

Model 9308 Assembly and Using Manual



It's hard to beat analog synths for fat, punchy bass lines. And for discovering new sounds, nothing comes close to real knobs operating in real time. The FatMan has all of the features that give analog it's warm, full tone in a MIDI controlled package. The classic normalization scheme of twin VCO/ VCF/VCA and Dual Transient Generators is brought up to date with the inclusion of Velocity CV not available on pre-MIDI synths. FatMan learns from the past by including features that were eccentricities of classic synths such as a unique "punch" switch that adds a subtle but useful fifth segment to the standard ADSR response.

Details specific to the installation of the FatMan circuit board in the 9308C Desk Top enclosure are covered in the 9308C Supplement. Follow the assembly instructions in this manual until instructed to reference the 9308C Supplement.



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FatMan Packing List

2 244-C373 8 BL Endon C22C4 3 10 ohm (brown-black-black) R38,R39,R33 1 DACces 8 BLPROM C3 1 10 h0m (brown-black-black) R38,R39,R33 1 DACces 8 BLPROM C3 10 h0m (brown-black-black) R38,R39,R33 1 Advace 8 BLPROM C3 10 h0m (brown-black-brown) R3,R18,R38,R1,Res 1 Advace Advace C11 C10 (brown-black-brown) R3,R18,R82,R14,Bes 1 Advace Case C12 C10 C10 R4,R58,R71,R8,R422,R30,R00 1 Advace Case C10 C12 100 (brown-red-brown) R2 1 Case C12 C12 1 100k (brown-red-brown) R2 R3,R18,R82 1 Case C12 C14 1 18k (brown-red-brown) R3,R18,R82 1 Case C12 C12 1 10k0 chm (brown-red-brown)	1	8031	8 Bit MicroController	IC1	1/4\	1/4W 5% resistors			
1 2764 B&EPACIM C2 3 10 ohm (brown-black-black) PR3.R38.R39 1 DACGB B Bit DAC (may be 146); ICS 10 100 ohm (brown-black-brown) PR3.R31.R82,R81.R82,R83,R83 1 HM339 Quel Comparator ICS 15 10K (brown-black-black) R82,R31.R83,R83 1 HM339 Quel Comparator ICS 15 10K (brown-black-wellow) R81,R38,R93,R93,R93 1 HM339 Quel Comparator ICS 1000 hm (brown-black-wellow) R81,R38,R93,R93,R93 1 HM339 Quel Comparator ICS 1000 hm (brown-black-wellow) R81,R38,R93,R93,R93 1 HM330 Quel Comparator ICS 12 100 hm (brown-black-wellow) R81,R38,R93,R93,R93 1 HM334 Quel Add DAmp (CA324) IC10,IC1 1 120 hm (brown-black-blue) R81,R93,R93,R93,R93,R93,R93,R93,R93,R93,R93									
1 DAC08 8 BLDAC (may be 1406) ICS 10 100 ohm (brown-black-brown) RS3,R81,R82,R81,R8 1 PR3,R16,R20,R28,R81,R3,R81,R8 RS3,R81,R82,R81,R8 RS3,R81,R82,R81,R8 RS3,R81,R82,R81,R8 1 LM330 Quad CAmper (CA324) IC10 10 Incom-black-brown) R84,R85,R81,R83,R81,R8 1 Mo52 Dual 1/4 CM0SMUX IC3 1 IOO (bm (brown-black-brown) R84,R85,R81,R83,R81,R8 1 Mo16 Quad Analog Switch IC11 1 100k (brown-black-black) R84,R85,R81,R81 1 T004 Quad Analog Switch IC11 1 100k (brown-red-orange) R74,R108 2 LM3300 Dual OTA IC17,IC18 5 12k (brown-red-orange) R74,R188,R82,R91,R9 2 Mu17300 mail Total IC12 1 100k (brown-red-orange) R74,R186 2 Mu176V * IC12 1 1800 (brown-black-black) R83,R14,R110 3 DuF16V					3	10 ohm	(brown-black-black)	R38,R39,R93	
i i No. 10. N					10	100 ohm	(brown-black-brown)	*R73,R16,R20,R26,R44,	
1 100,157,26,77,26,78,726,777,72,75,777,72,786,710,1100 R57 1 10022 1002,114 (CMOS MUX CG 1 10022 1002,114 (CMOS MUX CG 1 10022 1002,114 (CMOS MUX CG 1 1006 Clock (Clock) Clock (Clock) 1 1004 Auad Arabog Switch IC11 12 Iomegohm (brown-black-level)ow) R57 1 TABS Auad She Aw ** IC16 1 120 ob (brown-black-level) R41,R100 1 1002,P1/6V ** IC20 1 18k (brown-black-level) R41,R58,R82,R73,R7,R78,R78,R82 1 7912 *12V * IC16 3 16k (brown-black-level) R41,R58,R82,R73,R7,R78,R78,R82 3 1002/F1/6V * IC20 1 18k (brown-black-level) R41,R58,R82 1 1002/F1/6V * IC12 1 18k (brown-black-level) R41,R58,R82 102/F1/FV * C12,C			,				, , , , , , , , , , , , , , , , , , ,	R53.R81.R83.R91.R95	
