

1809806

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- ① RESEARCH FOR COMPONENTS SEEMS TO BE LIMITED TO RS.
- ② DESIGN METHOD WAS EXPLAINED. THERE WERE SOME EXTRA CALCS IN YOUR HEAT SINK WHICH DIDN'T SEEM NECESSARY.
- ③ TESTING WAS A BIT CONFUSED AND SLIPPED BACK INTO DESIGN.
- ④ GRAPH OF V_{OUT} / I_{OUT} SHOWED THE CIRCUIT WAS WITHIN SPEC.
- ⑤ SHOPPING LIST OF COMPONENTS PRODUCED.
- ⑥ SHORT CONCLUSIONS.

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Executive summary

A power regulator was designed to meet specifications provided by a customer. The design process followed a top-down approach about stage order, while each stage was designed using a bottom-up approach. This ensures the criteria for the finish product is met. The regulator and power delivery circuits were designed in turn and then fine-tuned to give the correct output. Once this was done parts were found which could be used to construct the design. However, some parts could not be found with specific, specified values wanted by the calculations. This meant the simulation had to be experimented with, adapted, and tested to ensure the use of these parts would not compromise circuit performance. Calculations were done with regards to thermal management of the transistor which will be used for boosting current since that will create the most heat, an appropriate heatsink was selected. For each of the chosen components their current, voltage, power and environmental specifications/ratings were considered. By plotting a graph of voltage against current the optimum load was found which allowed the voltage and current levels to stabilise at the values specified for by the consumer. Finally, conclusions were summarised about the design.

Researching requirements and compilation of the specification

The following design is for a customer which requires a trickle charger for equipment such as battery powered forklifts, battery-assisted pump trucks and other battery assisted specialised lifting equipment. The batteries need to be charged slowly, overnight which will maintain and extend battery life compared to faster charging solutions that shorten battery life and as a result, are less cost effective when fast charging is not necessary.

The design specified output is 12Vdc at 2amps using a standard mains single phase input of 230V. The unit must be IP67 rated and able to survive colder conditions if needed. The chosen design for the regulated power supply will feature four main stages. A transformer, rectifier, smoother and regulator. The unit will be enclosed within a sealed, protective enclosure and use suitable cable glanding to ensure it is watertight.

Design specification

V_{AC} Input	230V
Input frequency	50Hz
V_{DC} Output	12V
I_{DC} Output	2A
Temperature rating	7 – 10°C
Cost	£183.479
Environment	Hazardous

Table 1 - Design specification

Ethics

Ethically, the design should incorporate different environmental and ethical factors such as the use of recyclable/sustainable materials where possible while maintaining high efficiency levels. In this case, the biggest waste within the unit will likely be heat produced by the components while in use. To reach this goal, the product manufacturing process must have an optimised carbon footprint. Using rare materials from all corners of the globe is not as sustainable as if the product could be manufactured locally, within the user's country using locally sourced/recycled materials and be able to be repaired easily, being relatively modular. Meaning the whole unit does not need to be scrapped if one of its parts fails. I.e., one of the four main stages of the design. The unit needs to be as reliable as possible in the environment it is used in and require little or no maintenance. The

longer the lifecycle, the more sustainable the product. Things like build quality, component quality, ease to repair, modularity/upgradability and availability of replacement parts are all key factors in deciding a products life cycle.

Health and safety

In terms of health and safety, the two main risks will be electric shock and fire. The unit will need grounding at all necessary points, local fuses to prevent overload, MCBs to provide short-circuit protection and an isolation method which requires the power to be off before the unit can be powered on. Each board could also be individually fused to increase over current protection per stage. Other overcurrent protection could be added such as thermal/current overloads and local RCDs. For fire prevention, the enclosure cannot encapsulate the unit in such a way that there is no way for the heat to escape, overtime, increasing the risk of fire. For this reason, once the design has reached a certain stage, calculations will be done to determine whether a heatsink is required. If so, a heatsink case/enclosure will be used instead of a standard enclosure which will still need to be IP67 rated. Due to this the heatsink enclosure will need direct contact with the hotter components in the design like the rectifier, ideally with thermal paste applied to promote heat transfer.

PAST TENSE.

Design method, choices, and calculations

The regulated power supply design will be done from a top-down approach. Starting from the specified result and working back through the stages to the mains input source to ensure the output criteria is met. Whereas the individual stages will take on a bottom-up approach. Starting from the beginning of each sub-circuit and working through the design.

Regulator design

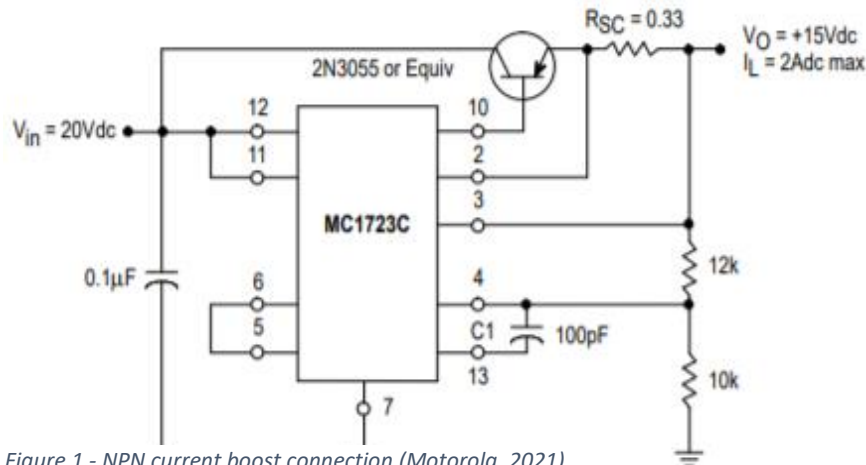


Figure 1 - NPN current boost connection (Motorola, 2021)

The regulator stage will use an MC1723C chip regulator circuit, simulated, and tested in multi-sim. Since that circuit is rated for a 12Vdc 2amp output (as shown in figure 1), which gives the standard circuit layout for the proposed regulator circuit. The circuit is arranged so the NPN transistor is used to boost the output current to 2amps since the IC chip cannot handle such high currents and can only take a maximum of 150mA. The positive VCC joins to the supply rail and the negative VCC is put to ground. Pin 11 supplies power to the output transistor within the chip itself and is common with pin 12 (grounded VCC negative) shown in figure 2.

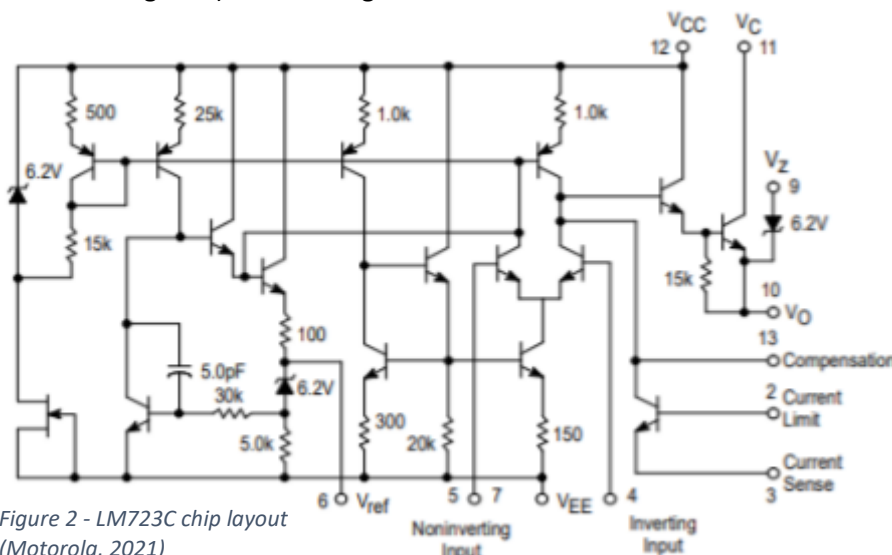


Figure 2 - LM723C chip layout (Motorola, 2021)

Appendix for this.

For the Multi-sim simulation and testing, the MC1723C chip is replaced with an LM723CN chip. The rest of the circuit is left the same until testing and analysis. The circuit shown in figure 1 above can limit or boost current by monitoring the voltage drop across the Rsc resistor. This is because it increases in proportion to the output current and if the voltage drop increases above 0.66V it will match the base-emitter, preventing it from conducting any further. This means the current will not exceed past that point which provides a form of overcurrent protection. The Rsc can be adjusted to increase or decrease the current limit to suit.

Using the diagram from figure 1, a prototype circuit can be created within multi-Sim using the LM723CN chip. To give a little headroom above the base 16.2V from the calculation, the VCC will be set to 20V. The output of the circuit as it is, is shown in figure 3.

Using Multi-sim, shown in figure 3, the circuit can now be adapted and tested to give the 12Vdc 2Amp output that is specified.

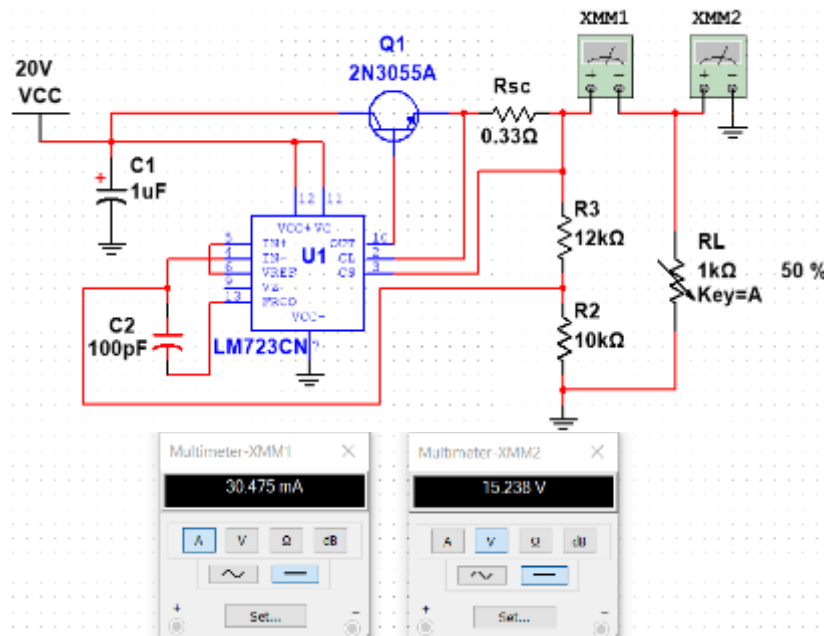


Figure 3 - Regulator circuit with calculated VCC and specified chip

This circuit is now ready for testing and analysis. This is where the circuit can be fine-tuned, experimented with, and optimised to obtain the desired results. As shown in figure 3, R2 and R3 must be correctly balanced because combined, they need to equal 22K Ω to achieve the specified output voltage and current levels.

Using the LM723CN datasheet shown in figure 23 (see annex), the reference voltage is 7.15V

$$R2 = \frac{V_{ref}}{V_{out}} (R2 + R3)$$

$$R3 = \frac{7.15}{12} (22K) = 13.1K\Omega$$

$$R2 = 22K - 13.1K = 8.9K\Omega$$

Base-emitter junction voltage drop divided by sensing current:

$$R_{sc} = \frac{0.6}{1.8} = 0.33\Omega$$

Your spec is 2A.

