APPLE PRODUCTS INFORMATION PKG.

--ASTEC POWER SUPPLIES--

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DATE: 6-Aug-82

apple computer inc.

POWER SUPPLY SCHEMATICS AND COMPONENT LAYOUTS

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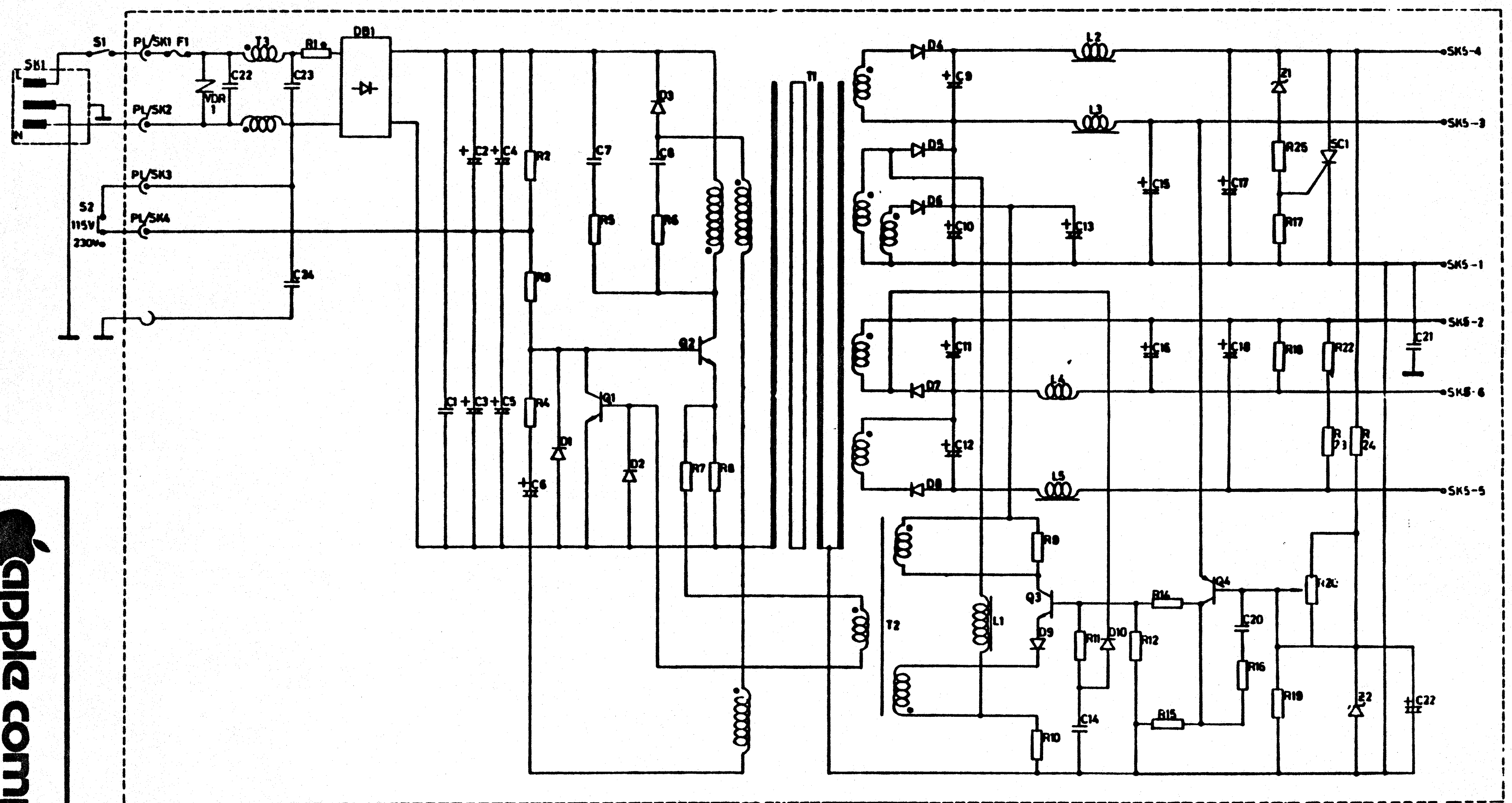
PLEASE NOTE

ASTEC Services, Ltd. may provide a suitable replacement with a different part number, depending on vendor availability. Also, not all ASTEC component parts are available from Apple Computer at this time. As of this release, we are in the process of obtaining piece part listings and costs to be entered onto the MIS Corporate system. When this has been done, all Service Sites will receive updated parts cross-reference listings and additional parts ordering information. The present cross-reference listing included in this package lists about 40% of the parts by Apple Part Number.



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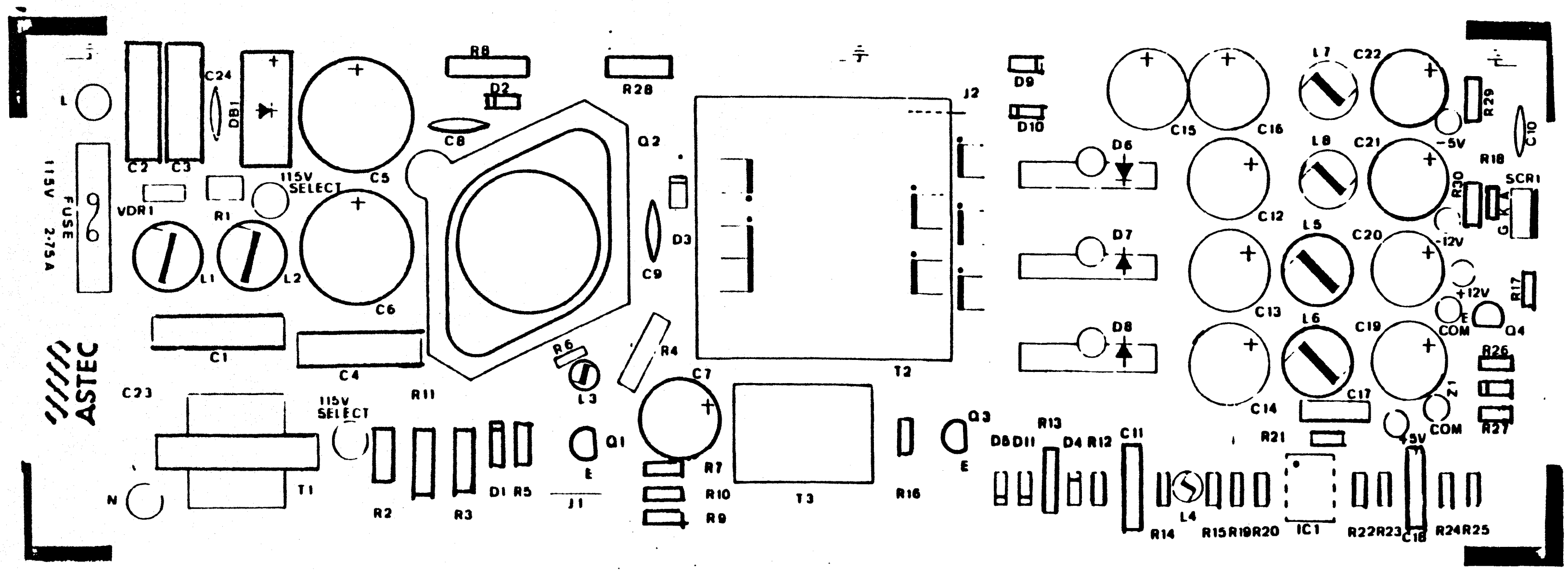
APPLE II

ASTEC #AA11040



APPLE II **ASTEC #AA11040**

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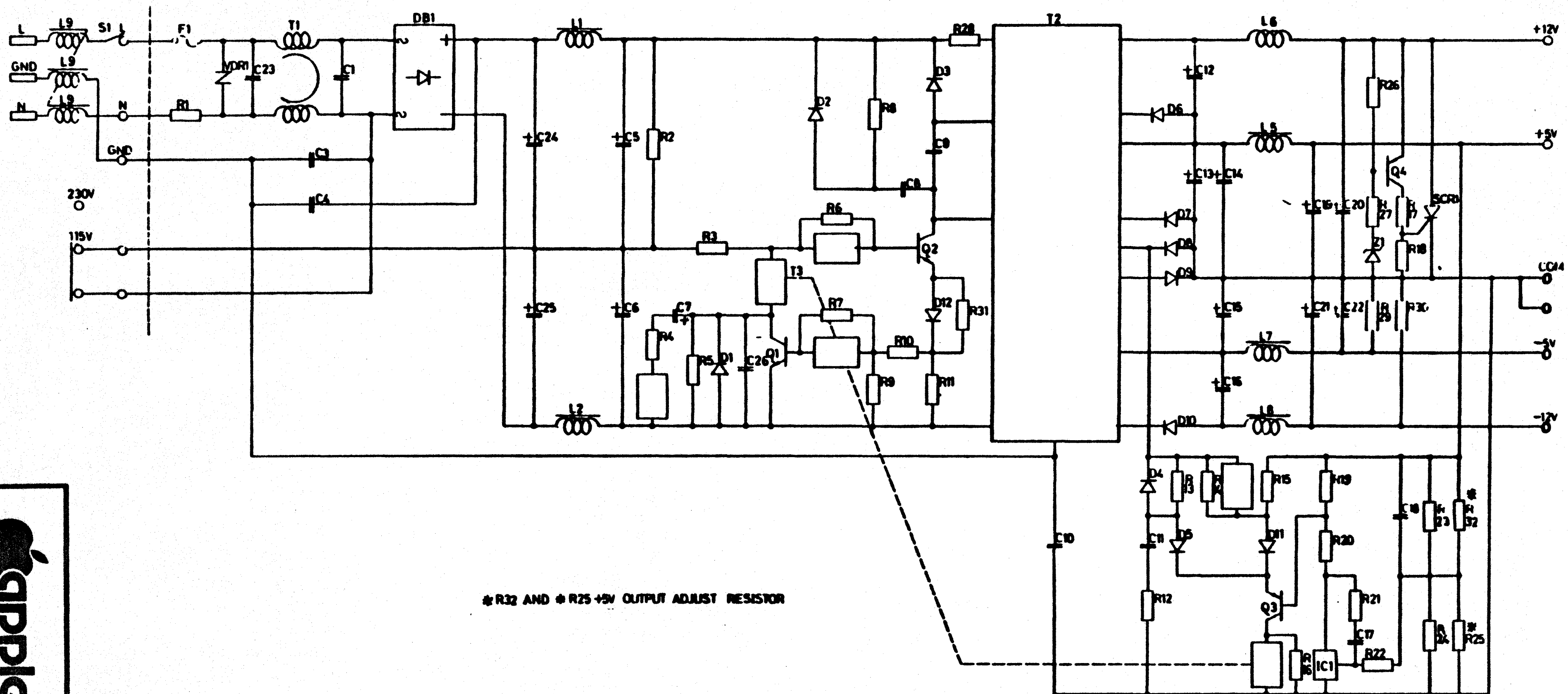

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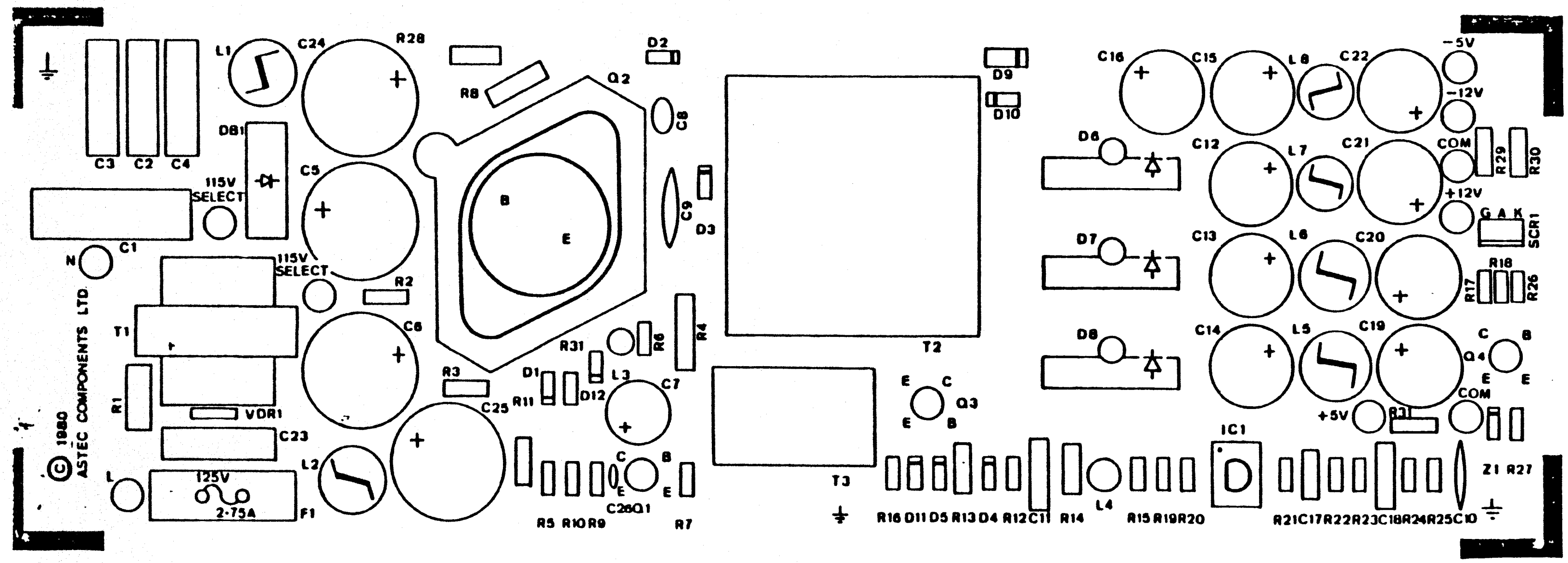

APPLE II **ASTEC #AA11040-B**

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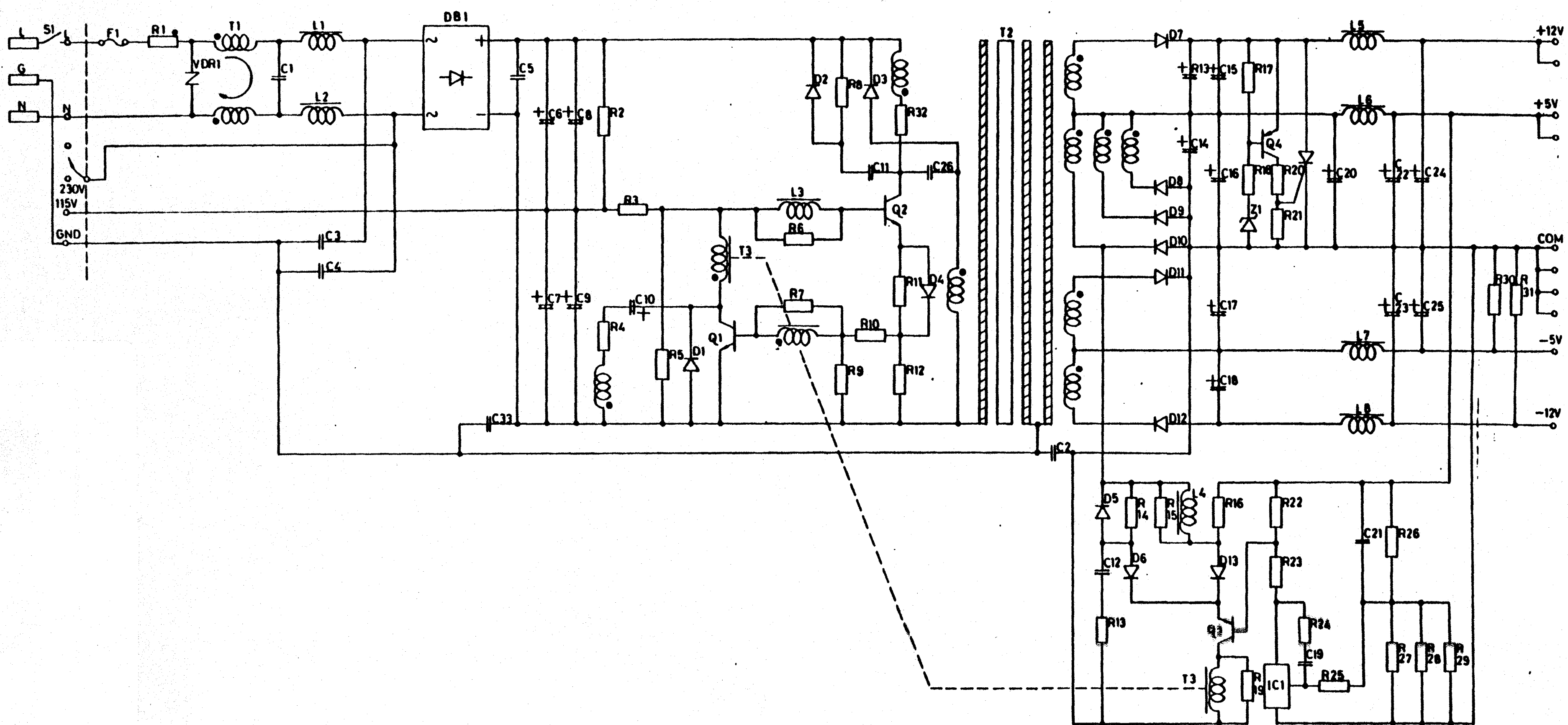