1 Likusa Chai af Comparation Ca 1 Likusa Chai af Conformation R48,R55,R77,R77,R77,R78,R71 1 Likusa Chai af Conformation R78,R51,R76,R77,R77,R77,R78,R71 1 Likusa Chai af Conformation R44,R51,R67,R77,R77,R77,R78,R71 1 Likusa Chai af Conformation R44,R100 1 Likusa Chai af Conformation R78,R78,R77,R77,R77,R78,R73 1 Chai af Conformation R44,R100 R77,R72,R73,R78,R77,R78,R73 1 Chai af Conformation R44,R53,R62 R78,R78,R77,R78,R73,R78,R73,R78,R78,R73,R78,R73,R78,R73,R78,R73,R78,R73,R73,R74,R58,R72,R77,R78,R73,R78,R73,R73,R74,R58,R72,R73,R73,R74,R58,R72,R73,R73,R74,R58,R71,R719 1 R360,R10,R78,R73,R78,R73,R74,R73,R73,R74,R58,R72,R73,R73,R74,R58,R71,R71,R73,R73,R74,R58,R72,R73,R74,R58,R71,R71,R73,R73,R74,R58,R72,R73,R73,R74,R58,R71,R71,R73,R73,R74,R58,R72,R73,R73,R74,R58,R74,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R73,R73,R74,R58,R74,R16,R71,R74,R70,R73,R73,R74,R58,R74,R16,R71,R74,R70,R73,R73,R74,R58,R74,R16,R11,R71,R74,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,R74,R73,					15	10k	(brown-black-orange)		
1 Likasso Dual 14 Comparison R3 4052 Dual 14 Comparison R57 1 1006 (brown-black-bulow) R57 1 1006 (brown-black-bulow) R41 R100 4016 Quad Ander Switch R57 1 1006 (brown-black-bulow) R57 1 1000 (brown-black-bulow) R41 R100 2 LM13600 Dual OTA IC17 IG18 1 1000 frife File Sile 1 1000 frife File Sile 1 1000 frife R57 R58 1 1800 ohm forown-red-orange) R48 1 1000 frife C122 1 180 ohm forown-black-red) R48 1 1000 frife C22 C101 R48 R58 R14 2 2.20 frife C1.23 32 220 ohm fred-red) R48 1 1000 frife C22 C70 ohm red-red) R48 R58 2 2.20 f			5				(
1 1002 Dual (MACMOSINDA) LS 1 100k (Drown-black-blue) R41, R100 1 4016 Quad Analog Switch IC11 1 12 10meging R41, R100 R41, R100 2 LM300 Dual OTA IC11, IC15 1 12 10meging R70, R72, R75, R72, R108 2 LM1360 Dual OTA IC11, IC15 1 18 (Drown-red-brown) R32 R33 708 +5V Viage Reg. IC13, IC16 1 18k (Drown-reg-orange) R89 R43, R35, R37, R48, R58, R60, R58, R44, R50 3 100F/16V * * C16 C38, C31, C22, C26 C30 1 1800 ohm (Drown-red-orange) R34, R56, R68, R60, R63, R64, R80 5 1uF/16V * * C16 C38, C31, C22, C26 C27 2 200 hm (red-red-orange) R34, R56, R81, R07 5 2.2uF/16V * * C26 C27 1 330k (orange-orange-yellow) R84 6 0.0uF * * C24 C37 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
Lining Outad Application Child of the constraint of the constra					1	100k	(brown black vollow)		
1 1 1 1 1 1 20 ohm (brown-red-orange) R22 2 LM13600 Dual OTA (C17, IC18) 5 12k (brown-red-orange) R70, R72, R75, R70, R72, R70, R70, R72, R70, R70, R72, R70, R70, R72, R70, R70, R70, R70, R70, R70, R70, R70	2	LM324	Quad OpAmp (CA324)	IC10,IC13					
1 LUbas Dual Drait CDTA	1	4016	Quad Analog Switch	IC11				-	
2 Lin 1500 Dial OTA C17/L16 The Provide Stress R78/L108 2 555 Timer R14,R63,R62 R78,R108 1 7705 +8V * * IC13 1 18k (brown-green-orange) R89 1 77912 -12V * * IC14 9 1000 hm fbrown-green-orange) R89 3 100LF/16V Electrolytic Capacitor C28,C29,C30 (c1,C23 R48,R63,R60,R68,R107 5 2.2.0F/16V * C16,C18,C31,C32 2.220 ohm (red-red-rag) R48,R63,R60,R68,R107 5 2.2.0F/16V * C26,C6,C19,C32,C22,C32 1.330,K (rad-red-orange) R48,R63,R66,R68,R107 4 2.2.0F/16V * C26,C6,C19,C32,C22,C32 1.330,K (orange-orange-orange) R48,R63,R66,R68,R107 5 2.2.0F/16V * C26,C6,C19,C22,C2,C32 2.2.270 ohm (red-red-rag) R48,R63,R107 6 .01uF * C26,C37 1.330,K (orange-orange-orange) R47,R54,R109 7 <	1	TL084	Quad Bi-fet Amp (CA084)	IC12			· ,		
2 555 Timer IC15/C16 IC19 15K (brown-green-orange) R49 1 7805 +6V Voltage Reg. IC19 1 18k (brown-green-orange) R39 1 7805 +6V Voltage Reg. IC19 1 1800 ohm (brown-green-orange) R39 1 7912 -12V ** * IC14 9 1000 ohm (brown-green-orange) R31,R35,R37, R34,R69,R60,R88,R107 2 2.220 ohm (red-red-red) R4,R69,R60, R34,R69,R60,R88,R107 3 2.220 ohm (red-red-red) R43,R64,R00 1 010F ** * C26,C27 2 270 ohm (red-violet-brown) R34,R64,R00 2 010F ** * C26,C27 2 200 ohm (red-red-red) R45,R64,R00 2 010F ** * C26,C27 330k (orange-orange-orange-orange) R45	2	LM13600	Dual OTA	IC17.IC18	5	12k	(brown-red-orange)		