Proposed transistor

The proposed transistor is a 2 pin, 2N3055G Onsemi NPN transistor which has a package type of TO-204AA. An image is shown in the annex (see figure 24)

Figure 4 below shows the transistor specifications.

Specifications

Attribute	Value
Transistor Type	NPN
Maximum DC Collector Current	15 A
Maximum Collector Emitter Voltage	60 V
Package Type	TO-204AA
Mounting Type	Through Hole
Maximum Power Dissipation	115 W
Transistor Configuration	Single
Maximum Collector Base Voltage	100 V
Maximum Emitter Base Voltage	7 V
Maximum Operating Frequency	2.5 MHz
Pin Count	2
Number of Elements per Chip	1
Dimensions	8.51 x 39.37 x 26.67mm
Maximum Operating Temperature	+200 °C

APPENDIX FOR TITUS
OR JUST SHOW
THE RELEVANT INFO

Figure 4 - Transistor specifications (RS components, 2022)

Smoothing design

$$\text{Ripple factor } R_f = \frac{3V}{2\sqrt{2} \times 20} \times 100 = 5.3\%$$

Using the graph shown in figure 5 and applying the 5.3% ripple factor, for a full waveform the ωCR_L range given is between 9 and 17. Therefore, $13\omega CR_L$ should be perfect since it is halfway within that range.

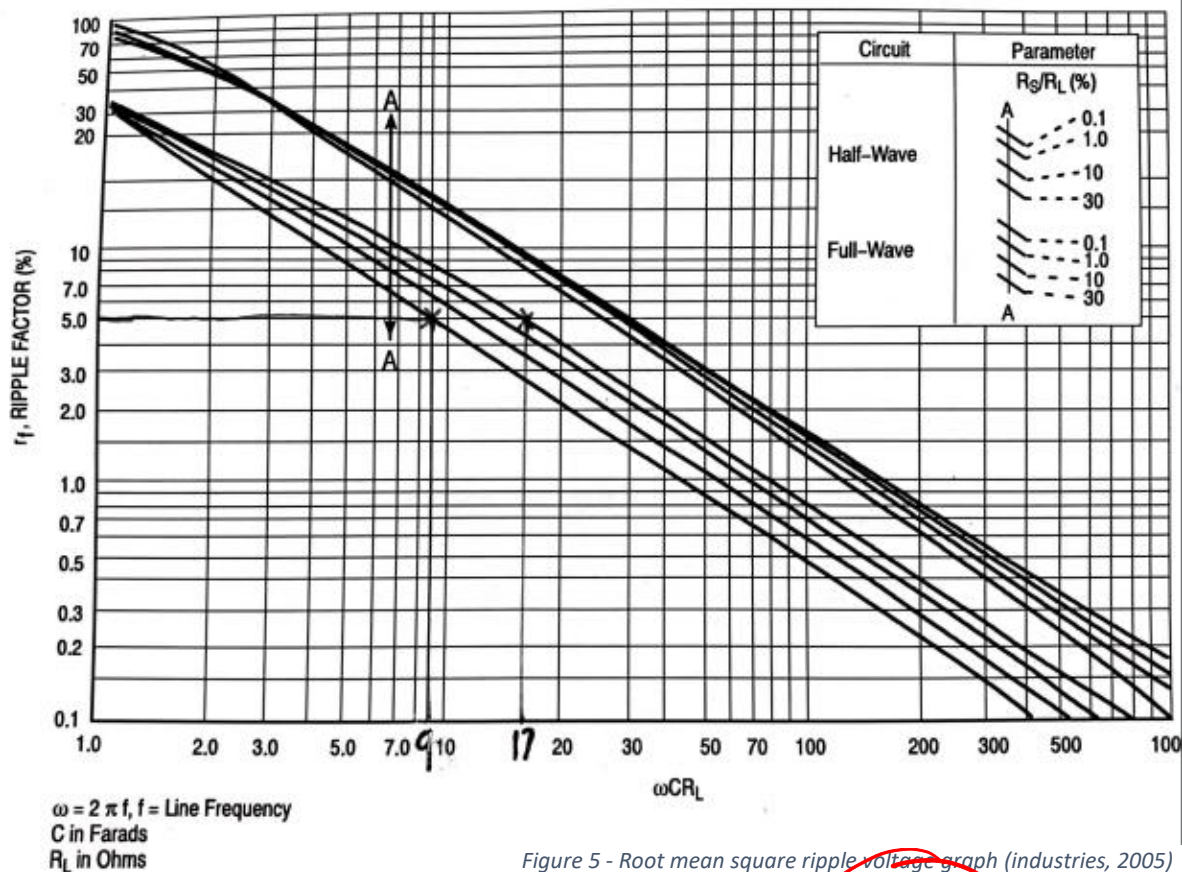


Figure 5 - Root mean square ripple voltage graph (industries, 2005)

The graph shown in figure 5 is also known as a ripple voltage graph, using $13\omega CR_L$ it can be seen on the graph that $R_f = 5.3\%$

$$\omega CR_L = 13$$

Using the Schade curve graph, the alternating peak voltage to DC can be determined for the full wave capacitor circuit (Figure 6).

$$\frac{V_c}{V_m} = \frac{20}{30} = 66\%$$

Figure 6 below shows the relationship between applied DC and AC peak voltage for full wave rectifiers.

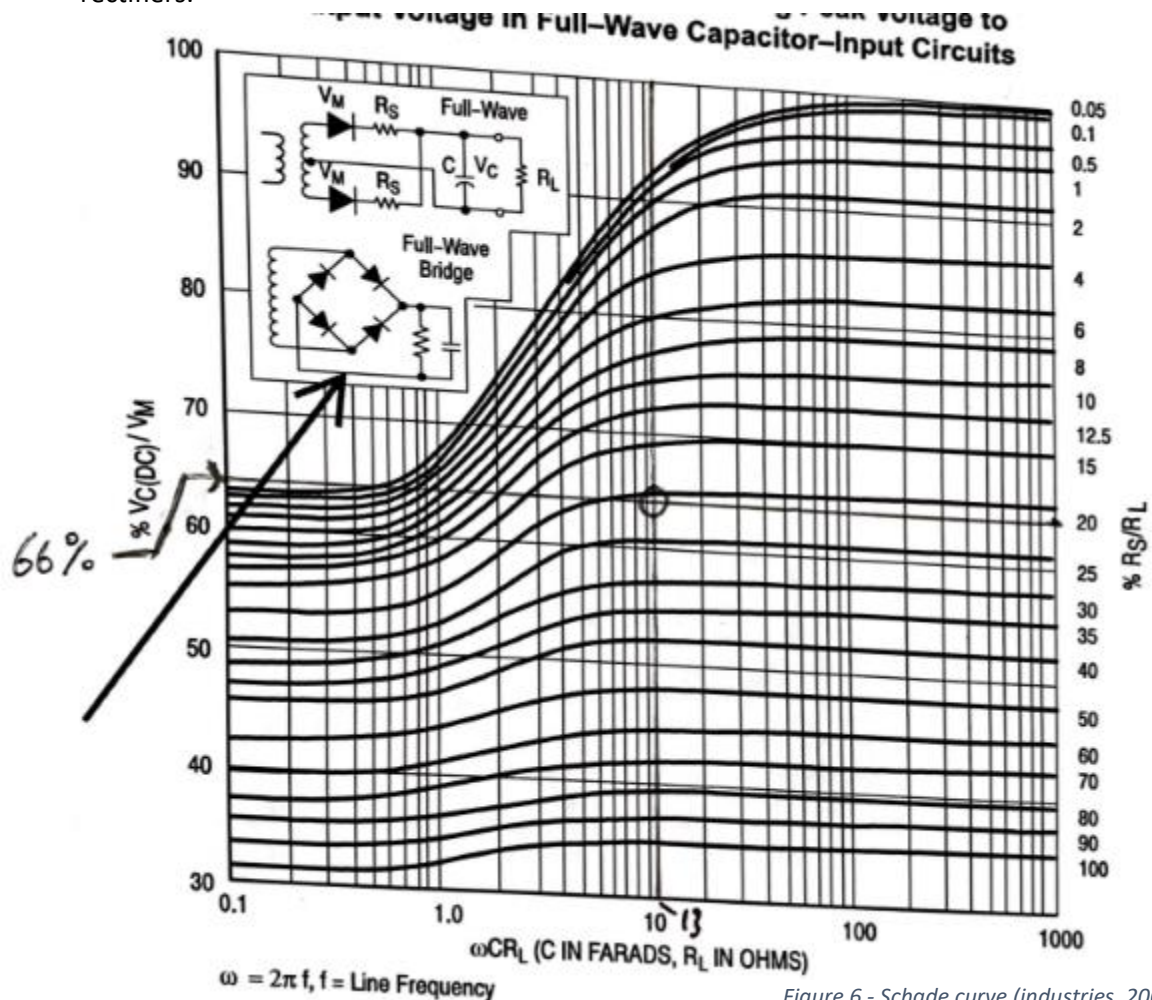


Figure 6 - Schade curve (industries, 2005)

Using figure 6 and cross referencing the $13\omega CR_L$ and the 66% on the graph gives a $\frac{R_s}{R_L}$ value of 0.2

$$R_L = \frac{V_c}{I_o} = 20 \div 2 = 10\Omega \text{ and } R_s = 0.2 \times 10\Omega = 2\Omega$$

Therefore:

$$\text{Capacitance} = \frac{13}{2\pi \times 50 \left(\frac{20}{2}\right)} = 4.138\text{mF}$$

$V_{\text{max}} = 30\text{V}$ which is doubled for the capacitor rating. Meaning 60V is sufficient. The closest actual rating is 63V so that or higher will be used when shopping for components.

