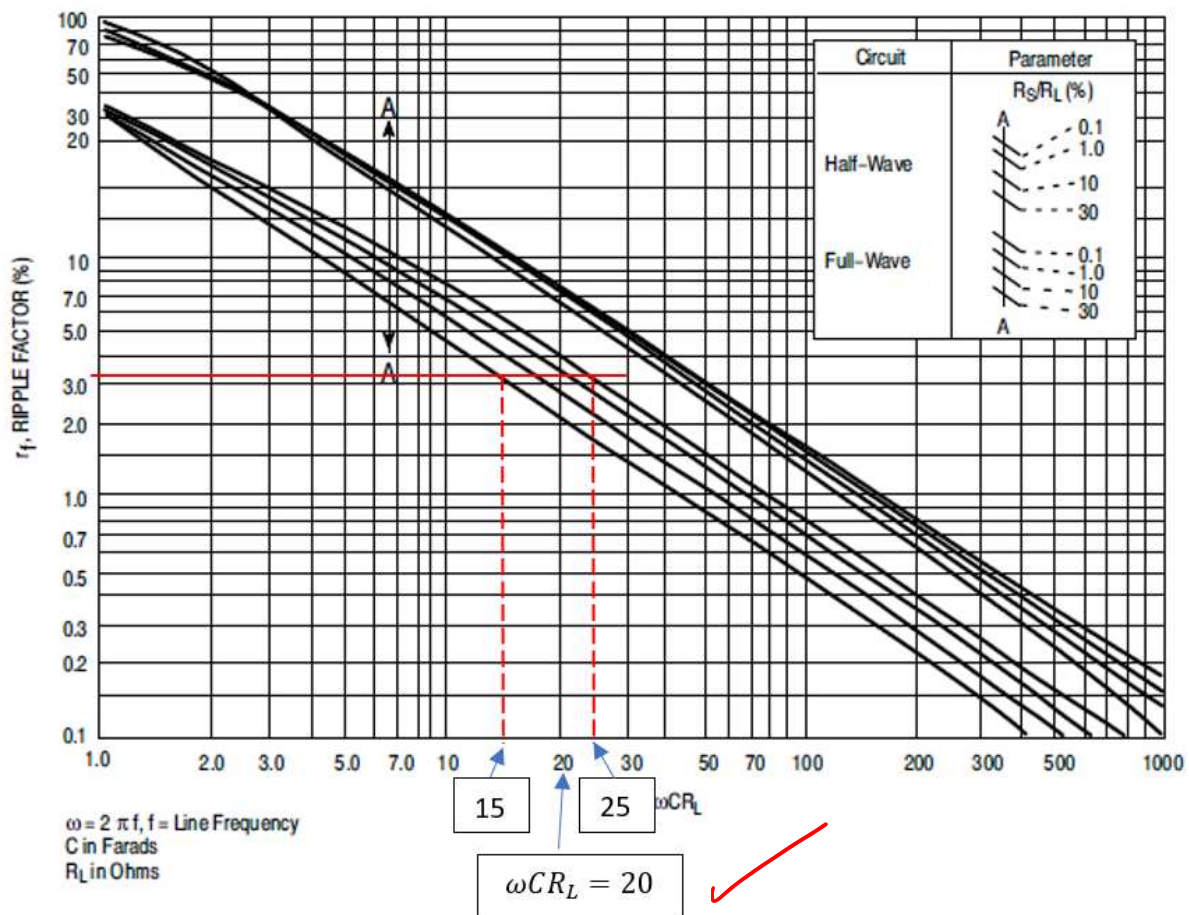


Figure 5 - Schade Curve - Capacitor Input Ripple Voltage (ON Semiconductor, 2002)

The Schade curve shown in figure 6 was utilised to find the value for R_S/R_L %. This value is ascertained through the applied AC peak voltage relationship with the output DC voltage.

The Y-axis shows the voltage relationship, which has to be calculated using the circuit values;

$$V_C/V_M = 30.2/45.3 = 0.6 = 60\%$$

60% on the y-axis is plotted against the ωCR_L value (20) on the x-axis, resulting in an R_S/R_L % value of 25%.

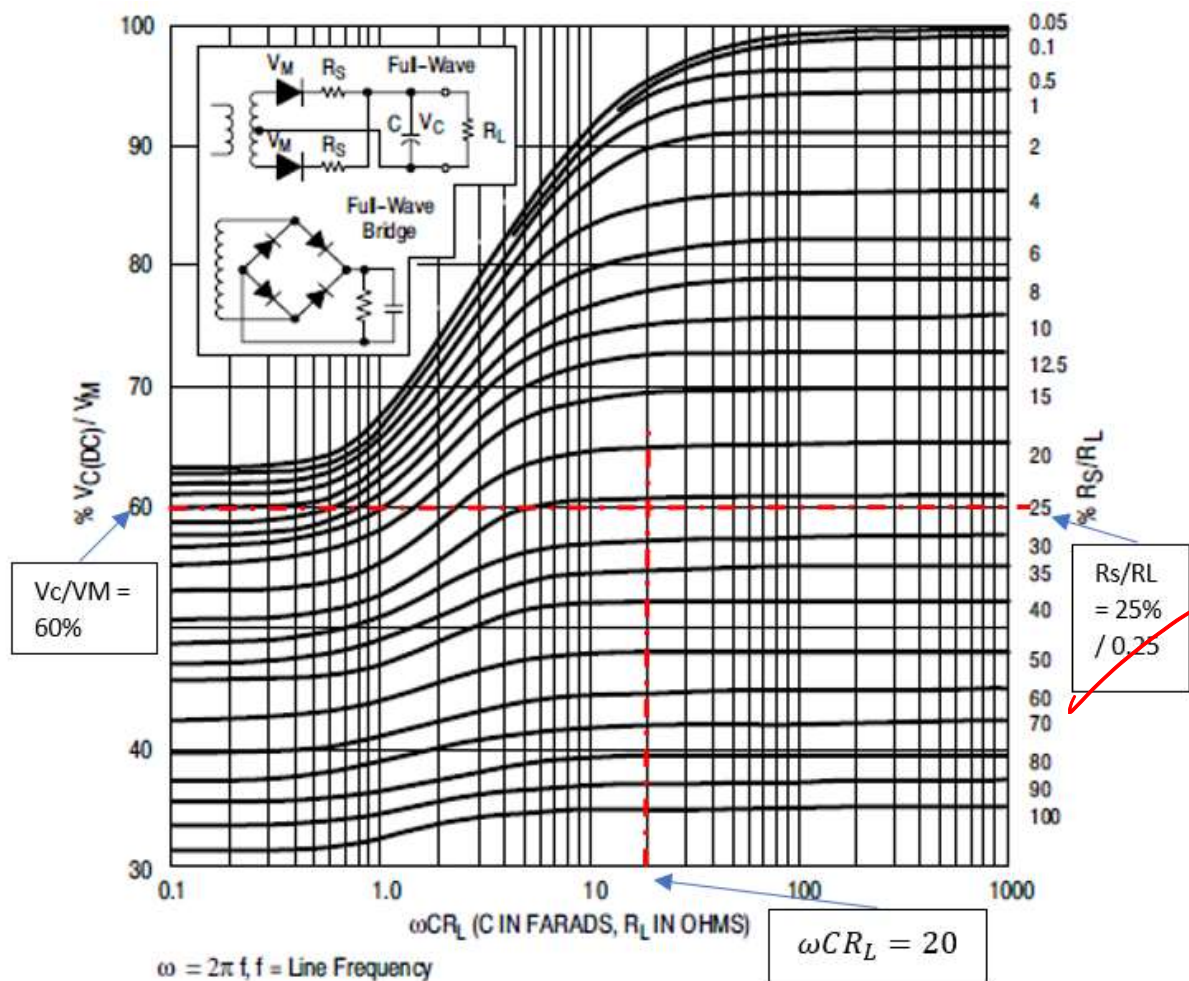


Figure 6 - V_C / V_M Relationship - R_S/R_L Value (ON Semiconductor, 2002)

3.3.3 R_L & R_S value:

Calculate R_L & R_S value:

$$R_L = \frac{V_C}{I_O} = \frac{30.2}{240 \times 10^{-3}} = 125.83 \Omega$$

$$R_S = 0.2 \times R_L = 0.2 \times 125.83 = 25.166 \Omega$$

3.3.4 Filter Capacitor Value:

$$C = \frac{\omega CR_L}{2\pi f \left(\frac{V_C(DC)}{I_O} \right)} = \frac{20}{2\pi 60 \left(\frac{30.2}{240 \times 10^{-3}} \right)} = 0.42 \times 10^{-3} \text{ (420 } \mu\text{F)}$$

SEEMS LOW, NORMALLY
IN mF REGION.