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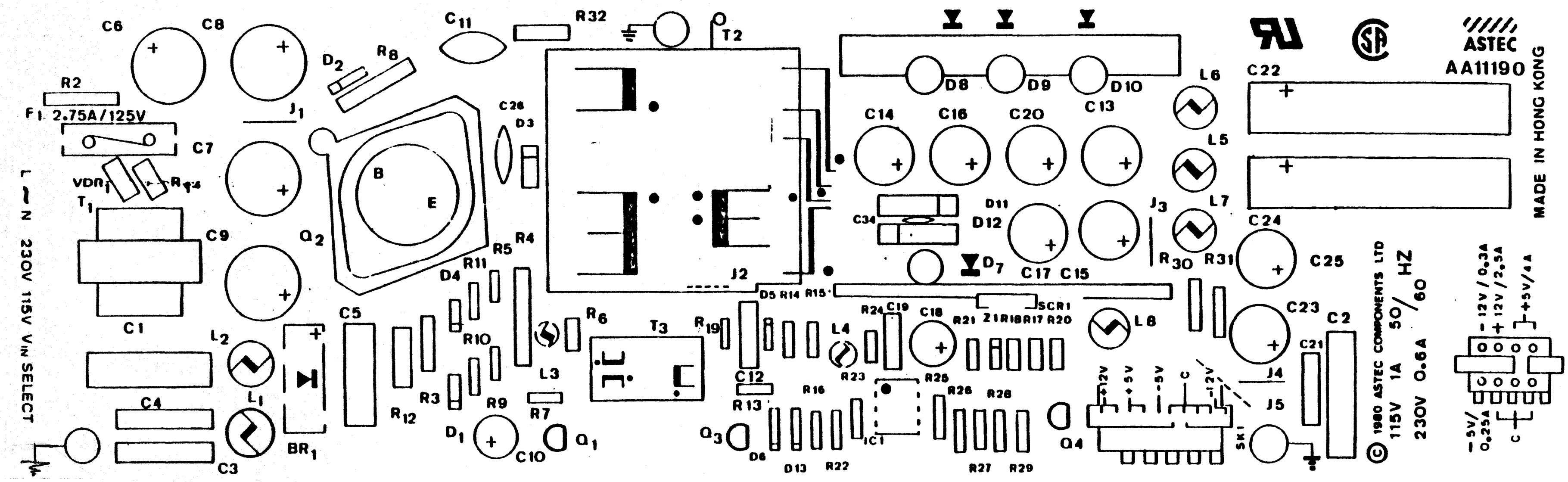
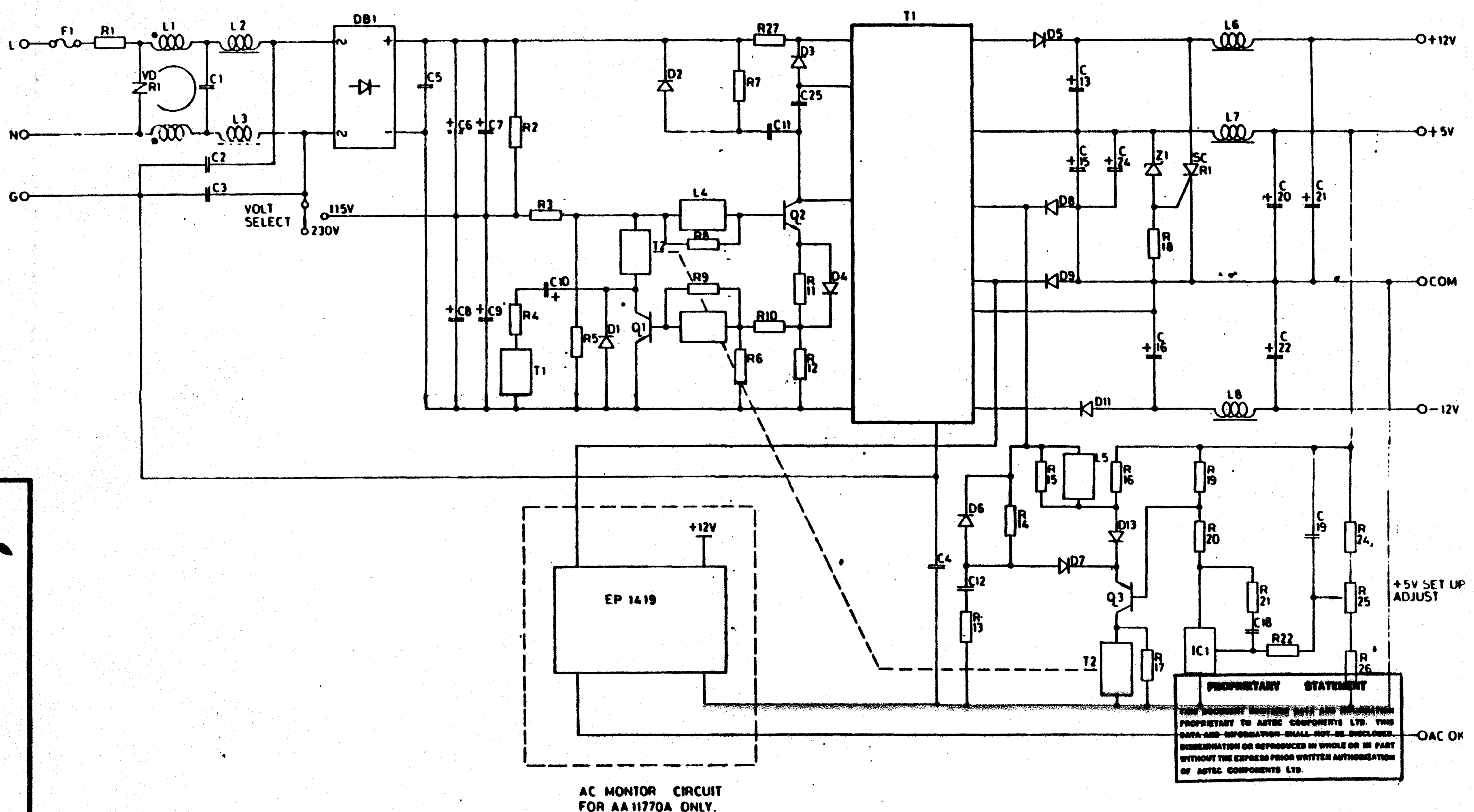


APPLE III

ASTEC #AA11190



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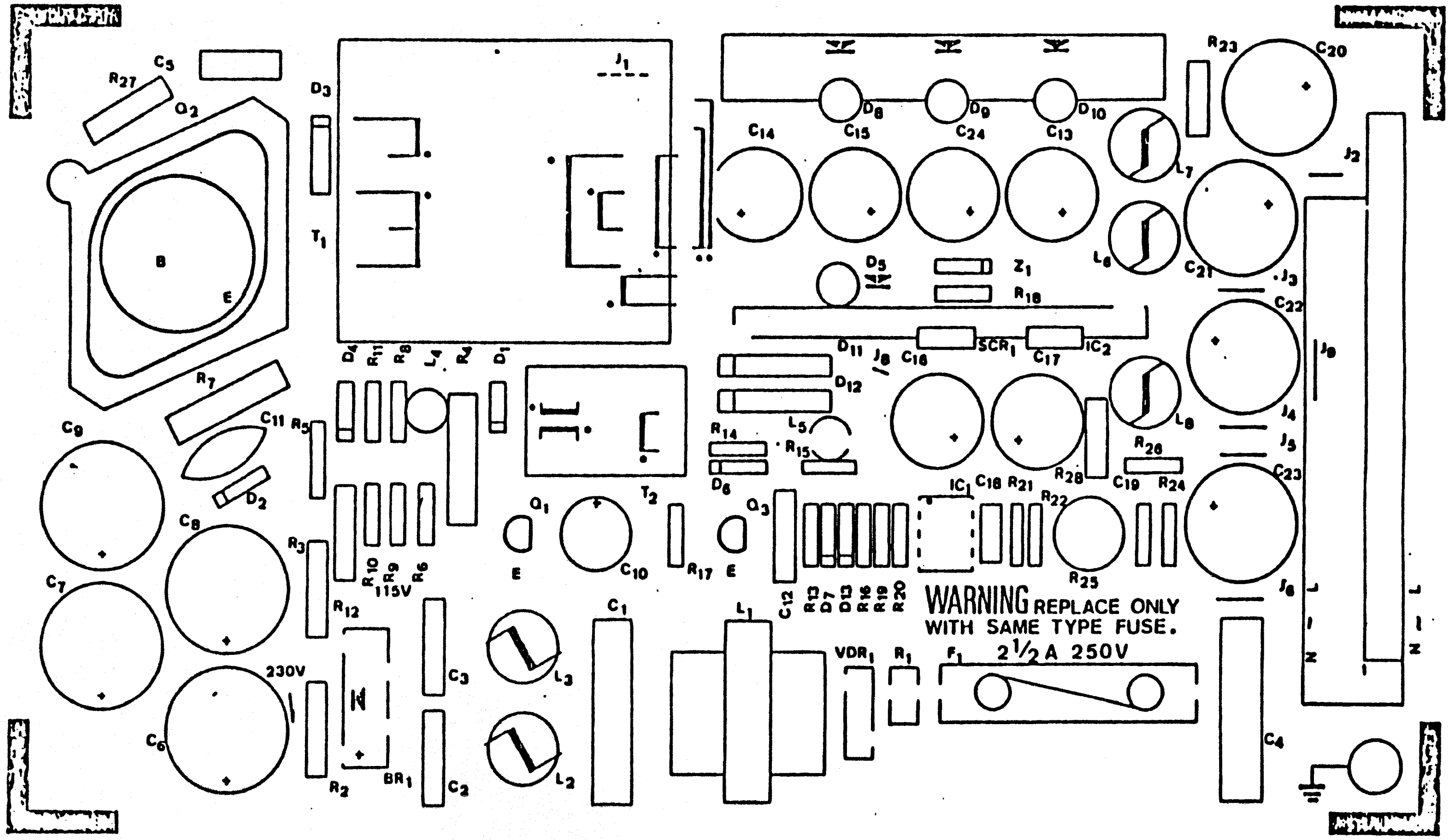
PROFILE III **ASTEC #AA11770**



PROFILE III **ASTEC #11770**

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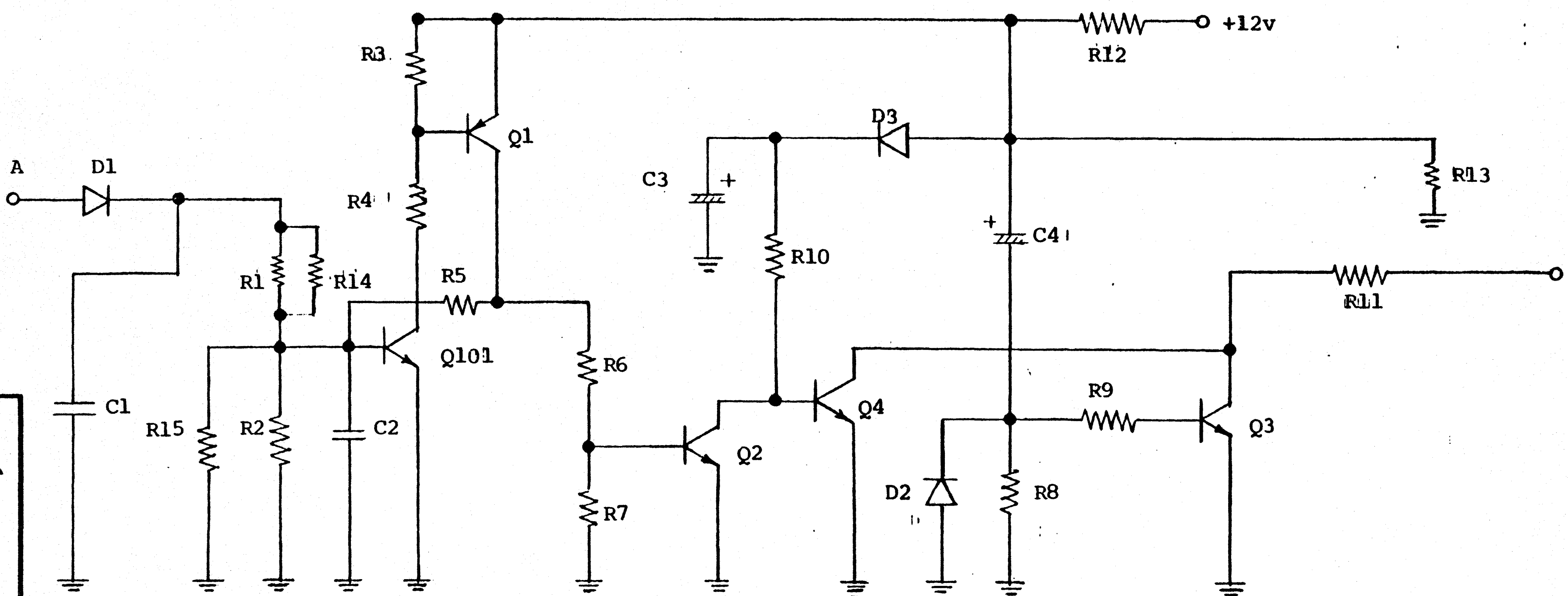
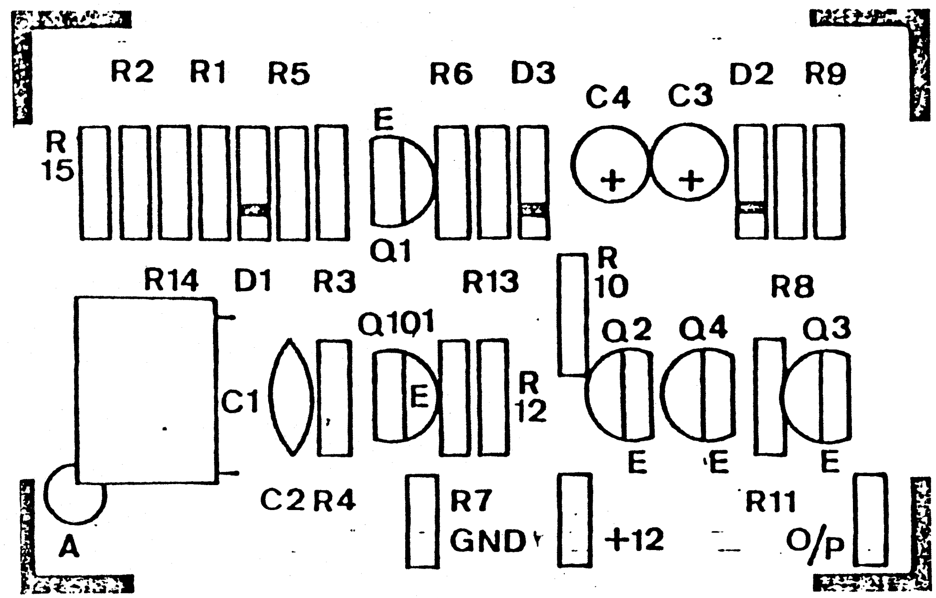


MONITOR BOARD - ASTEC #AA11770/A

PROFILE



MONITOR BOARD - ASTEC #AA11770/A

PROFILE

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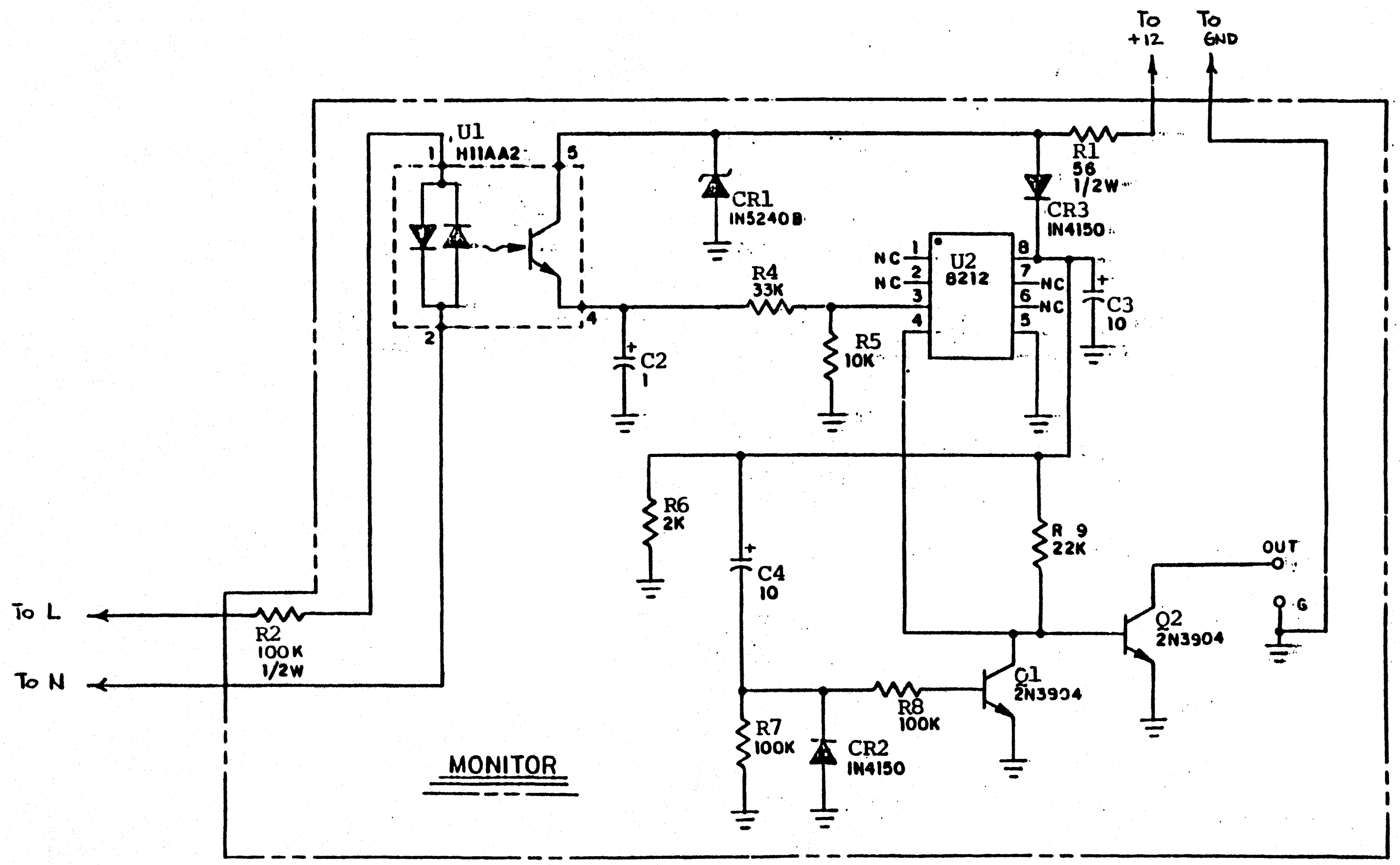

MONITOR BOARD - APPLE #656-0104

PROFILE

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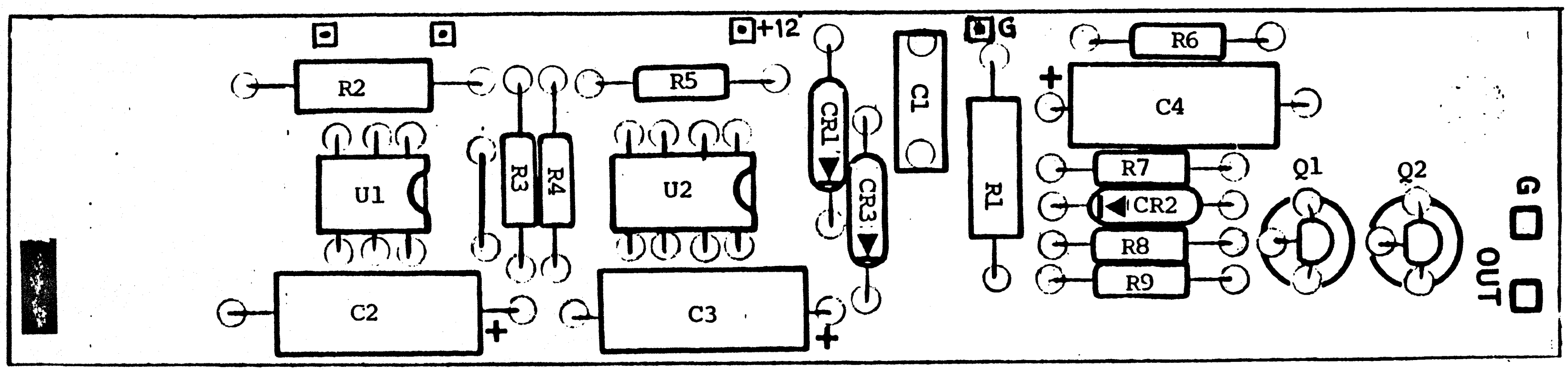

