

RADDRIZZATORI CONTROLLATI TAVOLA COMPARATIVA

SCR MANUAL

E = valore di picco

E_a = valore efficace totale $(V_{ac\text{eff}}^2 + V_{dc}^2)^{1/2}$

AC PHASE CONTROL

CIRCUIT		(c) LOAD VOLTAGE WAVEFORMS	(d) PEAK FORWARD VOLTAGE ON SCR	PEAK REVERSE VOLTAGE		(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		MAX STEADY-STATE CURRENT IN DIODE RECTIFIER		(p) ABILITY TO PUMPBACK INDUCTIVE LOAD ENERGY TO SUPPLY LINE	(q) FUNDAMENTAL FREQUENCY OF LOAD VOLTAGE (f = SUPPLY FREQUENCY)	(r) NOTES AND COMMENTS
(a) NAME	(b) CONNECTIONS			(e) ON SCR	(f) ON DIODE				(k) AVERAGE AMP	(l) COND ANGLE	(m) AVERAGE AMP	(n) COND ANGLE FOR MAX CURRENT			
(1) HALF-WAVE RESISTIVE LOAD			E	E	—	$E_D = \frac{E}{\pi}$ $E_a = \frac{E}{2}$	$E_D = \frac{E}{2\pi} (1 + \cos \alpha)$ $E_a = \frac{E}{2\sqrt{\pi}} (\pi - \alpha + \frac{1}{2} \sin 2\alpha)^{1/2}$	180°	$\frac{E}{\pi R}$	180°	—	—	—	f	
(2) HALF-WAVE INDUCTIVE LOAD WITH FREE-WHEELING RECTIFIER			E	E	E	$E_D = \frac{E}{\pi}$	$E_D = \frac{E}{2\pi} (1 + \cos \alpha)$	180°	$\frac{E}{2\pi R}$ (LOAD HIGHLY INDUCTIVE)	180°	$0.54 (\frac{E}{\pi R})$	210°	NO	f	
(3) CENTERTAP WITH RESISTIVE LOAD, OR INDUCTIVE LOAD WITH FREE-WHEELING RECTIFIER			E (POSSIBLY 2E IF LOAD OPEN)	2E	E	$E_D = \frac{2E}{\pi}$	$E_D = \frac{E}{\pi} (1 + \cos \alpha)$	180°	$\frac{E}{\pi R}$	180°	$0.26 (\frac{2E}{\pi R})$	148°	NO	2f	
(4) CENTERTAP WITH RESISTIVE OR INDUCTIVE LOAD—SCR IN D-C CIRCUIT			E	0	$\frac{2E}{\pi}$ ON CR1 $\frac{E}{\pi}$ ON CR2	$E_D = \frac{2E}{\pi}$	$E_D = \frac{E}{\pi} (1 + \cos \alpha)$	180°	$\frac{2E}{\pi R}$	360°	$CR1 = \frac{E}{\pi R}$ $CR2 = 0.26 (\frac{2E}{\pi R})$ WITH HIGHLY INDUCTIVE LOAD	180° 148°	NO	2f	CR2 NECESSARY WHEN LOAD IS NOT PURELY RESISTIVE. FREQUENCY LIMITED BY RECOVERY CHARACTERISTICS OF RECTIFIERS AND SCR.
(5) CENTERTAP WITH INDUCTIVE LOAD (NO FREE-WHEELING RECTIFIER)			2E	2E	—	$E_D = \frac{2E}{\pi}$	$E_D = \frac{2E}{\pi} \cos \alpha$ (ASSUMING CONTINUOUS CURRENT IN LOAD)	180°	$\frac{E}{\pi R}$	180°	—	—	YES	2f	
(6) SINGLE-PHASE BRIDGE WITH 2 SCR'S WITH COMMON ANODE OR CATHODE, RESISTIVE LOAD, OR INDUCTIVE LOAD WITH FREE-WHEELING RECTIFIER			E	E	$\frac{E}{\pi}$ (CR1 AND CR2)	$E_D = \frac{2E}{\pi}$	$E_D = \frac{E}{\pi} (1 + \cos \alpha)$	180°	$\frac{E}{\pi R}$	180°	$CR1 = \frac{E}{\pi R}$ $CR2 = 0.26 (\frac{2E}{\pi R})$	180° 148°	NO	2f	WITHOUT CR2, SCR'S MAY BE UNABLE TO TURN OFF AN INDUCTIVE LOAD. ALSO, CR2 RELIEVES SCR'S FROM FREEWHEELING DUTY.

† ASSUMES ZERO FORWARD DROP IN SEMICONDUCTORS WHEN CONDUCTING, AND ZERO CURRENT WHEN BLOCKING; ALSO ZERO α -c LINE AND SOURCE REACTANCE. INDUCTIVE d-c LOADS HAVE PURE d-c CURRENT.

