TABLE 1.3 Transistor and Diode Requirements for Switching Converters

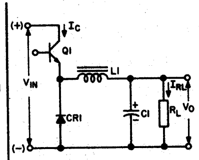
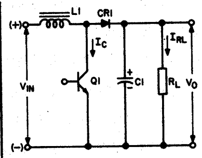
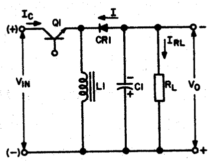
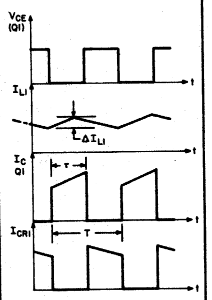
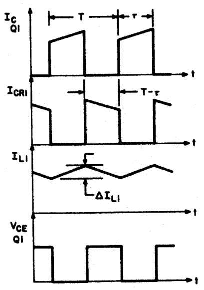
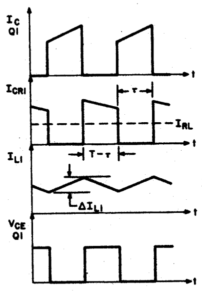
CIRCUIT CONFIGURATION			
TYPE OF CONVERTER	(A) BUCK (STEP DOWN)	(B) BOOST (STEP UP)	(C) BUCK-BOOST
IDEAL TRANSFER FUNCTION	$\frac{V_O}{V_{IN}} = \frac{\tau}{T} = D$	$\frac{V_O}{V_{IN}} = \frac{T}{T-\tau}$	$\frac{V_O}{V_{IN}} = \left(\frac{\tau}{T-\tau}\right)(-1)$
COLLECTOR CURRENT (I_C) *	$I_{C\,MAX} = I_{RL} + \Delta I_{L1}/2$	$I_{C\,MAX} = I_{RL}\left(\frac{T}{T-\tau}\right) + \frac{\Delta I_{L1}}{2}$	$I_{C\,MAX} = I_{RL}\left(\frac{T}{T-\tau}\right) + \frac{\Delta I_{L1}}{2}$
COLLECTOR VOLTAGE RATING *	$V_{CEO} = V_{IN}$	$V_{CEO} > V_O + 1$	$V_{CEO} > V_{IN} + V_O$
DIODE CURRENTS *	$I_{CR1} = I_{RL}\left(\frac{T-\tau}{T}\right)$	$I_{CR1} = I_{RL}$	$I_{CR1} = I_{RL}$
DIODE VOLTAGES (V_{RM}) *	$V_{RM} = V_{IN}$	$V_{RM} = V_O$	$V_{RM} = V_O + V_{IN}$
VOLTAGE AND CURRENT WAVEFORMS			
ADVANTAGES	HIGH EFFICIENCY, SIMPLE, NO TRANSFORMER, HIGH FREQUENCY OPERATION. EASY TO STABILIZE REGULATOR LOOP.	HIGH EFFICIENCY, SIMPLE, NO TRANSFORMER, HIGH FREQUENCY OPERATION.	VOLTAGE INVERSION WITHOUT USING A TRANSFORMER, SIMPLE, HIGH FREQUENCY OPERATION.
DISADVANTAGES	NO ISOLATION BETWEEN INPUT AND OUTPUT. REQUIRES A CROWBAR IF Q1 SHORTS. C1 HAS HIGH RIPPLE CURRENT. CURRENT LIMIT DIFFICULT. ONLY ONE OUTPUT IS POSSIBLE.	NO ISOLATION BETWEEN INPUT AND OUTPUT. HIGH PEAK COLLECTOR CURRENT, ONLY ONE OUTPUT IS POSSIBLE. POOR TRANSIENT RESPONSE. REGULATOR LOOP HARD TO STABILIZE.	Q1 MUST CARRY HIGH PEAK CURRENT, NO ISOLATION BETWEEN INPUT AND OUTPUT, ONLY ONE OUTPUT IS POSSIBLE, POOR TRANSIENT RESPONSE.

