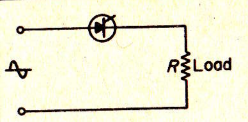
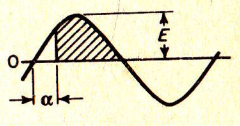
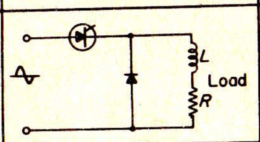
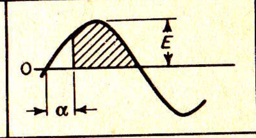
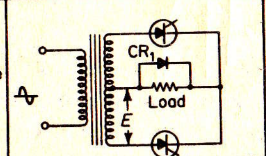
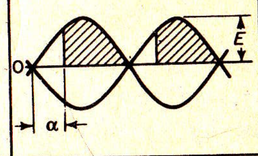
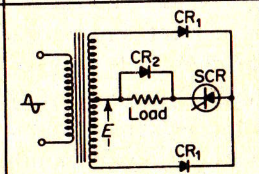
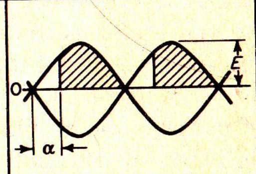
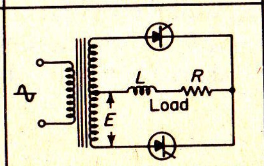
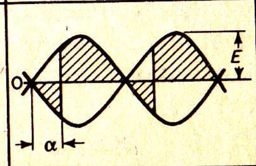
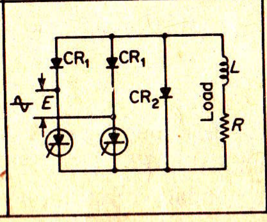
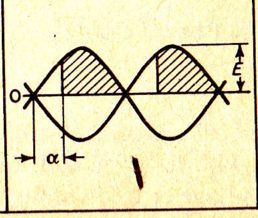
Chart 8.1 Circuit Constants of Some Major Phase Controlled Circuits†

Circuit (a) Name	Circuit (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
(1) Half-wave resistive load			E	E	—	$E_D = \frac{E}{\pi}$ $E_a = \frac{E}{2}$
(2) Half-wave inductive load with free-wheeling rectifier			E	E	E	$E_D = \frac{E}{\pi}$
(3) Centertap with resistive load, or inductive load with free-wheeling rectifier			E (possibly $2E$ if load open)	$2E$	E	$E_D = \frac{2E}{\pi}$
(4) Centertap with resistive or inductive load—SCR in d-c circuit			E	0	$2E$ on CR_1 E on CR_2	$E_D = \frac{2E}{\pi}$
(5) Centertap with inductive load (no free-wheeling rectifier)			$2E$	$2E$	—	$E_D = \frac{2E}{\pi}$
(6) Single-phase bridge with 2 SCR's with common anode or cathode. Resistive load, or inductive load with free-wheeling rectifier			E	E	E (CR_1 and CR_2)	$E_D = \frac{2E}{\pi}$

† Assumes zero forward drop in semiconductors when conducting, and zero current when blocking; also zero a-c line and source reactance. Inductive d-c loads have pure d-c current.

Chart 8.1 (cont.)

(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
$E_D = \frac{E}{2\pi}(1 + \cos \alpha)$ $E_a = \frac{E}{2\sqrt{\pi}}(\pi - \alpha + \frac{1}{2} \sin 2\alpha)^{1/2}$	180°	$\frac{E}{\pi R}$	180°	—	—	—	f	
$E_D = \frac{E}{2\pi}(1 + \cos \alpha)$	180°	$\frac{E}{2\pi R}$ (load highly inductive)	180°	$0.54\left(\frac{E}{\pi R}\right)$	210°	No	f	
$E_D = \frac{E}{\pi}(1 + \cos \alpha)$	180°	$\frac{E}{\pi R}$	180°	$0.26\left(\frac{2E}{\pi R}\right)$	148°	No	$2f$	
$E_D = \frac{E}{\pi}(1 + \cos \alpha)$	180°	$\frac{2E}{\pi R}$	360°	$CR_1 = \frac{E}{\pi R}$ $CR_2 = 0.26\left(\frac{2E}{\pi R}\right)$ with highly inductive load	180° 148°	No	$2f$	CR_2 necessary when load is not purely resistive. Frequency limited by recovery characteristics of rectifiers and SCR.
$E_D = \frac{2E}{\pi} \cos \alpha$ (assuming continuous current in load)	180°	$\frac{E}{\pi R}$	180°	—	—	Yes	$2f$	
$E_D = \frac{E}{\pi}(1 + \cos \alpha)$	180°	$\frac{E}{\pi R}$	180°	$CR_1 = \frac{E}{\pi R}$ $CR_2 = 0.26\left(\frac{2E}{\pi R}\right)$	180° 148°	No	$2f$	Without CR_2, SCR's may be unable to turn off an inductive load. Also, CR_2 relieves SCR's from free-wheeling duty. See Sec. 8.5.