Rectifier design

$$I_f(\text{average}) = I_o \div 2 = 2A \div 2 = 1A$$

Because the rectifier is full wave, $13\omega CR_L$ is doubled to $26\omega CR_L$ and $0.5 \times \frac{R_s}{R_L} = 0.1$ Using these two values, the point of intersection on the RMS/Peak to average graph can be found, which is 5.2 (shown in figure 7)

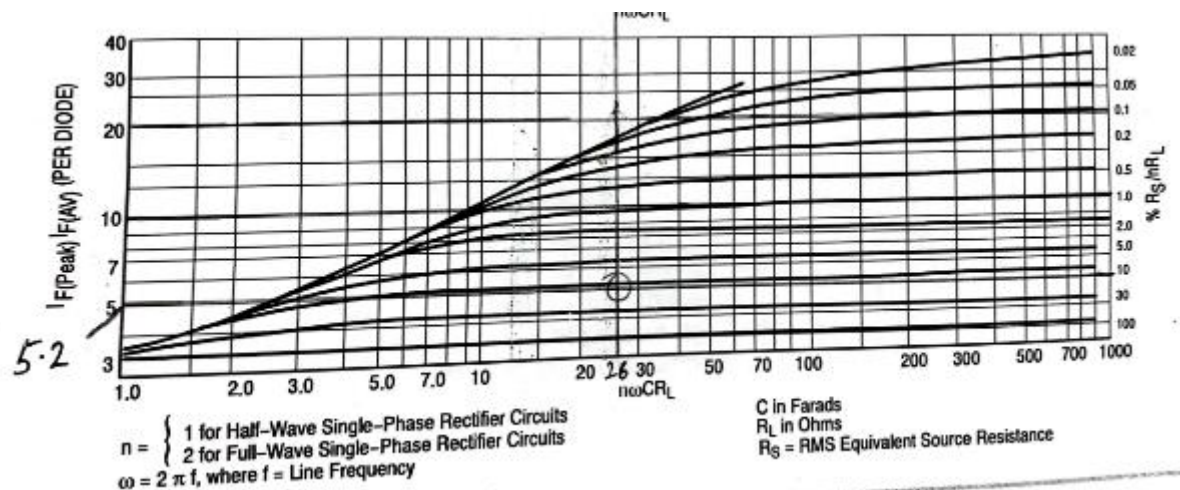


Figure 7 - RMS and peak to average diode current relationship (industries, 2005)

Peak current $I_{peak} = 5.2 \times 1A(\text{average}) = 5.2A$

$$I_{surge} = \frac{V_m}{R_s} = \frac{30}{2} = 15A$$

For Peak inverse voltage:

$$PIV = V_m \times 2 = 60$$

The design requires a bridge rectifier which can withstand a peak inverse voltage of >60V and a surge current of >15A. See Figure 30 in the annex for proposed rectifier datasheet and image.

Transformer design

$$V_{secondary} = \frac{V_m + 2}{\sqrt{2}} = \frac{30 + 2}{\sqrt{2}} = 22.627$$

$$I_{secondary} = I_o \times \sqrt{2} = 2 \times \sqrt{2} = 2.828$$

$$VA_{rating} = V_s \times I_s = 22.627 \times 2.828 = 64$$

Minimum power rating should be doubled for safety reasons. Transformer minimum = 128VA. As shown in figure 8, the transformer power rating is 200VA

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

UNITS !!

Because of the 230V mains supply for the system:

$$230 \div 22.627 = 10.165$$

Which accounts to a 10:1 turns ratio for the transformer.

Proposed transformer:

A suitable transformer supplied by RS components has been selected based upon the requirements and the calculated input/output values required by the specification. Figure 8 shows the specifications for the transformer. As shown below, the transformer uses 230V ac input operating at

Specifications

Attribute	Value
Primary Voltage Rating	230V ac
Secondary Voltage Rating	24V ac
Power Rating	200VA
Number of Outputs	2
Mounting Type	Chassis
Length	89mm
Width	68mm
Depth	75mm
Dimensions	89 x 68 x 75mm
Fixing Hole Diameter	4.7 x 7.9mm
Weight	1.6kg
Minimum Operating Frequency	50Hz
Maximum Operating Frequency	60Hz

Figure 8 - Transformer specification (RS components, 2022)

50-60Hz, is a chassis mounted transformer which outputs 24Vac. The power rating is 200VA which is higher than the load requirement. Since the transformer is the single biggest component in this design, the dimensions will be noted and considered when looking for and considering different cases/enclosures.

CHOICE OF CAPACITOR + RECTIFIER?

Heatsink design

Operational environment temperatures will range from 7-10 degrees Celsius.

- T_a is ambient temperature
- T_s is the max temperature you want the junction to run at
- P_d is the power dissipated by the IC
- ϕ_{ja} is the coefficient from the datasheet

The chip used is a LM723CN chip, however the transistor used to boost the output current will generate the most heat. Figure 9 shows the relevant datasheet. The airflow in the environment will be very low. Therefore, the "still air" readings will be used.

Using the transistor datasheet for the TO-204 package transistor:

THERMAL CHARACTERISTICS

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

Figure 9 - Transistor package thermal resistance (Camdenboss, 2021)

$T_a = 10^{\circ}C$, $T_j = 200^{\circ}C$ and bearing in mind with heatsink compound on anodised aluminium $\phi_{cs} = 0.36^{\circ}C/W$

$$P_D = (12V \times 2A) = 24W$$

So, in order to work out ϕ_{ja} using $P_D = 24W$,

$$\phi_{ja} = \frac{200^{\circ}C - 10^{\circ}C}{24W}$$
$$\phi_{ja} = 7.917$$

Therefore:

$$\phi_{sa} = 7.917 - (0.28 - 1.52)$$
$$\phi_{sa} = 6.117^{\circ}C/W$$

A heatsink with a thermal resistance below $6.117^{\circ}C/W$ will be required.

Proposed transistor heatsink

An image of the proposed transistor heatsink can be seen in the annex (figure 27)

Figure 10 below shows the specification sheet for the transistor heatsink. The TO-3 heatsink is compatible with the TO-204 package transistor because the TO-204 and TO-3 transistor packages are no different from each other physically, so a TO-3 heatsink can be fitted to the proposed transistor.

Specifications

Attribute	Value
Length	46.4mm
Width	46.4mm
Height	33.3mm
Dimensions	46.4 x 46.4 x 33.3mm
Thermal Resistance	2 (Forced) °C/W, 2 (Natural) °C/W
Mounting	Bolt On, Horizontal, Vertical
Colour	Black
Material	Aluminium
Package Type	TO-3
Series	RS AW294
Finish	Black Anodized

Figure 10 - Heatsink specifications (RS components, 2022)

The proposed transistor heatsink is priced at £1.252 per unit in a pack of 5. As shown in the specification, the natural thermal resistance is 2°C/W with no airflow over the heatsink and as stated on page 13 above, the required thermal resistance must be below 6.117°C/W.

Therefore the junction temperature (above ambient) of the transistor with no airflow over the heatsink can be calculated as:

$$24W \times (2 + 0.28 + 1.52) = 91.2^{\circ}\text{C}/\text{W}$$

Combined with the maximum ambient temperature:

$$91.2^{\circ}\text{C} + 10^{\circ}\text{C} = 101.2^{\circ}\text{C}$$

With a maximum ambient temperature of 101.2°C the transistor will operate well within its safe operating parameters. Its maximum being 200°C

NOT NEEDED.

Regarding the LM723CN chip shown in figure 3 page 7, Figure 11 shows the relevant datasheet:

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Average Temperature Coefficient of Output Voltage ⁽¹⁵⁾	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$		0.002	0.015				%/ $^{\circ}\text{C}$
	$0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$					0.003	0.015	%/ $^{\circ}\text{C}$
Short Circuit Current Limit	$R_{SC} = 10\Omega, V_{OUT} = 0$		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	$BW = 100 \text{ Hz to } 10 \text{ kHz}, C_{REF} = 0$		86			86		μVrms
	$BW = 100 \text{ Hz to } 10 \text{ kHz}, C_{REF} = 5 \mu\text{F}$		2.5			2.5		μVrms
Long Term Stability			0.05			0.05		%/1000 hrs
Standby Current Drain	$I_L = 0, V_{IN} = 30\text{V}$		1.7	3.5		1.7	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V
θ_{JA}	PDIP					105		$^{\circ}\text{C/W}$
θ_{JA}	CDIP		150					$^{\circ}\text{C/W}$
θ_{JA}	H10C Board Mount in Still Air		165			165		$^{\circ}\text{C/W}$
θ_{JA}	H10C Board Mount in 400 LF/Min Air Flow		66			66		$^{\circ}\text{C/W}$
θ_{JC}			22			22		$^{\circ}\text{C/W}$

Figure 11 - LM723C datasheet (Texas instruments, 2013)

$T_a = 25^{\circ}\text{C}, T_j = 214^{\circ}\text{C}, \varphi_{cs} = 0.36^{\circ}\text{C/W}, P_D = 1.8\text{W}, \varphi_{sa} = 6.117^{\circ}\text{C/W}$ and $\varphi_{ja} = 105^{\circ}\text{C/W}$

Max current for the chip is 150mA

$$P_D = (12\text{V} \times 0.15\text{A}) = 1.8\text{W}$$

$P_D = 1.8\text{W}$ because the chip can only handle this much, the transistor is boosting the current and creating the heat. Not the chip.

$$T_a = T_j - P_D \varphi_{ja}$$

$$T_j = T_a + P_D \varphi_{ja}$$

$$T_j = 25 + (1.8\text{W} \times 105^{\circ}\text{C/W})$$

$$T_j = 214^{\circ}\text{C}$$

$214^{\circ}\text{C} > 75^{\circ}\text{C}$ and therefore, a heatsink is required for the chip.

$$\varphi_{ja} = \frac{214^{\circ}\text{C} - 25^{\circ}\text{C}}{1.8\text{W}}$$

$$\varphi_{ja} = 105$$

$\varphi_{ja} = 22$ Therefore:

$$\varphi_{sa} = 105 - (22 - 1.52)$$

$$\varphi_{sa} = 84.52^{\circ}\text{C/W}$$

NOT SURE
WHY YOU HAVE
DONE THIS!

See figures 38 and 39 (annex) for the chip heatsink and datasheet.

Proposed enclosure

Figure 29 in the annex shows the proposed enclosure. Figure 12 below shows the specification and dimensions of the case.

Specifications

Attribute	Value
Body Material	Aluminium
External Length	220 mm
External Width	86.3 mm
External Height	86.3 mm
External Dimensions	220 x 86.3 x 86.3mm
Colour	Black
IP Rating	IP67
Series	AWN
Ventilated	No
Carrying Handle	No

SPECIFICATION	
Material	Ends - aluminium (powder coated) Body - aluminium (anodised)
Protection class	88 series has been designed to meet the requirements of IP67
Operating temperature	-40°C to + 105°C
Standard colours	Black or silver
Standard unit includes	2x ends, body 8x steel screws IP casting in hole

Figure 12 - Enclosure specifications
(RS uk, 2022) (Camdenboss, 2021)

To maintain the seal integrity, all aspects of the design will be housed within this enclosure. Transformer, regulator circuit etc. The casing will have two glands put in the side of one of the case ends, which will not compromise seal integrity. One for incoming power to the transformer and the other for output to the equipment being charged. The enclosure is also capable of being fitted with a screen in future if the upgrade is necessary. Meaning the unit could have charge timers set, and other functions added to it like the ability to adjust current output to different levels depending on the equipment being charged. The finned aluminium enclosure promotes heat dissipation through its outer fins and the material helps keep it relatively light. The IP67 rating means the unit will be completely dust-proof and be completely water-tight. Since the unit will not be used underwater and will receive only an occasional jet of water this is overkill. However, having more than enough water protection means less gradual water ingress over time and an extended product life.

