MicroNotes
Series 303

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Rectifier Bridges and Dual Rectifiers

A frequent use of rectifiers has been to redirect or steer current flow in one direction for dc requirements. With an alternating ac current source, this is easily accomplished with a rectifier bridge or center-tap dual rectifiers after the desired rms source voltage is achieved with a transformer. In many examples, this is often a step-down transformer to appliances requiring comparatively low dc voltage from a 120 Volt rms single-phase source provided by utility companies.

A single-phase rectifier bridge circuit is shown in Figure 1 and a three-phase bridge for larger multiple-phase power sources is in Figure 2. Also a center-tap dual rectifier is shown in Figure 3. Note that the transformer secondary side requires twice as much winding for the same voltage across the load R_L when only using two rectifiers from a dual center-tap compared to a full-wave bridge. There may also be further economic penalties in using a center-tap transformer for full-wave rectification despite the elimination of two rectifiers.

Single-phase or three-phase rectifier bridges can be acquired as completed assemblies or with four or six individual rectifier components respectively. They can also be provided with prepackaged “half-bridge dual rectifiers” as

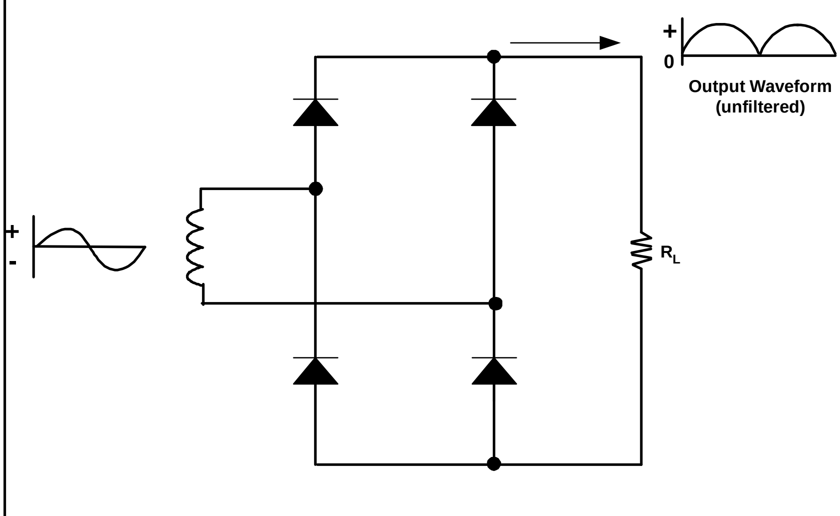

Figure 1. Single-Phase Bridge with secondary winding ac input also illustrated with rectified dc (unfiltered) output to load.

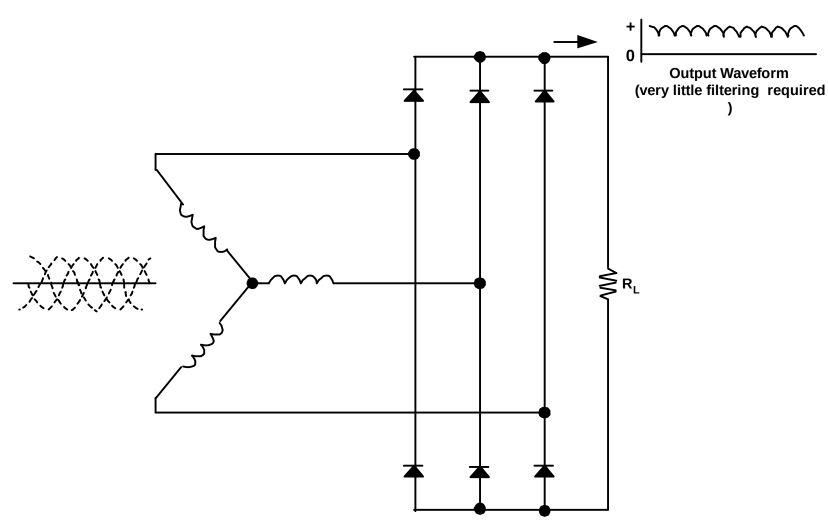

Figure 2. Three-Phase Bridge with secondary windings ac input also illustrated with rectified dc output to load. Very little filtering required.

shown in Figure 4. These half-bridge dual rectifiers are also useful in either single-phase or three-phase bridges by using one for each parallel path when comparing Figures 1 & 2 with Figure 4. As observed when comparing output waveforms of Figures 1 and 2 for a resistive load, the current-voltage output requires less filtering on a three-phase bridge than a single-phase bridge.