Il caso più gravoso si ottiene per $\alpha = 0$, per il quale è possibile utilizzare le tabelle dei raddrizzatori non controllati (es. dimensionamento del trasformatore)

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SCR

E = valore di picco

E_a = valore efficace totale ($V_{ac}^2 + V_{dc}^2$)^{1/2}

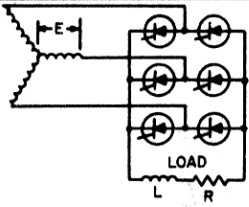
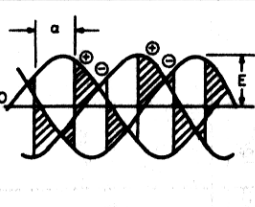
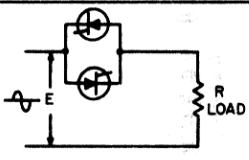
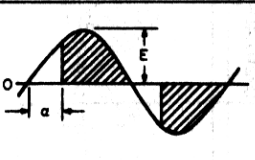
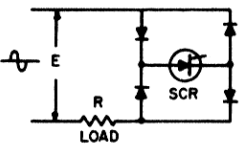
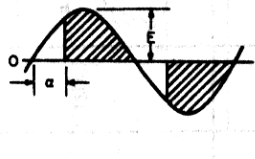
CIRCUIT		LOAD VOLTAGE WAVEFORMS	(d) PEAK FORWARD VOLTAGE ON SCR	PEAK REVERSE VOLTAGE		(q) MAX. LOAD VOLTAGE ($\alpha = 0$) $E_D = \text{AVERAGE D-C VALUE}$ $E_A = \text{RMS A-C VALUE}$	(h) LOAD VOLTAGE VS TRIGGER DELAY ANGLE α	(j) TRIGGER ANGLE RANGE FULL ON TO FULL OFF	MAX STEADY-STATE CURRENT IN SCR		MAX STEADY-STATE CURRENT IN DIODE RECTIFIER		(p) ABILITY TO PUMPBACK INDUCTIVE LOAD ENERGY TO SUPPLY LINE	(q) FUNDAMENTAL FREQUENCY OF LOAD VOLTAGE ($f = \text{SUPPLY FREQUENCY}$)	(r) NOTES AND COMMENTS
(a) NAME	(b) CONNECTIONS			(e) ON SCR	(f) ON DIODE				(k) AVERAGE AMP	(l) COND ANGLE	(m) AVERAGE AMP	(n) COND ANGLE FOR MAX CURRENT			
(7) SINGLE-PHASE BRIDGE WITH 2 SCR'S ON COMMON A-C LINE, RESISTIVE OR INDUCTIVE 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.
(8) SINGLE-PHASE BRIDGE WITH 4 SCR'S AND INDUCTIVE 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)
(9) SINGLE-PHASE BRIDGE WITH SINGLE SCR IN D-C CIRCUIT, RESISTIVE OR INDUCTIVE LOAD.			E	0	E (CRI AND CR2)	$E_D = \frac{2E}{\pi}$	$E_D = \frac{E}{\pi} (1 + \cos \alpha)$	180°	$\frac{2E}{\pi R}$	360°	$\text{CRI} = \frac{E}{\pi R}$	180°	NO	2f	CR2 NECESSARY WHEN LOAD IS NOT PURELY RESISTIVE, FREQUENCY LIMITED BY RECOVERY CHARACTERISTICS OF RECTIFIERS AND SCR'S
(10) THREE-PHASE HALF-WAVE WITH RESISTIVE LOAD OR INDUCTIVE LOAD WITH FREE-WHEELING RECTIFIER			E (POSSIBLY $\sqrt{3} E$ IF LOAD OPEN AND IF SCR'S HAVE HIGH REVERSE CURRENTS)	$\sqrt{3} E$	E	$E_D = \frac{3\sqrt{3}E}{2\pi}$	$E_D = \frac{3\sqrt{3}E}{2\pi} \cos \alpha$ ($0 < \alpha < 30^\circ$) $E = \frac{3E}{2\pi} [1 + \cos(\alpha + 30^\circ)]$ ($30^\circ < \alpha < 150^\circ$)	150°	$\frac{\sqrt{3}E}{2\pi R}$	120°	$0.16 \left(\frac{3\sqrt{3}E}{2\pi R} \right)$	134°	NO	3f	
(11) THREE-PHASE HALF-WAVE WITH INDUCTIVE LOAD (NO FREE-WHEELING RECTIFIER)			$\sqrt{3} E$	$\sqrt{3} E$	—	$E_D = \frac{3\sqrt{3}E}{2\pi}$	$E_D = \frac{3\sqrt{3}E}{2\pi} \cos \alpha$ (ASSUMING CONTINUOUS CURRENT IN LOAD)	150°	$\frac{\sqrt{3}E}{2\pi R}$	120°	—	—	YES	3f	
(12) THREE-PHASE BRIDGE WITH 3 SCR'S RESISTIVE LOAD OR INDUCTIVE LOAD WITH FREE-WHEELING RECTIFIER			$\sqrt{3} E$	$\sqrt{3} E$	$\sqrt{3} E$	$E_D = \frac{3\sqrt{3}E}{\pi}$	$E_D = \frac{3\sqrt{3}E}{2\pi} (1 + \cos \alpha)$	180°	$\frac{\sqrt{3}E}{\pi R}$	120°	$\text{CRI} = \frac{\sqrt{3}E}{\pi R}$	120°	NO	3f	WITHOUT CR2, SCR'S MAY BE UNABLE TO TURN OFF AN INDUCTIVE LOAD, ALSO CR2 RELIEVES SCR'S FROM FREE-WHEELING DUTY
(13) THREE-PHASE BRIDGE WITH 6 SCR'S, RESISTIVE LOAD, OR INDUCTIVE LOAD WITH FREE-WHEELING RECTIFIER			$\sqrt{3} E$ (1.5 E IF SCR'S SHUNTED BY RESISTANCE)	$\sqrt{3} E$	$\sqrt{3} E$	$E_D = \frac{3\sqrt{3}E}{\pi}$	$E_D = \frac{3\sqrt{3}E}{\pi} \cos \alpha$ ($0 < \alpha < 60^\circ$) $E_D = \frac{3\sqrt{3}E}{\pi} \left(1 + \frac{\cos \alpha}{2} - \frac{\sqrt{3}}{2} \sin \alpha \right)$ ($60^\circ < \alpha < 120^\circ$)	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 $> 60^\circ$