Full component list/breakdown

Component	Details	Manufacturer	Supplier	Product code	Cost	Figure
Enclosure	220x86.3x86.3 IP67 rated	Takachi electric industrial	RS	906-0351	£115.50	Figure 12, 29
Transformer	Chassis mount 230-24V 50/60Hz	RS Pro	RS	504-105	£42.46	Figure 8, 22
Transistor	NPN type Max temp: 200 degrees Celsius. Max power dissipation 115W	Onsemi	RS	103-2964	£4.84	Figure 4, 24
Transistors heatsink	TO-3 package aluminium	RS Pro	RS	176-4162	£1.502	Figure 10, 27, 28
Bridge rectifier	15A, 100V GBPC	Vishay	RS	165-7019	£3.392	Figure 30
Chip	Adjustable output 2-37Vdc	Motorola Semiconductor	Motorola	MC1723C	\$1.50	Figure 31
Rsc Resistor	0.3Ω, wire wound, Max rated power 25W	Ohmite	RS	893-2845	£7.54	Figure 32, 33
RL1 Resistor	8.2KΩ, wire wound	Arcol	RS	615-0448	£3.42	Figure 34
R2 Resistor	10KΩ, Aluminium chassis mount	RS Pro	RS	175-4105	£3.655	Figure 35
C1 Capacitor	1 micro-farad 50Vdc, through-hole	RS Pro	RS	170-1242	£0.05	Figure 36
C2 Capacitor	100nano-farad, 50Vdc, through-hole	RS Pro	RS	711-1396	£0.02	Figure 37
Chips heatsink	63K/W	Fischer Elektronik	Farnell	4302175	0.45	Figure 38, 39

Table 2 - Component list

Testing, results and analysis

To calculate the circuit input voltage (shown as VCC in the datasheet screenshot below)

$$V_{in} \geq V_o + 2\phi + 3 \text{ to } 38V = 12 + 1.2 + 3 \text{ to } 38V$$

3 to 38V is the input-output voltage differential for the chosen circuit according to the datasheet.

See figure 13.

ELECTRICAL CHARACTERISTICS ($T_A = +25^\circ\text{C}$, $V_{in} = 12\text{ Vdc}$, $V_o = 5.0\text{ Vdc}$, $I_L = 1.0\text{ mAdc}$, $R_{SC} = 0$, $C_1 = 100\text{ pF}$, $C_{ref} = 0$ and divider impedance as seen by the error amplifier $\leq 10\text{ k}\Omega$ connected as shown in Figure 2, unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
Input Voltage Range	V_I	9.5	—	40	Vdc
Output Voltage Range	V_O	2.0	—	37	Vdc
Input-Output Voltage Differential	$V_I - V_O$	3.0	—	38	Vdc

Figure 13 - Input-output voltage differential (Motorola, 2021)

2ϕ is a rough set value which considers the internal voltage losses from the transistors within the circuit. For simplicity's sake, 3V will be used.

$$V_{in} \geq V_o + 2\phi + 3 \text{ to } 38V = 12V + 1.2V + 3V$$

$$V_{in} \geq 16.2V$$

Experimenting with resistor RL1 and reducing it to 7.5K Ω is detailed below. Fine tuning the circuit to give the desired output voltage while reducing the value of the RL resistor to allow for a 2-amp output at 12Vdc. However, to achieve this, the Rsc resistor needs to be adjusted as well.

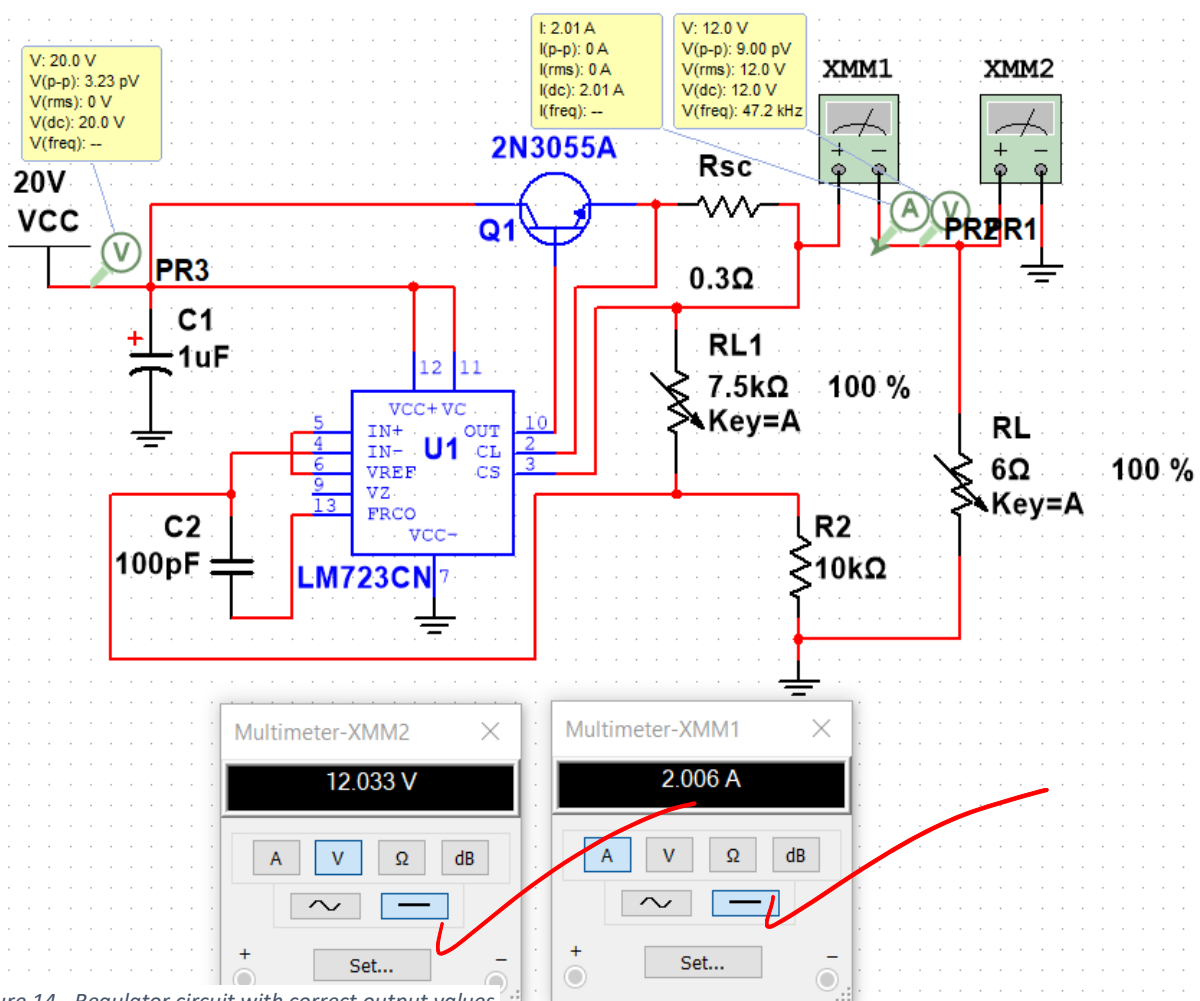
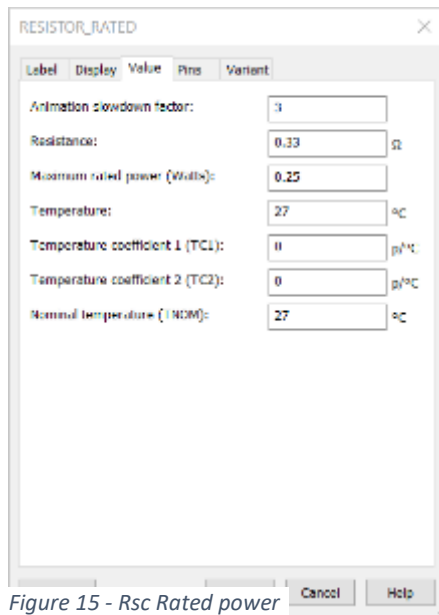


Figure 14 - Regulator circuit with correct output values

Analysis of the performance of the regulator stage of the power supply allows for testing to ensure the required input can achieve the specified results. Meaning the next stage of the build, the smoothing capacitor design part. Shown in figure 14 as 20V VCC. The 20V VCC is only there for testing purposes.

Regarding figure 14, originally, RL1 was 12K Ω which gave an output of 30mA at 15Vdc which does not meet the required specification. Adjusting resistor RL1 to a lower value will mitigate the voltage issue by regulating the circuit output closer to 12Vdc. However, at this point, the circuit is still not outputting the required amount of current.



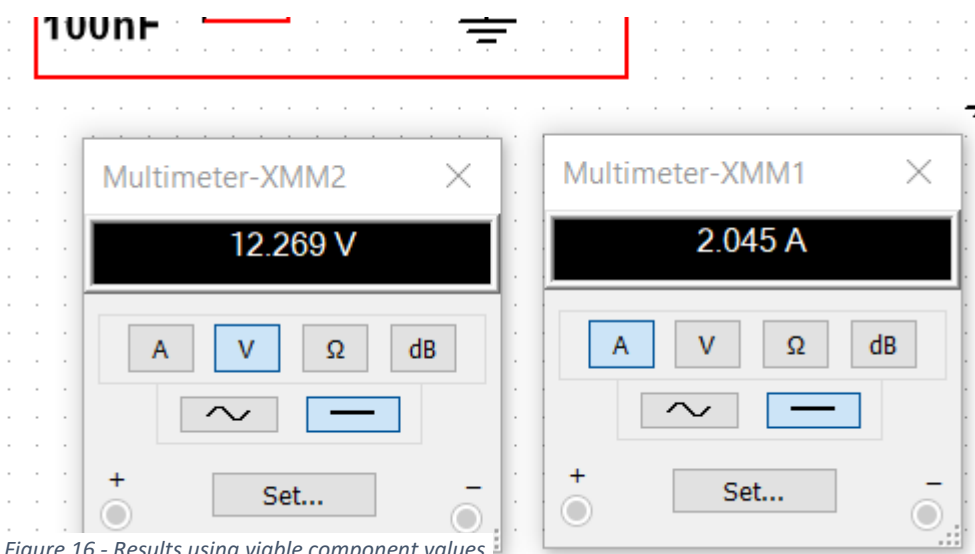
As the circuit is, the Rsc will break down because of its 0.25W rated power. This needs to be increased to prevent a fault in the circuit. Reducing RL increases the current output but not enough to reach 2amp output. Figure 15 shows the Rsc settings. Increasing its maximum rated power prevents break down since it has not currently got the required power rating.

It needs to be $12V \times 2A = 24Watts$. Adjusting the 0.25Watts to 24 (increasing the maximum rated power) means the resistor no longer breaks down.

Next, the Rsc resistance needs to be lowered from 0.33 Ω to 0.3 Ω . This raises the ceiling, allowing the current and voltage to reach higher combined levels and the desired output.

THIS IS DESIGN, NOT TEST.

