This file solves the equations for designing a power supply with a Linear voltage regulator.

Specify the output voltage and current

\[ V_{\text{supply}} := 5 \text{ volt} \quad I_{\text{supply}} := 300 \text{ mA} \]

Assume a full-wave rectifier

\[ T := \frac{1}{120} \text{ sec} \quad \omega := 2 \pi \cdot 60 \cdot \frac{1}{\text{sec}} \]

Specify the RMS voltage rating of the transformer

\[ V_{\text{RMS}} := 11.5 \text{ volt} \quad V_{\text{peak}} := V_{\text{RMS}} \sqrt{2} \]

The Minimum input to the regulator is 2.5 volts higher than the output voltage. The max input to the regulator is 2 diode drops less than the peak transformer voltage. Assume a 0.8 volt diode drop

\[ V_{\gamma} := 0.8 \text{ volt} \]

\[ V_{\text{in max}} := V_{\text{RMS}} \sqrt{2} - 2 \cdot V_{\gamma} \quad V_{\text{in max}} = 14.663 \text{ volt} \]

\[ V_{\text{in min}} := V_{\text{supply}} + 2.5 \text{ volt} \quad V_{\text{in min}} = 7.5 \text{ volt} \]

\[ \Delta V := V_{\text{in max}} - V_{\text{in min}} \quad \Delta V = 7.163 \text{ volt} \]

Find the minimum capacitor value. Assume a full wave rectifier.

\[ C := \frac{I_{\text{supply}} \cdot T}{\Delta V} \quad C = 349 \mu F \]

Pick a capacitor with a minimum rating greater than the calculated. Assume a tolerance of +/- 20%

\[ C := 470 \mu F \quad C_{\text{min}} := 0.2 \quad C_{\text{max}} := 0.8 \]

\[ C_{\text{min}} = C \cdot (1 - C_{\text{min}}) \quad C_{\text{min}} = 376 \mu F \]

\[ C_{\text{max}} = C \cdot (1 + C_{\text{max}}) \quad C_{\text{max}} = 846 \mu F \]

Now with the max and min values of the capacitor calculate the remaining parameters. 'MIN' variables refer to calculations using Cmin. "MAX" variables indicate calculations using Cmax, not necessarily numerical maximum values.
Delta $V_{\text{max}} := \frac{I_{\text{supply}} \cdot T}{C_{\text{max}}}$ \hspace{1cm} \text{Delta } V_{\text{max}} = 2.955 \cdot \text{volt}

Delta $V_{\text{min}} := \frac{I_{\text{supply}} \cdot T}{C_{\text{min}}}$ \hspace{1cm} \text{Delta } V_{\text{min}} = 6.649 \cdot \text{volt}

IF Delta $V_{\text{max}}$ is greater than Delta $V$ stated at the top of this page, we have a problem.

$V = 7.163 \cdot \text{volt}$

Calculate the min and max capacitor peak current

$$\text{ton}_{\text{max}} := \frac{\text{asin} \left( 1 - \frac{\Delta V_{\text{max}}}{V_{\text{peak}}} \right)}{\omega}$$  \hspace{1cm} \text{ton}_{\text{max}} = 2.542 \cdot 10^{-3} \cdot \text{sec}

$$\text{ton}_{\text{min}} := \frac{\text{asin} \left( 1 - \frac{\Delta V_{\text{min}}}{V_{\text{peak}}} \right)}{\omega}$$ \hspace{1cm} \text{ton}_{\text{min}} = 1.678 \cdot 10^{-3} \cdot \text{sec}

$$I_{\text{c peak \text{ max}}} := C_{\text{max}} \cdot \omega \cdot V_{\text{peak}} \cdot \cos \left( \omega \cdot \text{ton}_{\text{max}} \right)$$  \hspace{1cm} I_{\text{c peak \text{ max}}} = 2.981 \cdot \text{amp}

$$I_{\text{c peak \text{ min}}} := C_{\text{min}} \cdot \omega \cdot V_{\text{peak}} \cdot \cos \left( \omega \cdot \text{ton}_{\text{min}} \right)$$  \hspace{1cm} I_{\text{c peak \text{ min}}} = 1.859 \cdot \text{amp}

Calculate the Diode Parameters

$$\text{Id peak} := I_{\text{c peak \text{ max}}} + I_{\text{supply}}$$

$$\text{Id RMS} := \frac{\text{Id peak}}{\sqrt{2}}$$  \hspace{1cm} \text{Id RMS} = 2.32 \cdot \text{amp}

$$V_{\text{rrm}} := 2 \cdot V_{\text{peak}}$$  \hspace{1cm} V_{\text{rrm}} = 32.527 \cdot \text{volt}

$$I_{\text{FSM}} := C_{\text{max}} \cdot \omega \cdot V_{\text{peak}}$$  \hspace{1cm} I_{\text{FSM}} = 5.187 \cdot \text{amp}