3.3.5 Rectifier Requirements

Average current: $\frac{I_o}{2} = \frac{240 \times 10^{-3}}{2} = 120 \text{mA}$

Referring to figure 7, where $n=2$ for full-wave rectification, $\omega C R_L = 40$ which enabled the following values to be ascertained; $I_{f(RMS)} = 2.1$ & $I_{f(peak)} = 5.2$, as seen below.

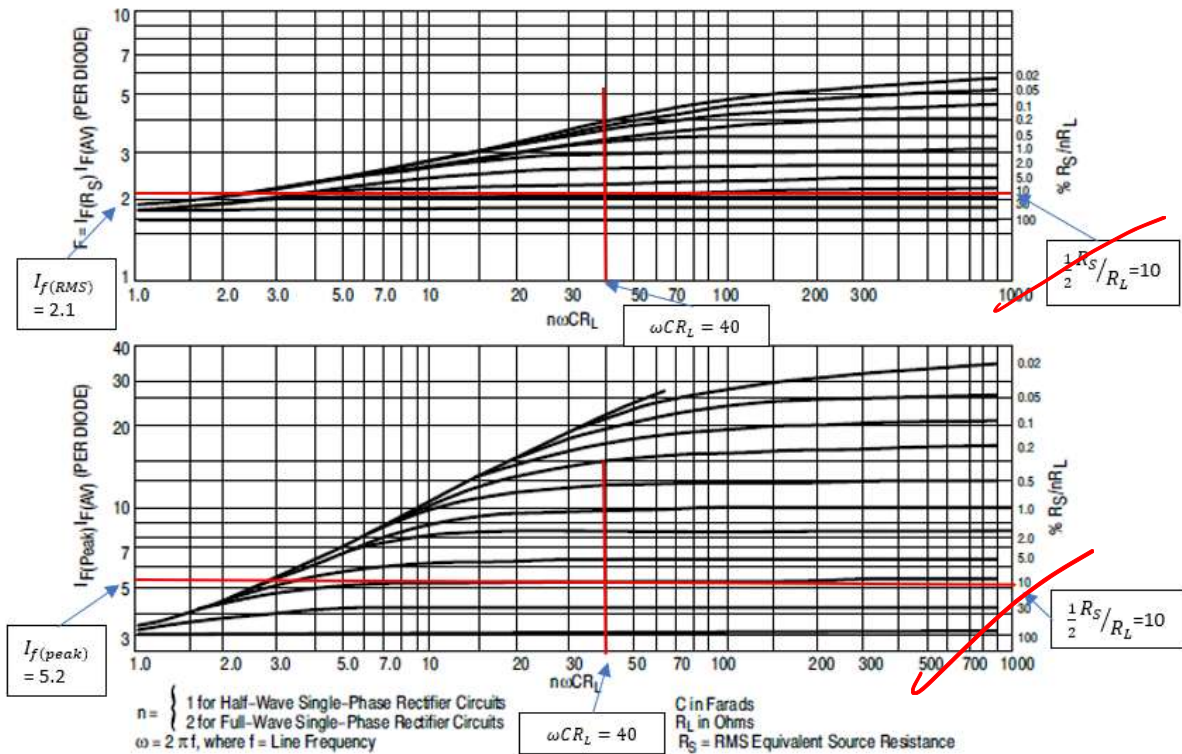


Figure 7 - $I_f(RMS)$ & $I_f(peak)$ Values (ON Semiconductor, 2002)

Peak inverse voltage, $PIV = V_m \times 2 = 45.3 \times 2 = 90.6 \text{V}$ Which acts as a safety margin.

Surge current, I_{surge} calculated: $\frac{V_m}{R_S + E} = \frac{45.3}{25.166} = 1.8 \text{A}$ (The ESR value is left out as it is negligible)

Appendix figure 4 shows the datasheet for the chosen rectifier chip which is the Vishay VS-KBPC101 which has a surge current rating of 3A and PIV of 100V.

3.3.6 Transformer Calculations

Secondary leg RMS voltage: $V_{secondary} = \frac{V_m + n}{\sqrt{2}} = \frac{V_m + 2}{\sqrt{2}} = \frac{47.3}{\sqrt{2}} = 33.45 \text{V}$ (where $n=2$ for full wave bridge)

Secondary leg RMS current: $\sqrt{2} \times I_{RMS} = \sqrt{2} \times 240 \times 10^{-3} = 0.34 \text{A}$

VA Rating (Full-wave bridge): $V_S \times I_{RMS} \times \sqrt{2} = 38.54 \times 0.34 \times \sqrt{2} = 18.53 \text{VA}$

Turns Ratio: $V_p : V_s = 110 : 35 \approx 3 : 1$

The chosen transformer is the SV single voltage transformer, sourced from Eastern Transformers & Equipment LTD. The VA rating is higher than specified, but will be sufficient for the intended application. The datasheet is shown in appendix figure 7. DIN mounting will be used to mount the transformer in close proximity to the rest of the circuit. The transformer design incorporates safety features such as IP20 touch-proof terminals, with EN 61558-1 Class E insulation (ETE, 2022).

3.3.7 Thermal Management and Heatsink Design

Thermal management requirements need to be ascertained to ensure the power supply functions reliably and safely. The use of the current boost NPN transistor is the first indicator that thermal management may be required.

Heat is released from an electronic device, like a semiconductor, in three different ways; Radiation, Convection and Conduction (Renesas, 2022).

The heat dissipation journey starts at the component, the generated heat travels to the component encapsulation (conduction), which is joined to the heatsink via a heat transfer medium (natural convection), after which the fins on the heat sink dissipates the heat into the ambient air by radiation. The component datasheet states the θ_{JA} coefficient, which represents the amount of heat dissipated.

Figure 8 shows a typical heatsink thermal model.

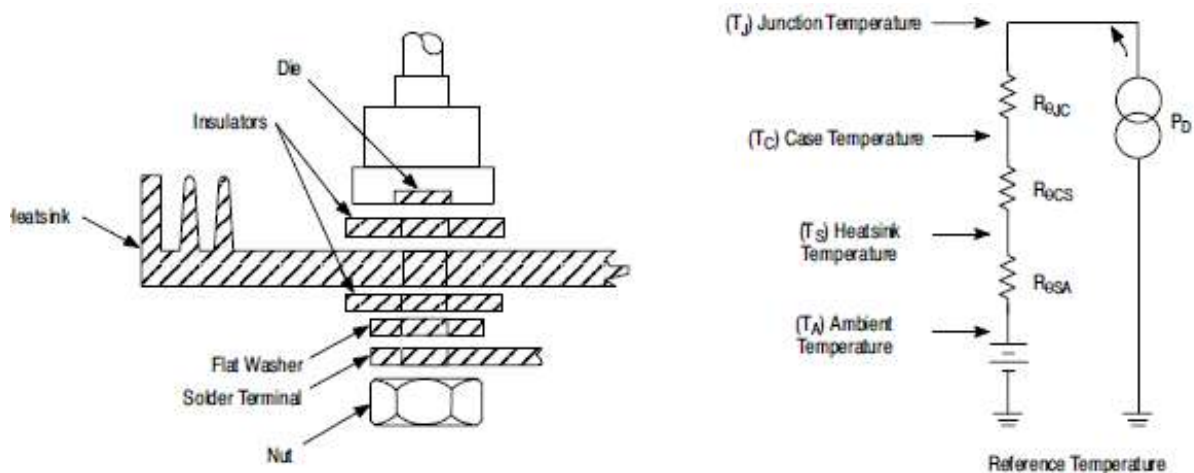


Figure 8 - Thermal Resistance Model (ON Semiconductor, 2002)

The following calculations were made, using the component datasheet (appendix figure 6), to ascertain whether a heatsink is required and what its thermal resistance value should be.