TABLE 1.3 (Continued)

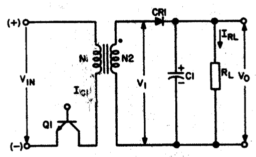
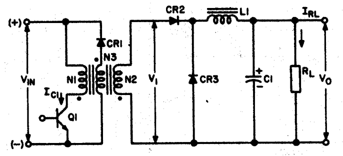
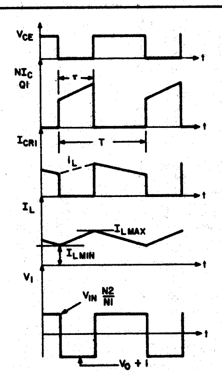
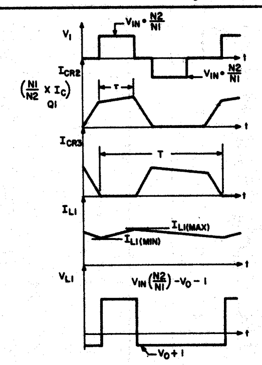
CIRCUIT CONFIGURATION		
TYPE OF CONVERTER	(D) FLYBACK	(E) FORWARD
IDEAL TRANSFER FUNCTION	$\frac{V_O}{V_{IN}} = \frac{N2}{N1}\left(\frac{\tau}{T-\tau}\right)$	$\frac{V_O}{V_{IN}} = \frac{N2}{N1}\left(\frac{\tau}{T}\right)$
COLLECTOR CURRENT (I_C) *	$I_{C\,MAX} = I_{RL}\cdot\frac{N2}{N1}\left(\frac{T}{T-\tau}\right) + \frac{\Delta I_{L1}}{2}$	$I_{C\,MAX} = \frac{N2}{N1}\left(I_{RL} + \frac{\Delta I_{L1}}{2}\right) + \hat{I}_{MAG}$
COLLECTOR VOLTAGE RATING *	$V_{CEO} > V_{IN} + \left(\frac{N1}{N2}\right) V_{OUT}$	$V_{CEO} > V_{IN}\left(1 + \frac{N1}{N3}\right)$
DIODE CURRENTS *	$I_{CR1} = I_{RL}$	$I_{CR1} = \frac{\hat{I}_{MAG}}{2}\left(\frac{\tau}{T}\right)$ $I_{CR2} = I_{RL}\left(\frac{\tau}{T}\right)$ $I_{CR3} = I_{RL}\left(\frac{T-\tau}{T}\right)$
DIODE VOLTAGES (V_{RM}) *	$V_{RM} = V_{IN}\left(\frac{N2}{N1}\right)$	$V_{CR1} = V_{IN}\left(1 + \frac{N3}{N1}\right)$ $V_{CR2} = V_{IN}\left(\frac{N2}{N3}\right)$ $V_{CR3} = V_{IN}\left(\frac{N2}{N1}\right)$ } V_{RM}
VOLTAGE AND CURRENT WAVEFORMS		
ADVANTAGES	SIMPLE, MULTIPLE OUTPUTS ARE POSSIBLE. COLLECTOR CURRENT REDUCED BY TURNS RATIO OF TRANSFORMER. LOW PARTS COUNT, ISOLATION.	SIMPLE, MULTIPLE OUTPUTS ARE POSSIBLE, COLLECTOR CURRENT REDUCED BY RATIO OF $\frac{N2}{N1}$. LOW OUTPUT RIPPLE.
DISADVANTAGES	POOR TRANSFORMER UTILIZATION, TRANSFORMER DESIGN CRITICAL, HIGH OUTPUT RIPPLE.	POOR TRANSFORMER UTILIZATION, POOR TRANSIENT RESPONSE, PARTS COUNT HIGH, TRANSFORMER DESIGN IS CRITICAL.

TABLE 1.3 (Continued)