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SCR MANUAL

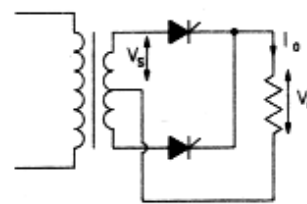
CIRCUIT		(c) LOAD VOLTAGE WAVEFORMS	(d) PEAK FORWARD VOLTAGE ON SCR	PEAK REVERSE VOLTAGE		(g) MAX LOAD VOLTAGE ($\alpha = 0$) E_D = AVERAGE D-C VALUE E_a = RMS A-C VALUE	(h) LOAD VOLTAGE VS TRIGGER DELAY ANGLE α	(j) TRIGGER ANGLE RANGE FULL ON TO FULL OFF	MAX STEADY-STATE CURRENT IN SCR		MAX STEADY-STATE CURRENT IN DIODE RECTIFIER		(p) ABILITY TO PUMPBACK INDUCTIVE LOAD ENERGY TO SUPPLY LINE	(q) FUNDAMENTAL FREQUENCY OF LOAD VOLTAGE (f = SUPPLY FREQUENCY)	(r) NOTES AND COMMENTS
(a) NAME	(b) CONNECTIONS			(e) ON SCR	(f) ON DIODE				(k) AVERAGE AMP	(l) COND ANGLE	(m) AVERAGE AMP	(n) COND. ANGLE FOR MAX CURRENT			
(14) THREE-PHASE BRIDGE WITH 6 SCR'S WITH INDUCTIVE LOAD			$\sqrt{3} E$ (1.5E IF SCR'S SHUNTED BY RESISTANCE)	$\sqrt{3} E$	—	$E_D = \frac{3\sqrt{3} E}{\pi}$	$E_D = \frac{3\sqrt{3} E}{\pi} \cos \alpha$ (ASSUMING CONTINUOUS CURRENT IN LOAD)	120°	$\frac{\sqrt{3} E}{\pi R}$	120°	—	—	YES	6f	SCR'S REQUIRE TWO GATE SIGNALS 60° APART EACH CYCLE, ALTERNATELY A GATE SIGNAL DURATION > 60°
AC RESISTIVE LOADS															
(15) TRIAC OR INVERSE PARALLEL SCR'S WITH RESISTIVE LOAD			E	E	—	$E_a = \frac{E}{\sqrt{2}}$	$E_a = \frac{E}{\sqrt{2\pi}} (\pi - \alpha + \frac{1}{2} \sin 2\alpha)^{1/2}$	180°	$\frac{E_a}{2.2R}$ OR $\frac{E}{\pi R}$	180°	—	—	—	f	WITH INDUCTIVE LOAD, LOAD VOLTAGE AND CURRENT DEPEND ON $\omega L/R$ AS WELL AS R AND α .
(16) SCR INSIDE BRIDGE WITH A-C RESISTIVE LOAD			E	0	E	$E_a = \frac{E}{\sqrt{2}}$	$E_a = \frac{E}{\sqrt{2\pi}} (\pi - \alpha + \frac{1}{2} \sin 2\alpha)^{1/2}$	180°	$\frac{E_a}{1.1R}$ OR $\frac{2E}{\pi R}$	360°	$\frac{E_a}{2.2R}$ OR $\frac{E}{\pi R}$	180°	—	f	INDUCTANCE IN D-C CIRCUIT MUST BE MINIMUM. FREQUENCY LIMIT DETERMINED BY RECOVERY CHARACTERISTICS OF RECTIFIERS AND SCR'S WITH INDUCTIVE LOAD, LOAD VOLTAGE AND CURRENT DEPEND ON $\omega L/R$ AS WELL AS R AND α .