Transistor

Under normal operating conditions;

$$T_A = T_J - (P_D \times \theta_{JA})$$

$$T_J = T_A + (P_D \times \theta_{JA})$$

$$T_J = 20 + (0.24 \times 200)$$

$$T_J = 70^\circ\text{C}$$

In the event the power consumption increases to 5W:

$$T_A = T_J - (P_D \times \theta_{JA})$$

$$T_J = T_A + (P_D \times \theta_{JA})$$

$$T_J = 20 + (5 \times 200)$$

$$T_J = 1020^\circ\text{C}$$

Therefore a heatsink will be required.

Heatsink size calculation:

$$P_D = 24 \times 240 \times 10^{-3} = 5.76\text{W (Power dissipated by IC)}$$

$$T_A = 20^\circ\text{C (Ambient Temperature)}$$

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

$$\frac{75-20}{5.76} - 4 - 1.6 = 3.95^\circ\text{C/W Thermal resistance}$$

From the calculations a TO-3 heatsink with a heat transfer characteristic of less than 3.95°C/W is required. The selected heatsink datasheet is shown in appendix figure 7.

THIS WAS THE
EXAMPLE, NOT
NECESSARILY WORK
YOU NEED TO DO.

3.3.8 Component Cost summary

Table 1 shows the individual component costs and the overall project cost. Some components are sold in multiples, which increases the cost approximately £50. The surplus components need to be labelled and stored for future projects.

Component	Cost	Part Number	Supplier	Pack Quantity
SV Transformer	£15.60	SV 50 POS6	ETE	1
Heatsink	£1.14	1764162	RS Pro	1
MC1723C	£0.96	UA723CN	Farnell	1
Rectifier	£1.22	VS-KBPC102	Digi-Key	1
2N3055 Transistor	£4.99	2N3055AG	Digi-Key	1
Resistor R1 7k Ω	£1.30	1155272	Farnell	1
Resistor R2 2.8k Ω	£0.15	164-4597	RS	50
Resistor Rsc 2.2 Ω	£0.05	161-6107	RS	100
Capacitor C1 420 μ F	£0.35	919-3558	RS	100
Capacitor C2 0.1 μ F	£0.06	711-1661	RS	100
Variable Resistor	£12.35	107-0735	RS	1
Enclosure	£44.93	867-2460	RS	1
Power Supply Cost	£83.57	Total Parts Cost		£136.09

Table 1 - Project Cost

4. Testing, Results and Analysis

4.1 Back End Simulation and Testing

The simulation circuit was built using multisim, shown in figure 9, where the calculated values were used. The multimeter measurements XMM2 and XMM3 show the regulator output voltage and current. It is clear that the component values needed to be tuned to achieve the correct voltage and current.

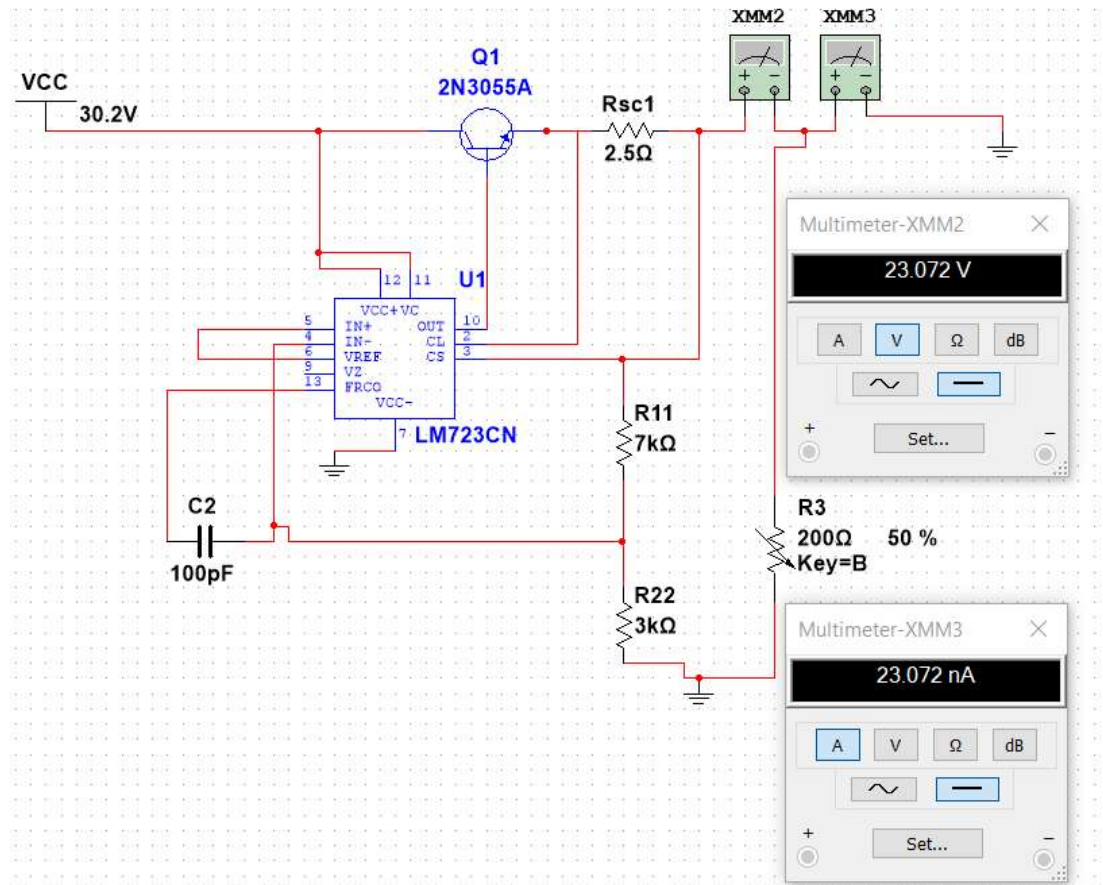


Figure 9 - Back End Simulation - Initial Circuit

Figure 10 shows the tuned component values that enabled the required output parameters to be achieved, using the DC supply.

By reducing R2 resistance to 2.835kΩ the output current increased to 239mA, where a reduction in Rsc1 resistance from 2.5 Ω to 2.2 Ω brought the output voltage and current to 24v and 240mA respectively.