Summary of results

$$C = 470 \cdot \mu\text{F} \hspace{1cm} \text{Tolerance } +80,-20\%$$

$$V_{\text{rrm}} = 32.527 \cdot \text{volt}$$

$$\text{Id RMS} = 2.32 \cdot \text{amp}$$

$$I_{\text{FSM}} = 5.187 \cdot \text{amp}$$
Amplitude={11.5*1.414}
Frequency=60

Cap min val used for simulation
Rload chosen to draw 300mA at 5V
Date: September 15, 1999

Time: 12:51:44

Temperature: 27.0

Graph showing a current waveform with time in milliseconds on the x-axis and current in amperes on the y-axis. The waveform appears to consist of periodic changes in current, with positive and negative values indicated.
**Axial-Lead Standard Recovery Rectifiers**

Lead mounted standard recovery rectifiers are designed for use in power supplies and other applications having need of a device with the following features:

- High Current to Small Size
- High Surge Current Capability
- Low Forward Voltage Drop
- Void–Free Economical Plastic Package
- Available in Volume Quantities

**Mechanical Characteristics**

- Case: Epoxy, Molded
- Weight: 1.1 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes: 220°C Max. for 10 Seconds, 1/16" from case
- Shipped in plastic bags, 5,000 per bag.
- Available Tape and Reeled, 1500 per reel, by adding a “RL” suffix to the part number
- Polarity: Cathode Indicated by Polarity Band
- Marking: 1N5400, 1N5401, 1N5402, 1N5404, 1N5406, 1N5407, 1N5408

**MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>1N5400</th>
<th>1N5401</th>
<th>1N5402</th>
<th>1N5404</th>
<th>1N5406</th>
<th>1N5407</th>
<th>1N5408</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>VRRM</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>800</td>
<td>1000</td>
<td>Volts</td>
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<tr>
<td>Working Peak Reverse Voltage</td>
<td>VRWM</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>800</td>
<td>1000</td>
<td>Volts</td>
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<tr>
<td>DC Blocking Voltage</td>
<td>VR</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Volts</td>
</tr>
<tr>
<td>Non–repetitive Peak Reverse Voltage</td>
<td>VRSM</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>525</td>
<td>800</td>
<td>1000</td>
<td>1200</td>
<td>Volts</td>
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<tr>
<td>Average Rectified Forward Current (Single Phase Resistive Load, 1/2&quot; Leads, T L  = 105°C)</td>
<td>Io</td>
<td>3.0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Amp</td>
</tr>
<tr>
<td>Non–repetitive Peak Surge Current (Surge Applied at Rated Load Conditions)</td>
<td>IFSM</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>200 (one cycle)</td>
<td>Amp</td>
</tr>
<tr>
<td>Operating and Storage Junction Temperature Range</td>
<td>T J</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td>T stg</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>°C/W</td>
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**THERMAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Thermal Resistance, Junction to Ambient (PC Board Mount, 1/2&quot; Leads)</td>
<td>RθJA</td>
<td>53</td>
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<td>°C/W</td>
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**ELECTRICAL CHARACTERISTICS**

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<th>Characteristic</th>
<th>Symbol</th>
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<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>*Instantaneous Forward Voltage (1) ((I F  = 9.4 \text{ Amp}))</td>
<td>v F</td>
<td>—</td>
<td>—</td>
<td>1.2</td>
<td>Volts</td>
</tr>
<tr>
<td>Average Reverse Current (1) ((T L  = 80°C))</td>
<td>(I_{R(AV)})</td>
<td>—</td>
<td>—</td>
<td>500</td>
<td>μA</td>
</tr>
<tr>
<td>DC Reverse Current (Rated dc Voltage, (T L  = 80°C))</td>
<td>(I_{R})</td>
<td>—</td>
<td>—</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

*JEDEC Registered Data.

(1) Measured in a single phase halfwave circuit such as shown in Figure 6.25 of EIA RS–282, November 1963. Operated at rated load conditions \(T L  = 80°C, I Q  = 3.0 \text{ A, } V F  = VRWM\).

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

Ratings at 25°C ambient temperature unless otherwise specified.

60 Hz resistive or inductive loads.

For capacitve load, derate current by 20%.
2 Rectifier Device Data

PACKAGE DIMENSIONS

NOTES:
2. CONTROLLING DIMENSION: INCH.

<table>
<thead>
<tr>
<th>INCHES</th>
<th>MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.370</td>
</tr>
<tr>
<td>B</td>
<td>0.190</td>
</tr>
<tr>
<td>D</td>
<td>0.048</td>
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<tr>
<td>K</td>
<td>1.000</td>
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</table>

STYLE:
1. PIN 1. CATHODE
2. ANODE

CASE 267–03
ISSUE C

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1N5400/D