1 7805 +5V Voltage Reg. IC19 3 15K (Drown-grey-orange) R89 1 7805 +8V * * IC20 1 188 (brown-grey-orange) R89 1 7912 -12V * IC14 1 1800 ohm (brown-grey-orange) R89 3 100uF/16V Electrolytic Capacitor C28.C29.C30 C1.C23 220 ohm (red-red-red) R83,R84,R80 5 2.2uF/16V * * * C32.C33 220 ohm (red-red-red) R49,R85,R16,R19 2 470uF/25V * * * C26.C27 1 330k (orange-orange) R84,R85,R16,R19 3 .01uF * * * C24.C27 1 330k (orange-orange) R84,R54,R40 4 .04uF * * C24.C27 1 330k (orange-orange) R47,R54,R54,R109 3 .04uF * * C24.C23,C26 2 470 ohm (yellow-violet-black) R10,R10,R106 1 .04uF * * C24.C21 3 38 (orange-white-brack) R10,R112 2 100uF *		555							
1 7808 +8V -12V " 1 18k (brown-grey-red) 'R89 1 7912 -12V " IC14 1 1800 ohm (brown-grey-red) 'R89 3 100uF/16V " " C28, C29, C30 (brown-grey-red) 'R48, R59, R60, R63, R64, R80 5 100/16V " " C32, C33, C15, C18, C31, C22, C22, C20 220 ohm (red-red-orange) R36, R66, R68, R107 5 2.2uF/16V " C5, C6, C19, C22, C25 2 270 ohm (red-red-orange) R36, R66, R68, R107 2 3.1uF Mylar Capacitor C7, C8, C12 1 330k (orange-orange-orange) R46, R56, R568, R109 2 .01uF " " C24, C17 1 330k (orange-white-brown) R17, R99 6 .01uF " C34, C35, C36 10 4700 ohm (yellow-violet-back) R23, R43, R52 1 .05uF Power Diodes D10,D11 1 560h (green-blue-orange) R170, R10, R111 3 RedLED D2,D12,D13 2 15 ohm </td <td></td> <td></td> <td></td> <td></td> <td>3</td> <td></td> <td>(brown-green-orange)</td> <td>R14,R58,R62</td>					3		(brown-green-orange)	R14,R58,R62	
1 7912 -12V " IC14 1 1800 ohm (Drown-Diack-red) R33 3 1000-F/16V Electrolytic Capacitor C28.C29.C30 C1.C23 R33,R35,R37, R48,R59,R60, R58,R60, R58,R10, R11 5 2.2uF/16V " " C26.C27 1 300 hm (red-red-red) R49,R58,R60, R58,R10, R1 2 470uF/25V " " C26.C27 1 330k (orange-orange) R54,R54,R10, R1 2 470uF/25V " " C26.C27 1 330k (orange-orange) R54,R54,R10, R1 2 33pF Caramic Disk Capacitor C2,C23 1 2 30k (orange-white-brown) R17,R99 2 33pF Caramic Disk Capacitor C2,C2 2 30k (orange-white-brown) R10,R11 3 .001uF " " " C34,C35,C36 10 470 ohm (yellow-violet-red) R10,R11 3 1041P Power Diodes D10,D11 1 56 bohm (green-blue-black) R2			0 0		1	18k	(brown-grey-orange)	R89	
9 1000 chm (brown-black-red) R31,R35,R37, R43,R59,R60, R63,R64,R80 100/F/16V * * C123 R44,R50,R60, R63,R64,R80 R63,R64,R80 5 10/F/16V * * C15,C18,C31, C32,C32,C22,C4 2 200 chm (red-red-orange) R48,R55,R16,R19 6 2,2uF/16V * * C26,C27 2 270 ohm (red-red-orange) R38,R66,R68,R107 7 1,uF Mylar Capacitor C7,C3,C12 1 330k (orange-orange-orange-yellow) R38 1,001uF * * C24,C37,C12 330k (orange-orange-orange-yellow) R38,R19 2,011uF * * C24,C37,C12 330k (orange-orange-orange-yellow) R38,R16,R19 1,001uF * * C24,C37,C12 390 ohm (red-red-orange) R48,R54,R109 2,011uF * * C24,C37,C12 390 ohm (orange-orange-orange-ville) R23,R52 1,001uF * * C34,C35,C36 10 470 ohm (yellow					1	1800 ohm	(brown-grey-red)	*R33	
3 Itour 16V RestRef.Red. RestRef.Red. 5 100F/16V ************************************	1	1312	-12 V	1014	9	1000 ohm	(brown-black-red)	R31,R35,R37,	
3 Itour 16V Res/R64/R80 Res/R64/R80 5 10/07/16V ************************************	~			COD COD COD			, , , , , , , , , , , , , , , , , , ,	R48,R59,R60,	
2 IULF/16V * C15C18_C31, C32_C33 3 220 ohm (red-red-rown) R2,R4,R5 5 12,F16V * C15C18_C31, C32_C33 4 2200 ohm (red-red-red) R49,R85,R116,R119 5 2,207,0 dnm (red-red-red) R30,R66,R68,R107 R33,R66,R68,R107 6 .1uF Mylar Capacitor C7,C8,C12 1 330k (orange-orange-orange) R48,R54,R109 7 .1uF Mylar Capacitor C7,C8,C12 1 330k (orange-orange) R48,R54,R109 8 .01uF * * C24 2 390 ohm (orange-white-orange) R17,R99 7 .041F * * * C24 2 470 ohm (yellow-violet-black) R23,R43,R52 1 .041F * * * C34,C35,C36 10 470 ohm (yellow-violet-black) R25 1 .0401 * Power Diodes D10,D11 1 566 hm (green-blue-black) R25 1 144148 Signal Diodes D10,D11 1 566 hm (green-blue-black) R25 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