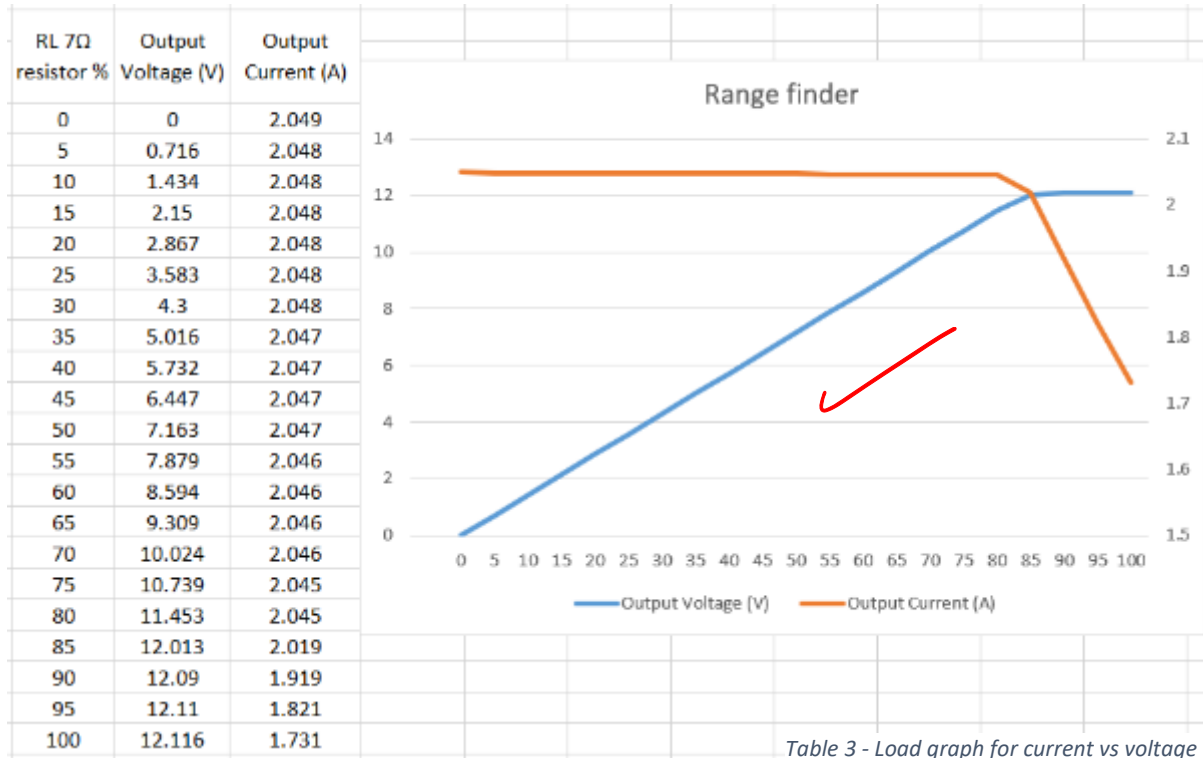
When creating a shopping list of parts, resistor RL1 and capacitor C2 was not available in the required ratings. The closest available values were 8.2K Ω for RL1 and 100nF for C2. After testing on multi-sim with these values, the output voltage and current only changed very slightly to 12.269Vdc at 2.045A. This slight increase is negligible and will not result in any damage or significant changes to the circuit in total. See figure 16.



ALREADY SHOWN IN FIG 14.

Figure 16 - Results using viable component values

Using a 70ohm resistor for RL, and logging it at percentages of 5% from 0 to 100, a graph can be created showing what the best setting would be to achieve the desired output of 12V at 2 amps. In this case, it is around 85%. 90% is too high a voltage and too low a current, while 80% has too low a voltage. 85% is almost exactly what is needed and could be tuned further. 85% of 70ohms is 5.95Ω. Therefore, 60ohms is suitable.



From the graph shown above, it can be seen tha the current is stable at approximately 2.05amps until the output voltage has climbed from zero to approximately 11.5Vdc. Once the voltage reaches this point Ohm's law takes effect and the current starts to drop off while the voltage overtakes it, stabilizing at 12Vdc as the current continues to decline. The point where current and voltage cross on the graph is where the output needs to be. 12Vdc at 2amps needs to be maintained to meet the specification and charge the battery of the equipment.

The load regulation can be worked out by testing the circuit under full and no-load conditions.

Removing the 6Ω RL resistor gives no-load conditions. Resulting in a 12.122V output. Putting the resistor back again gives a full load condition of 12.033V.

Calculation: $\% \text{ Regulation} = \frac{12.122 - 12.033}{12.033} = 0.0073963266768\%$ (see figure 17)

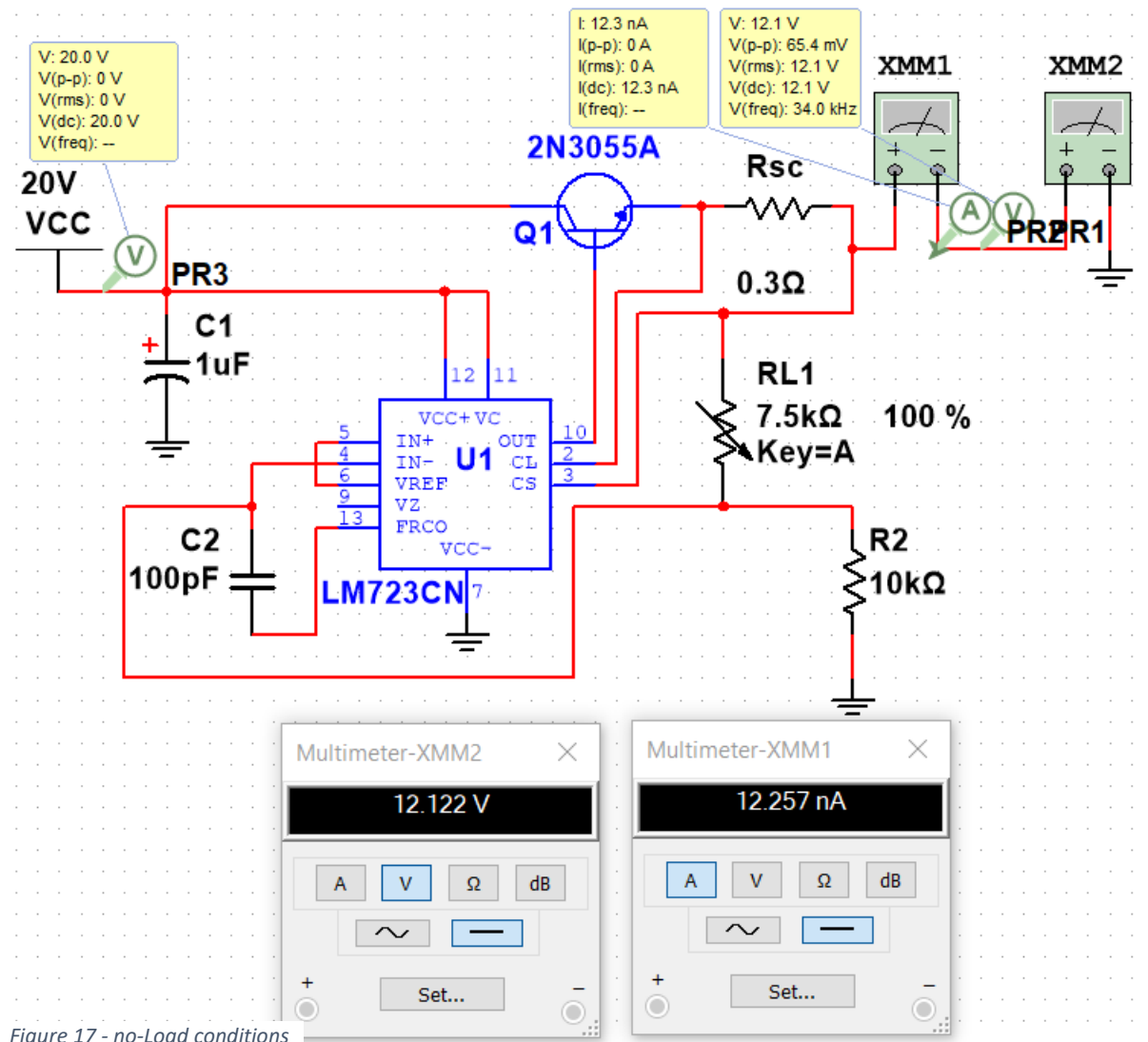


Figure 17 - no-Load conditions
From previous section:

$$V_c = \text{regulator CCT input } V_{cc} = 20V$$

$$I_{max} = 2A$$

$$\text{Standard 230V mains supply frequency} = 50_{hz}$$

$$V_R = 3V$$

$$V_{max} = V_c + (0.5 \times V_c) = 20V + (0.5 \times 20V) = 30V$$

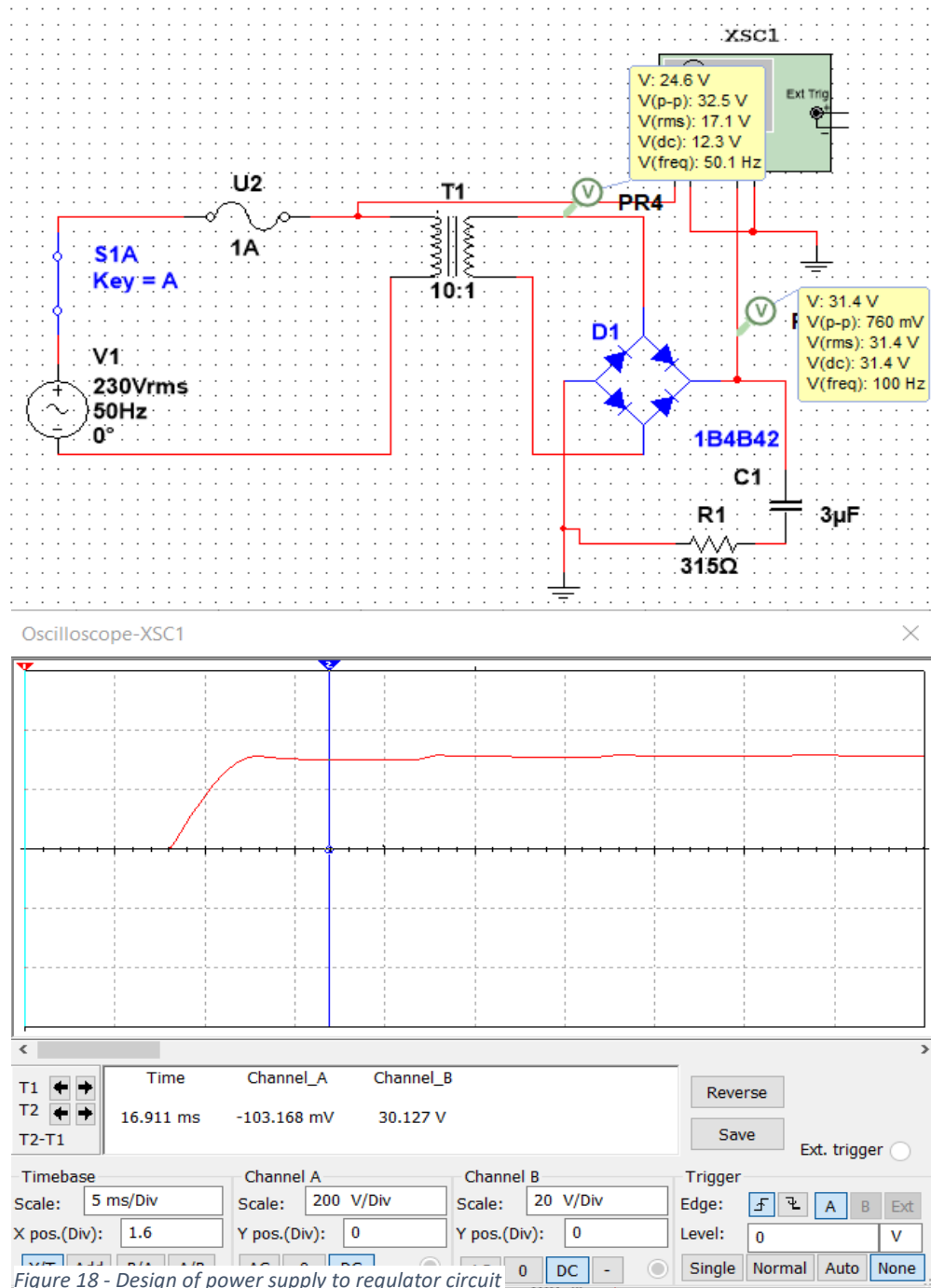


Figure 18 - Design of power supply to regulator circuit

Figure 18 shows the simulated design for the power conversion and delivery stages of the design, which inputs from the rectifier to the regulator circuit. The resultant output from the regulator circuit is 12.286Vdc at 2.048A. The 230Vac 50Hz mains supply is stepped down and rectified to 31.7Vdc as shown by the probes. The display from the oscilloscope above, shows the voltage climbing from zero to approximately 31.7Vdc once the circuit is complete. From here the voltage level stabilizes at 31Vdc because the capacitor is fully charged and cycling.