TAB. 11.I GRANDEZZE RELATIVE AI CIRCUITI DI FIG. 11.10

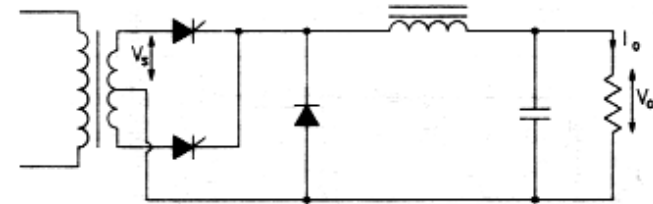
Figura	θ Gradi	Forma d'onda della tensione	$\frac{V_o}{V_{Smax}}$	$\frac{V_o}{V_{SRMS}}$	Forma d'onda della corrente	$\frac{I_{FRMS}}{I_o}$	$\frac{I_{Fmax}}{I_o}$	Ripple di tens. %	Ripple di corr. %
Fig. 11.10 A Fig. 11.10 C Fig. 11.10 E	0		.637	.90	Sono come le tensioni	.785	1.57	48	48.3
	30		.594	.84	"	.832	1.68	56	60.7
	60		.477	.675	"	.940	2.09	65	88.2
	90		.318	.45	"	1.11	3.14	62	121
	120		.159	.225	"	1.39	5.44	43	170
	150		.043	.06	"	1.99	11.72	18	264
Fig. 11.10 B Fig. 11.10 D Fig. 11.10 F	0		.637	.90		.707	1.00	48	
	30		.594	.84		.775	1.20	56	
	60		.477	.675		.866	1.50	65	
	90		.318	.45		1.0	2.0	62	
	120		.159	.225		1.225	3.0	43	
	150		.043	.06		1.73	6.0	18	
Fig. 11.10 G Fig. 11.10 H	0		.637	.90		.707	1.0		
	30		.551	.78		"	"		
	60		.318	.45		"	"		
	90		0	0		"	"		
	120		-.318	-.45		"	"		
	150		-.551	-.78		"	"		
	180		-.637	-.90		"	"		

Ripple di tensione relativo alla tensione di picco con $\theta = 0^\circ$
 Frequenza del ripple = $2 \times F$ rete

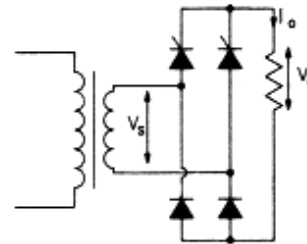
$$\frac{E_{DO}}{E_{Spx}} = \frac{V_o}{V_{Smax}}; \quad \frac{E_{DO}}{E_{SRMS}} = \frac{V_o}{V_{SRMS}}; \quad \frac{I_{FRMS}}{I_{DC}} = \frac{I_{FRMS}}{I_o}; \quad \frac{I_{FRM}}{I_{DC}} = \frac{I_{Fmax}}{I_o}$$



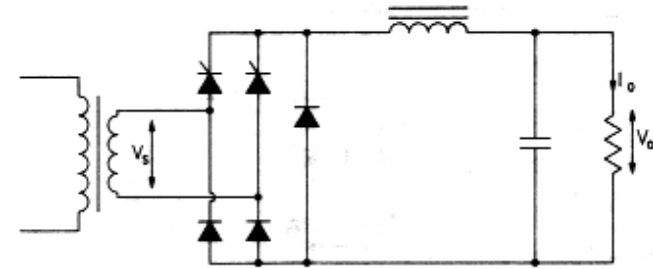
A



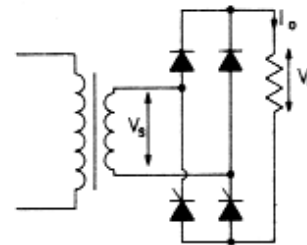
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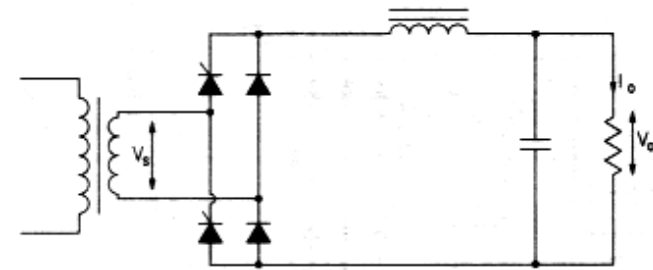
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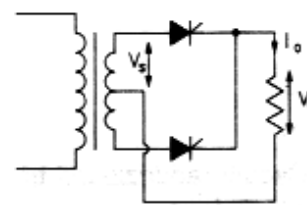
D