3 1uPr16V C32,C33 4 2200 ohm (red-red-red) R49,R85,R116,R119 5 2.2uF/16V " " C5,C6,C19,C22,C25 2 270 ohm (red-violet-brown) R3,R19 2 470uF/25V " " C26,C27 1 2700 ohm (red-violet-brown) R3,R19 2 470uF/25V " " C26,C27 1 2700 ohm (red-violet-brown) R17 2 33pf Ceramic Disk Capacitor C2,C3 2 390 ohm (orange-white-orange) R45,R54,R109 2 33pf Ceramic Disk Capacitor C2,C3 2 390 ohm (yellow-violet-brown) R17,R99 3 .01uF " " C24,G2,C10,C11, C13,C16 2 470 ohm (yellow-violet-brown) R10,R111 3 .05uF " " C24,C3,C35,C36 10 4700 ohm (yellow-violet-black) R23,R43,R52 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 3 RedLED D10,D11 1 56 ohm <td< td=""><td></td><td></td><td></td><td></td><td>З</td><td>220 ohm</td><td>(red-red-brown)</td><td></td></td<>					З	220 ohm	(red-red-brown)		
5 2.2uF/16V " C5.C6.C19.C22, C25 4 2.2k (red-violet-brown) (red-violet-red) (red-violet-black) (red-vi	5	1uF/16V	a a						
3 2.2UP/16V C25 2 270 ohm (red-violet-brown) R3.R19 2 470uF/25V * * C26.C27 1 2700 ohm (red-violet-brown) R3.R19 2 3.1uF Mylar Capacitor C26.C27 1 330k (orange-orange-yellow) R88 2 .01uF * * * C24.C9.C10.C11, 3 33k (orange-orange)-xellow) R88 2 .01uF * * * C24.C9.C10.C11, 3 3700 ohm (orange-white-orange) R10.0 R17.R99 3 .05uF * * * C24.C9.C10.C11, 3 470 ohm (yellow-violet-brown) R3.R13,R52 1 .001uF * * * C24.C9.C10.C11, 3 470 ohm (yellow-violet-brown) R3.R43,R52 2 10.01uF * * C24.C35.C36 10 4700 ohm (yellow-violet-brown) R3.R43,R52 2 11.4001 Power Diodes D10.D11 1 56 chm (green-blue-black) R25 2							· ,	, , ,	
2 470uF/25V " " C26 27 R10 R10 3 1uF Mylar Capacitor C7,C8,C12 1 330k (orange-orange-orange-orange) R45,R54,R109 2 33pF Ceramic Disk Capacitor C2,C3 2 380 hm (orange-white-brown) R17,R99 2 .01uF " " C2,C3 2 380 hm (orange-white-brown) R17,R99 3 .05uF " " C24,C3,C10,C11,C13,C16 2 470 ohm (yellow-violet-brown) R10,R111 1 .05uF " " C24,C35,C36 C20,C21 1 470k (yellow-violet-brown) R110,R111 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 3 1N4148 Signal Diodes D10,D11 1 56 ohm (blue-grey-red) R11 2 1N4001 Power Diodes D10,D14 1 56 hm (green-blue-black) R25 3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (se	5	2.2uF/16V	66 66	C5,C6,C19,C22,				, , ,	
2 4/00F/25V C26,C21 1 330k (orange-orange-orange-vellow) R88 1 .01uF " " 330k (orange-orange-orange) R45,R54,R109 2 .01uF " " 330k (orange-orange-orange) R45,R54,R109 3 .01uF " " C14,C17 2 330 k (orange-white-brown) R17,R99 6 .01uF " " C2,C3 2 390 ohm (orange-white-brown) R17,R99 1 .001uF " " C2,C3 2 390 ohm (vellow-violet-black) R23,R43,R52 2 .05uF " " C24,C35,C36 10 470 ohm (yellow-violet-brown) R11,R12,R15,R27,R28,R7,R112 7 .05uF Dio,D11 1 56 km (green-blue-orange) R47 1 14401 Power Diodes D10,D11 1 56 km (green-blue-orange) R47 1 14401 Signal Diodes D10,D11 1 56 km (green-blue-orange) R47 2 12V4126				C25			(
3 1/UF Mylar Capacitor C7,C8,C12 1 330k (orange-orange-orange-orange) R48,R54,R109 2 .01uF " " 333k (orange-white-orange) R48,R54,R109 3 33k (orange-white-orange) R17,R99 309 ohm (orange-white-orange) R17,R99 6 .01uF " " C4,C9,C10,C11, 2 39k (orange-white-orange) R17,R99 1 .001uF " " C2,C3 2 39k (orange-white-orange) R17,R99 3 .05uF " " C24,C21 470 ohm (yellow-violet-brown) R110,R111 7 .05uF " " C34,C35,C36 10 470 ohm (yellow-violet-brown) R112,R15,R27,R28,R61,R109 8 1N4148 Signal Diodes D10,D11 1 56 ohm (green-blue-black) R25 8 1N4148 Signal Diodes D1,D3,D4,D5,D6,D6,D7,D8,D9 1 6800 ohm W. Power Resistor R117 Sestion DIP Switch \$1,53,*S4 7 2N4126 NPN Silicon Transistors Q1,Q2,Q7,Q	2	470uF/25V	** **	C26,C27					
2 .01uF " " C14.C17 3 338 Corange-Value-orange) R43,R54,R109 2 33pF Ceramic Disk Capacitor C2,C3 2 390 ohm (orange-white-orange) R103,R105 6 .01uF " " C4,C9,C10,C11, 3 47 ohm (yellow-violet-black) R23,R43,R52 7 200 uF " " C34,C35,C36 10 470 ohm (yellow-violet-black) R23,R43,R52 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 8 1N4148 Signal Diodes D1,D3,D4,D5, D6,D7,D8,D9 1 6800 ohm (blue-grey-red) R11 3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (see pg 6) 5 2N4126 PNP Silicon Transistors Q1,Q2,Q7, Q3,Q4,Q5,Q6, 1 12 - 14/46, PWR WR1 1 1/4" Phone Jack "J6 1 28 FST Panel Mount Tragel Switches *51,*S3,*S4 2 10k ohm PC MountTrimmer R13,R42 *12 - 14/46, PWR X1 X1			ar Capacitor						