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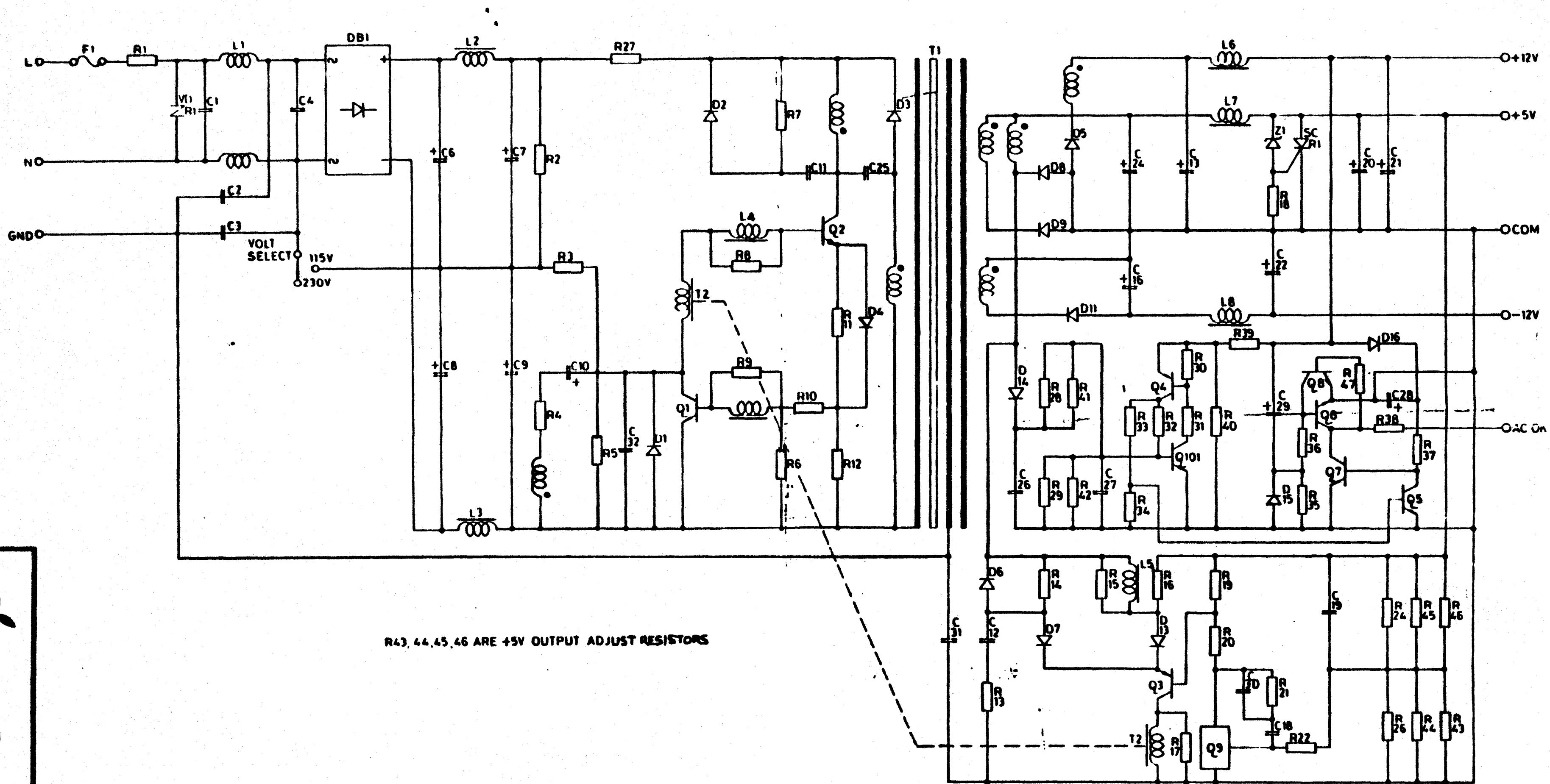
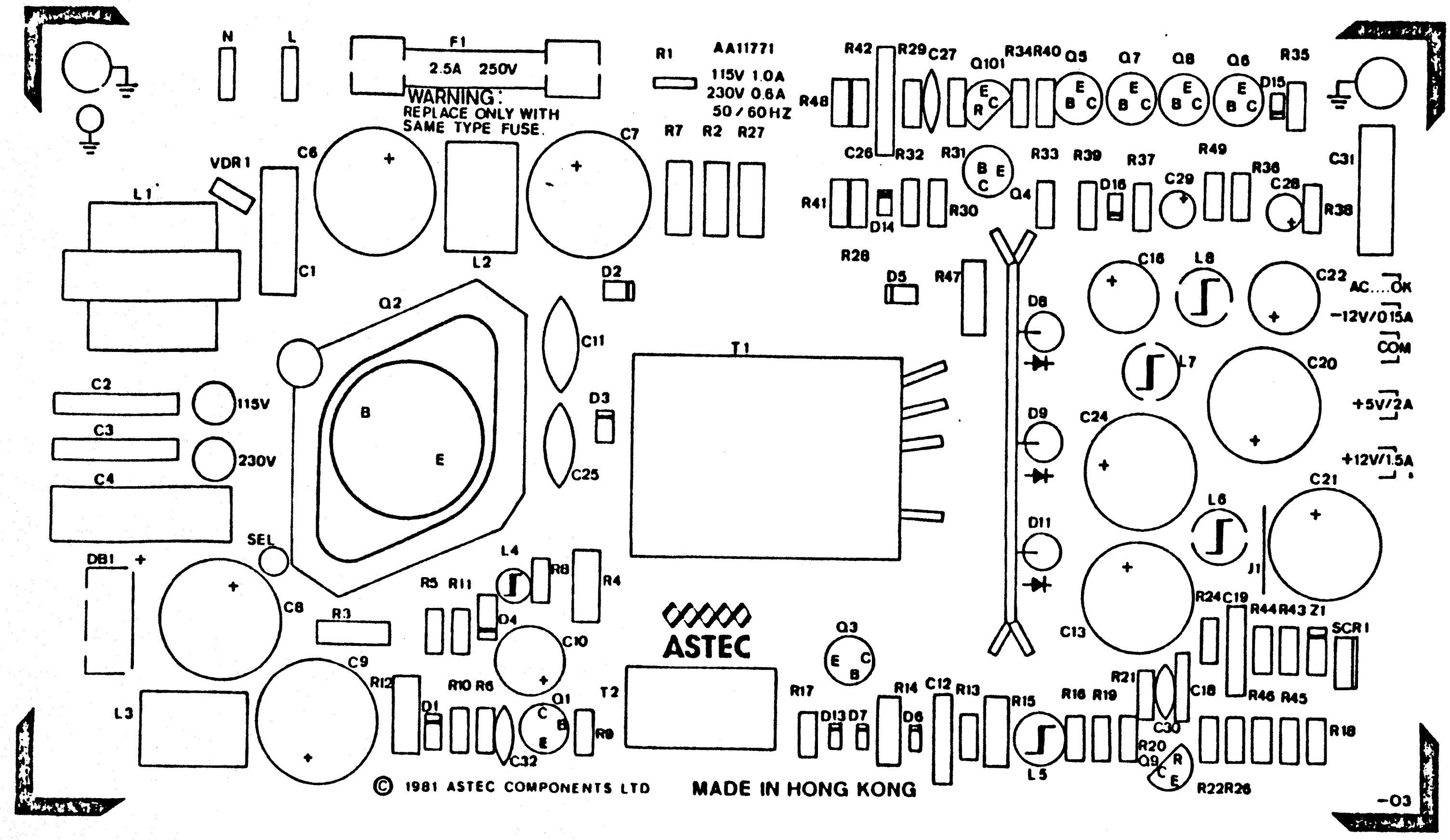
PROFILE



PROFILE III ASTEC #AA11771



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PROFILE III

ASTEC #AA11771

ASTEC 11040 STANDARD POWER SUPPLY

LOCATION	DESCRIPTION	VENDOR NO.
C1	POLYESTER CAPACITOR 0.1 UF 400V	058-10400100
C2	ELECTROLYTIC CAPACITOR 47 UF 250V	057-47020040
C3	ELECTROYLTIC CAPACITOR 47 UF 250V	057-47020040
C4	ELECTROYLTIC CAPACITOR 47 UF 250V	057-47020040
C5	ELECTROYLTIC CAPACITOR 47 UF 250V	057-47020040
C6	TANTALUM CAPACITOR 22 UF 16V	072-22600040
C7	CERAMIC CAPACITOR 1000 PF 3KV	055-10210001
C8	CERAMIC CAPACITOR 0.01 UF 1KV	055-10367325
C9	ELECTROYLITIC CAPACITOR 1000 UF 10V	057-10220020
C10	ELECTROYLITIC CAPACITOR 1000 UF 10V	057-10220020
C11	ELECTROYLITIC CAPACITOR 330 UF 16V	057-33120080
C12	ELECTROYLITIC CAPACITOR 220 UF 10V	057-22120060
C13	ELECTROYLITIC CAPACITOR 1000 UF 10V	057-10220020
C14	POLYESTER CAPACITOR 1000 PF 50V	058-10200020
C15	ELECTROYLITIC CAPACITOR 1000 UF 10V	057-10220020
C16	ELECTROYLITIC CAPACITOR 220 UF 10V	057-22120060
C17	ELECTROYLITIC CAPACITOR 680 UF 16V	057-68120010
C18	ELECTROYLITIC CAPACITOR 330 UF 16V	057-33120080
D1	RECTIFIER RPG10M	226-10400050
D2	SILICON DIODE 1N4150	212-10700050
D3	RECTIFIER RGP10M	226-10400100
D4	RECTIFIER/HEATSINK ASSEMBLY	853-00200020
D5	RECTIFIER/HEATSINK ASSEMBLY	853-00200020
D6	RECTIFIER/HEATSINK ASSEMBLY	853-00200020
D7	RECTIFIER RGP15B	226-10100040
D8	RECTIFIER RGP10B	226-10400070
D9	SILICON DIODE 1N4150	212-10700050
D10	SILICON DIODE 1N4150	212-10700050
D11	BLANK	
DB1	BRIDGE RECTIFIER KRP10	226-30500010
F1	FUSE 2.75 AMP 250 VOLTS	084-00200040
L1	CONTROL CHOKE COIL	328-00150016
L2	FILTER CHOKE COIL ASSEMBLY	TF-20100010
L3	FILTER CHOKE COIL ASSEMBLY	TF-20100050
L4	FILTER CHOKE COIL ASSEMBLY	TF-20100010
L5	FILTER CHOKE COIL ASSEMBLY	TF-20100020
Q1	TRANSISTOR NPN PE8050	209-11700382
Q2	TRANSISTOR NPN 2SC1358	209-10200020
Q3	TRANSISTOR NPN PE8050	209-11700382
Q4	TRANSISTOR PNP PE8550	210-11700322
R1	THERMISTER 4R @25 DEG.CEN +-10%	258-40970015
R2	RESISTOR CARBON FILM 2.2M +-5%	240-22506033

COMPONENT LISTING - ASTEC AA11040

R3	RESISTOR CARBON FILM 2.2M +-5%	240-22506033
R4	RESISTOR CARBON FILM 82R +-5%	240-82006033
R5	RESISTOR METAL OXIDE FILM 27R	248-27006052
R6	RESISTOR CARBON FILM 4.7R +-5%	240-47906033
R7	RESISTOR CARBON FILM 10R +-5%	240-10006022
R8	RESISTOR METAL FILM 0.33R +-5%	247-03386054
R9	RESISTOR CARBON FILM 180R +-5%	240-18106022
R10	RESISTOR CARBON FILM 12R +-5%	240-12006022
R11	RESISTOR CARBON FILM 470R +-5%	240-47106022
R12	RESISTOR CARBON FILM 1K +-5%	240-10206022
R13	BLANK	
R14	RESISTOR CARBON FILM 1K +-5%	240-10206022
R15	RESISTOR CARBON FILM 330R +-5%	240-33106022
R16	RESISTOR CARBON FILM 5.6K +-5%	240-56206022
R17	RESISTOR CARBON FILM 27R +-5%	240-27006022
R18	RESISTOR CARBON FILM 82R +-5%	240-82006033
R19	RESISTOR CARBON FILM 1K +-5%	240-10206022
R20	RESISTOR CARBON FILM 2.7K +-5%	240-27206022
R21	BLANK	
R22	RESISTOR CARBON FILM 100R +-5%	240-10106033
R23	RESISTOR CARBON FILM 100R +-5%	240-10106033
R24	RESISTOR CARBON FILM 390R +-5%	240-39106022
SC1	SILICON CONTROL RECTIFIER 2P 05M	227-12500010
T1	POWER TRANSFORMER ASSEMBLY	TF-10200370
T2	CONTROL TRANSFORMER ASSEMBLY	TF-10200200
T3	COMMON MODE TRANSFORMER ASSEMBLY	TF-20200010
Z1	ZENER DIODE 12.2V +-0.2V	222-12295001
Z2	ZENER DIODE 6.8V +-0.2V	222-06895003
VDR1	VARISTOR 260VAC	256-26100014
PCB	PRINTED CIRCUIT BOARD (NO PART'S)	042-02012202
CASE	SWITCH (ROCKER TYPE)	278-01200020
CASE	AC IMPUT SOCKET (THREE PRONG GROUND)	149-00200010
CASE	VOLTAGE SELECTION SWITCH 115/230	283-02200100
(CASE)	BOTTOM PLATE 1.6 AL SHEET	403-03100700
(CASE)	COVER (TOP) 1.6 AL SHEET	403-03100810

ASTEC POWER SUPPLY AA11040B

LOCATION	DESCRIPTION	VENDOR NO.
C1	MP CAP 0.1 UF +-20% 250 VAC	068-10400010
C3	CER CAP 2200 PF +-20% 400 VAC	055-22200010
C4	CER CAP 2200 PF +-20% 400 VAC	055-22220001
C5	ELEC CAP 47 UF +100-10% 250V	057-47020040
C6	ELEC CAP 47 UF +100-10% 250V	057-47020040
C7	ELEC CAP 220 UF +50 -10% 10V	057-22220080
C8	CER CAP 47 PF +-20% 3KV 250	055-47167728
C9	CER CAP 0.01 UF +-20% 1KV 25U	055-10358925
C10	CER CAP 0.01 UF +-20% 1KV 25V	055-10358925
C11	POLY CAP 0.22 UF +-10% 100V	058-22400120
C12	ELEC CAP 1000 UF +100 -10% 10V	057-10220020
C13	ELEC CAP 1000 UF +100 -10% 10V	057-10220020
C14	ELEC CAP 1000 UF +100 -10% 10V	057-10220020
C15	ELEC CAP 220 UF +100 -10% 10V	057-22120060
C16	ELEC CAP 220 UF +100 -10% 10V	057-22120060
C17	POLY CAP 0.022 UF +-20% 100V	058-22300080
C18	POLY CAP 0.22 UF +-10% 100V	058-22400120
C19	ELEC CAP 1000 UF +100 -10% 10V	057-10220020
C20	ELEC CAP 580 UF +100 -10% 16V	057-68120010
C21	ELEC CAP 330 UF +100 -10% 16V	057-33120080
C22	ELEC CAP 330 UF +100 -10% 16V	057-33120080
C23	CER CAP 0.01 UF +-20% 1KV 25U	055-10368925
C24	ELEC CAP 47 UF +100 -10% 250V	057-47020040
C25	ELEC CAP 47 UF +10 -10% 250V	057-47020040
D1	RECTIFIER RPG10A	226-10400050
D2	RECTIFIER RPG10M	225-10400100
D3	RECTIFIER RPG10M	226-10400100
D4	SILICON DIODE 1N4606	212-10700210
D5	SILICON DIODE 1N4606	212-10700210
D6	RECTIFIER ASSY	853-00200210
D7	RECTIFIER ASSY	853-00200210
D8	RECTIFIER ASSY	853-00200210
D9	RECTIFIER RGPA5B	226-11100040
D10	RECTIFER RGP158	226-10400070
D11	SILICON DIODE 1N4606	212-10700210
D12	RECTIIER RGP158	225-10200040
DB1	BRIDGE RECTIFIER KBP10	225-30500010
F1	FUSE 2.75A 125V	084-00200040
ICI	IC TL431CP/TL431CLP	211-10300100
L1	CHOKE COIL ASSY	852-20100140
L2	CHOKE COIL ASSY	852-20100140
L3	BASE CHOKE 2.2 UH	328-00100030
L4	CHOKE 1.5 MH (PROPRIETARY)	328-00100010
L5	CHOKE COIL ASSY	852-10100370

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COMPONENT LISTING - ASTEC AA11040B

L6	CHOKE COIL ASSY	328-20100010
L7	CHOKE COIL	852-10100490
L8	CHOKE COIL	852-10100490
Q1	NPN TRANSISTOR 2SD592NC	209-11700400
Q1	NPN TRANSISTOR 2SD467C	209-11700460
Q2	NPN TRANSISTOR 2SC1875	209-10200030
Q3	PNP TRANSISTOR 2SB621NC	210 11700330
Q3	PNP TRANSISTOR 2SB561C	210-11700350
Q4	PNP TRANSISTOR 2SB621NC	210-11700330
R1	THERMISTOR 4R +-10% OR 5R	258-40970015
R2	RESISTOR METAL FILM 150K +-5% 1/2 W	240-15406033
R3	RESISTOR METAL FILM 150K +-5% 1/2 W	240-15406033
R4	RESISTOR METAL OXY FILM 27R +-5% 2 W	248-27006063
R5	RESISTOR CARBON FILM 1K +-5% 1/2 W	240-10206022
R6	RESISTOR CARBON FILM 27R +-5% 1/2 W	240-27006022
R7	RESISTOR CARBON FILM +-5% 1/4W 68R	240-68006022
R8	RESISTOR METAL OXY FILM 120R +-5% 1W	248-12106052
R9	RESISTOR CARBON FILM 8.2R +-5% 1/4 W	240-82906022
R10	RESISTOR CARBON FILM 10R +-5% 1/4 W	240-10006022
R11	RESISTOR METAL FILM 0.56 +-5% 1W	247-05686054
R12	RESISTOR CARBON FILM 68R+-5% 1/4W	240-68006022
R13	RESISTOR CARBON FILM 270R +-5% 1/2W	240-27106033
R14	RESISTOR CARBON FIM D270R +-5% 1/2W	240-27106033
R15	RESISTOR CARBON FILM 8.2R +-5% 1/2W	240-39106022
R16	RESISTOR CARBON FILM 390R +-5% 1/4W	240-39106022
R17	RESISTOR CARBON FILM 22R +-5% 1/2W	240-22006022
R18	RESISTOR CARBON FILM 100R +-5% 1/4W	240-10106022
R19	RESISTOR CARBON FILM +-5% 1/4W 56R	240-56006022
R20	RESISTOR CARBON FILM 56R +-5% 1/2W	240-56006022
R21	RESISTOR CARBON FILM 12K +-5% 1/4W	240-12306022
R22	RESISTOR CARBON FILM 470R +-5% 1/4W	224-27106022
R23	RESISTOR METAL FILM 2.7K +-2% 1/4W	247-27015022
R24	RESISTOR METAL FILM 2.7K +-2% 1/4W	247-27015022
R25	RESISTOR CARBON FILM 100K +-5% 1/4W	240-10406022
R26	RESISTOR CARBON FILM 680R +-5% 1/4W	240-68106022
R27	RESISTOR CARBON FILM 1.8K +-5% 1/4W	240-18206022
R28	RESISTOR METAL FILM +-5% 1W 1R	247-10086-54
R29	RESISTOR METAL FILM +-5% 1/4W 32R	240-82006033
R30	RESISTOR METAL OXY FILM 220R +-5% 1W	248-22106052
R31	RESISTOR CARBON FILM 224 +-5% 1/4W	240-22006022
SCR1	SCR C122U/2N695	227-13000010
T1	COMMON MODE TRANSFORMER ASSY	852-20200950
T2	POWER TRANSFORMER ASSY	852-10200940
T3	POWER TRANSFORMER ASSY (SUB)	852-10200680
Z1	ZENER DIODE 9.8V +-0.2V (2K7)	222-98085002
VDR1	VDR 260 VAC	256-26100014
CASE	VOLTAGE SELECTION SWITCH 115/230V	283-02200100