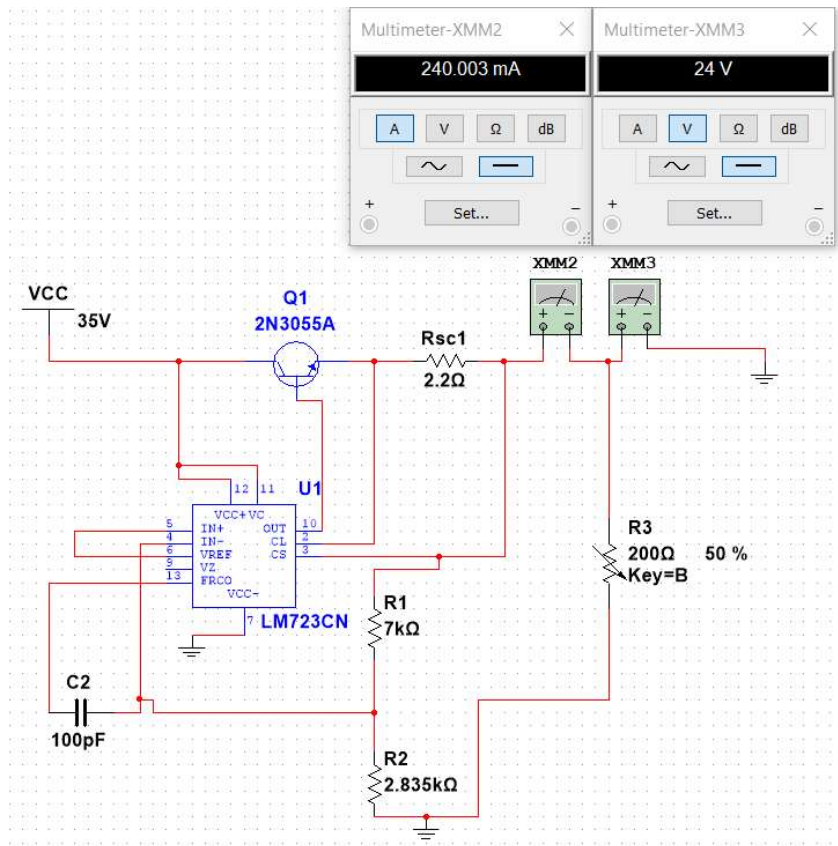


Figure 10 - Back End Simulation - Tuned Component Values

Various load resistances needed to be applied to the circuit to enable analysis of circuit performance, which was carried out using a variable resistor. Voltage (V) is shown by the blue line and current (mA) by the orange line plotted on the y-axis, with the resistance plotted on the x-axis.

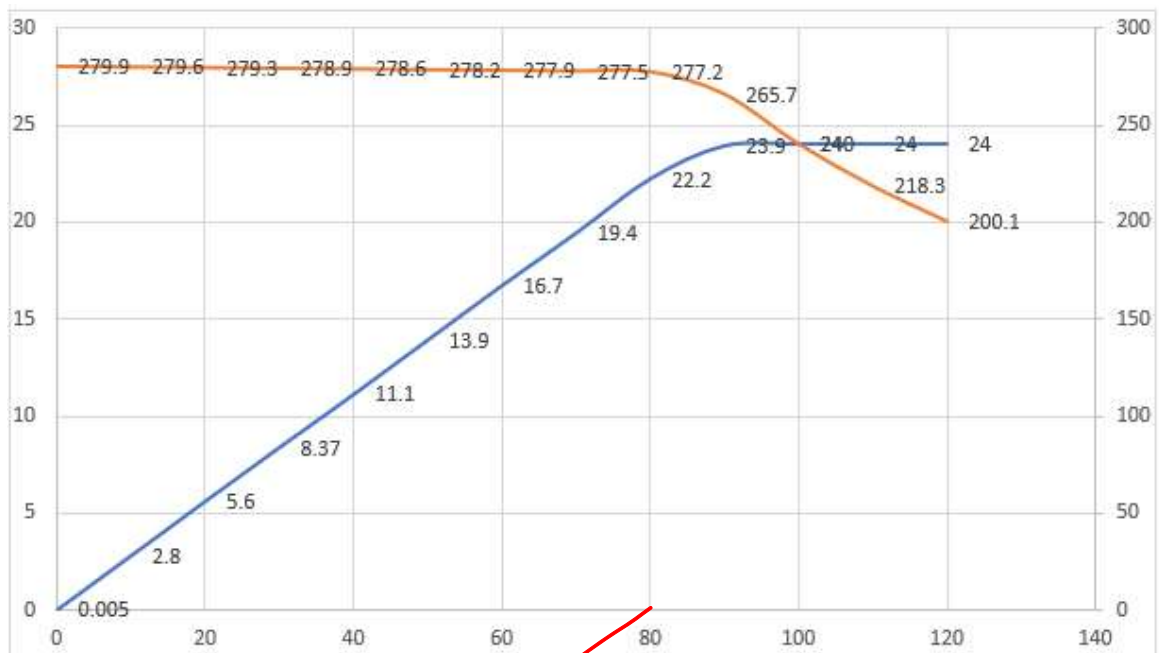


Figure 11 - Load Variation Test

From figure 11, it is clear that the output current shows very little variation whilst the load increases, causing an increase in output voltage. The output voltage shows a very steady increase of approximately $2.8\text{V} / 10\Omega$ resistance increase, in line with ohm's law.

The current starts to reduce once the voltage starts to reach the desired steady state output of 24V , once again, in line with Ohm's law, as the voltage is steady and the resistance increases, the current will reduce accordingly.

The intersect point is of most interest in this graph, as this is the ideal power and load point for the power supply with a 100Ω resistive load. See appendix figure 8 for the load testing table.

4.2 Front End Simulation and Testing

Figure 12 shows the AC supply conditioning, in the form of the step-down transformer & bridge rectifier. A functional test was carried out, to ascertain whether the transformer and rectifier was functioning correctly. It is clear from the resultant oscilloscope waveforms that the voltage has been stepped down successfully and that the rectifier has successfully produced a DC voltage, indicated by the flat wave-form.

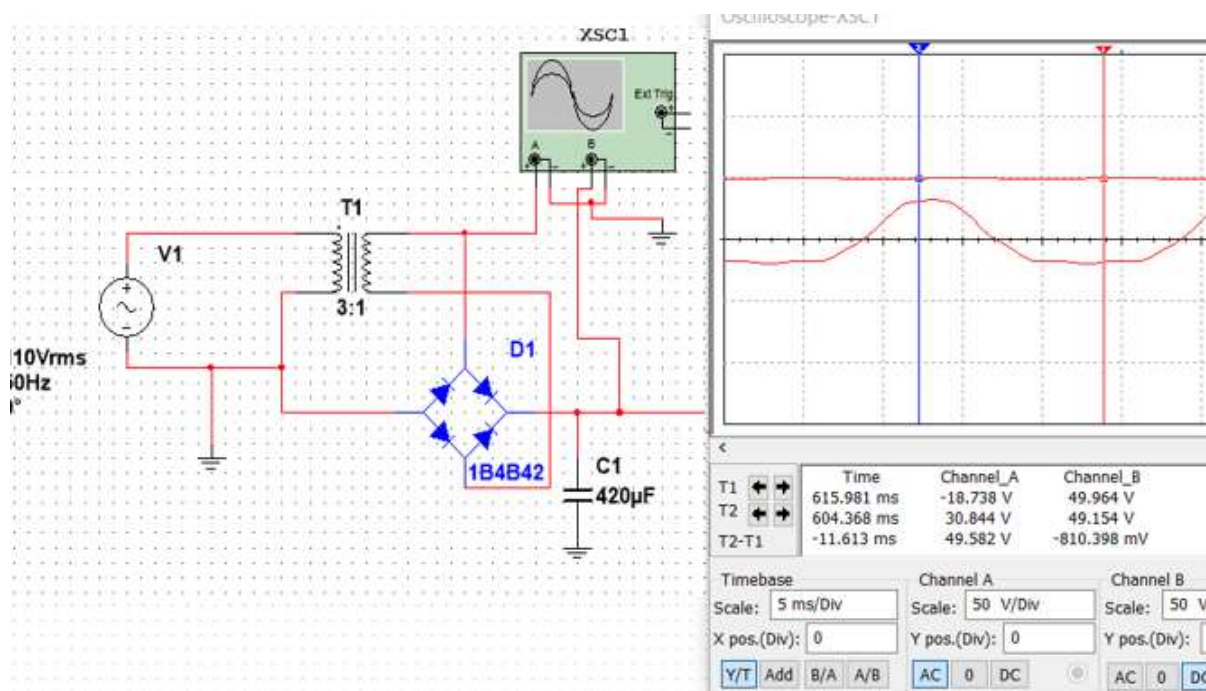


Figure 12 - Front End Testing - Transformer and Rectifier

Appendix figure 15 shows the transformer function test, where the input and output waveforms were analysed, which confirmed correct step-down operation from 110V to 37V .