2 330 F Ceramic Disk Capacitor C2,C3 2 390 onm (orange-white-orown) N17, K99 6 .01uF " " C4,C9,C10,C11, C13,C16 2 390 onm (orange-white-orown) R17, K99 1 .001uF " " " C4,C9,C10,C11, C13,C16 2 390 onm (orange-white-orown) R17, K99 1 .001uF " " " C4,C9,C10,C11, C13,C16 2 470 ohm (yellow-violet-black) R23,R43,R52 2 560pF Polystyrene Capacitor C20,C21 1 470 ohm (yellow-violet-black) R1,R12,R15,R27,R28, R61,R65,R88,R97,R112 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-orange) R47 3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (see pg 6) 5 2N4124 NPN Silicon Transistors Q1,Q2,Q7, Q1,Q,Q11 3 SPST Panel Mount Togle Switches *51,*S3,*S4 7 2N4126 PNP Silicon Transistors Q1,Q2,Q7, Q3,Q4,Q5,Q6, Q8,Q9,Q12 3 SPST Panel Mount Togle Switches *51,*S3,*S4 7 PC Mount Fin DIN	2		"			33k			
6 .01uF " " C4.C9.C10.C11, C13,C16			c Disk Capacitor	·		390 ohm	(orange-white-brown)	R17, R99	
1 .001uF " " R23,R43,R52 1 .001uF " " C24 2 47 ohm (yellow-violet-black) R23,R43,R52 2 560pF Polystyrene Capacitor C20,C21 10 4700 ohm (yellow-violet-red) R1,R12,R15,R27,R28,R61,R65,R88,R97,R112 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 8 1N4148 Signal Diodes D1,D3,D4,D5,D8,D9 1 560 ohm (green-blue-orange) R47 3 RedLED D2,D12,D13 1 56 ohm (green-blue-orange) R47 3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (see pg 6) 5 2N4124 NPN Silicon Transistors Q1,Q2,Q7,Q7,Q3,Q3,Q4,Q5,Q6,Q3,Q12 3 SPST Panel Mount Toggle Switches *51,*S3,*S4 2 PC Mount Phono Jack J3,J4,J5 1 12 - 14VAC, PWR1 S00mA (or greater) Wall Mount Transf. 1 1/4" Phone Jack J3,J4,J5 1 28 Pin IC Socket 1 440 Yi1/2" Machine Screws 3 16 kohm PC Mount Trimmer R13,R42 "L" Brackets 3			" "		2	39k	(orange-white-orange)	R103,R105	
1 .001µF " " " " .024µF " " " " C24 C26	0	.0101			3	47 ohm	(yellow-violet-black)	R23,R43,R52	
1 .05010 ¹¹ * * C34,C35,C36 C20,C21 10 4700 ohm (yellow-violet-red) R1,R12,R15,R27,R28,R61,R65,R88,R97,R112 2 560pF Polystyrene Capacitor C20,C21 1 470k (yellow-violet-yellow) R1,R12,R15,R27,R28,R61,R65,R88,R97,R112 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 3 RedLED D2,D12,D13 1 56 ohm (green-blue-yellow) R111 3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (see pg 6) 5 2N4124 NPN Silicon Transistors Q1,Q2,Q7,Q10,Q11 3 SPST Panel Mount Toggle Switches *51,*S3,*S4 7 2N4126 PNP Silicon Transistors Q3,Q4,Q5,Q6,Q12 1 12 + 14VAC,S00,MA (or greater) Wall Mount Transf. 1 1 1/4" Phone Jack *J6 1 12 + 14VAC, PWR1 500m A(or greater) Wall Mount Transf. 1 2 10k ohm PC Mount Phono Jack J3,J4,J5 18 Set Screw Knobs 1 28 Pin IC Socket 1 40 Pin IC Socket 2 "L" Brackets 3	4	001 "	"		2	470 ohm	(vellow-violet-brown)	R110,R111	
3 Jobdin R61,R65,R88,R97,R112 2 560pF Polystyrene Capacitor C20,C21 1 470k (yellow-violet-yellow) R99 2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 3 RedLED D2,D12,D13 1 56k (green-blue-orange) R47 3 RedLED D2,D12,D13 2 15 ohm (blue-grey-red) R117 5 2N4124 NPN Silicon Transistors C1,Q2,Q7, Q10,Q11 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 7 2N4126 PNP Silicon Transistors C1,Q2,Q7, Q3,Q4,Q5,Q6, 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 8 PC Mount Phono Jack *J6 1 12 - 14VAC, PWR1 State 2 10k ohm PC Mount Trimmer R13,R42 1 12 mHz Crystal X1 8 10k ohm Panel Mount Pot *R34,*R56, *R69,*R71, *R47,*R102, *R44,*R92, *R44,*R92, *R44,*R92, *R44,*R96 *44 Vuts 4 440 X 1/4* Machine Screws 4 1 1 kohm ** *R43,*R92, *R44,*R96, *R44,*R92, *R94,*R96 *		.00101				4700 ohm	()		
2 3600P Polysysteme Capaciton C20,C21 1 470k (yellow-violet-yellow) R99 2 1N4001 Power Diodes D10,D11 1 56 km (green-blue-black) R25 3 RedLED D2,D12,D13 1 56 km (green-blue-orange) R47 3 RedLED D2,D12,D13 2 15 ohm (blue-grey-red) R11 3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (see pg 6) 5 2N4126 PNP Silicon Transistors Q3,Q4,Q5,Q6,Q8,Q9,Q12 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 4 1 12 - 14VAC, PWR1 500mA (or greater) Wall Mount Transf. 1 12 - 14VAC, PWR1 3 PC Mount 5 Pin DIN Sockets J1,J2 1 12mHz Crystal X1 X1 8 10k ohm PC Mount Trimmer R13,R42 "L" Brackets 3 # 4-40 X 1/4" Machine Screws 4 140 khm PC Mount Trimmer R13,R42 "L" Brackets 3 # 4-40 X 1/4" Machine Screws 1 10k ohm Panel Mount Pot		.05ur					()()		