COMPONENT LISTING - ASTEC AA11040B

CASE	SWITCH ROCKER	278-01200020
CASE	AC INPUT SOCKET	149-00200010
CASE	BOTTOM PLATE 1.6 AL SHEET	403-03100700
CASE	COVER (TOP) 1.6 AL SHEET	403-03100810

COMPONENT LISTING - ASTEC AA11190

CODE	DESCRIPTION	PART NUMBER
BR1	Bridge rectifier KBP10	226-30500010
C1	Metallized paper cap 0.22uF 250VAC	068-22400010
C2	Metallized paper cap 0.1uF 250VAC	068-10400010
C3	Ceramic cap 4700pF 400VAC	055-47220001
C4	Ceramic cap 4700pF 400VAC	055-47220001
C5	Polyester cap 0.1uF 400V	058-10400100
C6	Electrolytic cap 100uF 250V	057-10120170
C7	Electrolytic cap 100uF 250V	057-10120170
C8	Electrolytic cap 100uF 250V	057-10120170
C9	Electrolytic cap 100uF 250V	057-10120170
C10	Electrolytic cap 220uF 10V	057-22120080
C11	Ceramic cap 0.001uF 3KV	055-10261328
C12	Polyester cap 0.22uF 100V	058-22400120
C13	Electrolytic cap 1000uF 10V	057-10220020
C14	Electrolytic cap 1000uF 10V	057-10220020
C15	Electrolytic cap 1000uF 10V	057-10220020
C16	Electrolytic cap 1000uF 10V	057-10220020
C17	Electrolytic cap 330uF 16V	057-33120080
C18	Electrolytic cap 22ouF 10V	057-22120060
C19	Polyester cap 0.022uF 100V	058-22300080
C20	Electrolytic cap 1000uF 10V	057-10220020
C21	Polyester cap 0.22uF 100V	058-22400120
C22	Electrolytic cap 1000uF 10V	057-10220020
C23	Electrolytic cap 330uF 16V	057-33120080
C24	Electrolytic cap 680uF 16V	057-68120010
C25	Electrolytic cap 330uF 16V	057-33120080
C26	Ceramic cap 0.1/1KV	055-10360925
D1	Rectifier RGP10A	226-10400050
D2	Rectifier RGP10M	226-10400100
D3	Rectifier RGP10M	226-10400100
D4	Rectifier 1N4001GP	226-10400080
D5	Silicon diode 1N5282	212-10700200

CODE	DESCRIPTION	PART NUMBER
D6	Silicon diode 1N5282	212-10700200
D7	Rectifier / SCR assembly	853-00700010
D8	Rectifier assembly	853-00200140
D9	Rectifier assembly	853-00200140
D10	Rectifier assembly	853-00200140
D11	Schottky diode S3SC3M	212-31100030
D12	Rectifier RG3B	226-10700010
D13	Silicon diode 1N5282	212-10700200
F1	Fuse 2.75A 125V	084-00200040
IC1	Regulator TL431CP	211-10800070
J1	Jumper wire	358-80810011
J2	Jumper wire	358-80810011
J3	Jumper wire	358-80810011
J4	Jumper wire	358-80810011
J5	Jumper wire	358-80800001
L1	choke	852-20100350
L2	Choke	852-20100350
L3	Base choke	328-00100030
L4	Choke 1.5mH	328-00100010
L5	Choke coil assemb;y	852-20100010
L6	Choke coil	852-10100370
L7	Choke coil	328-00100060
L8	Choke coil	328-00100060
Q1	Transistor SD467	209-11700463
Q2	Transistor 2SC1358	209-10200010
Q3	Transistor SB561	210-11700353
Q4	Transistor SB561	210-11700353

COMPONENT LISTING - ASTEC AA11190

CODE	DESCRIPTION	PART NUMBER
R1	Thermistor 4R @25°C +-10%	258-40970015
	6R @ 25°C +-20%	258-60990010
R2	Resistor carbon film 150K +-5% ¼W	240-15406033
R3	Resistor carbon film 150K +-5% ¼W	240-15406033
R4	Resistor metal oxide film +-5% 47R 2W	248-47006063
R5	Resistor carbon film +-5% ¼W 1.2K	240-12206022
R6	Resistor carbon film 5.6R +-5% ¼W	240-56906022
R7	Resistor carbon film +-5% 56R ¼W	240-56006022
R8	Resistor metal oxide film +-5% 120R 2W	248-12106063
R9	Resistor carbon film +-5% ¼W 15R	240-15006022
R10	Resistor carbon film +-5% ¼W 10R	240-10006022
R11	Resistor carbon film +-5% ¼W 15R	240-15006022
R12	Resistor metal film 0.47R	247-04786054
R13	Resistor carbon film +-5% ¼W 39R	240-39006022
R14	Resistor carbon film +-5% 270R ¼W	240-27106033
R15	Resistor carbon film +-5% 270R ¼W	240-27106033
R16	Resistor carbon film 8.2R +-5% ¼W	240-82906022
R17	Resistor carbon film +-5% 680R ¼W	240-68106022
R18	Resistor carbon film +-5% 2.7K ¼W	240-27206022
	2.2K	240-22206022
	1.8K	240-18206022
R19	Resistor carbon film +-5% 560R ¼W	240-56106022
R20	Resistor carbon film 22R ¼W +-5%	240-22006022
R21	Resistor carbon film 100R +-5% ¼W	240-10106022
R22	Resistor carbon film 56R +-5% ¼W	240-56006022
R23	Resistor carbon film 56R +-5% ¼W	240-56006022
R24	Resistor carbon film 12K +-5% ¼W	240-12306022
R25	Resistor carbon film +-5% ¼W 470R	240-47106022
R26	Resistor metal film +-2% 2.7K ¼W	247-27015022
R27	Resistor metal film +-2% 2.7K ¼W	247-27015022
R28	Resistor carbon film 100K +-5% ¼W	240-10406022
R29	Resistor carbon film 100K +-2% ¼W	240-10406022
R30	Resistor metal oxide film +-5% 56R 1W	248-56006052
R31	Resistor metal oxide film +-5% 220R 1W	248-22106052

COMPONENT LISTING - ASTEC AA11190

CODE	DESCRIPTION	PART NUMBER
R32	Resistor metal film 1R 1W	247-10086054
T1	Common mode choke assembly	852-20200010
T2	Power transformer assembly	852-10200760
T3	Control transformer assembly	852-10200680
VDR1	Varistor 260VAC	256-26100014
Z1	Zener diode 9.6 to 10.0V @1mA	222-98085002

COMPONENT LISTING - ASTEC AA11770

CODE	DESCRIPTION		PART NO.
BR1	Bridge rectifier KBP10		226-30500010
C1	MP cap 0.1uF +-20% 250VAC		068-10400010
C2	Cer cap 2200pF +-20% 400VAC		055-22220001
C3	Cer cap 2200pF +-20% 400VAC		055-22220001
C4	MP cap 0.1uF +-20% 250VAC		068-10400010
C5	Poly cap 0.1uF +-10% 400V		058-10400100
C6	Elect cap 47uF +100 -10% 250V		057-47020040
C7	Elect cap 47uF +100 -10% 250V		057-47020040
C8	Elect cap 47uF +100 -10% 250V		057-47020040
C9	Elect cap 47uF +100 -10% 250V		057-47020040
C10	Elect cap 220uF +50 -10% 10V		057-22120080
C11	Cer cap 470pF +-20% 3KV Z5P		055-47167728
C12	Poly cap 0.22uF +-10% 100V		058-22400120
C13	Elect cap 1000uF +100 -10% 10V		057-10220020
C14	——		——
C15	Elect cap 1000uF +100 -10% 10V		057-10220020
C16	Elect cap 330uF +-20% 16V		057-33120120
C17	——		——
C18	Poly cap 0.022uF +-20% 100V		058-22300080
		or	058-22300090
C19	Poly cap 0.22uF +-10% 100V		058-22400120
		or	058-22400240
C20	Elect cap 1000uF +50 -10% 25V		057-10220040
C21	Elect cap 470uF +50 -10% 25V		057-47120110
C22	Elect cap 470uF +50 -10% 25V		057-47120110
C23	——		——
C24	Elect cap 1000uF +100 -10% 10V		057-10220020
C25	Cer cap 0.01uF +-20% 1KVZ5U		055-10368925
D1	Rectifier RGP10B		226-10400070
D2	Rectifier RGP10J		226-10400060
D3	Rectifier RGP10M		226-10400100
D4	Rectifier RGP15B		226-10100040

COMPONENT LISTING - ASTEC AA11770

CODE	DESCRIPTION	PART NO.
D5	Rectifier 3S4M	226-11400010
D6	Silicon diode 1N4606	212-10700210
D7	Silicon diode 1N4606	212-10700210
D8	Schottky diode S3SC3M	212-31100030
D9	Schottky diode S3SC3M	212-31100030
D10	——	——
D11	Rectifier RGP10B	226-10400070
D12	——	——
D13	Silicon diode 1N4606	212-10700210
F1	Fuse 2.5A 250V 3AG	084-00200060
IC1	IC TL431CLP	211-10800100
IC2	-	-
J1	Jumper wire 10.2mm	358-10920011
J2	Jumper wire dia 0.8mm L=3.0mm	358-80810011
J3	Jumper wire 10.2mm	358-10920011
J4	Jumper wire 10.2mm	358-10920011
J5	——	——
J6	Jumper wire 10.2mm	358-10920011
J7	——	——
J8	Jumper wire dia 0.8mm	358-80810011
J9	——	——
L1	Common mode choke assembly	852-20200120
L2	Toroid	124-00000110
L3	Toroid	124-00000110
L4	Base choke 2.2uH	328-00100030
L5	Choke 1.5mH	328-00100010
L6	Choke coil assembly	852-20100010
L7	Choke coil assembly	852-10100370
L8	Choke coil assembly	852-10100490

COMPONENT LISTING - ASTEC AA11770

CODE	DESCRIPTION		PART NO.
Q1	NPN transistor SD467		209-11700460
		or	209-11700400
Q2	NPN transistor 2SC1875		209-10200030
Q3	PNP transistor SB561		210-11700350
		or	210-11700330
R1	Thermistor 4R +-10%		258-40970015
		or	258-50990010
		or	258-60990010
R2	Resistor carbon film 150K +-5% ¼W		240-15406033
R3	Resistor carbon film 150K +-5% ¼W		240-15406033
R4	Resistor metal oxide film 68R +-5% 1W		248-68006052
R5	Resistor carbon film 820R +-5% ¼W		240-82106022
R6	Resistor carbon film 5.6R +-5% ¼W		240-56906022
R7	Resistor metal oxide film 120R +-5% 1W		248-12106052
R8	Resistor carbon film 5.6R +-5% ¼W		240-56906022
R9	Resistor carbon film 47R +-5% ¼W		240-47006022
R10	Resistor carbon film 10R +-5% ¼W		240-10006022
R11	Resistor carbon film 5.6R +-5% ¼W		240-56906022
R12	Resistor metal film 0.47R +-5% 1W		247-04786054
R13	Resistor carbon film 39R +-5% ¼W		240-39006022
R14	Resistor carbon film 270R +-5% ¼W		240-27106033
R15	Resistor carbon film 330R +-5% ¼W		240-33106033
R16	Resistor carbon film 8.2R +-5% ¼W		240-82906022
R17	Resistor carbon film 330R +-5% ¼W		240-33106022
R18	Resistor carbon film 12R +-5% ¼W		240-12006022
R19	Resistor carbon film 56R +-5% ¼W		240-56006022
R20	Resistor carbon film 56R +-5% ¼W		240-56006022
R21	Resistor carbon film 12K +-5% ¼W		240-12306022
R22	Resistor carbon film 470R +-5% ¼W		240-47106022
R23	———		———
R24	Resistor carbon film 2.2K +-5% ¼W		240-22206022
R25	Trimpot 1K +-20%		254-10280014
R26	Resistor carbon film 2.2K +-5% ¼W		240-22206022
R27	Resistor metal film 1R +-5% 1W		247-10086054

COMPONENT LISTING - ASTEC AA11770

CODE	DESCRIPTION	PART NO.
R28	-	-
T1	Power transformer ass'y	852-10201210
T2	Control transformer ass,y	852-10200680
SCR1	SCR C122U	227-13000010
VDR1	VDR 260VAC	256-26100014
I/P connector	Locking header 2cct	146-00200490
O/P Connector	Locking header 12cct	146-00200500

COMPONENT LISTING - ASTEC AA11770A

CODE	DESCRIPTION	PART NUMBER
C1	Cap Poly 0.22uF 100V	058-22400120
C2	Cap Ceramic 0.01uF 100V	055-10382125
C3	Cap Tant 10uF 25V	072-10600070
C4	Cap Tant 10uF 25V	072-10600070
D1	Diode IN4606	212-10700210
D2	Diode IN4606	212-10700210
D3	Diode IN4606	212-10700210
R1	Resistor CF 12K 5% ¼W	240-12306022
R2	Resistor CF 2.7K 5% ¼W	240-27206022
R3	Resistor CF 100R 5% ¼W	240-10106022
R4	Resistor CF 470R 5% ¼W	240-47106022
R5	Resistor CF 100K 5% ¼W	240-10406022
R6	Resistor CF 100K 5% ¼W	240-10406022
R7	Resistor CF 10K 5% ¼W	240-10306022
R8	Resistor CF 100K 5% ¼W	240-10406022
R9	Resistor CF 100K 5% ¼W	240-10406022
R10	Resistor CF 100K 5% ¼W	240-10406022
R11	Resistor CF 47R 5% ¼W	240-47006022
R12	Resistor CF 47R 5% ¼W	240-47006022
R13	Resistor CF 2.2K 5% ¼W	240-22206022
R14	Resistor CF 470K 5% ¼W	240-47406022
R15	Resistor CF 100K 5% ¼W	240-10406022
Q1	2SB561C	210-11700353
Q2	2SD467C	209-11700463
Q3	2SD467C	209-11700463
Q4	2SD467C	209-11700463
Q101	TL431CLP	211-10800100

COMPONENT LISTING - APPLE MONITOR #656-0104

CODE	DESCRIPTION	APPLE PART #
C1	(not used)	
C2	Capacitor, 1uF, 20%, 35v	048 127-0001
C3	Capacitor, 10uF, 20%, 16v	049 127-0101
C4	Capacitor, 10uF, 20%, 16v	049 127-0101
CR1	Diode, Zener 5%, 10v	050 371-5240
CR2	Diode, Switching 1N4150 50v	035 371-4150
CR3	Diode, Switching 1N4150 50v	035 371-4150
R1	Resistor 56 ohm 1/2w 5%	041 101-2560
R2	Resistor 100K ohm 1w 10%	042 107-0023
R3	(not used)	
R4	Resistor 33K ohm 1/4w 5%	043 101-4333
R5	Resistor 10K ohm 1/4w 5%	045 101-4103
R6	Resistor 2K ohm 1/4w 5%	047 101-4202
R7	Resistor 100K ohm 1/4w 5%	044 101-4104
R8	Resistor 100K ohm 1/4w 5%	044 101-4104
R9	Resistor 22K ohm 1/4w 5%	046 101-4223
Q1	Transistor, NPN Sw.& Amp. 2N3904	003 372-3904
Q2	Transistor, NPN Sw.& Amp. 2N3904	003 372-3904
U1	Transistor, NPN Optocoupler	054 327-0011
U2	Voltage Detector/Indicator, 8 Pin	055 353-8212

COMPONENT LISTING - ASTEC AA11771

CODE	DESCRIPTION		PART NUMBER
BR1	Bridge rectifier KBP10		226-30500010
C1	MP cap 0.01uF +-20% 250VAC		068-10300010
C2	Cer cap 2200pF +-20% 400VAC		055-22220001
	MP cap 2200pF +-20% 250VAC	or	068-22200020
C3	Cer cap 2200pF+-20% 400VAC		055-22220001
	MP cap 2200pF +-20% 250VAC	or	068-22200020
C4	MP cap 0.1uF +-20% 250VAC		068-10400010
C6	Elect cap 47uF +100-10% 250V		057-47020040
C7	Elect cap 47uF +100-10% 250V		057-47020040
C8	Elect cap 47uF +100-10% 250V		057-47020040
C9	Elect cap 47uF +100-10% 250V		057-47020040
C10	Elect cap 220uF +-20% 10V SXA		057-22120300
C11	Cer cap 470pF +-20% 3KV Z5P		055-47167728
C12	Poly cap 0.22uF +-10% 100V		058-22400120
C13	Elect cap 1000uF +-20% 16V SXA		057-10220180
C16	Elect cap 100uF +-20% 25V SXA		057-10120270
C18	Poly cap 0.022uF +-20% 100V		058-22300080
		or	058-22300090
C19	Poly cap 0.22uF +-10% 100V		058-22400120
		or	058-22400240
C20	Elect cap 1000uF +-20% 16V SXA		057-10220180
C21	Elect cap 1000uF +-20% 16V SXA		057-10220180
C22	Elect cap 100uF +-20% 25V SXA		057-10120120
C24	Elect cap 2200uF +-20% 10V SXA		057-22220120

COMPONENT LISTING - ASTEC AA11771

CODE	DESCRIPTION	PART NUMBER
C25	Cer cap 0.01uF +-20% 1KV Z5U	055-10368925
C26	Cap Poly 0.22uF 100V	058-22400120
C27	Cap Ceramic 0.01uF 100V	055-10382125
C28	Cap Tant 10uF 25V	072-10600070
C29	Cap Tant 10uF 25V	072-10600070
C30	Cer cap 470pF +-10% 100V Z5F	055-47152126
C31	MP cap 0.01uF +-20% 250VAC	068-10300010
C32	Cap ceramic 0.01uF 100V	055-10382125
D1	Rectifier RGP10B	226-10400070
D2	Rectifier RGP10J	226-10400060
D3	Rectifier RGP10M	226-10400100
D4	Rectifier RGP15B	226-10100040
D5	Rectifier RGP10B	226-10400070
D6	Silicon diode 1N4606	212-10700210
D7	Silicon diode 1N4606	212-10700210
D8	Schottky diode S3SC3M	212-31100030
D9	Schottky diode S3SC3M	212-31100030
D11	Rectifier 3S4M	226-11400010
D13	Silicon diode 1N4606	212-10700210
D14	Diode 1N4606	212-10700210
D15	Diode 1N4606	212-10700210
D16	Diode 1N4606	212-10700210