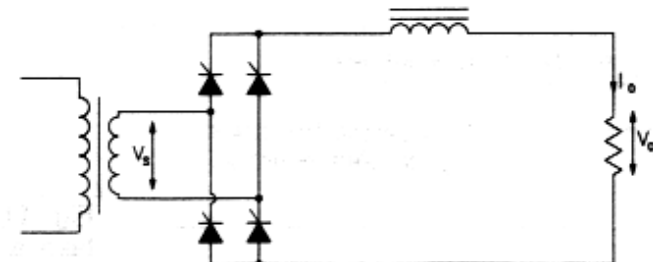
E



F



G



H

V_o = tensione di uscita
 I_o = corrente di uscita

Fig. 11.10 - Circuiti raddrizzatori monofase a controllo di fase.

Figura	Θ Gradi	Forma d'onda della tensione	$\frac{V_o}{V_{Smax}}$	$\frac{V_o}{V_{SRMS}}$	Forma d'onda della corrente	$\frac{I_{F RMS}}{I_o}$	$\frac{I_{F max}}{I_o}$	Tens. di ripple	Corr. di ripple	Carico
Fig. 11.12 C	30°		.891	1.26	come la tens.	.584	1.12	11	17.3	R
										L + CR
	60°		.716	1.01	come la tens.	.615	1.377	29	35.2	R
										L + CR
Fig. 11.12 C	90°		.478	.675	come la tens.	.729	2.07	40	75	R
										L + CR
	120°		.239	.337	come la tens.	1.11	3.58	32	122	R
										L + CR
	150°		.064	.090	come la tens.	1.35	7.94	14	208	R
										L + CR
Fig. 11.12 E	30°				come la tens.			13		R
										L + CR
	60°				come la tens.			26		R
										L + CR
Fig. 1.12 F	90°				come la tens.			17		r
										L + CR

La tensione di ripple si riferisce alla tensione di picco per $\Theta = 0$
 Frequenza del ripple = $2 \times F$ rete

$$\frac{E_{DO}}{E_{Spx}} = \frac{V_o}{V_{S max}}; \quad \frac{E_{DO}}{E_{SRMS}} = \frac{V_o}{V_{SRMS}}; \quad \frac{I_{FRMS}}{I_{DC}} = \frac{I_{FRMS}}{I_o}; \quad \frac{I_{PX}}{I_{DC}} = \frac{I_{F max}}{I_o}$$

(3)

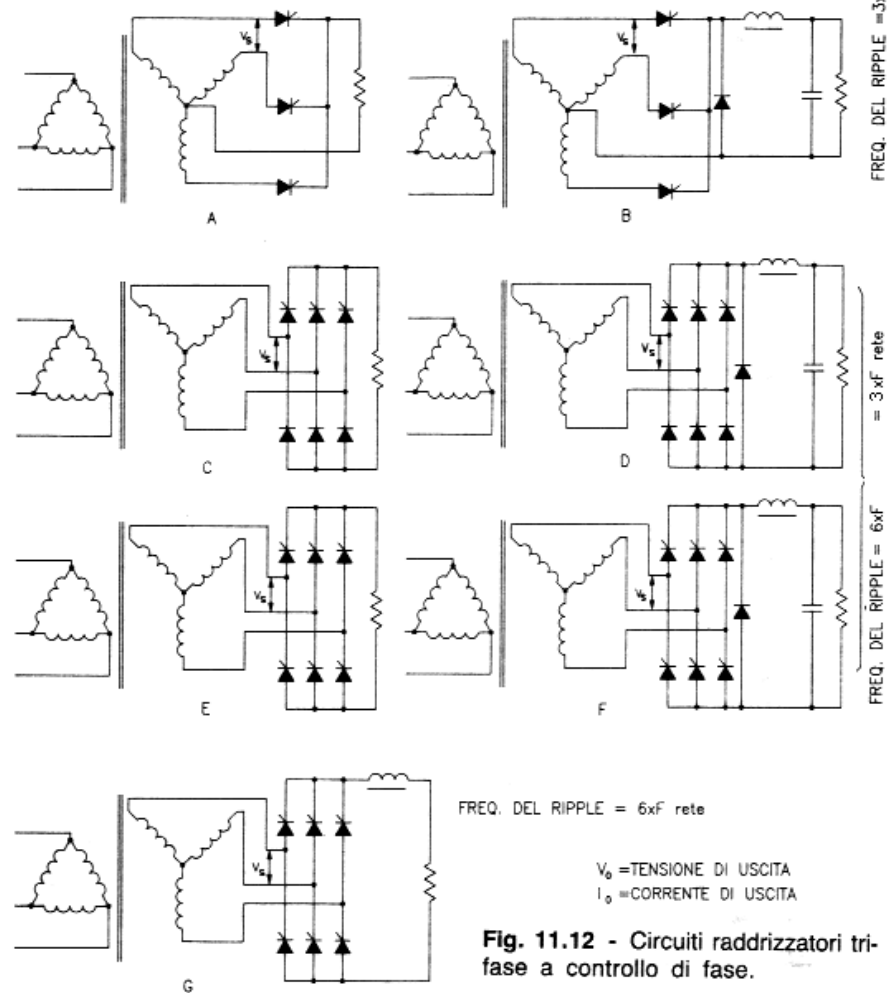


Fig. 11.12 - Circuiti raddrizzatori tri-fase a controllo di fase.