2 1N4001 Power Diodes D10,D11 1 56 ohm (green-blue-black) R25 8 1N4148 Signal Diodes D1,D3,D4,D5, D6,D7,D8,D9 1 56k (green-blue-orange) R47 3 RedLED D2,D12,D13 2 15 ohm (blue-grey-red) R11 5 2N4124 NPN Silicon Transistors Q1,Q2,Q7, Q3,Q4,Q5,Q6, Q8,Q9,Q12 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 7 2N4126 PNP Silicon Transistors Q3,Q4,Q5,Q6, Q8,Q9,Q12 1 12 - 14VAC, S00mA (or greater) Wall Mount Transf. PWR1 2 PC Mount 5 Pin DIN Sockets J1,J2 1 12mHz Crystal X1 3 PC Mount Trimmer R13,R42 1 28 Pin IC Socket 1 40 Pin IC Socket 2 10k ohm Panel Mount Pot *R34,R56, "R69,R71, "R74,R102," "Wire "Wire " 8 10k ohm Panel Mount Pot *R34,R56, "R69,R71, "R74,R102," 1 44 O X 1/2" Machine Screws 1 44 O X 1/2" Machine Screws 4 1 400 rin IC Socket 1 Nylon Cable Clamp * * * *	2	560pF Polyst	syrene Capacitor	C20,C21	1	470k	(vellow-violet-vellow)		
2 IN4001 Power Diodes D1,D3,D4,D5, D6,D7,D8,D9 1 56k (green-blue-orange) R47 3 RedLED D2,D12,D13 2 15 ohm (blue-grey-red) R11 5 2N4124 NPN Silicon Transistors Q1,Q2,Q7, Q1,Q,Q11 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 7 2N4126 PNP Silicon Transistors Q3,Q4,Q5,Q6, Q8,Q9,Q12 1 12 - 14VAC, 500mA (or greater) Wall Mount Transf. PWR1 1 1/4" Phone Jack *J6 1 12mHz Crystal X1 2 10k ohm PC Mount Trimmer R13,R42 1 12mHz Crystal X1 3 PC Mount Phono Jack J3,J4,J5 18 Set Screw Knobs 1 28 Pin IC Socket 2 10k ohm PC Mount Trimmer R18,R21,R24 2 "L" Brackets 3 #4 Nuts 8 10k ohm Panel Mount Pot *R34,*R56, *R59,*R71, *R74,*R102, *R41,4*R115 1 440 X 1/2" Machine Screw 440 X 1/2" Machine Screw 6 1megohm """"""""""""""""""""""""""""""""""""									
o 1144145 Signal Diodes Di, D, D4, D5, D5, D4, D5, D5, D5, D5, D5, D5, D5, D5, D5, D5		1N4001							
3 RedLED D2,D12,D13 2 15 ohm 1W. Power Resistor R117 (see pg 6) 5 2N4124 NPN Silicon Transistors Q1,Q2,Q7, Q10,Q11 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 7 2N4126 PNP Silicon Transistors Q3,Q4,Q5,Q6, Q8,Q9,Q12 3 SPST Panel Mount Toggle Switches *S1,*S3,*S4 1 1/4" Phone Jack *J6 1 12 - 14VAC, Q8,Q9,Q12 PWR1 3 PC Mount 5 Pin DIN Sockets J1,J2 12 12 - 14VAC, S00mA (or greater) Wall Mount Transf. X1 2 10k ohm PC Mount Trimmer R13,R42 1 12mHz Crystal X1 3 1k ohm PC Mount Trimmer R18,R21,R24 1 40 Pin IC Socket 1 44 OX 1/4" Machine Screws 3 10k ohm Panel Mount Pot *R34,*R56, *R69,*R71, *R74,*R102, *R104,*R115 1 #4 Nuts 4 44 OX 1/4" Machine Screws 6 1megohm " " *R29,*R82, *R84,*R92, *R84,*R92, *R84,*R92, *R94,*R96 *Small Insulated Sleeving * #22 issulated, stranded wire (4 ea. 9.5' lengths) 1 1 1 1 kohm " " *R90<	8	1N4148	Signal Diodes	D1,D3,D4,D5,					
215 ohm1W. Power ResistorR117 (see pg 6)52N4124 NPN Silicon TransistorsQ1,Q2,Q7, Q10,Q113SPST Panel Mount Toggle Switches*S1,*S3,*S472N4126 PNP Silicon TransistorsQ3,Q4,Q5,Q6, Q8,Q9,Q12112 - 14VAC, 500mA (or greater) Wall Mount Transf.PWR111/4" Phone Jack*J6112 - 14VAC, 500mA (or greater) Wall Mount Transf.PWR1210k ohmPC Mount TrimmerR13,R42112mHz CrystalX13PC Mount Phono JackJ3,J4,J518Set Screw Knobs1410k ohmPC Mount TrimmerR13,R42"L" Brackets331k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R14,*R112, *R14,*R102, *R04,*R964 -40 X 1/4" Machine Screws61megohm""""""""""""""*R32,*R82, *R84,*R92, *R84,*R92, *R84,*R9642" Bare Wire1100k ohm"""""""""""""*R401100k ohm"""""""""""""""""""""""""""""""""				D6,D7,D8,D9	1	6600 0nm	(blue-grey-red)	RH	
