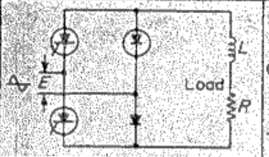
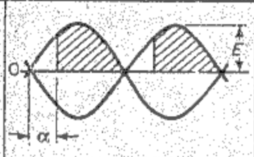
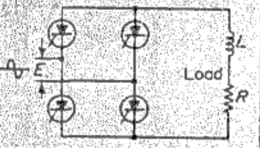
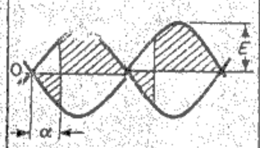
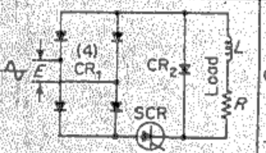
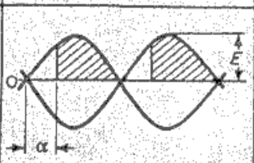
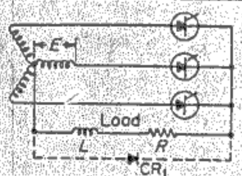
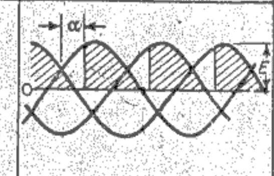
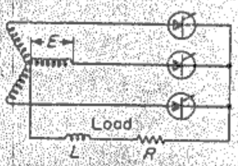
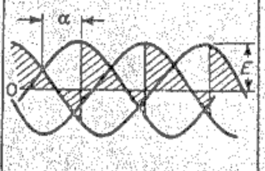
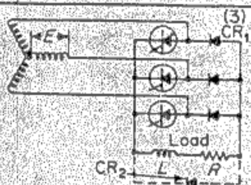
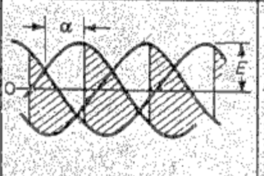
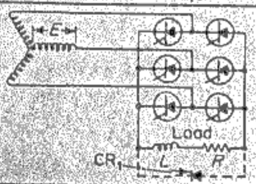
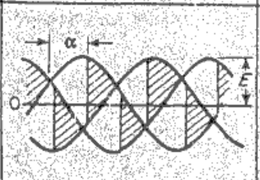
Chart 8.1 (cont.)

(a) ...me	(b) Connections	(c) Load voltage waveforms	(d) Peak forward voltage on SCR	Peak reverse voltage: (e) On SCR	Peak reverse voltage: (f) On diode	(g) Max. load voltage ($\alpha = 0$) E_D = average d-c value, E_a = RMS a-c value	(h) Load voltage vs trigger delay angle α	(j) Trigger angle range full ON to full OFF	Max. steady-state current in SCR: (k) Average amp	Max. steady-state current in SCR: (l) Cond. angle	Max. steady-state current in diode rectifier: (m) Average amp	Max. steady-state current in diode rectifier: (n) Cond. angle for max. current	(p) Ability to pumpback inductive load energy to supply line	(q) Fundamental frequency of load voltage (f = supply frequency)	(r) Notes and comments
...le-phase with ...s on ...n a-c line ...e or ...e load			E	E	E	$E_D = \frac{2E}{\pi}$	$E_D = \frac{E}{\pi}(1+\cos\alpha)$	180°	$\frac{E}{\pi R}$	180°	$\frac{E}{\pi R}$	180°	No	$2f$	Diode rectifiers act as free-wheeling path, conduct $(\pi + \alpha)$ degrees with inductive load.
...le-phase with ...s and ...ve load			E	E	—	$E_D = \frac{2E}{\pi}$	$E_D = \frac{2E}{\pi}\cos\alpha$ (assuming continuous current in load)	180°	$\frac{E}{\pi R}$	180°	—	—	Yes	$2f$	With resistive load operation is same as circuit (7).
...le-phase with SCR circuit ...e or ...e load			E	0	E (CR_1 and CR_2)	$E_D = \frac{2E}{\pi}$	$E_D = \frac{E}{\pi}(1+\cos\alpha)$	180°	$\frac{2E}{\pi R}$	360°	$CR_1 = \frac{E}{\pi R}$ $CR_2 = 0.16\left(\frac{2E}{\pi R}\right)$	180° 148°	No	$2f$	CR_2 necessary when load is not purely resistive. Frequency limited by recovery characteristics of rectifiers and SCR's.
...e-phase ...e with ...load, ...tive ...h ...eeling			E (possibly $\sqrt{3}E$ if load open and if SCR's have high reverse currents)	$\sqrt{3}E$	E	$E_D = \frac{3\sqrt{3}E}{2\pi}$	$E_D = \frac{3\sqrt{3}E}{2\pi}\cos\alpha$ ($0 < \alpha < 30°$) $E_D = \frac{3E}{2\pi}[1+\cos(\alpha+30°)]$ ($30° < \alpha < 150°$)	150°	$\frac{\sqrt{3}E}{2\pi R}$	120°	$0.16\left(\frac{3\sqrt{3}E}{2\pi R}\right)$	134°	No	$3f$	
...-phase ...a ...uctive ...eeling			$\sqrt{3}E$	$\sqrt{3}E$	—	$E_D = \frac{3\sqrt{3}E}{2\pi}$	$E_D = \frac{3\sqrt{3}E}{2\pi}\cos\alpha$ (assuming continuous current in load)	150°	$\frac{\sqrt{3}E}{2\pi R}$	120°	—	—	Yes	$3f$	
...-phase ...ith ...load, ...tive ...eling			$\sqrt{3}E$	$\sqrt{3}E$	$\sqrt{3}E$	$E_D = \frac{3\sqrt{3}E}{\pi}$	$E_D = \frac{3\sqrt{3}E}{2\pi}(1+\cos\alpha)$	180°	$\frac{\sqrt{3}E}{\pi R}$	120°	$CR_1 = \frac{\sqrt{3}E}{\pi R}$ $CR_2 = 0.14\left(\frac{3\sqrt{3}E}{\pi R}\right)$	120° 132°	No	$3f$	Without CR_2, SCR's may be unable to turn off an inductive load. Also, CR_2 relieves SCR's from free-wheeling duty.
...-phase ...ith 6 ...esistive ...nductive ...ing			$\sqrt{3}E$ (1.5E if SCR's shunted by resistance)	$\sqrt{3}E$	$\sqrt{3}E$	$E_D = \frac{3\sqrt{3}E}{\pi}$	$E_D = \frac{3\sqrt{3}E}{\pi}\cos\alpha$ ($0 < \alpha < 60°$) $E_D = \frac{3\sqrt{3}E}{\pi}\left(1+\frac{\cos\alpha}{2}-\frac{\sqrt{3}}{2}\sin\alpha\right)$ ($60° < \alpha < 120°$)	120°	$\frac{\sqrt{3}E}{\pi R}$	120°	$0.056\left(\frac{3\sqrt{3}E}{\pi R}\right)$	212°	No	$6f$	SCR's require two gate signals 60° apart each cycle, alternately a gate signal duration > 60°.