Il ripple della corrente è calcolato
 nel modo usuale: $r = I_{aceff} / I_{dc}$

Raddrizzatori a diodi controllati (Immagine tratta da "Mialich Rossi – Elettronica Industriale - Calderini")

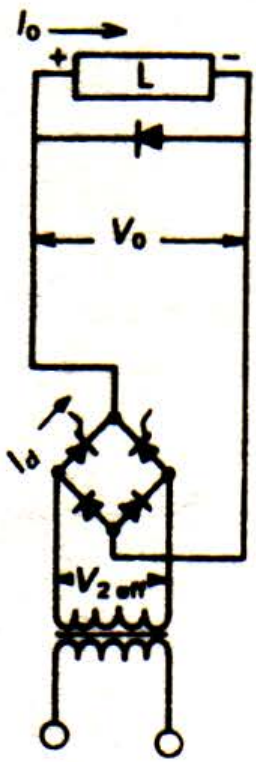
Circuito	angolo di conduzione γ	Grandezze di uscita					Grandezze relative ai diodi controllati						potenza apparente (VA) trasformatore	
		forme d'onda tensioni	$\frac{V_0}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_0}$	ripple r%	forme d'onda correnti	$\frac{I_{dm}}{I_{dM}}$	$\frac{I_{dm}}{I_0}$	$\frac{I_{d\text{ eff}}}{I_0}$	$\frac{V_{DRM}}{V_{2\text{ eff}}}$	$\frac{V_{RM}}{V_{2\text{ eff}}}$	$\frac{P_{1\text{ APP}}}{V_0 I_0}$	$\frac{P_{2\text{ APP}}}{V_0 I_0}$
	60°		.060	.170	2.82	264		.043	.500	1.98	1.41	.71	47	47
	120°		.226	.445	1.97	170		.092	.500	1.39	1.41	1.23	8.82	8.82
	180°		.450	.707	1.57	124		.159	.500	1.11	1.41	1.41	3.49	3.49
	240°		.676	.900	1.33	88		.239	.500	.938	1.23	1.41	1.97	1.97
	300°		.840	.985	1.17	61		.297	.500	.832	.71	1.41	1.39	1.39
	360°		.900	1.00	1.11	48.0		.318	.500	.786	0	1.41	1.24	1.24

Nota: η = Potenza al carico in d.c. / Potenza attiva erogata dal trasformatore

$V_{\text{oeff}} = \text{valore efficace totale} = (V_{\text{aceff}}^2 + V_{\text{dc}}^2)^{0.5}$

$r\% = V_{\text{aceff}} / V_{\text{picco}} (\phi = 0)$

Raddrizzatori a diodi controllati (Immagine tratta da "Mialich Rossi – Elettronica Industriale - Calderini")

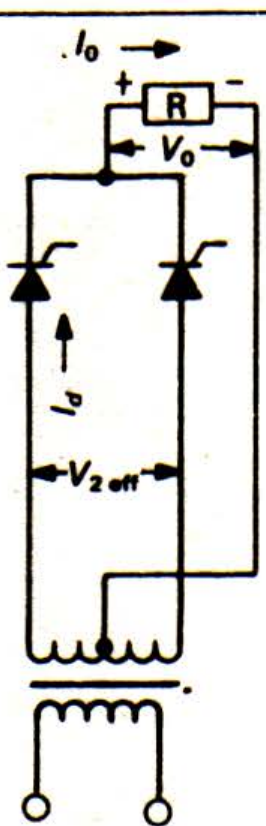
Circuito	angolo di conduzione γ	Grandezze di uscita					Grandezze relative ai diodi controllati						potenza apparente (VA) trasformatore	
		forme d'onda tensioni	$\frac{V_0}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_0}$	ripple r%	forme d'onda correnti	$\frac{I_{dm}}{I_{dM}}$	$\frac{I_{dm}}{I_0}$	$\frac{I_{d\text{ eff}}}{I_0}$	$\frac{V_{DRM}}{V_{2\text{ eff}}}$	$\frac{V_{RM}}{V_{2\text{ eff}}}$	$\frac{P_{1\text{ APP}}}{V_0 I_0}$	$\frac{P_{2\text{ APP}}}{V_0 I_0}$
	60°		.060	.170	2.82			.084	.500	1.73	1.414	1.414	6.41	6.41
	120°		.226	.445	1.97			.167	.500	1.22	1.414	1.414	2.53	3.53
	180°		.450	.707	1.57			.250	.500	1.00	1.414	1.414	1.57	1.57
	240°		.676	.900	1.33			.333	.500	.866	1.23	1.414	1.21	1.21
	300°		.840	.985	1.17			.417	.500	.775	.707	1.414	1.09	1.09
	360°		.900	1.00	1.11			.500	.500	.707	0	1.414	1.11	1.11