COMPONENT LISTING - ASTEC AA11771

CODE	DESCRIPTION		PART NUMBER
F1	Fuse 2.5A 250V 3AG		084-00200060
L1	Common mode choke assembly		852-20200120
L2	Toroid		124-00000110
L3	Toroid		124-00000110
L4	Base choke 2.2uH		328-00100030
L5	Choke 1.5mH		328-00100010
L6	Choke coil assembly		852-20100180
L7	Choke coil assembly		852-20100180
L8	Choke coil assembly		852-10100490
Q1	NPN transistor SD467		209-11700460
		or	209-11700400
Q2	NPN transistor 2SC1875		209-10200030
Q3	PNP transistor SB561		210-11700350
		or	210-11700330
Q4	2SB561C		210-11700353
Q5	2SD467C		209-11700463
Q6	2SD467C		209-11700463
Q7	2SD467C		209-11700463
Q9	TL431CLP		211-10800100
Q101	TL431CLP		211-10800100

COMPONENT LISTING - ASTEC AA11771

CODE	DESCRIPTION		PART NUMBER
R1	Thermistor 4R +-10%		258-40970015
		or	258-50990010
		or	258-60990010
R2	Resistor carbon film 100K +-5% 1W		240-10406033
R3	Resistor carbon film 100K +-5% 1W		240-10406033
R4	Resistor metal oxide film 68R +-5% 1W		248-68006052
R5	Resistor carbon film 820R +-5% ¼W		240-82106022
R6	Resistor carbon film 5.6R +-5% ¼W		240-56906022
R7	Resistor metal oxide film 120R +-5% 1W		248-12106052
R8	Resistor carbon film 5.6R +-5% ¼W		240-56906022
R9	Resistor carbon film 47R +-5% ¼W		240-47006022
R10	Resistor carbon film 10R +-5% ¼W		240-10006022
R11	Resistor carbon film 5.6R +-5% ¼W		240-56906022
R12	Resistor metal film 0.47R +-5% 1W		247-04786054
R13	Resistor carbon film 39R +-5% ¼W		247-39006022
R14	Resistor carbon film 270R +-5% ½W		240-27106033
R15	Resistor carbon film 330R +-5% ½W		240-33106033
R16	Resistor carbon film 8.2R +-5% ¼W		240-82906022
R17	Resistor carbon film 330R +-5% ¼W		240-33106022
R18	Resistor carbon film 12R +-5% ¼W		240-12006022
R19	Resistor carbon film 56R +-5% ¼W		240-56006022
R20	Resistor carbon film 56R +-5% ¼W		240-56006022
R21	Resistor carbon film 12K +-5% ¼W		240-12306022
R22	Resistor carbon film 470R +-5% ¼W		240-47106022
R24	Resistor carbon film 2.7K +-2% ¼W		247-27015022

COMPONENT LISTING - ASTEC AA11771

CODE	DESCRIPTION	PART NUMBER
R26	Resistor carbon film 2.7K +-2% ¼W	247-27015022
R27	Resistor metal film 1R +-5% 1W	247-10086054
R28	Resistor CF 12K 5% ¼W	240-12306022
R29	Resistor CF 2.7K 5% ¼W	240-27206022
R30	Resistor CF 100R 5% ¼W	240-10106022
R31	Resistor CF 470R 5% ¼W	240-47106022
R32	Resistor CF 100K 5% ¼W	240-10406022
R33	Resistor CF 100K 5% ¼W	240-10406022
R34	Resistor CF 10K 5% ¼W	240-10306022
R35	Resistor CF 100K 5% ¼W	240-10406022
R36	Resistor CF 100K 5% ¼W	240-10406022
R37	Resistor CF 100K 5% ¼W	240-10406022
R38	Resistor CF 56R 5% ¼W	240-56006022
R39	Resistor CF 56R 5% ¼W	240-56006022
R40	Resistor CF 1K 5% ¼W	240-10206022
R41	Resistor CF 100K 5% ¼W	240-10406022
R42	Resistor CF 100K 5% ¼W	240-10406022
R43	Resistor CF 220K 5% ¼W	240-22406022
R44	Resistor CF 100K 5% ¼W	240-10406022
R45	Resistor CF 220K 5% ¼W	240-22406022
R46	Resistor CF 100K 5% ¼W	240-10406022
R48	Resistor CF 100K 5% ¼W	240-10406022

COMPONENT LISTING - ASTEC AA11771

CODE	DESCRIPTION	PART NUMBER
T1	Power transformer ass'y	852-10201210
T2	Control transformer ass'y	852-10200680
SCR1	SCR C122U	227-13000010
VDR1	VDR 260VAC	256-26100014
Z1	Zener 5.6 ±5% 1W 40mA	222-56086002

ASTEC - APPLE PART NUMBER CROSS REFERENCE LISTING

ASTEC PART #	DESCRIPTION	APPLE #
TF-10200200	CONTROL TRANSFORMER ASSEMBLY	U157-0005
TF-10200370	POWER TRANSFORMER ASSEMBLY	U157-0004
TF-20100010	FILTER CHOKE COIL ASSEMBLY, RADIAL	U155-0008
TF-20100020	FILTER CHOKE COIL ASSEMBLY, RADIAL	U155-0010
TF-20100050	FILTER CHOKE COIL ASSEMBLY, RADIAL	U155-0009
TF-20200010	TRANSFORMER, COMMON MODE ASSEMBLY	U157-0006
042-02012202	P.C. BOARD (ASTEC 11040 STD.)	U820-0010
055-10210001	CAPACITOR, CERAMIC DISC, Z5U, 1000pF, 3KV	U132-0003
055-10367325	CAPACITOR, CERAMIC DISC, 0.01uF, 1KV	U132-0004
055-10368925	CAPACITOR, CERAMIC DISC, Z5U,(VDE) 0.01uF, 1KV	U132-0002
055-22220001	CAPACITOR, CERAMIC DISC, (VDE) 2200pF, 400V	U132-0001
055-47167728	CAPACITOR, CERAMIC DISC, Z5P,(VDE) 47pF, 3KV	U131-0001
057-10220020	CAPACITOR, ELECTRO.,SW.TYPE,RDL.LD.,1000uF, 10V	U128-0003
057-22120060	CAPACITOR, ELECTRO.,SW.TYPE,RDL.LD., 220uF, 10V	U124-0004
057-22120080	CAPACITOR, ELECTRO., RDL.LD., 220uF, 10V	U126-0001
057-33120080	CAPACITOR, ELECTRO.,SW.TYPE,RDL.LD., 330uF, 16V	U124-0002
057-47020040	CAPACITOR, ELECTRO.,SW.TYPE,RDL.LD., 47uF, 250V	U124-0001
057-68120010	CAPACITOR, ELECTRO.,SW.TYPE,RDL.LD., 680uF, 16V	U124-0005
058-10200020	CAPACITOR, METALIZED POLY, RDL.LD.,1000pF, 50V	U121-0102
058-10400100	CAPACITOR, METALIZED POLY, RDL.LD., 0.1uF, 400V	U121-0101
058-22300080	CAPACITOR, POLYESTER FILM, RDL.LD.,.022uF, 100V	U119-0002
058-22400120	CAPACITOR, POLYESTER FILM, RDL.LD.,0.22uF, 100V	U119-0001
068-10400010	CAPACITOR, METALIZED POLY, 0.01uF, 250V	U121-0100
072-22600040	CAPACITOR, TANTALUM, RDL.LD., 22uF, 16V	U127-0001
084-00200040	FUSE, 2.75A, 125V	U740-0001
209-10200020	TRANSISTOR, NPN 2SC1358	U376-0005
209-10200030	TRANSISTOR, NPN 2SC1875	U376-0002
209-11700382	TRANSISTOR, NPN PE8050	U376-0004
209-11700400	TRANSISTOR, NPN 2SD592NC/2SD467C	U376-0001
210-11700322	TRANSISTOR, PNP PE8550	U376-0006
210-11700330	TRANSISTOR, PNP 2S8621NC/2SB561C	U376-0003
211-10800100	I.C. ,OPTICAL COUPLER, TL431CP/TL431CLP	U327-0001
212-10700210	DIODE, SILICON, 1N4606	U371-0001
222-06895003	DIODE, ZENER, 6.8V +/-0.2V	U371-0003
222-12295001	DIODE, ZENER, 12.2V +/-0.2V	U371-0004
222-98085002	DIODE, ZENER, 9.8V +/-0.2V (2K7)	U371-0002
226-10100040	RECTIFIER, RG15B	U375-0015
226-10400050	RECTIFIER, RGP10A (G.I.)	U375-0014
226-10400070	RECTIFIER, RGP10B	U375-0016
226-10400100	RECTIFIER, RGP10M (G.I.)	U375-0013
226-30500010	RECTIFIER, BRIDGE, KBP10	U351-0001
227-12500010	RECTIFIER, SCR, 2P 05M	U376-0007
227-13000010	RECTIFIER, SCR, C122U/2N6395	U372-0001

ASTEC - APPLE PART NUMBER CROSS REFERENCE LISTING

ASTEC PART #	DESCRIPTION	APPLE #
240-10006022	RESISTOR, CARBON FILM, +-5% 1/4W 10 OHM	U101-4100
240-10106022	RESISTOR, CARBON FILM, +-5% 1/4W 100 OHM	U101-4101
240-10406022	RESISTOR, CARBON FILM, +-5% 1/4W 100K OHM	U101-4104
240-12206022	RESISTOR, CARBON FILM, +-5% 1/4W 1.2K OHM	U101-4122
240-12306022	RESISTOR, CARBON FILM, +-5% 1/4W 12K OHM	U101-4123
240-15406033	RESISTOR, METAL FILM, +-5% 1/2W 150K OHM	U107-0001
240-18206022	RESISTOR, CARBON FILM, +-5% 1/4W 1.8K OHM	U101-4182
240-22206022	RESISTOR, CARBON FILM, +-5% 1/4W 2.2K OHM	U101-4222
240-27106033	RESISTOR, CARBON FILM, +-5% 1/4W 270 OHM	U101-4271
240-27206022	RESISTOR, CARBON FILM, +-5% 1/4W 2.7K OHM	U101-4272
240-47106022	RESISTOR, CARBON FILM, +-5% 1/4W 470 OHM	U101-4471
240-56006022	RESISTOR, CARBON FILM, +-5% 1/4W 56 OHM	U101-4560
240-56106022	RESISTOR, CARBON FILM, +-5% 1/4W 560 OHM	U101-4561
240-68106022	RESISTOR, CARBON FILM, +-5% 1/4W 680 OHM	U101-4681
240-82006033	RESISTOR, METAL FILM, +-5% 1/2W 82 OHM	U107-0001
247-03386054	RESISTOR, METAL FILM, +-5% 1 W .33 OHM	U107-0010
247-05686054	RESISTOR, METAL FILM, +-5% 1 W .56 OHM	U107-0004
247-10086054	RESISTOR, METAL FILM, +-5% 1 W 1 OHM	U107-0006
248-12106052	RESISTOR, MTL-OX FILM, +-5% 1 W 120 OHM	U107-0003
248-22106052	RESISTOR, MTL-OX FILM, +-5% 1 W 220 OHM	U107-0008
248-27006052	RESISTOR, MTL-OX FILM, +-5% 1 W 27 OHM	U107-0009
248-27006063	RESISTOR, MTL-OX FILM, +-5% 2 W 27 OHM	U107-0002
247-27015022	RESISTOR, MTL-OX FILM, +-2% 1/4W 2.7K OHM	U107-0005
256-26100014	TRANSIENT SUPPRESSOR, VDR 260VAC	U377-0001
258-40970015	THERMISTOR, 4R, 10% or 5R	U107-0100
283-02200100	VOLTAGE SELECTION SWITCH 115/230	U705-0003
328-00100010	CHOKE, 1.5 mH, RADIAL	U155-0003
328-00100030	BASE CHOKE, 2.2 uH, RADIAL	U155-0002
328-00150016	CHOKE COIL, CONTROL, RADIAL	U155-0007
328-20100010	CHOKE COIL ASSEMBLY, RADIAL	U155-0005
852-10100370	CHOKE COIL ASSEMBLY, RADIAL	U155-0004
852-10100490	CHOKE COIL, RADIAL	U155-0006
852-10200680	CONTROL TRANSFORMER ASSEMBLY	U157-0003
852-10200940	POWER TRANSFORMER ASSEMBLY	U157-0002
852-20100140	CHOKE COIL ASSEMBLY, RADIAL	U155-0001
852-20200950	COMMON MODE TRANSFORMER ASSEMBLY	U157-0001
853-00200210	RECTIFIER ASSEMBLY	U375-0017
853-00200020	RECTIFIER, HEATSINK ASSEMBLY	U375-0018

With Compliments

ASTEC *EUROPE LTD*

NOTES ON POWER SUPLIES

CONTENTS

1.0 Introduction
2.0 What's a Power Supply
3.0 SMPS Basics
4.0 Advantages & Disadvantages of SMPS
5.0 Types of SMPS
6.0 How to read Data Sheets
Appendix

ASTEC EUROPE LTD

November 1981

1.0 INTRODUCTION

ASTEC manufactures flyback and feed-forward, single and multi-rail output Power Supplies.

The Company places a lot of emphasis on the production of ultra-reliable power supplies. Special consideration is given to thermal criteria during the design phase. High temperature (125 deg C) reverse bias Burn-in for a minimum of 24 hours is standard procedure for all critical transistors and diodes. Elimination of doubtful components by comparative measurements before and after Burn-in prior to their use in assembly contribute to our ability to ship Power Supplies that will continue to give years of satisfactory life.

Additional information concerning our manufacturing process will be found in the Appendix.

Electro-magnetic disturbances from Switching Mode Power Supplies are a potential problem. ASTEC solves these problems and reduces both line conducted and radiated radio frequency noise to meet the International performance standards by incorporating correctly designed line filters and electrostatic shielding of the power switching transformer.

In the following pages we will be describing in detail the circuit tecniques we use and comparing various types of Power Supply solutions.

A section is devoted to an explanation of how to read and interpret our Data Sheets.

2.0 WHAT IS A POWER SUPPLY ?

In essence there are two basic types of regulated power supplies.

Linear Supplies - series and shunt varieties.
Characterised by dissipating as heat the surplus power

Switching Supplies - buck and boost varieties
Characterised by using only that part of the input power tht is required and hence not dissipating the surplus as heat

(Note:- This fundamental difference is important. All electronic circuits become less reliable at high temperatures. Thus by avoiding creating excess heat the switching power supply becomes inherently better.)

To look at these varieties in a little more detail:-

2.1 Linear supplies.

A linear regulator absorbs the difference between the input voltage at the source and the regulated voltage at the load.

(see fig 1)

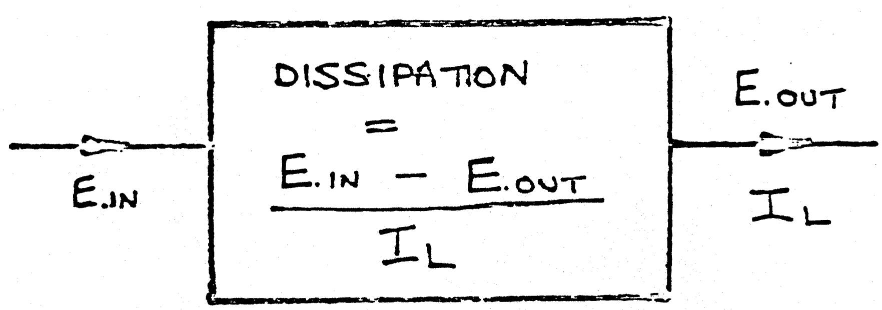


FIG 1. LINEAR REGULATOR

2.2 Switching supplies.

A switching regulator stores the excess power in a LC filter (a network consisting of an inductor and a capacitor) and delivers the power to the load in measured intervals.

The two basic varieties of switching regulators are:-

2.2.1 Buck. (see fig 2)

During the time the switch is ON, energy is stored in the network consisting of the inductor L and capacitor C and is delivered to the load as required.

The output voltage of the Buck regulator is controlled by the duty cycle of the switch.

$$E\ out = \frac{t.on}{T} \cdot E\ in$$

The output voltage may be controlled from zero volts to E in.

2.2.2 Boost. (see fig 3)

The Boost regulator is similar to the Buck regulator except that the circuit is designed to provide an output voltage that is higher than the input voltage.

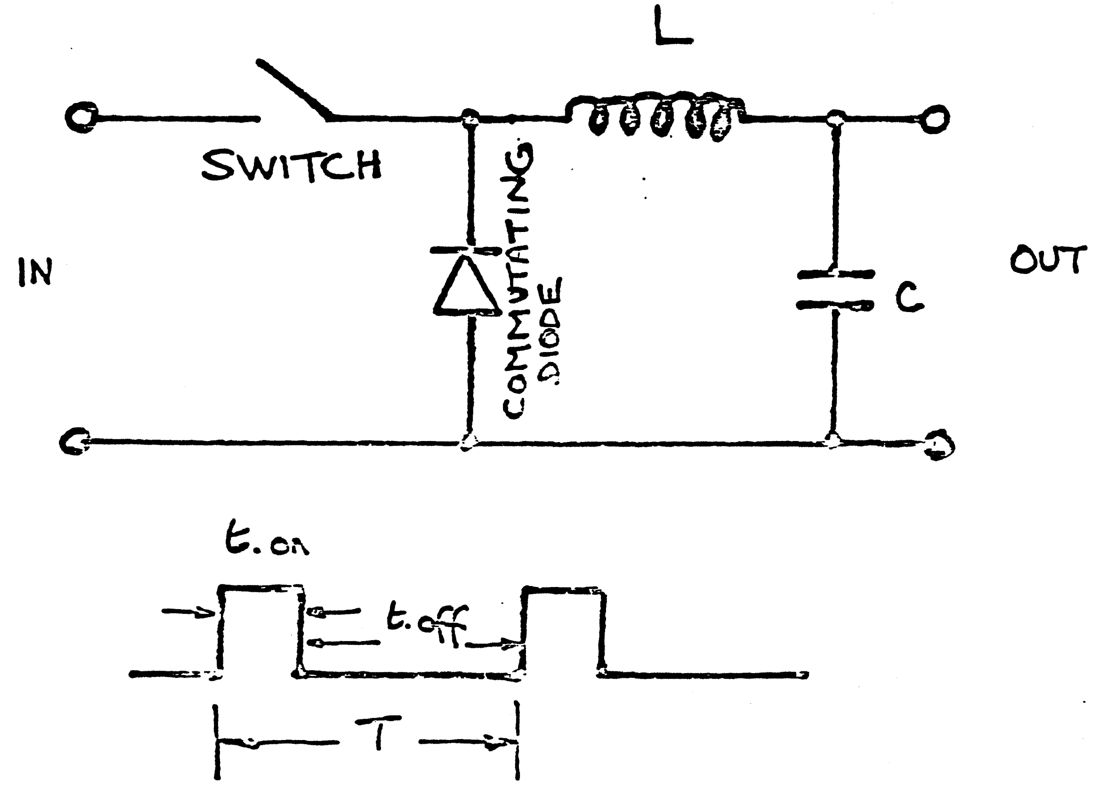


FIG 2. SWITCHING BUCK REG.