4.3 Combined Circuit Testing

The circuit was combined to enable further testing. Figure 13 shows the circuit complete and functioning correctly.

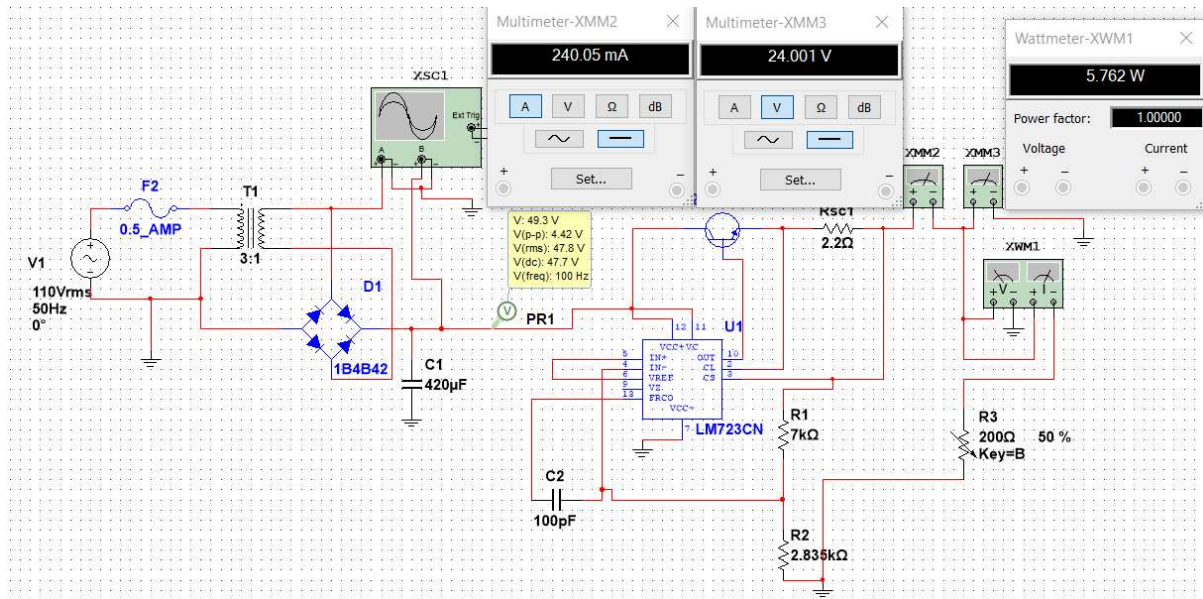


Figure 13 - Combined Simulation Circuit

Figure 14 show the DC voltage with the inherent ripple, as well as the AC line voltage. From this DC wave-form it is clear to see the need for further smoothing and filtering to achieve a steady DC output voltage.

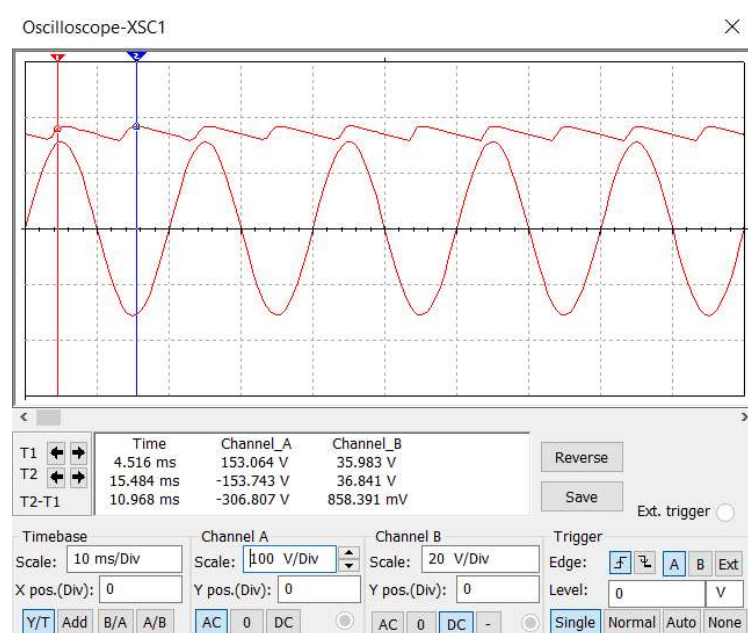


Figure 14 - Rectified DC voltage with AC Ripple

In figure 15 both DC voltage waveforms are shown, pre-filter and post filter and regulator. The stable DC voltage show that the circuit is performing as intended.



Figure 15 - DC Voltage Comparison

4.4 Over voltage & Short Circuit Protection

Consideration was given to overvoltage protection, where a very basic series regulator was incorporated in the circuit and tested to confirm correct operation. The series regulator consisted of a 2N3055A transistor, 1N4754A Zener diode and a 500Ω biasing resistor, as shown in figure 16.

The over voltage protection circuit was tested by simulating a fault on the transformer, where 108.4 V was applied to the circuit. The voltage is rectified with ease as shown by multimeter XMM 1, the protection circuit is shown to work correctly, as the voltage applied to the back-end circuit is limited to 38V. Multimeters XMM2 & XMM3 show that the rest of the circuit is operating correctly.

This method is very basic and is very inefficient due to heat produced, more efficient methods like the SCR crowbar would be more suitable.

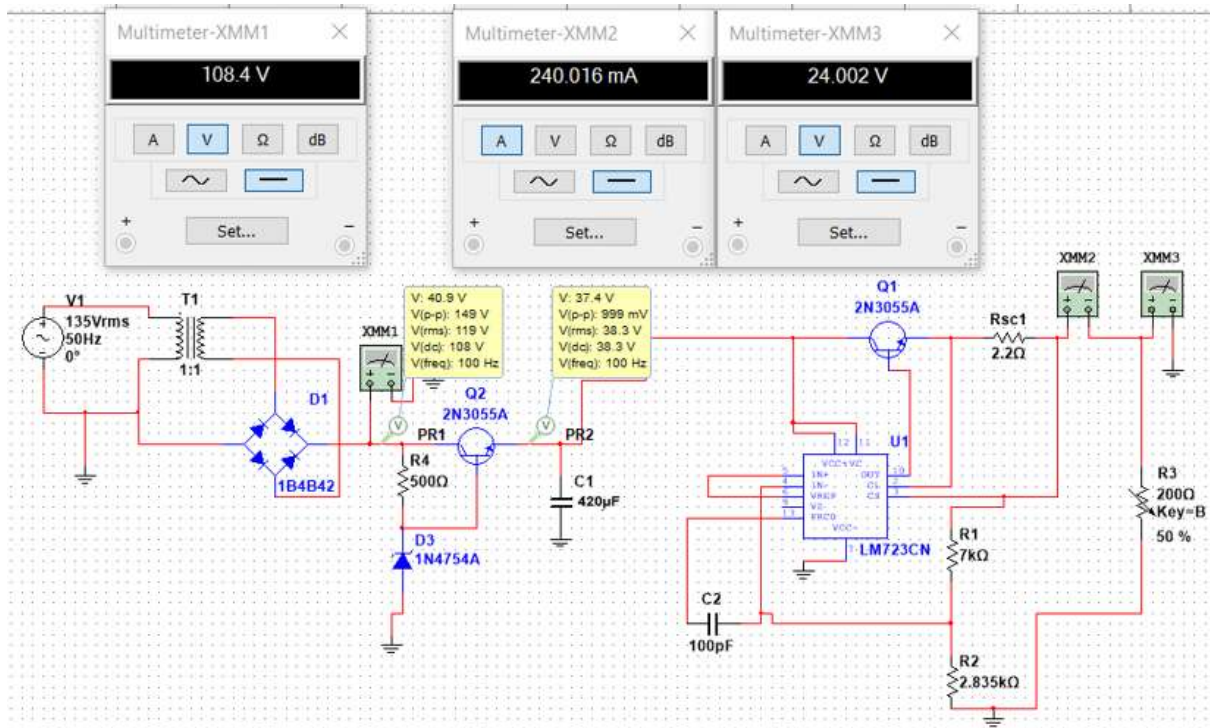


Figure 16 - Over Voltage Protection Simulation

Figure 17 shows the fuse incorporated in the supply as short circuit protection and has been sized to twice the circuit current to reduce the likelihood of nuisance blowing.