The curve shown on the oscilloscope has slight ripples, which are the result of the bridge rectifier. However, to minimise the effect of these ripples, multiple smaller capacitors could be used instead of one bigger one, which would smoothen out the curve and further stabilise the supply of DC to the regulator.

IN PARALLEL.

During simulation and testing of the stages of the design, the regulator could not be connected to the supply without creating errors due to limitations within the multi-sim software. Because of this the two had to be tested individually. By testing the output of the rectifier and then using a standard VCC supply of the same voltage to feed the regulator. The regulator circuit was also tested using the resistor and capacitor values available on the components list. The results are shown in figure 19 below.

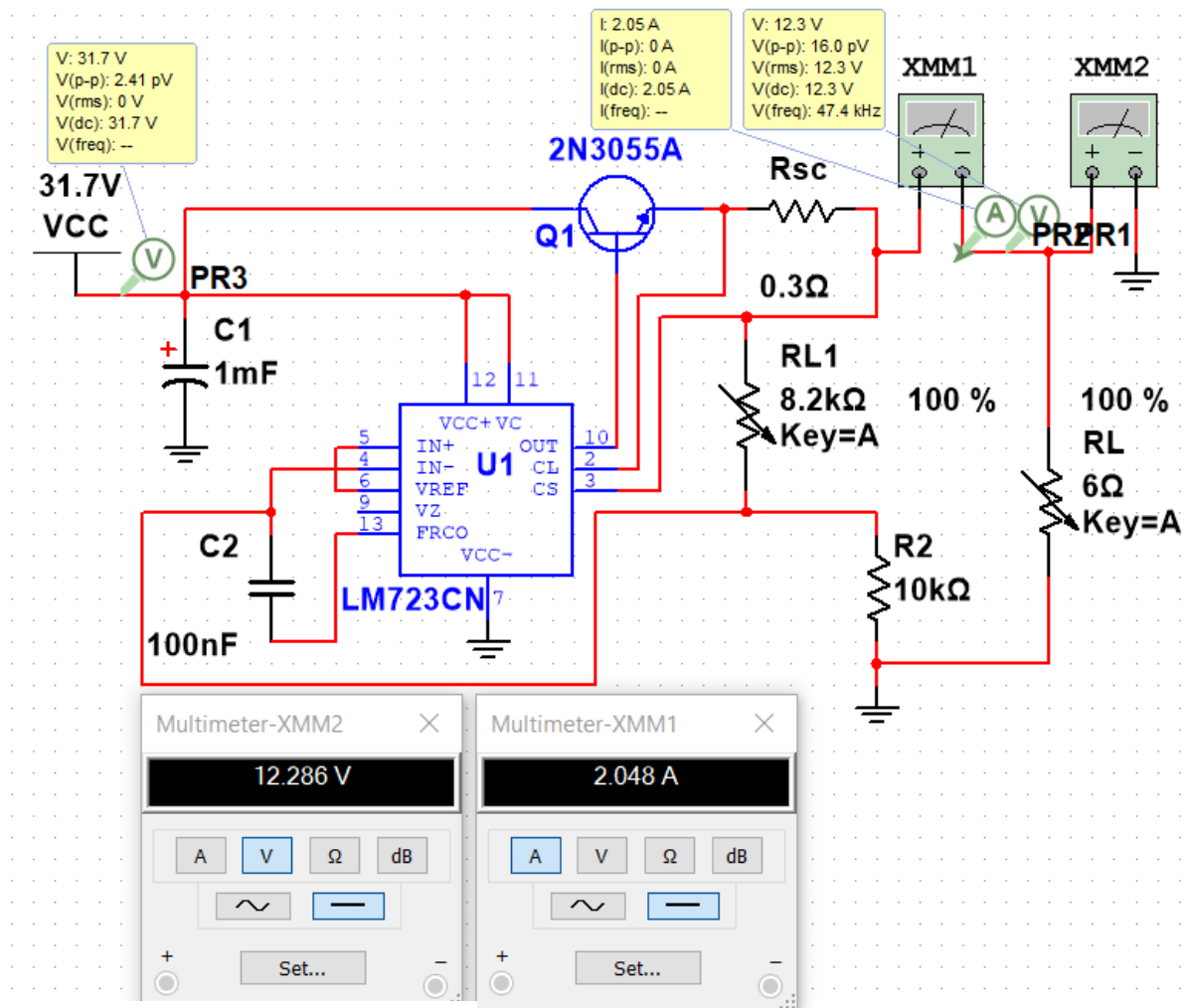


Figure 19 - Regulator testing using typical supply

Figure 19 above shows the regulator circuit can meet the specification with the supply given by the transformer/rectifier circuit. Outputting 12.286Vdc at 2.048amps when the load on the regulator is kept at a constant 60hms to maintain peak performance. While lowering the load on the regulator lowers the output voltage in turn and lowering RL1 has the effect of lowering the current output.

Conclusions

The regulator has been designed to meet the specification provided by the customer. The design process focusses off the output requirements of the specification, following a top-down approach about the order the stages were done. Starting with the final stage and working back to the start. However, each individual stage was still designed from the bottom-up. This meant the final output of the design could be determined first and working back through the stages, each stage had to output what the last stage specified for as an input for the design to work. This also meant the values for the supply circuit design could be changed if needed to give the correct output to the regulator design.

The components listed in table 2-page 17 cost £183.529 in total. But that sum could be lessened by buying smaller components in bulk. That would mean the enclosure and transformer would be the bulk of the cost per unit. The AC supply into the unit is fused and the LM723C chip has current limiting built in. Since 150mA is the maximum current for the chip, the transistor bypasses the chip to produce the higher 2A output. To improve the function of the circuit the transistor could be split into two separate transistors to reduce heat output. The same could be done for the rectifier capacitor. Multiple smaller capacitors would improve and smoothen the DC output. These smaller capacitors and transistors would improve the circuit operation and lifetime.

In summary, using a top-down approach gave specified results within a margin that could be fine-tuned to better meet the customer's needs.

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Annexe for diagrams, data sheets, results tables etc

ABSOLUTE MAXIMUM RATINGS⁽¹⁾⁽²⁾

Pulse Voltage from V^+ to V^- (50 ms)	50V
Continuous Voltage from V^+ to V^-	40V
Input-Output Voltage Differential	40V
Maximum Amplifier Input Voltage (Either Input)	8.5V
Maximum Amplifier Input Voltage (Differential)	5V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation Metal Can ⁽³⁾	800 mW
CDIP ⁽³⁾	900 mW
PDIP ⁽³⁾	660 mW
Operating Temperature Range	
LM723	-55°C to +150°C
LM723C	0°C to +70°C
Storage Temperature Range Metal Can	
	-65°C to +150°C
PDIP	-55°C to +150°C
Lead Temperature (Soldering, 4 sec. max.)	
Hermetic Package	300°C
Plastic Package	260°C
ESD Tolerance	1200V
(Human body model, 1.5 k Ω in series with 100 pF)	

- (1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits.
- (2) A military RETS specification is available on request. At the time of printing, the LM723 RETS specification complied with the Min and Max limits in this table. The LM723E, H, and J may also be procured as a Standard Military Drawing.
- (3) See derating curves for maximum power rating above 25°C.

ELECTRICAL CHARACTERISTICS⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	$V_{IN} = 12V$ to $V_{IN} = 15V$ $-55^\circ C \leq T_A \leq +125^\circ C$ $0^\circ C \leq T_A \leq +70^\circ C$ $V_{IN} = 12V$ to $V_{IN} = 40V$		0.01	0.1		0.01	0.1	% V_{OUT}
				0.3				% V_{OUT}
							0.3	% V_{OUT}
			0.02	0.2		0.1	0.5	% V_{OUT}
Load Regulation	$I_L = 1$ mA to $I_L = 50$ mA $-55^\circ C \leq T_A \leq +125^\circ C$ $0^\circ C \leq T_A \leq +70^\circ C$		0.03	0.15		0.03	0.2	% V_{OUT}
				0.6				% V_{OUT}
							0.6	% V_{OUT}
Ripple Rejection	$f = 50$ Hz to 10 kHz, $C_{REF} = 0$ $f = 50$ Hz to 10 kHz, $C_{REF} = 5$ μ F		74			74		dB
			86			86		dB

Figure 20 - LM723C electrical characteristics and ratings (Texas instruments, 2013)

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish ⁽⁵⁾	MSL Peak Temp ⁽³⁾	Op Temp (°C)	Device Marking ⁽⁴⁾
LM723CH	ACTIVE	TO-100	LME	10	500	TBD	Call TI	Call TI	0 to 70	(LM723CH, LM723CH)
LM723CHNOPB	ACTIVE	TO-100	LME	10	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	0 to 70	(LM723CH, LM723CH)
LM723CNVNOPB	NRND	PDIP	NFF	14	25	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM723CN

Figure 21 - LM723C packaging information (Texas instruments, 2013)

ELECTRICAL CHARACTERISTICS⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾ (continued)

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Average Temperature Coefficient of Output Voltage ⁽⁵⁾	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$		0.002	0.015				%/ $^{\circ}\text{C}$
	$0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$					0.003	0.015	%/ $^{\circ}\text{C}$
Short Circuit Current Limit	$R_{SC} = 10\Omega$, $V_{OUT} = 0$		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	$BW = 100\text{ Hz to }10\text{ kHz}$, $C_{REF} = 0$		86			86		μVrms
	$BW = 100\text{ Hz to }10\text{ kHz}$, $C_{REF} = 5\text{ }\mu\text{F}$		2.5			2.5		μVrms
Long Term Stability			0.05			0.05		%/1000 hrs
Standby Current Drain	$I_L = 0$, $V_{IN} = 30\text{V}$		1.7	3.5		1.7	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V
θ_{JA}	PDIP					105		$^{\circ}\text{C/W}$
θ_{JA}	CDIP		150					$^{\circ}\text{C/W}$
θ_{JA}	H10C Board Mount in Still Air		165			165		$^{\circ}\text{C/W}$
θ_{JA}	H10C Board Mount in 400 LF/Min Air Flow		66			66		$^{\circ}\text{C/W}$
θ_{JC}			22			22		$^{\circ}\text{C/W}$

Figure 23 - LM723C electrical characteristics (continued) (Texas instruments, 2013)

RS PRO 100VA 2 Output Chassis Mounting Transformer, 24V ac

RS Stock No.: **504-105** | Brand: **RS PRO**




3 YEAR WARRANTY

Available to

Price Each
£35.38
(exc. VAT)

Units
1 - 24

Figure 22 - Proposed transformer (RS components, 2022)

onsemi 2N3055G NPN Transistor, 15 A, 60 V, 2-Pin TO-204AA

onsemi

RS Stock No.: 103-2964 | Mfr. Part No.: 2N3055G | Brand: onsemi



Available to back order for despatch when stock is available

100 Units

Back order

This product is currently unavailable to backorder.