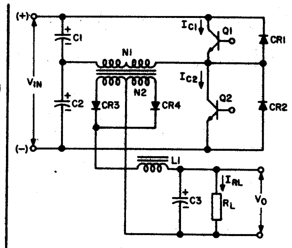
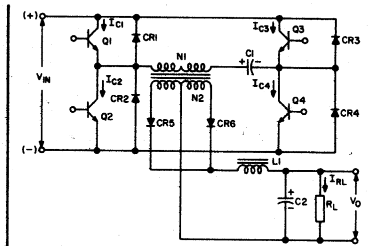
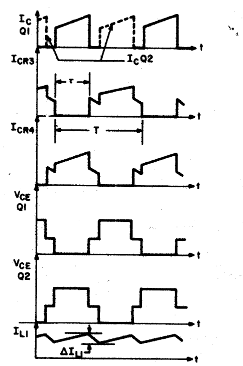
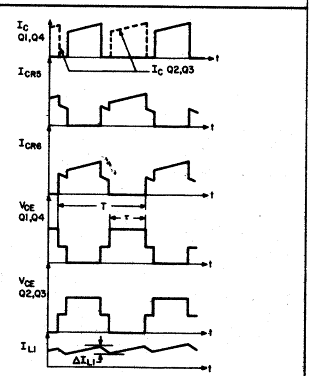
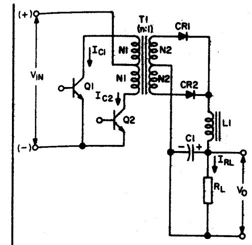
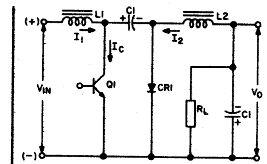
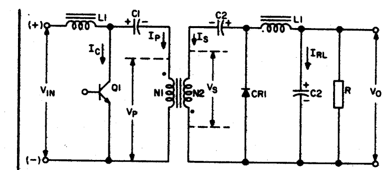
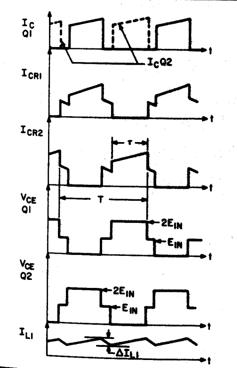
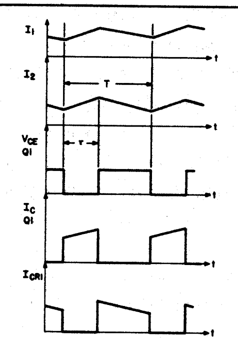
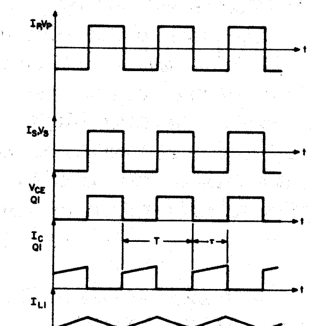
CIRCUIT CONFIGURATION		
TYPE OF CONVERTER	(F) HALF BRIDGE	(G) FULL BRIDGE
IDEAL TRANSFER FUNCTION	$\frac{V_O}{V_{IN}} = \frac{N2}{N1}\left(\frac{\tau}{T}\right)$	$\frac{V_O}{V_{IN}} = 2\frac{N2}{N1}\left(\frac{\tau}{T}\right)$
COLLECTOR CURRENT (I_C) *	$I_{C\,MAX} = \frac{N2}{N1}\left(I_{RL} + \frac{\Delta I_{L1}}{2}\right) + \hat{I}_{MAG}$	$I_{C\,MAX} = \frac{N2}{N1}\left(I_{RL} + \frac{\Delta I_{L1}}{2}\right) + \hat{I}_{MAG}$
COLLECTOR VOLTAGE RATING *	$V_{CEO} = V_{IN}$	$V_{CEO} = V_{IN}$
DIODE CURRENTS *	$I_{CR3} = \frac{I_{RL}}{2}$ $I_{CR4} = \frac{I_{RL}}{2}$	$I_{CR5} = I_{RL}$ $I_{CR6} = I_{RL}$
DIODE VOLTAGES (V_{RM}) *	$V_{RM}\begin{cases} V_{CR3} = V_{IN}\left(\frac{N2}{N1}\right) \\ V_{CR4} = V_{IN}\left(\frac{N2}{N1}\right)\end{cases}$	$V_{RM}\begin{cases} V_{CR5} = 2\,V_{IN}\left(\frac{N2}{N1}\right) & V_{CR1} = V_{IN} \\ V_{CR6} = 2\,V_{IN}\left(\frac{N2}{N1}\right) & V_{CR2} = V_{IN}\end{cases}$
VOLTAGE AND CURRENT WAVEFORMS		
ADVANTAGES	SIMPLE, GOOD TRANSFORMER UTILIZATION, TRANSISTORS RATED AT V_{IN}. ISOLATION, MULTIPLE OUTPUTS, I_C REDUCED AS A RATIO OF $\frac{N2}{N1}$. HIGH POWER OUTPUT.	SIMPLE, GOOD TRANSFORMER UTILIZATION, TRANSISTORS RATED AT V_{IN}. ISOLATION, MULTIPLE OUTPUTS, I_C REDUCED AS A RATIO OF N2/N1. HIGH POWER OUTPUT. PREFERRED TO CKT (F) WHERE HIGH POWER REQUIRED.
DISADVANTAGES	POOR TRANSIENT RESPONSE, HIGH PARTS COUNT, C1 AND C2 HAVE HIGH RIPPLE CURRENT. LIMITED DYNAMIC RANGE. REQUIRES AUXILLIARY POWER SUPPLIES FOR CONTROL CIRCUITS.	POOR TRANSIENT RESPONSE, HIGH PARTS COUNT, C1 AND C2 HAVE HIGH RIPPLE CURRENT. LIMITED DYNAMIC RANGE. REQUIRES AUXILLIARY POWER SUPPLIES FOR CONTROL CIRCUIT.