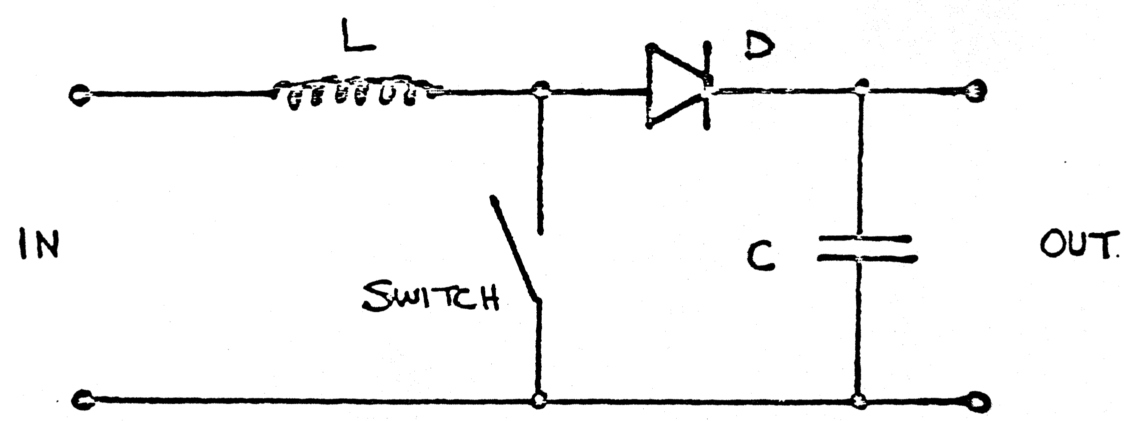


FIG. 3. SWITCHING BOOST REG

3.0 SWITCHING POWER SUPPLIES

The basic schematic diagram of a Switch Mode Power Supply is shown in Figure 4.

The mode of operation of this power supply is as follows:-

The AC input from the line is rectified and filtered to obtain a DC voltage that has an acceptable ripple content.

The transistor switch chops the DC voltage into a series of rectangular waves which are changed to the required voltage by a transformer. The voltage appearing on the secondary of this transformer is rectified and filtered to produce the final output voltage(s) required.

In order to ensure that the output voltage stays within the required tolerances, a modulation control circuit senses the output voltage and compares it with a reference voltage. The resultant difference from this comparism is used to adjust the ON/OFF ratio of the rectangular waveform. The variation off this ON/OFF ratio determines the amount of energy that is transferred from the primary store to the secondary store(s).

It is in this way that a Switching Power Supply is able to respond to varying load demands without having to dissipate a surplus of power as heat.

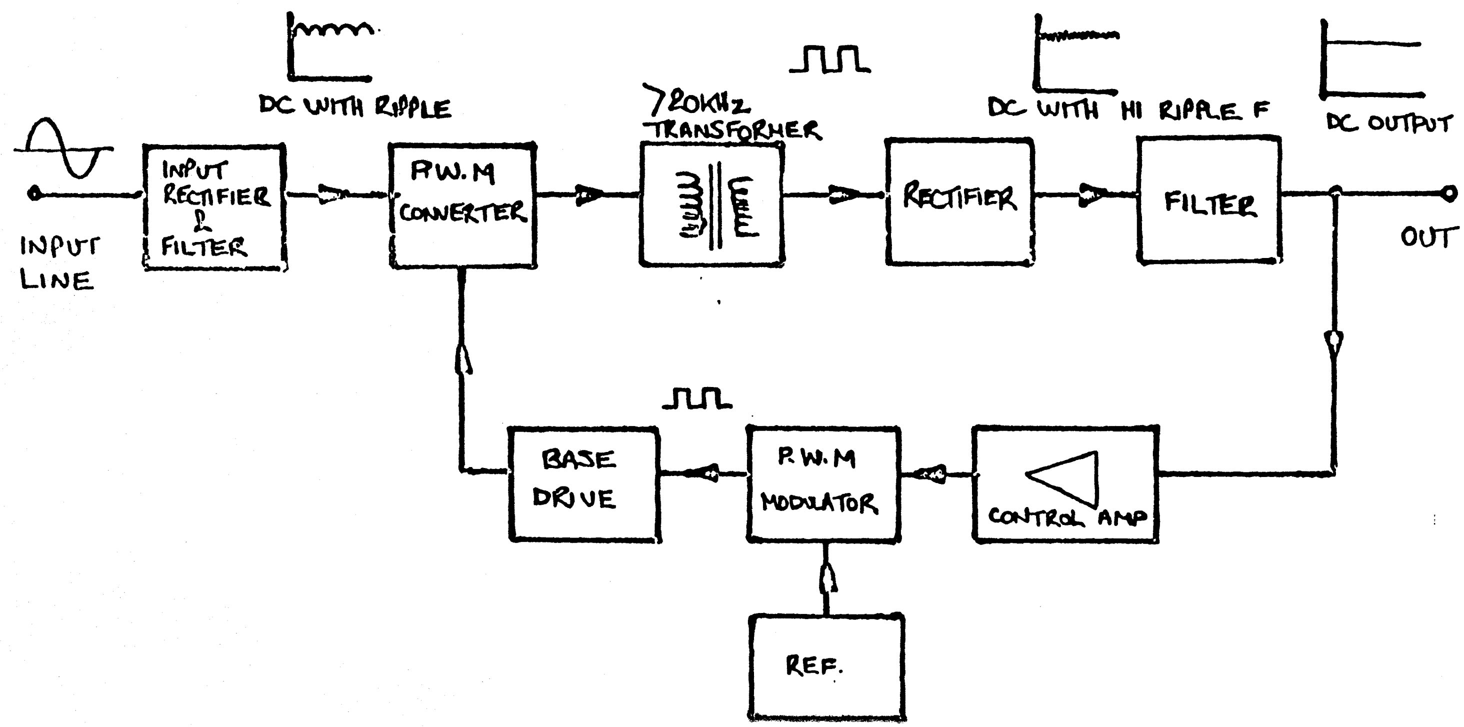


FIG.4.
BASIC SMPS DIAGRAM

4.0 ADVANTAGES & DISADVANTAGES OF S.M.P.S.

The basic requirements of microprocessor based equipment and other associated applications for power supplies are:-

- the power supply must produce all the required voltages / currents within the proscribed tolerances
- the power supply must be as small as practical
- the power supply must weigh a little as possible
- the power supply must be as reliable as possible and produce as little heat as possible
- the power supply must conform to or meet all the mandatory International standards that relate to Safety and Interference

ADVANTAGES

Efficiency

In a linear regulating supply the power losses are very high. This is due to the continuous operation of the series pass regulating device. Consequently, the power efficiency is poor - ranging from 10% to 40%, the average being around 30%.
This figure of 30% means that of the total power put into the power supply only about 30% of it gets to the load - the remaining 70% is dissipated in the linear power supply as heat.
In a Switch Mode Power Supply the device that acts as the regulating switch (usually a power transistor) is operated in either a fully saturated state or is completely turned off. Since the ON and OFF states are the ones of minimum power dissipation the power efficiency of a SMPS is much higher and ranges from 65% to 80% or more.

Figure 5 illustrates the comparism between the power efficiencies of linear and SMPS.

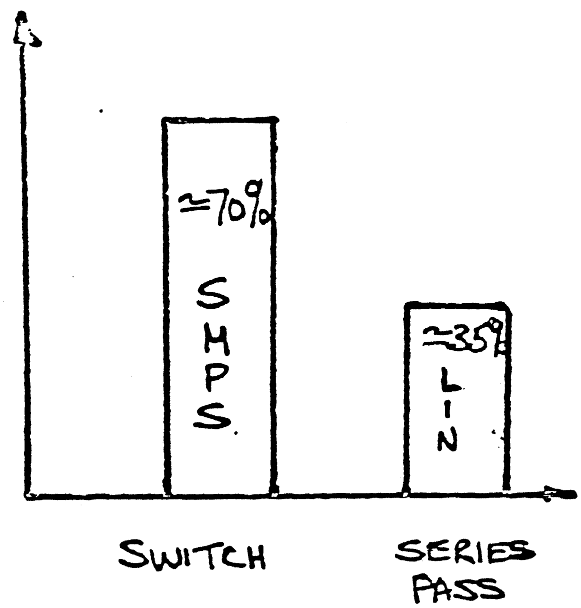


FIG 5

EFFICIENCY COMPARISON

This can also be illustrated by looking at a typical power supply. For example:-

For a Power Output of	125 Watts
Linear power consumption	232 Watts
SMPS power consumption	54 Watts
Power saved	178 Watts

Size & Weight

Linear supplies taking power from the mains supply work at 50Hz (or 60Hz). Since isolation between the input and output is needed a transformer is required. The low working frequency dictates that the transformer core must be of silicon steel which in turn results in a component that is both big and heavy.
SMPS operate at much higher frequencies - typically about 25,000Hz. This means that the transformer can use ferrite materials which are both smaller and lighter than silicon steel. An extra benefit is that the efficiency of ferrite in terms of magnetic saturation is better than silicon steel which means that the power losses through the transformer are lower for SMPS than for linear supplies.
A further benefit of using high frequency switching that contributes to the reduction of size and weight is that the secondary electrolytic capacitors can be much smaller. For linear supplies it is common to see filter capacitors of 40,000 uF being used. SMPS can use 1,000 uF capacitors.

These size and weight advantages can be summarised as follows:-

Using the example of a 125 Watt power supply.

	Linear	SMPS
Volume comparism	4 cu in/W	1 cu in/W
Area reduction ratio	3.3	1
Weight reduction ratio	5	1

Operating Voltage Range

Linear supplies tend to have restricted input voltage ranges. Often multi-tapped transformers are used. This requires the equipment end user to set the correct voltage tap according to where the equipment is to be used.
SMPS have very wide operating voltage ranges. Providing the SMPS is designed to use primary capacitors sufficient to store the energy required even when fed from the low limit of input voltage the power supply will continue to function correctly. This is because unlike the linear supply the SMPS is not concerned with primary volts but only with the energy source.
The typical operating range of ASTEC SMPS, when set for nominal 230 V input, is from 180 V to 265 V without need to change any input voltage selector. A comparable range for the nominal 117 V setting is also obtained. The change over from nominal 230 V to nominal 117 V input setting is achieved by simple altering the input rectifier circuit from that of a simple bridge (on 230 V) to a voltage doubler (on 117 V) . Thus the resultat DC that is used by the switching transistor remains the same for both input voltage ranges.

DISADVANTAGES

Noise

We have to accept that SMPS can produce more radiated and/or line conducted noise than linear supplies.
Careful design by ASTEC does reduce both radiated and line conducted noise to acceptable amounts.
Special design features are:-

Use of special input filters in series with the line. These are carefully balanced to obtain the maximum rejection of the switching frequency and its harmonics.

Pi section filters on the outputs.

Use of a copper shield between the primary and secondary of the power transformer. This acts as an electrostatic shield as is connected to the safety ground of the power supply.

Correct and balanced layout of critical conductors on the PCB to ensure that fields cancel.

Use of another copper shield wound over the secondary windings of the power transformer to reduce magnetic radiation.

As stated earlier, ASTEC Switching Power Supplies do meet the International Standards for both radiated and line conducted noise. The most widely specified standards are the VDE0875 and VDE0871 and CISPR 1 and 3.

Transient Response

Note:- Transient response is the time required for the output voltage to return to within the specified regulation limits when there is an abrupt change on either the load or the line.
For a conventional linear regulator the figures would be of the order of 10's of microseconds.
For a SMPS these figure are around 10's of milliseconds.
These times result from the system used and are a function of the switching frequency - eventually if we can increase the switching frequency sufficiently (to 10 MHz) then the response time will come down. Meanwhile, in most practical systems we can live with the Transient Response times we get.

SUMMARY

The Advantages of the SMPS in terms of Size, Weight, Efficiency and Reliability more than compensate for the disadvantages.

5.0 TYPES OF SMPS

There are a number of different ways that a SMPS can be designed. There are two main variants:-

Flyback Converters
Feed Forward Converters

The range of SMPS that ASTEC manufactures mainly use Flyback techniques. The Flyback converter is very suitable for power supplies up to about 150 Watts. Above this power the Feed Forward types tend to predominate. ASTEC make both types but by virtue of the number of power supplies in the 50 - 100 Watt range that we build the Flyback is the most common circuit solution in our current production.

5.1 The Flyback Converter

Figure 6 shows the basic Flyback circuit and figure 7 shows the theorectical waveforms of it.

The name 'Flyback' is derived from the fact that the energy that is stored in the primary winding inductance of the transformer is transferred to secondary load during the OFF or 'Flyback' time of the switching transistor.

The circuit operates at a fixed frequency and the period δT (the switched ON time) is varied in order to control the output voltage.
The switching transistor is in a saturated state and is conducting for the period . The input voltage V.in is developed across the primary inductance of the transformer causing a linear increase in the primary current.
The voltage now produced at the secondary is such that the rectifier diode is reverse biased.
At the end of the ON time the primary current reaches a maximum

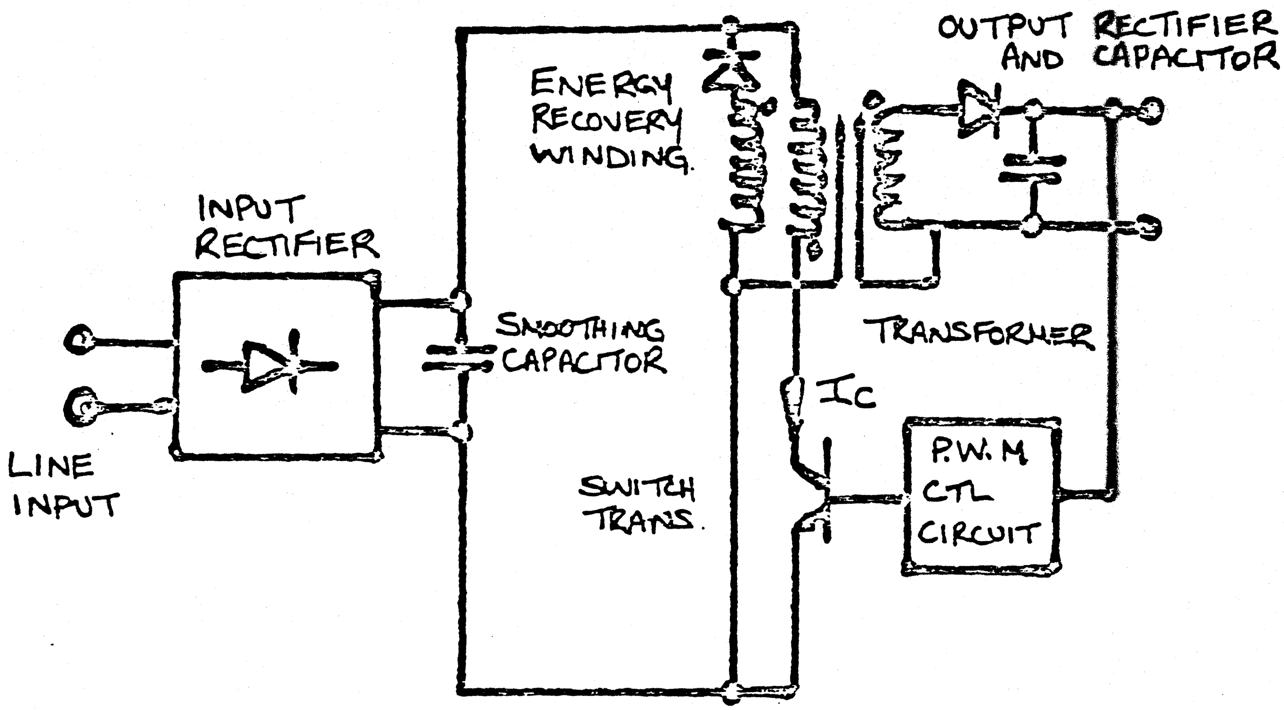


FIG. 6. BASIC FLYBACK CIRCUIT

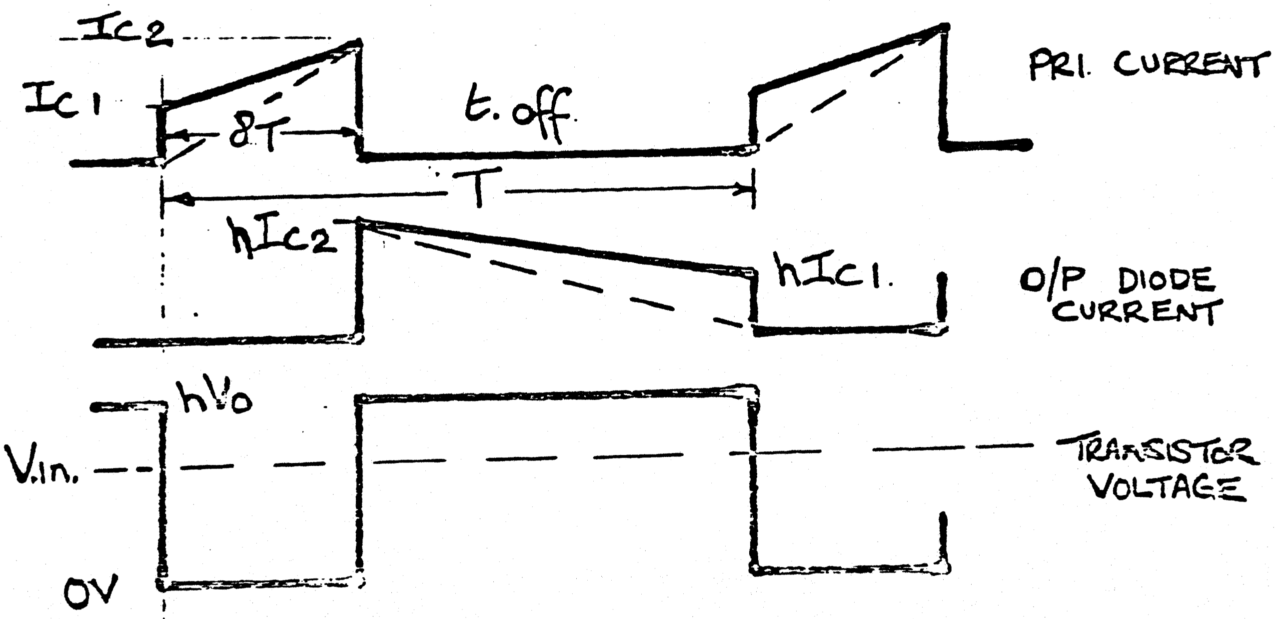


FIG. 7. WAVEFORMS OF FLYBACK CONVERTER

value I2 after which it falls to zero.

$$I2 = \frac{V.in. \delta T}{L}$$

where L is the primary inductance.

The energy stored in the primary inductance is:-

$$\frac{L.I^2}{2}$$

The stored energy per cycle W is given by:-

$$W = \frac{L}{2}\left(\frac{V.in. \delta T}{L}\right)^2$$

or

$$W = \frac{V.in^2 . \delta T^2}{2L}$$

Hence the output power available =
energy in joules x switching frequency

Therefore:-

$$\text{Output Power} = \frac{V.in^2 \delta T^2}{2L}$$

As the primary current falls to zero the voltage across the transistor increases from that of its saturation to a positive value that is in excess of that of the supply voltage V.in. A

capacitive network is connected across the transistor to limit the rate of rise of this voltage.
When the voltage across the transistor exceeds V.in, the transformer primary is reversed and reverses the secondary voltage thus causing the output rectifier diode to conduct.
An energy recovery winding and a diode limits the voltage across the switching transistor and returns the energy stored in this inductance to the supply when the circuit is operated without a load on the secondary. This winding is bifilar wound with the primary in order to minimise the leakage inductance between these windings.

In summary:-

First: Transistor conducts for a period (t.on)
Energy is taken from the input and stored in the inductor.

Second: During remainder of period (t.off) the output diode conducts and the energy stored in the inductor is transferred to the output.