Unfortunately, we don't have this product in stock and it's not available to backorder at this time.

Price Each (In a Tray of 100)

£4.033

(exc. VAT)

£4.84

(inc. VAT)

Units	Per unit	Per Tray*
100 - 100	£4.033	£403.30
200 - 400	£3.906	£380.60
500 +	£3.579	£357.90

*Price indicative

[View all Bipolar Transistors](#)

Figure 24 - Proposed transistor (RS components, 2022)

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.

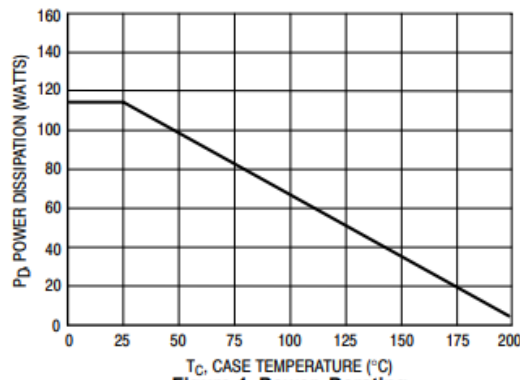


Figure 1. Power Derating

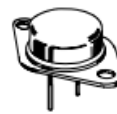
*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.



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.

2N3055(NPN), MJ2955(PNP)

THERMAL CHARACTERISTICS

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

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS*

Collector-Emitter Sustaining Voltage (Note 1) ($I_C = 200\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	60	–	Vdc
Collector-Emitter Sustaining Voltage (Note 1) ($I_C = 200\text{ mAdc}$, $R_{BE} = 100\ \Omega$)	$V_{CER(sus)}$	70	–	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $I_B = 0$)	I_{CEO}	–	0.7	mAdc
Collector Cutoff Current ($V_{CE} = 100\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 100\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 150^{\circ}\text{C}$)	I_{CEX}	–	1.0 5.0	mAdc
Emitter Cutoff Current ($V_{BE} = 7.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	–	5.0	mAdc

ON CHARACTERISTICS* (Note 1)

DC Current Gain ($I_C = 4.0\text{ Adc}$, $V_{CE} = 4.0\text{ Vdc}$) ($I_C = 10\text{ Adc}$, $V_{CE} = 4.0\text{ Vdc}$)	h_{FE}	20 5.0	70 –	–
Collector-Emitter Saturation Voltage ($I_C = 4.0\text{ Adc}$, $I_B = 400\text{ mAdc}$) ($I_C = 10\text{ Adc}$, $I_B = 3.3\text{ Adc}$)	$V_{CE(sat)}$	–	1.1 3.0	Vdc
Base-Emitter On Voltage ($I_C = 4.0\text{ Adc}$, $V_{CE} = 4.0\text{ Vdc}$)	$V_{BE(on)}$	–	1.5	Vdc

SECOND BREAKDOWN

Second Breakdown Collector Current with Base Forward Biased ($V_{CE} = 40\text{ Vdc}$, $t = 1.0\text{ s}$, Nonrepetitive)	$I_{s/b}$	2.87	–	Adc
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DYNAMIC CHARACTERISTICS

Current Gain – Bandwidth Product ($I_C = 0.5\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$)	f_T	2.5	–	MHz
*Small-Signal Current Gain ($I_C = 1.0\text{ Adc}$, $V_{CE} = 4.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	15	120	–
*Small-Signal Current Gain Cutoff Frequency ($V_{CE} = 4.0\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $f = 1.0\text{ kHz}$)	f_{hfe}	10	–	kHz

*Indicates Within JEDEC Registration. (2N3055)

1. Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

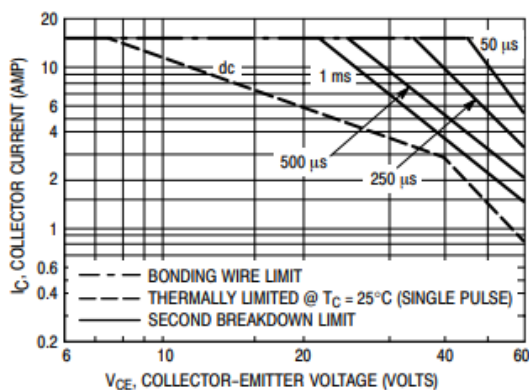


Figure 26 - Transistor datasheet continued (industries, 2005)

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on $T_C = 25^{\circ}\text{C}$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 1.

Heatsink, 2 (Forced) °C/W, 2 (Natural) °C/W, 46.4 x 46.4 x 33.3mm, Bolt On, Horizontal, Vertical



RS Stock No.: 176-4162 | Brand: RS PRO



60 In stock - FREE next working day delivery available

5 Units

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Price Each (In a Pack of 5)

£1.252
(exc. VAT)

£1.502
(inc. VAT)

Units	Per unit	Per Pack*
5 - 49	£1.252	£6.26
50 - 120	£1.152	£5.76
125 - 249	£1.102	£5.61
250 - 499	£1.064	£5.32
500 +	£0.976	£4.88

*price indicative

[View all Heatsinks](#)

Figure 27 - Transistor heatsink (RS components, 2022)



ENGLISH

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

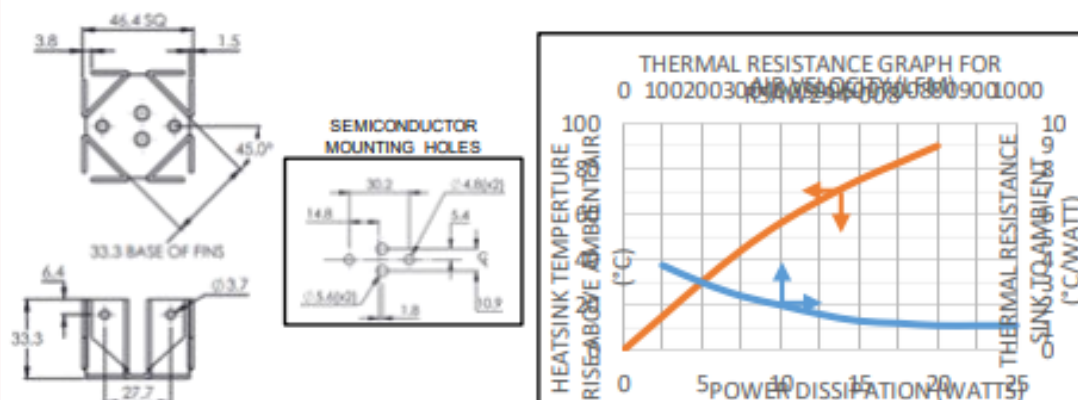


Figure 28 - Transistor heatsink datasheet (RS components, 2022)

Takachi Electric Industrial AWN Black Aluminium Heat Sink Case, 220 x 86.3 x 86.3mm

TAKACHI

RS Stock No.: 906-0351 Mfr. Part No.: AWN9-9-22EBB Brand: Takachi Electric Industrial



2 In stock - FREE next working day delivery available

-

1

+

Units

Add to basket

[Check stock levels](#)

Price Each

£96.25

(exc. VAT)

£115.50

(inc. VAT)

Units	Per unit
1 - 5	£96.25
6 - 9	£91.67
10 +	£86.57

[View all Instrument Cases](#)

Figure 29 - Proposed enclosure (RS uk, 2022)

Vishay GBPC1501-E4/51, Bridge Rectifier, 15A 100V, 4-Pin GBPC



RS Stock No.: 165-7019 | Mfr. Part No.: GBPC1501-E4/51 | Brand: Vishay



Available to back order for despatch when stock is available

100 Units

Back order

This product is currently unavailable to backorder.

Unfortunately, we don't have this product in stock and it's not available to backorder at this time.

Price Each (in a Box of 100)

£2.827
(excl. VAT)

£3.392
(incl. VAT)

Units	Per unit	Per Box*
100 +	£2.827	£282.70

*price indicative

[View all Bridge Rectifiers](#)

Specifications

Attribute	Value
Peak Average Forward Current	15A
Bridge Type	Single Phase
Peak Reverse Repetitive Voltage	100V
Mounting Type	Screw Mount
Package Type	GBPC
Pin Count	4
Diode Technology	Silicon Junction
Configuration	Single
Peak Non-Repetitive Forward Surge Current	300A
Maximum Operating Temperature	+150 °C
Minimum Operating Temperature	-55 °C
Peak Forward Voltage	1.1V
Peak Reverse Current	500µA
Dimensions	28.8 x 28.8 x 7.87mm
Length	28.8mm
Height	7.87mm
Width	28.8mm

Figure 30 - Rectifier specifications and image (RS UK, 2022)

Chip

Home » Integrated Circuits » Special Function » Motorola

MC1723CP - MC1723C Voltage Regulator



Features

- Positive or Negative Regulator
- Output Voltage Adjustable from 2 to 27Vdc
- Output Current to 100mA DC
- Soft-Power-On and Over-Current Regulation
- Adj. Short-Circuit Protection

Part Summary	
Manufacturer	Motorola Semiconductor
Manufacturer's Part Number	MC1723CP
Manufacturer's Web Site	
Manufacturer's Part Number	MC1723CP
Department	Integrated Circuit
Category	Special Function - Motorola
RoHS Compliant	-
Package Type	16 Pin DIP
Technical Data	MC1723CP Datasheet

Pricing Information	
1+	\$1.30
25+	\$1.20
100+	\$1.10
Larger quantities	Contact Sales Department

Ordering	
Pricing Unit	1
Package Qty	1
Minimum order quantity	1
Order quantity:	1 Order

Accessories	
MC1723C - 16 pin DIP, Surface	

Figure 31 - MC1723C Voltage regulator (Futurlec, 2019)

Rsc

Ohmite, 300mΩ 25W Wire Wound Chassis Mount Resistor 825FR30E ±1%

RS Stock No.: 893-2845 | Mfr. Part No.: 825FR30E | Brand: Ohmite

You may also like



Schneider Electric Harmony
XB Contact Block 1NO



Rohco St 25 25 Piece 1/4 in
Socket Set

Available to back order for despatch 30/03/2022

1 Units

Back order

Price Each

£6.28
(exc. VAT)