TABLE 1.3 (Continued)

		
(H) PUSH-PULL	(I) ĆUK (BOOST - BUCK INVERTING)	(J) ĆUK (WITH TRANSFORMER)
$\frac{V_O}{V_{IN}} = 2\frac{N2}{N1}\left(\frac{\tau}{T}\right)$	$\frac{V_O}{V_{IN}} = \left(\frac{\tau}{T-\tau}\right)\ (-1)$	$\frac{V_O}{V_{IN}} = \frac{\tau}{T-\tau}$, $D = \frac{\tau}{T}$, $0 \le D \le 1$
$I_{C\,MAX} = \frac{N2}{N1}\left(I_{RL} + \frac{\Delta I_{L1}}{2}\right) + \hat{I}_{MAG}$	$I_{C\,MAX} = I_1 + I_2 = I_1\left(\frac{T}{\tau}\right)$	$I_C = 1.5\ I_{RL}$ FOR $D = .33$ ($V_O = .5V_{IN}$) $I_C = 2\ I_{RL}$ FOR $D = .50$ ($V_O = V_{IN}$) $I_C = 2.5\ I_{RL}$ FOR $D = .60$ ($V_O = 1.5V_{IN}$)
$V_{CEO} = 2\ V_{IN}$	$V_{CEO} \ge 2\ V_{IN}$	$V_{CEO} = \underbrace{1.5\ V_{IN}}_{D=.33},\ \underbrace{2\ V_{IN}}_{D=.5},\ \underbrace{2.5\ V_{IN}}_{D=.6}$
$I_{CR1} = \frac{I_{RL}}{2}$ $I_{CR2} = \frac{I_{RL}}{2}$	$I_{CR1} = I_1 + I_2$ $I_1 + I_2 = I_1\left(\frac{T}{\tau}\right)$	$I_{CR1} = 1.5\ I_{RL}$ FOR $D = .33$ $I_{CR1} = 2\ I_{RL}$ FOR $D = .50$ $I_{CR1} = 2.5\ I_{RL}$ FOR $D = .60$
$V_{RM}\begin{cases} V_{CR1} = 2\,V_{IN}\left(\frac{N2}{N1}\right) \\ V_{CR2} = 2\,V_{IN}\left(\frac{N2}{N1}\right)\end{cases}$	$V_O + 1$	$1.5\ V_{IN}$ FOR $D = .33$ $2\ V_{IN}$ FOR $D = .50$ $2.5\ V_{IN}$ FOR $D = .60$
		
SIMPLE, GOOD TRANSFORMER UTILIZATION. COLLECTOR CURRENT REDUCED AS A FUNCTION OF $\frac{N2}{N1}$. GOOD AT LOW VALUES OF V_{IN}.	CONTINUOUS INPUT AND OUTPUT CURRENT, HIGHEST EFFICIENCY, LOW RIPPLE, SMALLEST NUMBER OF SWITCHING COMPONENTS, SWITCHING LOSSES CUT IN HALF, DRIVE CIRCUIT REFERENCED TO GROUND. HIGHEST OPERATING FREQUENCY.	CONTINUOUS INPUT AND OUTPUT CURRENT, HIGHEST EFFICIENCY, VERY LOW RIPPLE, SMALLEST NUMBER OF SWITCHING COMPONENTS, SWITCHING LOSSES LOW, DRIVE CURRENT REFERENCED TO GROUND. HIGHEST OPERATING FREQUENCY.
CROSS CONDUCTION OF Q1, Q2 POSSIBLE, HIGH PARTS COUNT. TRANSFORMER DESIGN CRITICAL. POOR DYNAMIC RANGE. POOR TRANSIENT RESPONSE.	HIGH COLLECTOR CURRENT. C1 HAS HIGH RIPPLE CURRENT REQUIREMENT. HIGH VOLTAGE REQUIRED FOR Q1. POWER OUTPUT LIMITED.	C1 AND C2 HAVE HIGH RIPPLE CURRENT REQUIREMENTS. TRANSFORMER DESIGN CRITICAL. POWER OUTPUT IS LIMITED.

*For reliable operation, it is suggested and recommended that all voltage and current ratings be increased to 125% of the required maximum.