The output voltage is dependent on the input voltage and the conduction period of the transistor.

To stabilise the output voltage the control circuit determines a value for the period appropriate to the input voltage and to the loading.

5.2 The Feed Forward Converter

Figure 8 shows the basic circuit.

The operation of the Feed Forward converter is opposite to that of the Flyback converter.

In the Flyback energy is transferred from primary to secondary during the OFF state of the switching transistor. In the Feed Forward energy is transferred during the ON state.

The smoothing inductor L1 in series with the rectifier diode D1 provides a voltage that is proportional to the transistor ON time. The diode D2 provides the path for the output current when the transistor is not conducting. When the transistor is OFF the transformer magnetizing current is returned to the supply by an energy recovery winding in a similar mode to that of the Flyback converter.

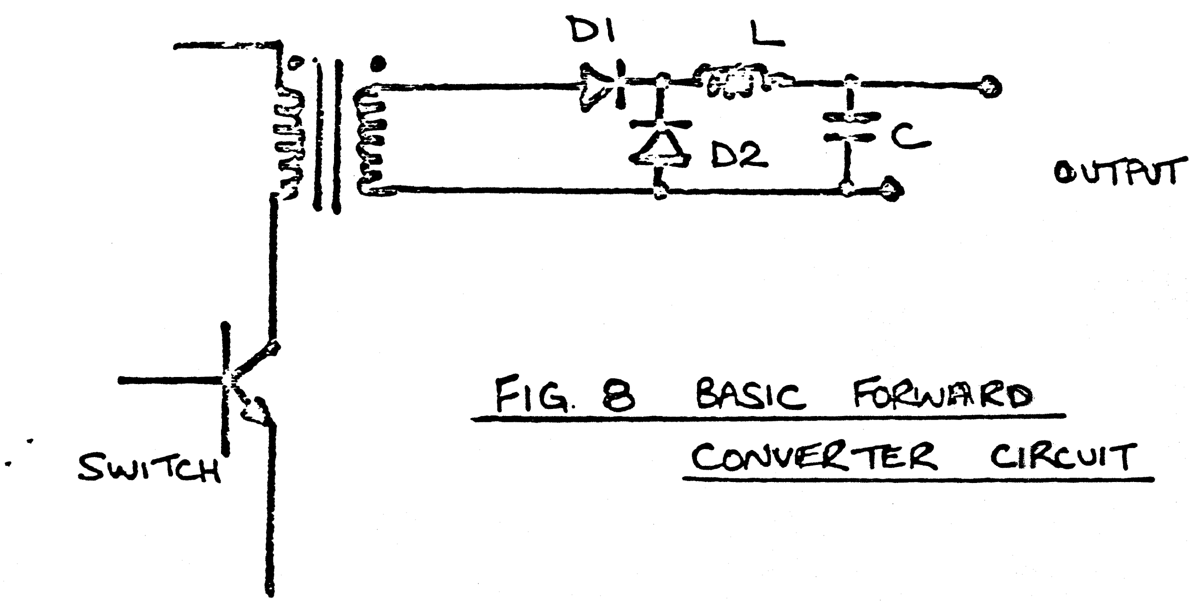


FIG. 8 BASIC FORWARD CONVERTER CIRCUIT

Our Data Sheets DO contain the answers to most questions put by potential customers. The purpose of these few notes is to explain how to find those answers.

We have recently started to introduce the 'NewlooK' Data Sheets. We will use one of these (AC9231) as an example.

Front page - the side with the photo

Between the heavy red lines you will find the basic Volts and Amps

PLUS

any special features that the supply has. For example, the AC9231 has the 'negative' outputs floating. This means these can have either terminal tied to ground or to another output. The output described as '-12V' could be stacked on top of the +12V output to get a +24V output that would then have a current rating of 0.5 Amp which is the lower of the two 12V outputs current ratings.

The rest of the front page is devoted to the mechanical dimensions and pin connections. Note that we are getting better and giving such details as the mating connector details.

NO - WE DO NOT SUPPLY THE MATING PARTS

Unless we state otherwise, the power supply may be mounted in any plane. The photo, apart from being pretty is there so that engineers can see the internal layout and hence deduce where the hot-spots will be.
The heat producing items are the power transistor, secondary diodes, transformer and ripple capacitors.
Again unless otherwise stated on the Data Sheet we do not expect the customer to provide any extra cooling for the power supply - normal convection and radiation cooling up to the rated ambient

(usually 50 deg. C) is adequate.

Back Page.

From the top of the page to the first heavy red line we show the main Volt/Amp load data and the line input limits.

Input Voltage:- The min and max figures are those between which the power supply will stay within the specified output volts for all specified output loads. The 9231 will continue to work with inputs lower than 180V - in fact it continues down to around 150V but we don't spec it down to that level. Above 270V we have a margin for short duration operation - line spikes and such like - but not for sustained use. Nowhere in Europe can you find mains supplies that exceed 270 Volts.

Input Frequency:- We test the supply over the specified range. In fact since the input circuit is only a rectifier and capacitor it is obvious that the supply can accept a much wider range of input frequencies should anyone come up with that requirement.

Outputs:- The min and max voltage of each output is specified as is the min and max load. The two specs have to be read together. For the 9231 +5V output, it means that the volts stay between 4.9 and 5.1 over the load current range from 6.0 Amps to 1.2 Amps - again for any value of line input volts within that spec.
The minimum load specified may not be the minimum load the power supply needs to keep working BUT it is the minimum that we gaurantee the spec to hold.
NOTE:- The new family of SMPS have a much better control window than the earlier types. This means that the 25% minimum load requirement has gone and also it means that the problems of tracking between one output and another are very much less.

In between the two heavy red lines are the remainder of the electrical specifications and notes.

Efficiency:- This is percentage of the input power that can be delivered to the load. It will vary with the load. Mostly the SMPS will be at its most efficient when delivering the maximum power. The figure specified is a minimum - the real typicals are nearer to 70% and some units o as high as 75%.

Operating Temp:- When we say 'Ambient' we mean the ambient around the power supply not that around the equipment that houses the power supply.

Output Power:- This is the max continuous power that can be drawn. It is the sum of all the loads. If you sum the VA products on each of the outputs it is higher than 50 Watts because the practical case is that although higher currents may be needed on the +5 and +12 the demand does not occur at the same time.

Output Ripple:- This is measured with a Wideband instrument across the output terminals. We specify it as a percentage of the output voltage on each given output rail. Thus for the 9231 it means a max ripple figure of 50mV on the +5V rail and 120mV on the +12V one. In both cases these are peak-to-peak figures. The best instrument for measuring Ripple is a 'scope which has a suitable bandwidth.

Line regulation:- This defines the variation in the output voltages over the line input range - thus the +5V could change by +/- 0.2% , or 10mV for a line input change from 180V to 270V.

Load regulation:- This defines the variation in the output voltages over the whole of the specified load range. Thus for the +5V output it means that it may vary by 2.0% , or 100mV when the load changes from 6.0 A to 1.2 A. If you look at the 'Outputs' specs above it may look as though there is a 200mV variation possible due to load but this is not so. Due to load the variation is 100mV - the other 100mV is the variation in the absolute value of the +5V output.

Over Voltage Protection:- The main output lines have crowbar circuits to protect equipment connected to the power supply in the event of a total failure in the control circuits. The crowbar firing voltage is specified in this way.

Hold up Time:- This is the time for which the power supply will continue to deliver power after the mains input has failed. The specification refers to the line input voltage - normally we spec at the nominal line input but for maximum load which is a worst case condition. The hold-up time extends until the output voltage has fallen outside the rated tolerance.

The remainder of this section deals with any special points. For exampe the note about the max voltage that can occur between the 'floating' outputs on the AC9231.

Most of our SMPS will stand indefinite short circuit and open circuit load conditions. Short circuits are defined as being less than 50 m ohms. For the power supplies of 150 W ratings or more we have to incorporate secondary fuses since it is possible in the practical case to have a 'short' circuit that is not a real short at all. The power supply sees it as a very low impedance load and tries to deliver all the power into one output. Without the secondary fuse as protection there could occur a failure of the secondary diodes. This case is not applicable to such units as the Ac9231.

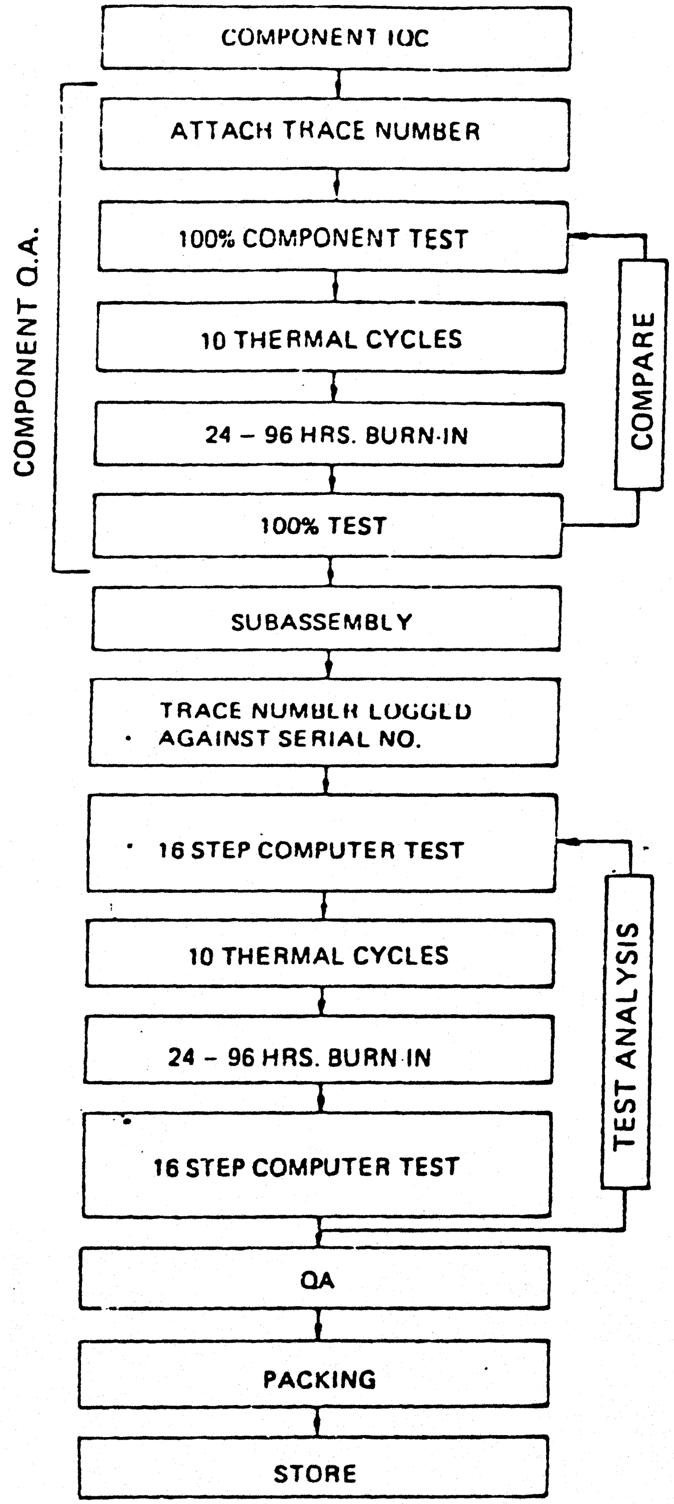
Notes on applicable Safety specs and EMI and radiated Noise specs are also given.

In general we are complying with all the European safety standards. Transformer design complys with the construction tecniques specified, PCB layout conforms to the required spacings. Materials conform to both European and UL/CSA needs.

Further details on these matters are available from us for specific customers if needed.

TARGET M.T.B.F. – 100,000 HOURS!

SUMMARISED MANUFACTURING PROCESS



This chart details the step-by-step procedures taken by ASTEC to ensure that the final product has reliability built in.

All critical components, semi-conductors and capacitors, are tested before and after pre-assembly burn-in. Comparison of test results enables us to eliminate any suspect components before assembly starts.

The assembled power supply is then computer tested, the test results stored, run up under worst case input conditions and with maximum rated loads for 96 hours and then re-tested.

Comparison of test results enables us to reject any units showing parameter changes likely to cause failures during use.

It is our target to offer a power supply that system designer can specify with absolute confidence, can fit and can then forget. The name ASTEC is synonymous with quality and reliability.

apple computer inc.

SWITCHING POWER SUPPLIES

Editor's note: The material for this article was edited from HP's DC Power Supply Handbook (AN 90B), originally written by Richard Tomasetti of the Marketing Communications group at HP's power supply division in Rockaway, New Jersey.

Electronic power supplies are defined as units that convert power from an ac or dc source into ac or dc power at voltages suitable for supplying an electronic device.

Within this definition, electronic power supplies can be divided into four broad classifications:

(1) ac in, ac out — line regulators and frequency changers
(2) dc in, dc out — converters and dc regulators
(3) dc in, ac out — inverters
(4) ac in, dc out — "common" power supply

This last category is by far the most common of the four and is generally the one referred to when speaking of a "power supply."

Four basic outputs or modes of operation can be provided by dc output power supplies:

- *Constant Voltage:* The output voltage is maintained constant in spite of changes in load, line, or temperature.
- *Constant Current:* The output current is maintained constant in spite of changes in load, line, or temperature.
- *Voltage Limit:* Same as Constant Voltage except for less precise regulation characteristics.
- *Current Limit:* Similar to Constant Current except for less precise regulation.

Within each type of power supply, different forms of regulation are used to maintain a constant output. Switching is one of the forms used in a constant voltage power supply.

Therefore, a switching power supply is defined as an ac in, dc out, constant voltage power supply that uses a "switching technique" for regulation.

Basic Switching Supply

In a switching supply, the regulating elements consist of series-connected transistors that act as rapidly opened and closed switches (Figure 1). The input ac is first converted to unregulated dc, then "chopped" by the switching element operating at a rapid rate (typically 20kHz). The resultant 20kHz pulse train is transformer-coupled to an output network which provides final rectification and smoothing of the dc output. Regulation is accomplished through control circuits that vary the on-off periods (duty cycle) of the switching elements.

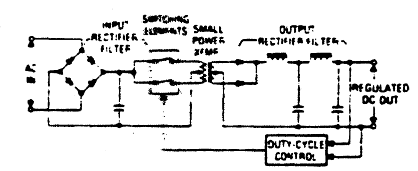


Figure 1. Basic Switching Supply

Operating Advantages. Because switching regulators are basically on/off devices, they avoid the higher power dissipation associated with the rheostat-like action of a series regulator. The switching transistors dissipate very little power when either saturated (on) or nonconducting (off); most of the power losses occur elsewhere in the supply. Efficiencies ranging from 65% to 85% are typical for switching supplies, as compared to 30% to 45% efficiencies for linear types. With less wasted power, switching supplies run at cooler temperatures, cost less to operate, and have smaller regulator heat sinks.

The size and weight reductions for switching supplies are achieved because of their high switching rate. The power transformer, inductors, and filter capacitors for 20kHz operation are much smaller and lighter than those required for operation at power line frequencies. Typically, a switching supply is less than one-third size and weight of a comparable series regulated supply.

Another aspect of performance is the switcher's ability to operate under low ac input voltage (brownout) conditions and substain a relatively long carryover (or holdup) of its output if input power is lost momentarily. The switching supply is superior to the linear supply in this regard because more energy is stored in its input filter capacitance. In a switching supply, the input ac is rectified directly and the filter capacitor charges to the voltage peaks on the ac line. This is opposed to the linear supplies' ac input being stepped down through a power transformer, then rectified, which results in a lower voltage across its filter capacitor.

Since the energy stored in a capacitor is proportional to CV^2, and V is higher in switching supplies, their storage capability (and thus their holdup time) is better.

Operating Disadvantages. Although its advantages are impressive, a switching supply does have some inherent operating characteristics that could limit its effectiveness in certain applications. One of these is that its transient recovery time (dynamic load regulation) is slower than that of a series regulated supply. In a linear supply, recovery time is limited only by the speeds of the semiconductors used in the series regulator and control circuitry. However, in a switching supply, recovery is limited mainly by the inductance in the output filter. This may or may not be of significance to the user, depending upon the specific application.

Also, electro-magnetic interference (EMI) is a natural by-product of the on-off switching. This interference can be conducted to the load (resulting in higher output ripple and noise), it can be conducted back into the ac line, and it can be radiated into the surrounding atmosphere.

For this reason, all Hewlett-Packard switching supplies have built-in shields and filter networks that substantially reduce EMI and control output ripple and noise.

Typical Switching Regulated Power Supply

Figure 2 shows a schematic of one of HP's higher power, yet less complex, switching supplies. Regulation is accomplished by a pair of push-pull switching transistors operating under control of a feedback network consisting of a pulse-width modulator and a voltage comparison amplifier. The feedback elements control the ON periods of the switching transistors to adjust the duty cycle of the bipolar waveform (E) delivered to the output rectifier/filter. Here the waveform is rectified and averaged to provide a dc output level that is proportional to the duty cycle of the waveform. Hence, increasing the ON times of the switches increases the output voltage and vice-versa.

The waveforms of Figure 2 provide a more detailed picture of circuit operation. The voltage comparison amplifier continuously compares a fraction of the output voltage with a stable reference (E_{REF}) to produce the $V_{CONTROL}$ level for the turn-on comparator. This device compares the $V_{CONTROL}$ input with a triangular ramp waveform (A) occurring at a fixed 40kHz rate. When the ramp voltage is more positive than the control level, a turn-on signal (B) is generated. Notice that an increase or decrease in the $V_{CONTROL}$ voltage varies the width of the output pulses at B and thus the ON time of the switches.

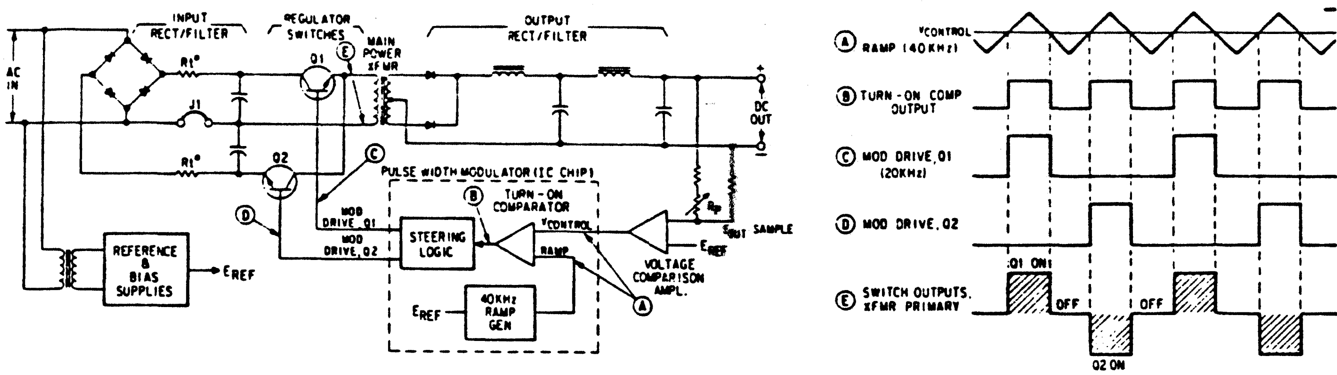


Figure 2. Switching Supply with Push-Pull Transistors and Feedback for Regulation

Steering logic within the modulator chip causes switching transistors Q1 and Q2 to turn on alternately, so that each switch operates at one-half the ramp frequency or 20kHz.