215 onm1W. Power ResistorR117 (see pg 6)52N4124 NPN Silicon TransistorsQ1,Q2,Q7, Q10,Q113SPST Panel Mount Toggle Switches 8 Position DIP Switch*S1,*S3,*S472N4126 PNP Silicon TransistorsQ3,Q4,Q5,Q6, Q8,Q9,Q12112 - 14VAC, 500mA (or greater) Wall Mount Transf.PWR1 500mA (or greater) Wall Mount Transf.11/4" Phone Jack*J6500mA (or greater) Wall Mount Transf.X12PC Mount 5 Pin DIN SocketsJ1,J2112mHz CrystalX13PC Mount Phono JackJ3,J4,J518Set Screw KnobsX1210k ohmPC Mount TrimmerR13,R42140 Pin IC Socket231k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R14,*R1102, *R14,*R112, *R14,*R1144-40 X 1/4" Machine Screws4-40 X 1/2" Machine Screws61megohm""*R32,*R82, *R84,*R92, *R84,*R9642" Bare Wire11kohm"""*R94,*R961100k ohm""*R4011100k ohm""*R401500k ohm""*R14	3	RedLED		D2,D12,D13					
Q10,Q113SPS1 Panel Mount Toggle Switches*51,*53,*5472N4126 PNP Silicon TransistorsQ3,Q4,Q5,Q6, Q8,Q9,Q1218Position DIP SwitchS211/4" Phone Jack*J6112 - 14VAC,PWR12PC Mount 5 Pin DIN SocketsJ1,J2500mA (or greater) Wall Mount Transf.X13PC Mount Phono JackJ3,J4,J5112mHz CrystalX1210k ohmPC Mount TrimmerR13,R42140 Pin IC Socket31k ohmPC Mount TrimmerR18,R21,R242"L" Brackets310k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102, *R74,*R102, *R84,*R92, *R94,*R964 -40 X 1/4" Machine Screws61megohm" " " " " " " " " " " " " " " " " " "					2	15 onm	1W. Power Resistor	R117 (see pg 6)	
Q10,Q113SPS1 Panel Mount Toggle Switches'51,'53,'5472N4126 PNP Silicon TransistorsQ3,Q4,Q5,Q6, Q8,Q9,Q1218Position DIP SwitchS211/4" Phone Jack*J6112 - 14VAC,PWR12PC Mount 5 Pin DIN SocketsJ1,J2500mA (or greater) Wall Mount Transf.X13PC Mount Phono JackJ3,J4,J5112mHz CrystalX1210k ohmPC Mount TrimmerR13,R42140 Pin IC Socket31k ohmPC Mount TrimmerR18,R21,R242"L" Brackets310k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102, *R74,*R102, *R84,*R92, *R94,*R964 -40 X 1/4" Machine Screws61megohm" " " " " " " " " " " " " " " " " " "	5	2N4124 NPN	Silicon Transistors	Q1,Q2,Q7,					
72N4126 PNP Silicon TransistorsQ3,Q4,Q5,Q6, Q8,Q9,Q1218 Position DIP SwitchS211/4" Phone Jack*J6112 - 14VAC,PWR12PC Mount 5 Pin DIN SocketsJ1,J2112mHz CrystalX13PC Mount Phono JackJ3,J4,J518Set Screw Knobs210k ohmPC Mount TrimmerR13,R42140 Pin IC Socket31k ohmPC Mount TrimmerR13,R422"L" Brackets31k ohmPanel Mount Pot*R34,*R56,44-40 X 1/4" Machine Screws810k ohmPanel Mount Pot*R32,*R82,*R69,*R71,1*R104,*R115*R104,*R1151Nylon Cable Clamp61megohm" " " " " " " " " " " " " " " " " " "									
Q8,Q9,Q12112 - 14VAC, 500mA (or greater) Wall Mount Transf.11/4" Phone Jack*J62PC Mount 5 Pin DIN SocketsJ1,J23PC Mount Phono JackJ3,J4,J5210k ohmPC Mount Trimmer210k ohmPC Mount Trimmer810k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102,*R34,*R56, *R69,*R71, *R104,*R11561megohm"11k ohm"4*R32,*R82, *R84,*R92, *R94,*R961100k ohm"11k ohm11k ohm11k ohm11k ohm11k ohm1*R444*R444*R901100k ohm**R44**R401500k ohm**	7	2N4126 PNP Silicon Transistors							
11/4" Phone Jack*J62PC Mount 5 Pin DIN SocketsJ1,J23PC Mount Phono JackJ3,J4,J5210k ohmPC Mount TrimmerR13,R4231k ohmPC Mount TrimmerR13,R4231k ohmPC Mount TrimmerR18,R21,R24810k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102,144.40 X 1/4" Machine Screws514.40 X 1/4" Machine Screws61megohm""11kohm"*R32,*R82, *R94,*R961100k ohm""1100k ohm"1100k ohm"1100k ohm"1100k ohm"1500k ohm"2*31314*4*4*515151514*5151 </td <td>•</td> <td></td> <td>1</td> <td colspan="3">12 - 14VAC, PWR1</td>	•				1	12 - 14VAC, PWR1			
2PC Mount 5 Pin DIN SocketsJ1,J2112mHz CrystalX13PC Mount Phono JackJ3,J4,J518Set Screw Knobs210k ohmPC Mount TrimmerR13,R42140 Pin IC Socket31k ohmPC Mount TrimmerR13,R422"L" Brackets31k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102, *R104,*R1154 4-40 X 1/4" Machine Screws61megohm""*R32,*R82, *R84,*R92, *R94,*R96111k ohm""*R34,*R56, *R69,*R71, *R104,*R115161megohm"**R34,*R92, *R94,*R96111k ohm""**11k ohm"**11kohm"**1100k ohm"**1100k ohm"**1500k ohm"**31kohm"**4***4***500k ohm"** </td <td>1</td> <td colspan="2">1/4" Phone lock</td> <td></td> <td></td> <td colspan="2">500mA (or greater) Wall Mount Transf.</td> <td>f.</td>	1	1/4" Phone lock				500mA (or greater) Wall Mount Transf.		f.	