In some applications, individual rectifiers and half bridges or center-tap rectifiers may offer greater options in selective performance features not found in available bridge assemblies. These include high frequency applications requiring ultrafast rectifier components or Schottky rectifiers for minimal parasitic losses in low voltage applications. Many of these selective examples are offered by Microsemi.

Other basic performance features that deserve consideration for rectifier bridges (or center taps) relative to their individual rectifier components are the average output current I_O thermal performance needed to achieve this rating, and package isolation for ease of mounting.

Since there are two parallel paths in a bridge for current to flow through each rectifier in Figure 1, the average output current I_O for a single-phase bridge is twice each *subassembled* rectifier component or $I_O = 2 \times I_{O(SUB)}$. With two diodes in series for each path ($2V_F$) in Figure 1, total power dissipated in the bridge then becomes four times that of each subassembled rectifier, or

$$\text{Power} = 2\ V_F \times 2\ I_{O(SUB)} = 2(V_F \times I_O)$$

To make efficient use of each subassembled rectifier in a single-phase bridge and optimize overall thermal

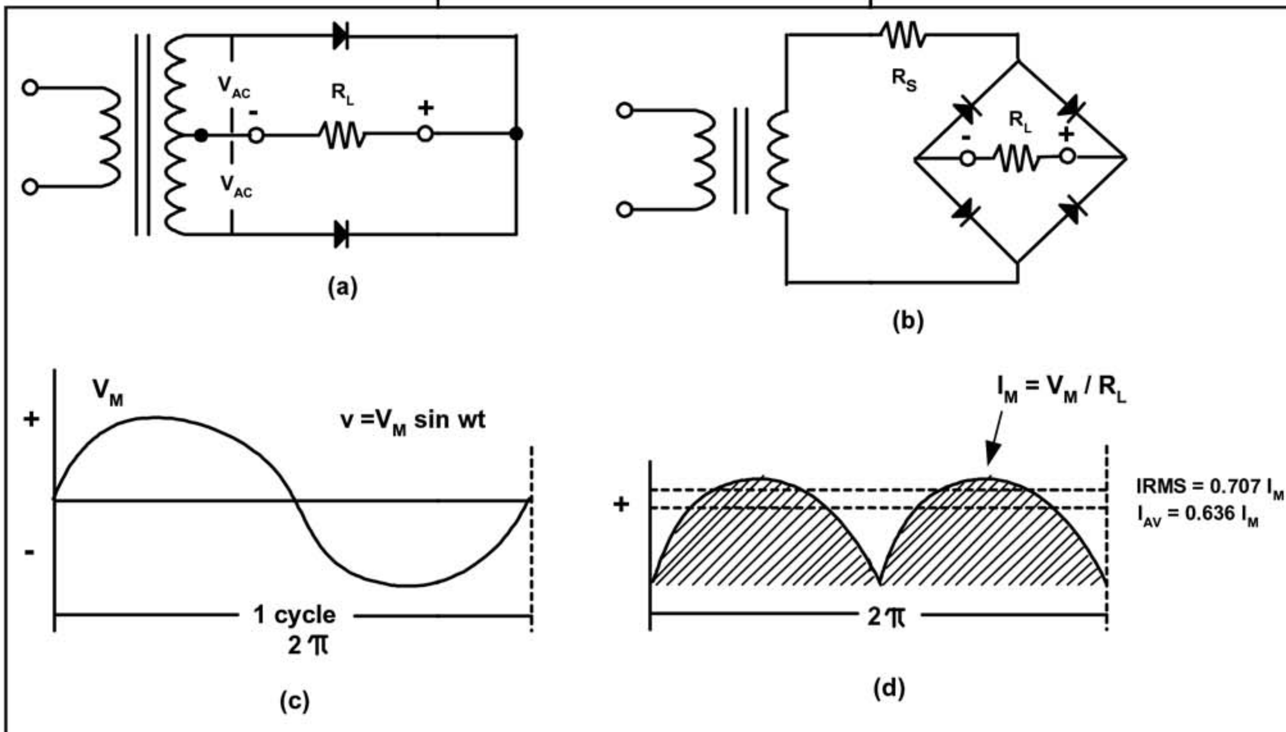

Figure 3. Circuits and Waveshapes for Full-Wave Rectification; (a) Center-Tap Circuit; (b) Bridge Circuit; (C) Input Waveform; (d) Output Waveform.

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management and power, thermal resistance $R_{\theta JC}$ junction to case in ºC/W for a bridge package should be ¼ or less compared to each discrete rectifier component that may otherwise be used. This is determined as shown in the following thermal resistance equation where the average change in rectifier junction temperature ΔT_J is divided by the total power dissipated by the bridge:

$$R_{\theta JC} = \Delta T_J/(2V_F \times 2I_{O(SUB)}) = ¼T_J/(V_F \times I_{O(SUB)})$$