Nota: η = Potenza al carico in d.c. / Potenza attiva erogata dal trasformatore

$V_{\text{oeff}} = \text{valore efficace totale} = (V_{\text{aceff}}^2 + V_{\text{dc}}^2)^{0.5}$

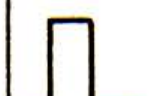
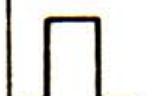
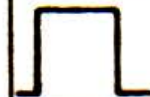
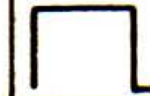
$r\% = V_{\text{aceff}} / V_{\text{picco}} (\varphi_i = 0)$

Raddrizzatori a diodi controllati (Immagine tratta da "Mialich Rossi – Elettronica Industriale - Calderini")

Circuito	angolo di conduzione γ	Grandezze di uscita					Grandezze relative ai diodi controllati						potenza apparente (VA) trasformatore	
		forme d'onda tensioni	$\frac{V_0}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_0}$	ripple r%	forme d'onda correnti	$\frac{I_{dm}}{I_{dM}}$	$\frac{I_{dm}}{I_0}$	$\frac{I_{d\text{ eff}}}{I_0}$	$\frac{V_{DRM}}{V_{2\text{ eff}}}$	$\frac{V_{RM}}{V_{2\text{ eff}}}$	$\frac{P_{1\text{ APP}}}{V_0 I_0}$	$\frac{P_{2\text{ APP}}}{V_0 I_0}$
	60°		.030	.085	2.82	264		.043	.500	1.98	.71	.71	47	66.4
	120°		.113	.223	1.97	170		.092	.500	1.39	.71	1.23	8.82	12.5
	180°		.225	.354	1.57	121		.159	.500	1.11	.71	1.41	3.49	4.94
	240°		.338	.450	1.33	88		.239	.500	.938	.62	1.41	1.97	2.79
	300°		.420	.493	1.17	61		.297	.500	.832	.36	1.41	1.39	1.97
	360°		.450	.500	1.11	48		.318	.500	.786	0	1.41	1.24	1.75

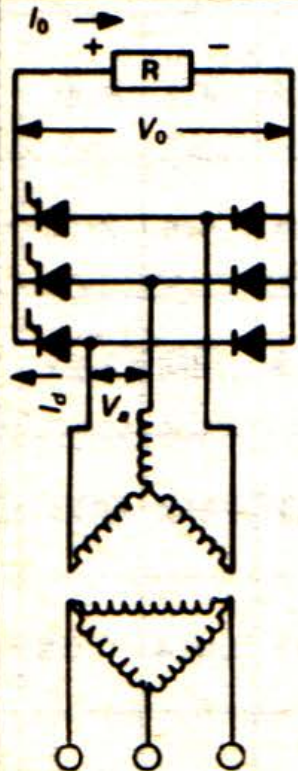
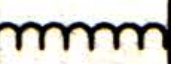
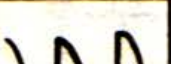
Nota: η = Potenza al carico in d.c. / Potenza attiva erogata dal trasformatore
 $V_{\text{oeff}} = \text{valore efficace totale} = (V_{\text{aceff}}^2 + V_{\text{dc}}^2)^{0.5}$
 $r\% = V_{\text{aceff}} / V_{\text{picco}} (\varphi = 0)$

Raddrizzatori a diodi controllati (Immagine tratta da "Mialich Rossi – Elettronica Industriale - Calderini")

Circuito	angolo di conduzione γ	Grandezze di uscita					Grandezze relative ai diodi controllati						potenza apparente (VA) trasformatore	
		forme d'onda tensioni	$\frac{V_0}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_{2\text{ eff}}}$	$\frac{V_{0\text{ eff}}}{V_0}$	ripple r%	forme d'onda correnti	$\frac{I_{dm}}{I_{dM}}$	$\frac{I_{dm}}{I_0}$	$\frac{I_{d\text{ eff}}}{I_0}$	$\frac{V_{DRM}}{V_{2\text{ eff}}}$	$\frac{V_{RM}}{V_{2\text{ eff}}}$	$\frac{P_{1\text{ APP}}}{V_0 I_0}$	$\frac{P_{2\text{ APP}}}{V_0 I_0}$
	60°		.030	.085	2.82			.084	.500	1.73	.71	.71	6.41	9.06
	120°		.109	.214	1.97			.167	.500	1.22	.71	1.23	2.53	3.58
	180°		.225	.360	1.57			.250	.500	1.00	.71	1.414	1.57	2.22
	240°		.338	.450	1.20			.333	.500	.866	.62	1.414	1.21	1.71
	300°		.420	.494	1.17			.417	.500	.775	.36	1.414	1.09	1.54
	360°		.450	.500	1.11			.500	.500	.707	0	1.414	1.11	1.57