Included, but not shown, in the modulator chip are additional circuits that establish a minimum "dead-time" (off time) for the switching transistors. This ensures that both switching transistors cannot conduct simultaneously during maximum duty cycle conditions.

Ac Input Surge Current Protection. Because the input filter capacitors are connected directly across the rectified line, some form of surge protection must be provided to limit line surge currents at turn-on. If not controlled, large surges could trip circuit breakers, weld switch contacts, or affect the operation of other equipment connected to the same ac line. Protection is provided by a pair of thermistors (Rt^0) in the input rectifier circuit. With their high negative temperature coefficient of resistance, the thermistors present a relatively high resistance when cold (during the turn-on period) and a very low resistance after they heat up.

A shorting strap (J1) permits the configuration of the input rectifier-filter to be altered for different ac inputs. For a 174-250Vac input, the strap is removed and the circuit functions as a conventional full-wave bridge. For 87-127Vac inputs, the strap is installed and the input circuit becomes a voltage doubler.

Switching Frequencies. Presently, 20kHz is a popular repetition rate for switching regulators because it is an effective compromise with respect to size, cost, dissipation, and other factors. Decreasing the switching frequency would bring about the return of the acoustical noise problems that plagued earlier switching supplies, and would increase the size and cost of the output inductors and filter capacitors.

Increasing the switching frequency, however, would result in certain benefits, including further size reductions in the output magnetics and capacitors. Furthermore, transient recovery time could be decreased because a higher operating frequency would allow a proportional decrease in the output inductance, which is the main constraint in recovery performance.

Unfortunately, higher frequency operation has certain drawbacks. One is that filter capacitors have an Equivalent Series Resistance (ESR) that limits their effectiveness at high frequencies. Another disadvantage is that power losses in the switching transistors, inductors, and rectifier diodes increase with frequency. To counteract these effects, critical components such as filter capacitors with low ESRs, fast recovery diodes, and high-speed switching transistors are required.

Some of these components are already available, others are not. Switching transistors are improving, but remain one of the major problems at high frequencies. However, further improvements in high-speed switching devices, such as the new power Field Effect Transistors (FETs) would make high frequency operation and its associated benefits a certainty for future switching supplies.

Preregulated Switching Supply

Figure 3 shows a schematic of another switching supply similar to Figure 2 except for the addition of a triac preregulator and associated control circuit. The triac is a bidirectional device and is usually connected in series with one side of the input primary. Whenever a gating pulse is received, the triac conducts current in a direction that is dependent on the polarity of the voltage across it. The goal is to control the triac so that the bridge rectifier output (dc input to the switches) is held relatively constant. This is accomplished by a control circuit that issues a phase-adjusted firing pulse to the triac once during each half-cycle of the input ac. The control circuit compares a ramp function to a rectified ac sinewave to compute the proper firing time for the triac.

Although the addition of the preregulator circuitry increases complexity, it provides three important benefits.

(1) By keeping the dc input to the switches constant, it permits the use of more readily available lower voltage switching transistors.

(2) The coarse preregulation it provides allows the main regulator to achieve a finer regulation.

(3) Through the use of slow-start circuits, the initial conduction of the triac is controlled, providing an effective means of limiting input surge current.

Note that the preregulator triac is essentially a switching device and, like the main regulator switches, does not absorb a large amount of power. Hence, the addition of the preregulator does not significantly reduce the overall efficiency of this supply.

Single Transistor Switching Regulator

At lower output power levels, a one-transistor switch becomes practical. The single transistor regulator of Figure 4 is referred to as a forward, or feed-through, converter. It can receive a dc input from either one of two sources without a change in its basic configuration. For ac-to-dc requirements, the regulator is connected to a line rectifier and SCR preregulator. For dc-to-dc converter applications it is connected directly to an external dc source.

Like the previous switching supplies, the output voltage is controlled by varying the ON time of the regulator switch. The switch is turned on by the leading edge of each 20kHz clock pulse and turned off by the pulse-width modulator at a time determined by output load conditions.

While the regulating transistor is conducting, the half-wave rectifier diode is forward biased and power is transferred to the output filter and the load. When the regulator is turned off, the "flywheel" diode conducts, sustaining current flow to the load during the off period. A flywheel diode (sometimes called a freewheeling or catch diode) was not required in the two transistor regulators of Figures 2 and 3 because of their full-wave rectifier configuration.

Another item not found in the previous regulators is "flyback" diode CR_F. This diode is connected to a third transformer winding which is bifilar wound with the primary. During the off periods of the switch, CR_F is forward biased, allowing the return of surplus magnetizing current to the input filter, and thus preventing saturation of the transformer core. This is an important function because core saturation often leads to the destruction of switching transistors. In the previously described two transistor push-pull circuits, core saturation is easier to avoid because magnetizing current is applied to the core in both

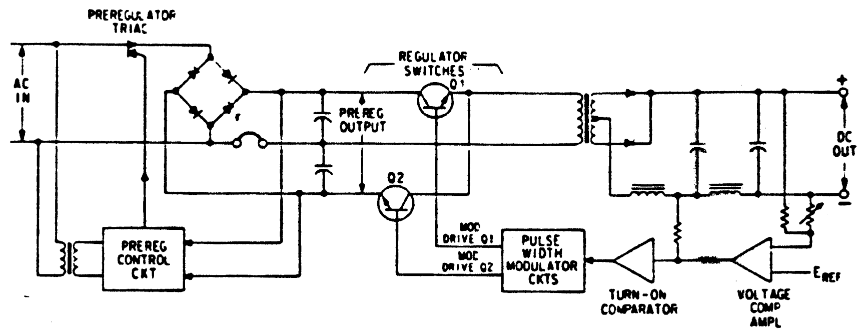


Figure 3. Push-Pull Switching Supply with Triac Preregulator

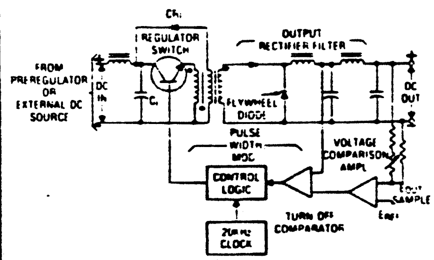


Figure 4. Single Transistor Switching Regulator called a Forward or Feed-Through Converter

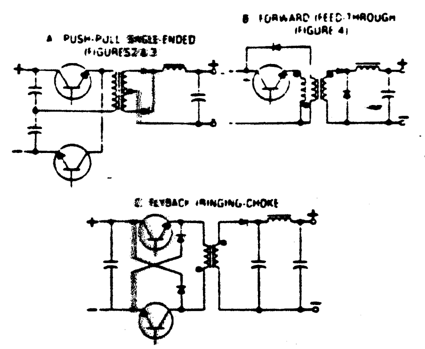


Figure 5. Summary of Basic Switching Regulator Configurations

directions (i.e., before saturation, the current is reversed). Nevertheless, matched switching transistors and balancing capacitors must still be used in these configurations to ensure that core saturation does not occur.

Configuration B is a useful alternative to push-pull operation for lower power requirements. It is called a forward or feed-through converter because energy is transferred to the power transformer secondary immediately following turn-on of the switch. Although the ripple frequency is inherently lower, output ripple amplitude can be effectively controlled by the choke in the output filter. Two-transistor configurations of forward converters also exist wherein both transistors are switched simultaneously. They provide the same output power as the single transistor versions, but the transistors need handle only half the peak voltage.

Summary of Basic Switching Regulator Configurations

Figure 5 shows three basic switching regulator configurations that are often used in today's power supplies. Configuration A is of the push-pull class, and this version was used in the switching supplies shown in Figures 2 and 3. Other variations of this circuit are used also, including two-transistor balanced push-pull and four transistor bridge circuits.

As a group, push-pull configurations are the most effective for low-voltage, high-power and high performance applications. Push-pull circuits have the advantage of a ripple frequency that is double that of the other two basic configurations and, of course, output ripple is inherently lower.

Configuration C is known as a flyback, or ringing choke, converter because energy is transferred from primary to secondary when the switches are off (during flyback). In the example, two transistors are used and both are switched simultaneously. While the switches are on, the output rectifier is reverse biased and current in the primary inductance rises in a linear manner. When the switches are turned off, the collapsing magnetic field reverses the voltage across the primary, and the previously stored energy is transferred to the output filter and load. The two diodes in the primary protect the transistors from inductive surges that occur at turn-off.

Flyback techniques have long been used as a means of generating high voltages (e.g., the high voltage power supply in television receivers). As you might expect, this configuration is capable of providing higher output voltages than the other two methods. Also, the flyback regulator provides a greater variation of output voltage with respect to changes in duty cycle. Hence, the flyback configuration is the most obvious choice for high, and variable output voltages while the push-pull and forward configurations are more suitable for providing low, and fixed output voltages.

Protection Circuits for Switching Supplies

Figure 6 shows typical protection circuits that are used in HP switching regulated power supplies. The following is a brief description of those protection circuits shown.

A. EMI Filter. Helps prevent high frequency spikes (RFI) from being conducted to the load or back into the ac line. HP switching supplies also contain built-in shields for additional control of conducted and radiated interference.

B. Thermistor. Limits ac input surge current by its negative temperature coefficient of resistance. Has a high resistance when cold (during turn-on) and low resistance after it heats up.

C. Regulator Overcurrent Limit. This circuit is much faster than the current limit comparator and protects the regulator switches from overcurrent conditions of a transient nature. It monitors current flow through the switches and prevents it from exceeding a harmful level.

D. Output Rectifier Diodes. Besides final rectification, these diodes also protect internal components against reverse currents that could be injected into supply by an active load or series connected supply.

E. AC Undervoltage. This circuit performs a dual function. It protects the supply from damage that could result from a prolonged condition of low ac input voltage, and it limits output overshoot during turn-on. During undervoltage or turn-on conditions, the low ac input level reduces the V_{BIAS} voltage and activates the undervoltage detector. When activated, the modulator pulses are inhibited and the regulator switches turned off.

F. Overvoltage Detector. Monitors output voltage and turns off regulator switches if output attempts to rise above a preset value. Similar to a crowbar circuit except that output voltage is removed by turning off regulator rather than by shorting the output.

G. Temperature Switch. Opens in case of high ambient temperature that could be caused, for example, by a misapplication or cooling fan failure. The switch opens and removes VBIAS which activates the ac undervoltage detector. The switch closes again after temperature cools to a safe level.

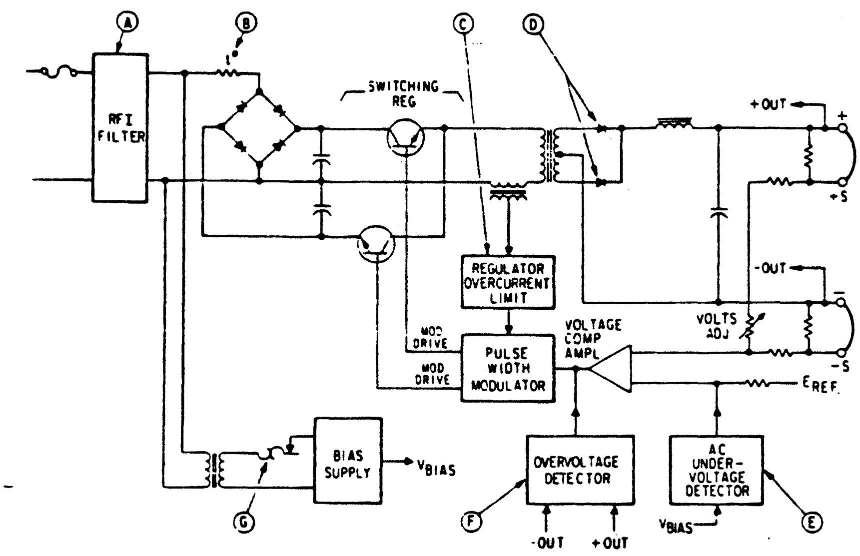


Figure 6. Protection Circuits, Switching Type Supply

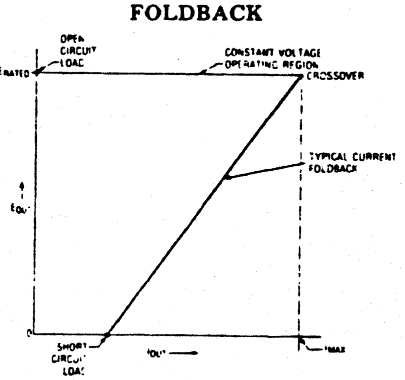
SWITCHING SUPPLY TERMINOLOGY

The following is a brief glossary of terms encountered in dealing with switching supplies.

Brown Out Rated

The ability of a power supply to maintain regulated output voltages in the event that the input line voltage should drop to a low or zero level.

FOLDBACK



Current Foldback

An overload protection method where output voltage and current decrease simultaneously as the load resistance decreases below a preset crossover point and begins to approach a short circuit. Also known as output short circuit protection, this mechanism monitors the output current and, if it exceeds a preset crossover value, turns down the regulator output.

EMI (RFI)

Electromagnetic interference (radio frequency interference) — unwanted high frequency energy caused primarily by the switching components in the power supply. EMI can be conducted through the input or output lines or radiated through the unit's case. Conducted EMI (RFI) can be reduced using proper filtering, and radiated EMI (RFI) can be reduced by judicious board layout and enclosing the supply in a metal enclosure.

The terms "noise" EMI and RFI are sometimes used in the same context.

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ESR (Equivalent Series Resistance)

The amount of resistance in series with an ideal (lossless) capacitor which exactly duplicates the performance of a real capacitor. In general, the lower the ESR, the better the quality of the capacitor and the more effective it is as a filtering device. ESR is a prime determinant of ripple in switching supplies.

Flyback

Precisely, it's the shorter of the two time intervals comprising a sawtooth wave. In a switching power supply, the shorter interval is produced when the transistors are switched off. This causes a rapidly collapsing magnetic field in the transformer which reverses the voltage across the primary, transferring a high energy to the output.

Ground Loop

A feedback problem caused by two or more circuits sharing a common electrical line, usually a common ground line. Voltages gradients in this line caused by the first circuit may be resistively, inductively, or capacitively coupled into the other circuit via the common line. With power supplies, this problem can be reduced using single point grounding near the supply.

Hold-up Time

The total time any output will remain within its regulation band after line input voltage has suddenly dropped to zero or below rating. Hold-up is measured at full load and nominal line conditions.

Input Surge Current

The peak line current which flows during turn-on. Surge current is caused by charging of the input capacitor, and limited primarily by an input thermistor or preregulator.

Input Voltage Range

The range of line voltages for which the power supply meets its specifications. The lowest line voltage is important in defining the relative degree of brown-out protection.

Isolation Voltage

The maximum voltage by which any part of the circuit can be operated away from chassis ground. Also the maximum voltage between any output and input terminal.

Line Regulation

See Source Effect.

Line Frequency Regulation

The variation of an output voltage due to a change in line input frequency with all other factors held constant. This effect is negligible in switching and most linear supplies, but is very critical in ferroresonant supplies.

Load Effect Transient Recovery Time

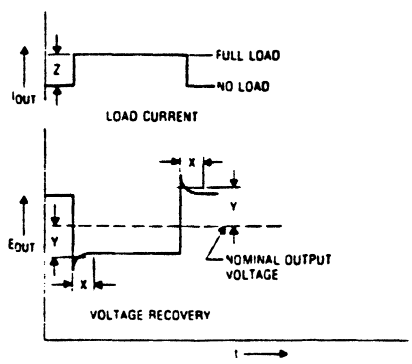
Sometimes referred to as transient recovery time or transient response time, it is, loosely speaking, the time required for the output voltage of a power supply to return to within a level approximating the normal dc output following a sudden change in load current. More exactly, Load Transient Recovery Time for a CV supply is the time "X" required for the output voltage to recover to, and stay within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current — where:

(1) "Y" is specified separately for each model, but is generally of the same order as the load regulation specification.

(2) The nominal output voltage is defined as the dc level halfway between the steady state output voltage before and after the imposed load change.

(3) "Z" is the specified load current change, typically equal to the full load current rating of the supply.

TRANSIENT RECOVERY TIME



Overcurrent Limiting

A protection mechanism which limits the output current of a supply without materially affecting the output voltage.

Overshoot

The amount by which an output exceeds its final value in a transient response to a rapid change in load or input voltage. In power supply design this parameter is particularly important at turn-on.

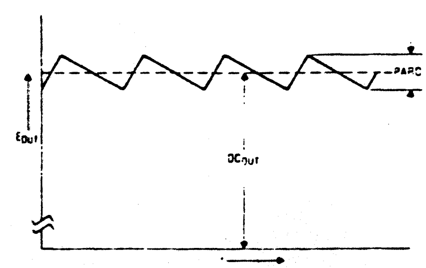
Overvoltage Protection

A protection mechanism for the load which reduces the output voltage to a very low value in the event that the output exceeds a certain threshold voltage. In a switching supply, the regulator is turned off if the threshold is exceeded, reducing the output voltage and current to zero. In linear supplies, an SCR "crowbar" is used to rapidly place a short circuit across the output terminals whenever the threshold voltage is exceeded.

PARD (Ripple and Noise)

The term PARD is an acronym for "periodic and random deviation" and replaces the former term ripple and noise. PARD is the residual ac component that is superimposed on the dc output voltage or current of a power supply. It is measured over a specified bandwidth with all influence and control quantities maintained constant. PARD is specified in rms and/or peak-to-peak values over a bandwidth of 20Hz to 20MHz. Fluctuations below 20Hz are treated as drift. Attempting to measure PARD with an instrument that has insufficient bandwidth may conceal high frequency spikes that could be detrimental to a load.

DC OUTPUT OF POWER SUPPLY AND SUPERIMPOSED PARD COMPONENT



Peak Charging

A rise in voltage across a capacitor caused by the charging of the capacitor to the peak rather than RMS value of the input voltage. This generally occurs when a capacitor has a high discharge resistance across it and large ripple or spikes on its input line. In a switcher this effect determines minimum load (discharge resistance) conditions on each output to maintain regulation.

Post Regulator

A linear (dissipative) regulator used on the output of a switching supply to further improve over-all regulation performance of the supply. Post regulators can be either the 3 terminal I.C. type or a custom discrete design. Since the differential voltage across the post regulator can be kept to a minimum, dissipative losses are generally small.

Rise Time and Fall Time

When applied to the switching transistor, that time in which non-zero currents and voltages result in high peak power dissipation. Careful attention must be paid to reducing these times, particularly when switching inductive loads.

Ripple and Noise

See PARD.

Short Circuit Protection

See Current Foldback.

Source Effect (Line Regulation)

Formerly known as line regulation, source effect is the change in the steady-state value of the dc output voltage (of a CV supply) or current (of a CC supply) due to a specified change in the source (ac line) voltage, with all other influence quantities maintained constant. Source effect is usually measured after a "complete" change in the ac line voltage from low line to high line or vice-versa.

Switcher

A common industry-wide name for a switching power supply.

Temperature, Coefficient

The average percent change in output voltage per degree change in temperature with load and input voltage held constant. The coefficient is usually derived from output voltage measurements taken at room temperature (25°C) and at the two specified operating temperature extremes.