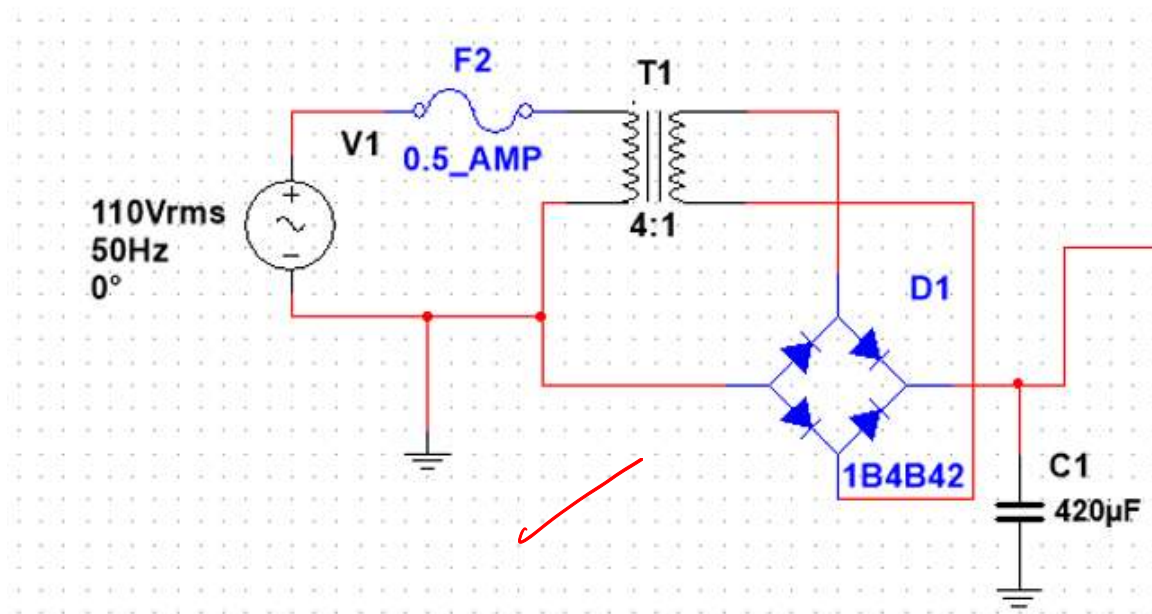


Figure 17 - 5 Amp Fuse for S/C Protection

Figure 18 shows a wattmeter utilised to confirm that the IC power dissipation calculations were carried out correctly, as indicated by XWM1 the circuit power is measured to be 5.76W, with the calculated value 5.76W. The power factor of 1 shows that the system is functioning efficiently and confirms that the load is resistive.

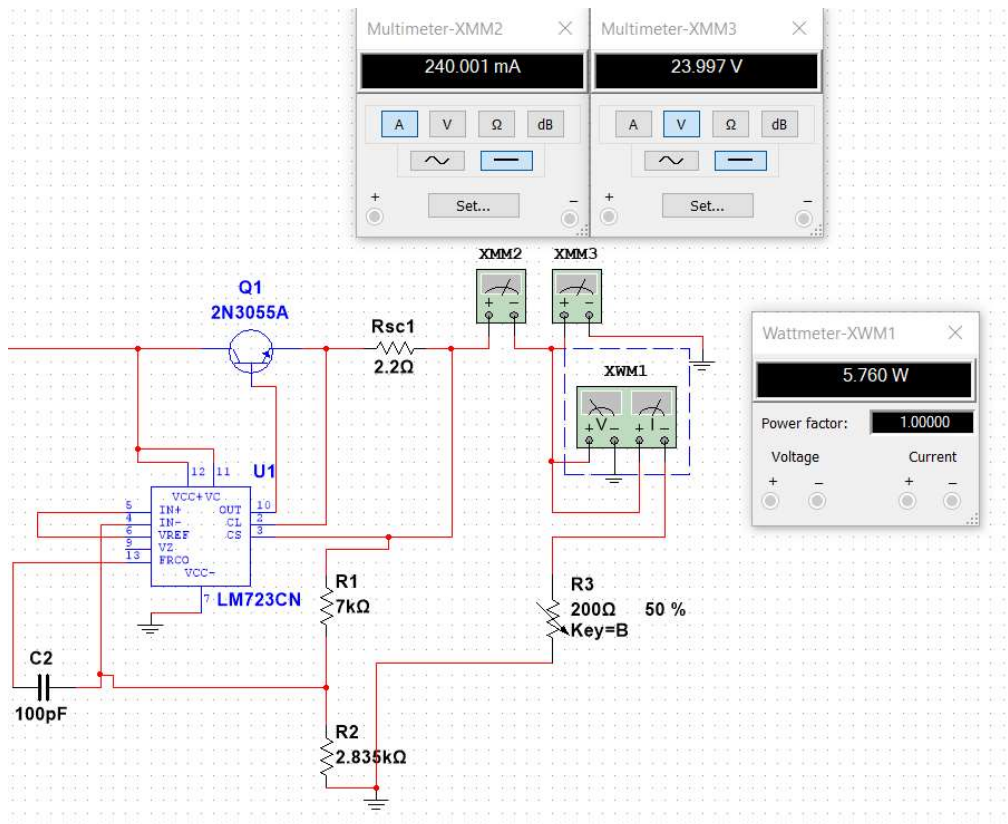


Figure 18 - Circuit Power Dissipation

5. Conclusions and Recommendations

Following the bottom-up approach to the design, the power supply was split into the front end and back end, which allowed the individual halves to be fine-tuned once the component values were calculated. Once both sections were functioning correctly the circuit was combined for further testing to ensure the supply met the customers specifications.

The back-end consisted of the MC1723C voltage regulator, which was found to be limited to 150mA current output, therefore the need for a current boost transistor became clear. The transistor most suited for this application was the 2N3055 silicon power transistor in NPN configuration, which allowed the higher output current to be achieved.

The back-end design required various loads to be applied to the regulator through the use of a variable resistor, to ascertain the optimal load where the output current and voltage reach the specified values of 24V and 240mA, this value was found to be 100Ohm.

The use of the current boost transistor presented the need for a heatsink, due to the generated heat, which could be alleviated through the use of a secondary transistor to share the load.

The front-end design led to a step-down transformer with a turns ration of 4:1 to be utilised to provide the voltage rectifier with the required 38V. An oscilloscope was used to confirm the rectified DC voltage was suitable. The inherent AC ripple was evident before the smoothing effect of the capacitor and regulator reduced it to a more stable and suitable waveform.

Safety features in the design included the built in current limiting feature in the regulator, the option to add over-voltage protection utilising a Zener diode-based method and insulated terminals on the transformer as well as encapsulation. Furthermore, a correctly rated fuse was added to provide short-circuit protection.

The power supply component cost, including the power supply enclosure, amounted to £83.57 which was within the specified budget.

Further improvements to the design could include a current bleed device, which would dissipate power when the supply output is disconnected as well as a dedicated over-voltage protection circuit.

The next step of the design, pending approval of the customer would be to build the circuit on PCB design software like Eagle, which would enable a purpose-built circuit board, with appropriate layout to be manufactured to complete the design in an aesthetically appropriate manner.

In conclusion, the design specifications have been successfully met and this power supply will function in a reliable and safe manner.

VERY GOOD CONCLUSIONS.