Nota: η = Potenza al carico in d.c. / Potenza attiva erogata dal trasformatore
 $V_{\text{oeff}} = \text{valore efficace totale} = (V_{\text{aceff}}^2 + V_{\text{dc}}^2)^{0.5}$
 $r\% = V_{\text{aceff}} / V_{\text{picco}} (\varphi = 0)$

Raddrizzatori a diodi controllati (Immagine tratta da "Mialich Rossi – Elettronica Industriale - Calderini")

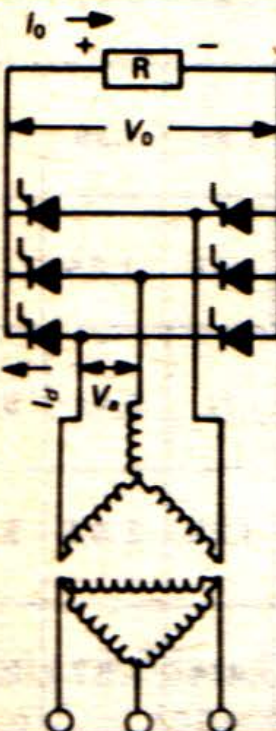
Circuito	angolo di innesco φ_i	Grandezze di uscita					Grandezze relative ai diodi controllati						potenza apparente (VA) trasformatore	
		forme d'onda tensioni	$\frac{V_0}{V_s}$	$\frac{V_{0\text{eff}}}{V_s}$	$\frac{V_{0\text{eff}}}{V_0}$	ripple r %	forme d'onda correnti	$\frac{I_{dm}}{I_{dM}}$	$\frac{I_{dm}}{I_0}$	$\frac{I_{d\text{eff}}}{I_0}$	$\frac{V_{DRM}}{V_s}$	$\frac{V_{RM}}{V_s}$	$\frac{P_{1APP}}{V_0 I_0}$	$\frac{P_{2APP}}{V_0 I_0}$
	0°		1.35	1.35	1.002	4.6		.318	.333	.579	0	1.41	1.05	1.05
	30°		1.26	1.28	1.015	17.3		.297	.333	.584	.707	1.41	1.13	1.13
	60°		1.01	1.07	1.06	35.2		.242	.333	.615	1.22	1.41	1.48	1.48
	90°		.675	.846	1.25	75		.161	.333	.729	1.41	1.41	2.70	2.70
	120°		.337	.531	1.58	122		.093	.333	1.11	1.41	1.22	4.80	4.80
	150°		.091	.210	2.31	208		.042	.333	1.35	1.41	.707	9.18	9.18

Nota: η = Potenza al carico in d.c. / Potenza attiva erogata dal trasformatore

$$V_{0\text{eff}} = \text{valore efficace totale} = (V_{0\text{aceff}}^2 + V_{0\text{dc}}^2)^{0.5}$$

$$r\% = \frac{V_{0\text{aceff}}}{V_{0\text{picco}}} (\varphi_i = 0)$$

Raddrizzatori a diodi controllati (Immagine tratta da "Mialich Rossi – Elettronica Industriale - Calderini")

Circuito	angolo di innescio φ_i	Grandezze di uscita					Grandezze relative ai diodi controllati						caratteristiche del convertitore	
		forme d'onda tensioni	$\frac{V_0}{V_s}$	$\frac{V_{0\text{eff}}}{V_s}$	$\frac{V_{0\text{eff}}}{V_0}$	ripple r %	forme d'onda correnti	angolo di conduz.	$\frac{I_{dm}}{I_0}$	$\frac{I_{d\text{eff}}}{I_0}$	$\frac{V_{DRM}}{V_s}$	$\frac{V_{RM}}{V_s}$	rendim. di convers. η	fattore di potenza
	0°		1.35	1.35	1.002	4.6		120°	.333	.577	0	1.41	99.5	.951
	30°		1.16	1.165	1.015	15.3		120°	.333	.56	.745	1.41	96.5	.84
	60°		.67	.67	1.1	26.8		60° 2 pulses	.333	.52	1.192	1.41	77	.54
	90°		.133	.133	1.6	17.3		30° 2 pulses	.333	.36	1.29	1.41	37.5	.20
	120°		0	0	0	0		0	0	0	1.41	1.41	0	0

Nota: η = Potenza al carico in d.c. / Potenza attiva erogata dal trasformatore

$$V_{\text{oeff}} = \text{valore efficace totale} = (V_{\text{aceff}}^2 + V_{\text{dc}}^2)^{0.5}$$

$$r\% = \frac{V_{\text{aceff}}}{V_{\text{picco}}} (\varphi_i = 0)$$