Note that thermal resistance of each rectifier is $R_{\theta JC} = \Delta T_J / (V_F \times I_{O(SUB)})$. The ΔT_J is the average change in the pn junction temperatures of the four discrete rectifiers from applied power, V_F is the average of the maximum forward voltage of each discrete rectifier, and $I_{O(SUB)}$ is again the average-output current rating of each rectifier.

For a three-phase bridge, the I_O is three times that of the individual rectifiers chosen and the power capability is six times that of each rectifier. Similarly the $R_{\theta JC}$ for a three-phase bridge design should be 1/6 or less that of its individual rectifiers for optimum thermal management.

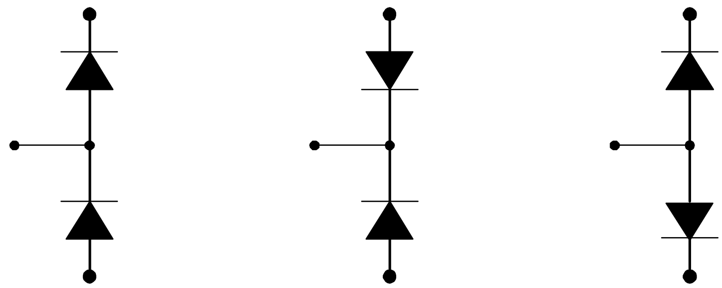

Figure 4. DUAL RECTIFIERS

For higher current (power) rated bridges, these same concerns must include applicable package design and thermal heatsink considerations to accommodate overall thermal performance requirements. Further details to $R_{\theta JC}$ or $R_{\theta JL}$ thermal measurement techniques for bridges are available in JEDEC Standard No. 45.

When using dual rectifier package assemblies with three terminals such as "half bridges" or "centertaps", they are designed and rated in the industry with the total cumulative output current I_O from each rectifier or twice that of each rectifier component. Therefore dual rectifier I_O ratings are identical to a bridge or center-tap average output current for full-wave-single-phase bridge applications.

Microsemi has a variety of bridges in single-phase and three-phase designs in I_O current ratings from 0.125 Amps to 150 Amps. Many dual ultrafast rectifiers (6 to 200 Amps) and dual Schottkys (6 to 600 Amps) are also available as half bridges or centertaps including TO-220, TO-3P, TO-249, or the MiniMod and other power packages. These various dual configuration options are illustrated in Figure 4. Special surface mount options are also available in the LCC-3, lead-formed TO-220AB and TO-3P, as well as the new hermetic CoolPack™ by Microsemi.