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7. Appendix

2N3055 Transistor Datasheet

Full datasheet can be seen on <https://www.onsemi.com/pdf/datasheet/2n3055-d.pdf>

MAXIMUM RATINGS (Note 1)

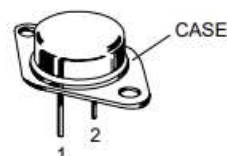
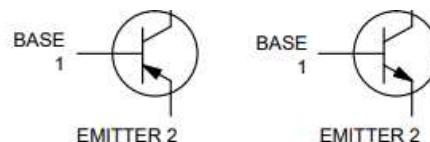
Rating	Symbol	Value	Unit
Collector-Emitter Voltage 2N3055AG MJ15015G, MJ15016G	V_{CEO}	60 120	Vdc
Collector-Base Voltage 2N3055AG MJ15015G, MJ15016G	V_{CBO}	100 200	Vdc
Collector-Emitter Voltage Base Reversed Biased 2N3055AG MJ15015G, MJ15016G	V_{CEV}	100 200	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current - Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ 2N3055AG MJ15015G, MJ15016G Derate above 25°C 2N3055AG MJ15015G, MJ15016G	P_D	115 180 0.65 1.03	W W W/ $^\circ\text{C}$ W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Indicates JEDEC Registered Data. (2N3055A)

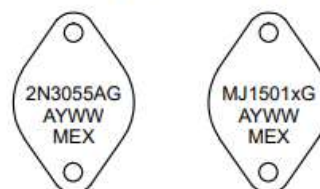
THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Max	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	1.52	0.98	$^\circ\text{C/W}$

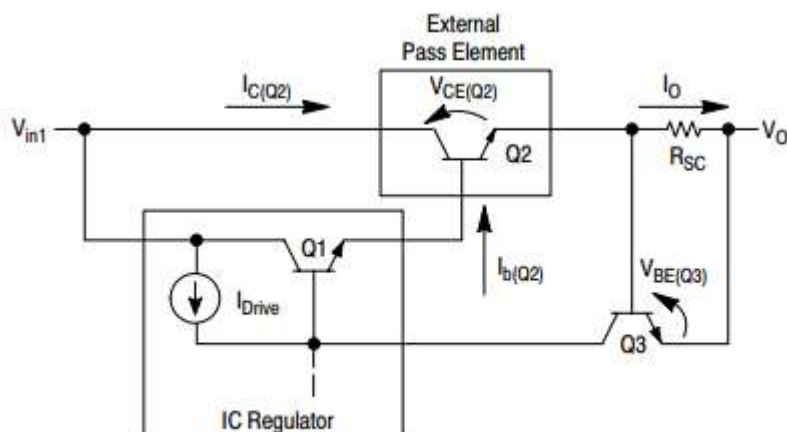


TO-204 (TO-3)
CASE 1-07
STYLE 1

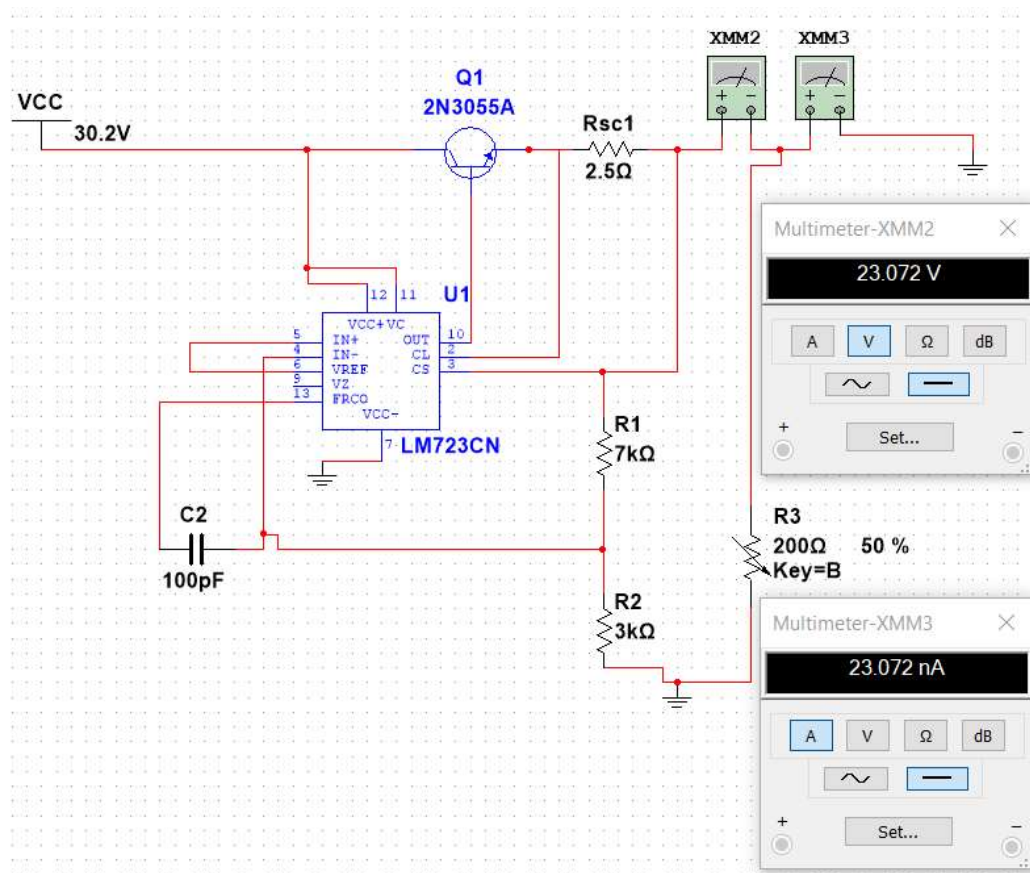
MARKING DIAGRAMS



2N3055A = Device Code
MJ1501x = Device Code
x = 5 or 6
G = Pb-Free Package
A = Assembly Location
Y = Year
WW = Work Week
MEX = Country of Origin



Appendix Figure 2 - Constant Current Limiting Configuration



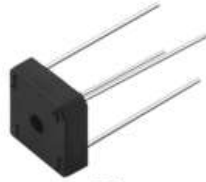
Appendix Figure 3 - Simulated Circuit with Calculated Component Values



KBPC1, KBPC6 Series

Vishay High Power Products

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
- Compliant to RoHS directive 2002/95/EC



DESCRIPTION

The 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

$I_{O(AV)}$	3.0 A, 6.0 A
V_{RRM}	50 V to 1000 V

MAJOR RATINGS AND CHARACTERISTICS

SYMBOL	CHARACTERISTICS	KBPC1	KBPC6	UNITS
I_O		3	6	A
I_{FSM}	50 Hz	50	125	A
	60 Hz	55	137	
I^2t	50 Hz	12.5	78	A ² s
	60 Hz	11.4	71	
V_{RRM}	Range	50 to 1000		V
T_J		- 40 to 150		°C

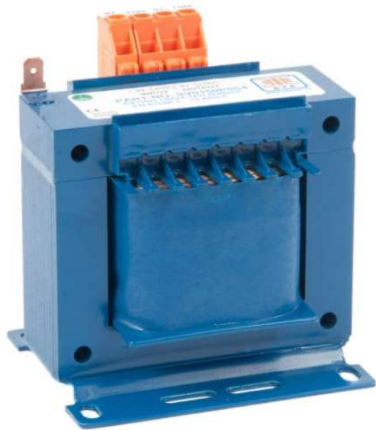
ELECTRICAL SPECIFICATIONS

VOLTAGE RATINGS

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

Appendix Figure 4 - Rectifier Chip Data Sheet

Transformer Data Sheet



[Click here to view the PDF Engineering Drawing](#)

SV Single Voltage 110V to 24V Transformer (50~500VA)