£7.54
(Inc. VAT)

Units	Per unit
1 +	£6.28

Figure 32 - 300mOhm resistor (RS, 2022)

Specifications

Attribute	Value
Resistance	300mΩ
Power Rating	25W
Series	825
Package/Case	Aluminium Housed
Tolerance	±1%
Technology	Wire Wound
Termination Style	Axial, Solder
Minimum Operating Temperature	+25°C
Maximum Operating Temperature	+275°C
Minimum Temperature Coefficient	-90ppm/°C
Maximum Temperature Coefficient	+90ppm/°C
Dimensions	51 x 28 x 14.8mm
Overall Width	28mm
Overall Height	14.8mm
Overall Length	51mm

Figure 33 - 300mOhm resistor specification (RS, 2022)

Arcol, 8.2kΩ 25W Wire Wound Chassis Mount Resistor HS25 8K2 J ±5%



RS Stock No.: 615-0448 | Mfr. Part No.: HS25 8K2 J | Brand: Arcol



188 In stock - FREE next working day delivery available

-

1

+

Units

Add to basket

Check stock levels

Price Each	
£2.85	£3.42
(exc. VAT)	(inc. VAT)
Units	Per unit
1 - 24	£2.85
25 - 74	£2.03
75 - 99	£2.01
100 - 249	£1.81
250 +	£1.62

[View all Chassis Mount Resistors](#)

Specifications

Attribute	Value
Resistance	8.2kΩ
Power Rating	25W
Series	HS25
Package/Case	Aluminium Housed
Tolerance	±5%
Technology	Wire Wound
Termination Style	Axial
Minimum Temperature Coefficient	-25ppm/°C
Maximum Temperature Coefficient	+25ppm/°C
Dimensions	14.6 x 51 x 28mm
Overall Height	14.6mm
Overall Width	28mm
Overall Length	51mm

Figure 34 - Arcol 8.2KOhm wire wound resistor (RS, 2022)

RS PRO, 10kΩ 25W Aluminium Chassis Mount Resistor ±5%



RS Stock No.: 175-4105 | Brand: RS PRO



[View all Chassis Mount Resistors](#)

10 In stock - FREE next working day delivery available

-

5

+

Units

Add to basket

Check stock levels

Price Each (In a Pack of 5)
£3.046
(exc. VAT)

£3.655
(inc. VAT)

Units	Per unit	Per Pack*
5 - 20	£3.046	£15.23
25 - 40	£2.965	£14.83
50 - 120	£2.884	£14.42
125 - 245	£2.803	£14.01
250 +	£2.746	£13.73

*price indicative

You may also like

Specifications

Attribute	Value
Resistance	10kΩ
Power Rating	25W
Package/Case	Aluminium Housed
Tolerance	±5%
Technology	Aluminium
Maximum Operating Temperature	+200°C
Dimensions	27.3 x 28 x 14.8mm
Overall Width	28mm
Overall Height	14.8mm
Overall Length	27.3mm

Figure 35 - RS Pro 10KOhm aluminium chassis mount resistor (RS, 2022)

C1

RS PRO 1µF Electrolytic Capacitor 50V dc, Through Hole

RS Stock No.: 170-1242 | Brand: RS PRO



20000 in stock - FREE next working day delivery available

1000 Units

Add to basket

[Check stock levels](#)

Price Each (in a Bag of 1000)

£0.042

(exc. VAT)

£0.05

(inc. VAT)

Units	Per unit	Per Bag*
1000 - 1000	£0.042	£42.00
2000 - 3000	£0.039	£39.00

Specifications

Attribute	Value
Capacitance	1µF
Voltage	50V dc
Mounting Type	Through Hole
Technology	Electrolytic
Dimensions	5 (Dia.) x 11mm
Height	11mm
Length	11mm
Minimum Operating Temperature	-40°C
Diameter	5mm
Maximum Operating Temperature	+105°C
Lifetime	1000h
Lead Pitch	2mm
Polarised	Polar
Tolerance	±20%
Ripple Current	14mA
Leakage Current	≤0.01 CV or 3 µA @ 1 min
Series	RS
Dissipation Factor	10%

Figure 36 - RS pro 1uF capacitor C1 (RS-online, 2022)

RS PRO 100nF Electrolytic Capacitor 50V dc, Through Hole

RS Stock No.: 711-1396 | Brand: RS PRO



Available to back order for despatch when stock is available

100 Units

Back order

This product is currently unavailable to backorder.

Unfortunately, we don't have this product in stock and it's not available to backorder at this time.

Price Each (In a Pack of 100)

£0.02

(exc. VAT)

£0.02

(Inc. VAT)

Units	Per unit	Per Pack*
100 - 900	£0.02	£2.00

Specifications

Attribute	Value
Capacitance	100nF
Voltage	50V dc
Mounting Type	Through Hole
Technology	Electrolytic
Dimensions	5 (Dia.) x 11mm
Height	11mm
Length	11mm
Minimum Operating Temperature	-40°C
Diameter	5mm
Maximum Operating Temperature	+105°C
Lead Pitch	2mm
Lifetime	1000h
Tolerance	±20%
Leakage Current	≤0.01 CV or 3 µA @ 1 min
Ripple Current	1.3mA
Polarised	Polar
Series	RS
Dissipation Factor	10%

Figure 37 - 100nF electrolytic capacitor (RS-online, 2022)

ICK SMD A 8 SA

Heat Sink, Black Anodised, 87 °C/W, For DIP, PLCC, SMD, 4.8mm/6.3mm/8mm



© Farnell Farnell
Farnell Group Limited

Fischer Elektronik

Manufacturer: FISCHER ELEKTRONIK

Manufacturer Part No: ICK SMD A 8 SA

Order Code: 4302175

Technical Datasheet: [ICK SMD A 8 SA Datasheet](#)

[See all Technical Docs](#)

[Add to compare](#)

Image is for illustrative purposes only. Please refer to product description.

Product Information

- ☐ Thermal Resistance: 87°C/W
- ☐ Packages Cooled: DIP-8, SSOP-20, SSOP-24, SSOP-28, TSSOP-24, TSSOP-28, TSSOP-38
- ☐ External Width - Metric: 6.3mm
- ☐ External Height - Metric: 4.8mm
- ☐ External Length - Metric: 8mm
- ☐ External Diameter - Metric: -

- ☐ Heat Sink Material: Aluminium
- ☐ External Width - Imperial: 0.25"
- ☐ External Height - Imperial: 0.19"
- ☐ External Length - Imperial: 0.31"
- ☐ External Diameter - Imperial: -
- ☐ Product Range: -

£0.45 (ex VAT)

Price for: Each

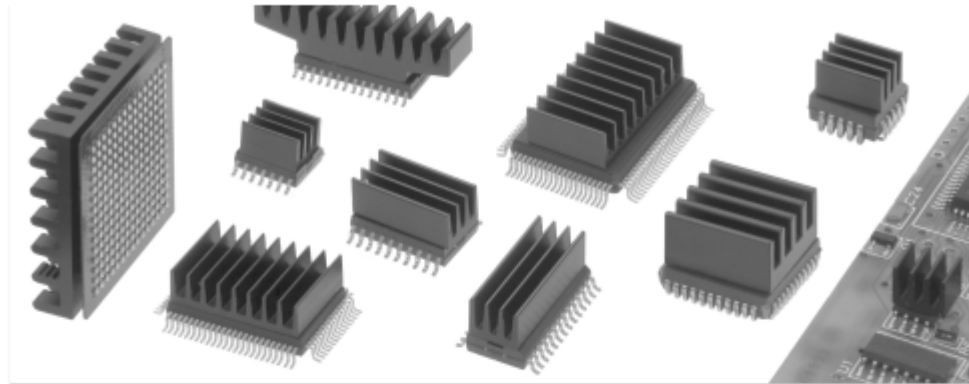
Multiple: 10 Minimum: 10

Quantity	Price (ex VAT)
10+	£0.45
50+	£0.375
100+	£0.351
250+	£0.331

Figure 38 - Lm723c heatsink (Farnell, 2022)

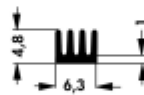
A

B

Heatsinks for SMD


- particularly suitable for SMD components
- low profile
- reduced weight
- effective heat dissipation
- can be glued directly onto the component
- solderable versions
- customer specific versions on request
- special packaging like tape and reel, bar magazin, tray etc. on request

G



art. no.	R_{th} [K/W]	l [mm]
ICK SMD A 5 ...	123	5
ICK SMD A 8 ...	87	8
ICK SMD A 10 ...	75	10
ICK SMD A 13 ...	63	13
ICK SMD A 17 ...	51	17
ICK SMD A 22 ...	34	22



art. no.	R_{th} [K/W]	l [mm]
ICK SMD B 5 ...	56	5
ICK SMD B 7 ...	47	7
ICK SMD B 10 ...	35	10
ICK SMD B 13 ...	29	13
ICK SMD B 19 ...	22	19

please indicate: ... surface treatment
 SA=black anodised
 MI=solderable surface

M

N

B 25

Aluminium oxide wafers
 Mica wafers
 Kapton insulator washers
 Insulating clamping parts

→ E 9 – 10
 → E 11
 → E 8
 → E 35

Profiles for PCB components
 Heatsinks for PCB
 SMD-heatsinks
 Profiles for PCB mounting

→ A 89
 → A 87
 → B 25 – 27
 → A 87 – 108

Figure 39 - Lm723c heatsink datasheet (Fischer Elektronik, 2022)

FINAL GRADE

GENERAL COMMENTS

Instructor

60/100

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RICHARD HARRISON

60

RESEARCH-INFORMED LITERATURE



There was evidence of further reading and research and some in text referencing. Your references were mainly appropriate to the task, however the reference list was short and you should increase the breadth of your research for future assignments. There was a heavy reliance on information gained from the course notes.

5

KNOWLEDGE AND UNDERSTANDING



The knowledge and understanding of the subject demonstrated by this assignment was reasonably detailed and mainly accurate. There were very few gaps in your knowledge of the basic concepts and your understanding of the higher level concepts was demonstrated to a limited degree - you could have explained in more detail how the circuit evolved. Further work – Your explanations need to be more detailed and written with a greater emphasis on critical evaluation rather than description.

18

ANALYSIS



Your analysis of the task was generally satisfactory, both in class and as shown in this assignment, however it did tend more towards descriptive rather than analytical. You have demonstrated some analytical skills and your approach to the task was logical. You wrote a short conclusion that demonstrated some skills in analysing quantitative and qualitative data, however this was generally basic in nature. Further work – in your conclusion, you should relate the results to the original specification and to accepted theory and provide a detailed critical analysis of this.

16

PRACTICAL APPLICATION AND DEP.



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

14

SKILLS FOR PROFESSIONAL PRAC.



In this assignment you have demonstrated skills in working individually and also collaboratively. Your written report was generally good and contained most of the required detail, it was also written in a

7

coherent and logical way. The available word count was in the main effectively used.