Please select your VA rating option from the dropdown below

50VA

▼

Quantity	Your Price
1 - 1 (pcs)	£15.60
2 - 3 (pcs)	£14.00
4 or more (pcs)	£12.50

Out of stock

SKU: SV 50 P056

Category: SV Single Voltage Series

Tags: Air conditioning units, Control panel builders, Food packaging

Appendix Figure 5 - Transformer Data Sheet

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}	–85 to +175	°C
Operating Ambient Temperature Range	T _A	0 to +70	°C

Appendix Figure 6 - MC1723C Data Sheet

Datasheet
 Stock No: 1764162
RS Pro
Heatsink TO-3



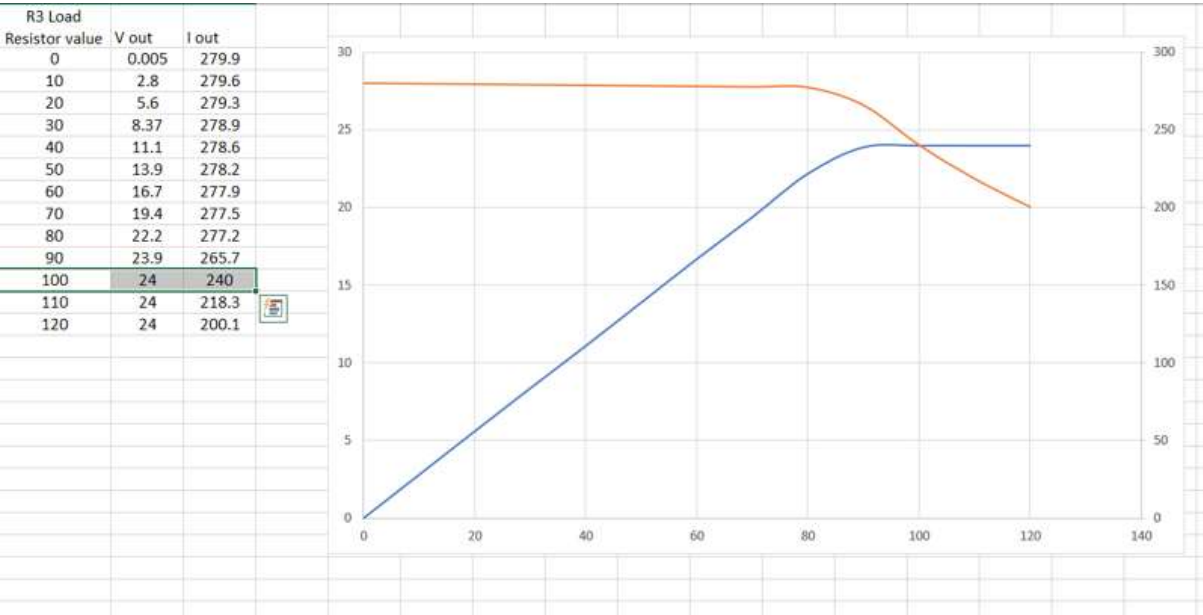
Type: Board Level, Vertical
 Package Cooled: TO-3
 Attachment: Bolt On
 Shape: Rectangular, Fins
 Length: 47.2mm
 Width: 47.2mm
 Height of Fins: 33.3mm
 Power Dissipation @ Temperature Rise: 7.5W @ 44 °C
 Thermal Resistance Forced Air Flow: 2.0 °C/W @ 400LFM
 Thermal Resistance Natural: 2.0 °C/W
 Material: Aluminium
 Finish: BlackAnodise



RS PRO MPN	Height above PC Board (mm)	Footprint Dimensions (mm)	Mounting Configuration	Mounting Style	Thermal Performance Natural Convection	Forced Convection
RSAW294-008	33.3	47.2 x 47.2	Vertical / Horizontal	Bolt On	7.5W @ 44°C	2.0°C/W @ 400 LFM

Appendix Figure 7 - Heatsink with Thermal Resistance <3.95° c/w

Load testing values



Appendix Figure 8 - Load Testing Table

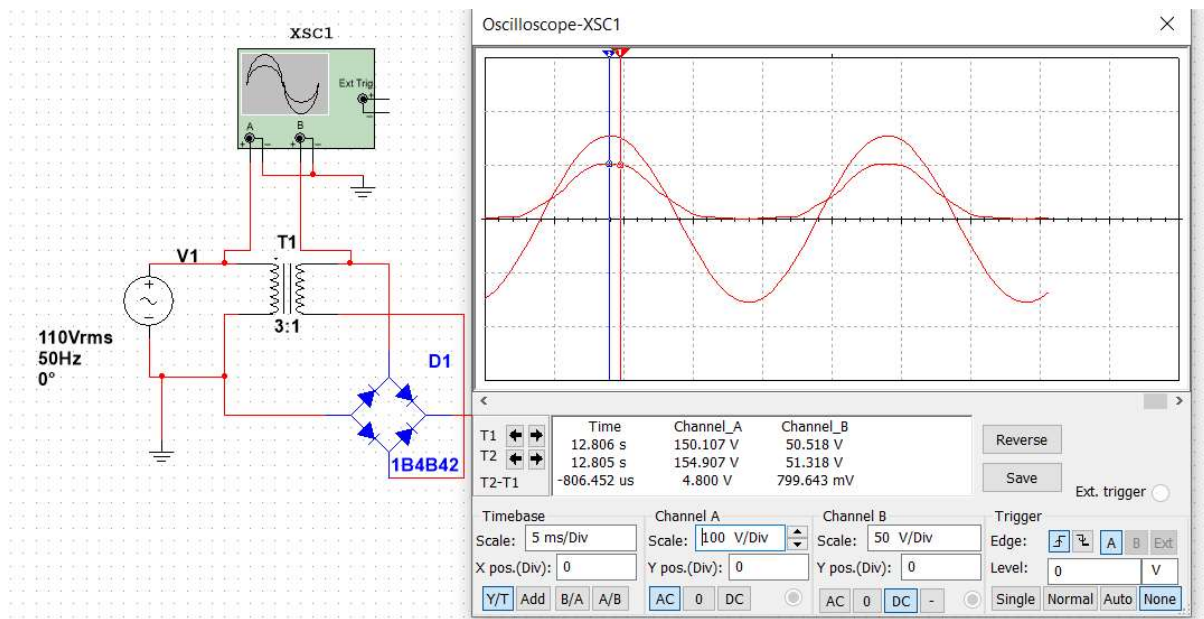


Figure 19 - Transformer Performance Test

FINAL GRADE

GENERAL COMMENTS

Instructor

80/100

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GRADING FORM: CSG-RUBIC

LOURENS BRITS

80

RESEARCH-INFORMED LITERATURE



There was evidence of extensive further reading and research from credible and reliable sources. Your interpretation and understanding of the additional research was very good and demonstrated a deep underlying appreciation of the subject. Your references were consistently

9

applied and appropriate to the task and your reference list was of an appropriate length for this assignment.

KNOWLEDGE AND UNDERSTANDING

 The knowledge and understanding of the subject demonstrated by this assignment was generally excellent. There were very few gaps in your knowledge of the basic principles and your understanding of the higher level concepts was demonstrated to a high degree. You have demonstrated a highly competent critical understanding of the main concepts and expanded your knowledge well beyond that contained in the course notes.

24

ANALYSIS

 Your analysis of the task was excellent, both in class and as shown in this assignment. You have demonstrated highly competent analytical skills and your approach to the task was highly logical. You carried out a detailed evaluation of the results and included an excellent conclusion relating your practical results to accepted theory. You have demonstrated a capacity for independent thought and your interpretation of the quantitative and qualitative data was excellent with sound judgements based on wholly valid arguments.

23

PRACTICAL APPLICATION AND DEP.



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

SKILLS FOR PROFESSIONAL PRAC.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was written in a professional and confident style, however you still need to be more efficient with your word count. The report was very well presented, with excellent diagrams in appropriate places, good sentence/paragraph structure and clear calculations.