3PC Mount Phono JackJ3, J4, J518Set Screw Knobs210k ohmPC Mount TrimmerR13, R42 R18, R21, R2418Set Screw Knobs31k ohmPC Mount TrimmerR13, R42 R18, R21, R242"L" Brackets310k ohmPanel Mount Pot*R34, *R56, *R69,*R71, *R74,*R102, *R104,*R1154440 X 1/4" Machine Screws61megohm""*R34, *R52, *R44,*R92, *R94,*R961Nylon Cable Clamp11k ohm""*R90 *R44,*R961Small Insulated Sleeving *B3' #22 insulated, stranded wire (4 ea. 9.5' lengths)11 Nok ohm""*R40 *R11419308 FatMan Printed Circuit Board					1	12mHz Crystal X1		X1	
210k ohmPC Mount TrimmerR13,R42 R13,R42 R18,R21,R2418Set Screw Knobs 1210k ohmPC Mount TrimmerR13,R42 R18,R21,R24140 Pin IC Socket 11310k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102, *R104,*R11544-40 X 1/4" Machine Screws 14-40 X 1/4" Machine Screws61megohm" " " " " " *R94,*R9614-40 X 1/2" Machine Screws 1161megohm" " " " " " *R94,*R96* *R901Nylon Cable Clamp 42" Bare Wire 8" Small Insulated Sleeving 38' #22 insulated, stranded wire (4 ea. 9.5' lengths) 1111k ohm" " " " " * 1* *R4019308 FatMan Printed Circuit Board1100k ohm" " " " " " *									
210k ohm 3PC Mount Trimmer PC Mount TrimmerR13,R42 R13,R21,R24128 Pin IC Socket 131k ohmPC Mount TrimmerR13,R42 R18,R21,R242"L" Brackets 3#4 Nuts810k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102, *R104,*R11544-40 X 1/4" Machine Screws61megohm""*R34,*R92, *R84,*R92, *R94,*R96*411k ohm"""*11k ohm""**11k ohm"""*11k ohm"""*1100k ohm"""*1500k ohm""**1500k ohm""**2500k ohm""*2****31500k ohm"*31500k ohm"*4***4**4**4**4**4**4**4**4**4**5**4**4*4*4*4*4*4*	3	PC Mount Ph	UNUJACK	J3,J4,J5	18	Set Screw k	Knobs		
210k ohm 3PC Mount Trimmer PC Mount TrimmerR13,R42 R18,R21,R24140 Pin IC Socket 2"I"310k ohmPanel Mount Pot*R34,*R56, *R69,*R71, *R74,*R102, *R104,*R11514-40 X 1/4" Machine Screws 1461megohm""*R34,*R56, *R69,*R71, *R74,*R102, *R104,*R11514-40 X 1/2" Machine Screws 161megohm""*R34,*R92, *R94,*R96 *R94,*R96*R32,*R82, *R94,*R96%11k ohm"""*R90 *R401100k ohm"""*R401500k ohm""*R14*					1	28 Pin IC Soc	cket		
2 10k ohm PC Mount Trimmer R13,R42 2 "L" Brackets 3 1k ohm PC Mount Trimmer R18,R21,R24 2 "L" Brackets 8 10k ohm Panel Mount Pot *R34,*R56, *R69,*R71, *R74,*R102, *R104,*R115 4 4-40 X 1/4" Machine Screws 6 1megohm " " *R34,*R56, *R69,*R71, *R74,*R102, *R104,*R115 1 4-40 X 1/4" Machine Screws 1 4-40 X 1/2" Machine Screws 1 4-40 X 1/2" Machine Screw 1 Nylon Cable Clamp * * 42" Bare Wire 8" Small Insulated Sleeving * 38' #22 insulated, stranded wire (4 ea. 9.5' lengths) 1 Voltage Regulator Cooling Fin 1 100k ohm " " * 1 500k ohm " * * * 500k ohm " * *	_								
3 1k ohm Periodial Hinnel K18,K21,K24 3 #4 Nuts 8 10k ohm Panel Mount Pot *R34,*R56, 4 4-40 X 1/4" Machine Screws 8 10k ohm Panel Mount Pot *R69,*R71, 1 4-40 X 1/2" Machine Screws 6 1megohm " " *R104,*R102, 1 #4 Flat Washer 1 1k ohm " " *R32,*R82, *R84,*R92, *R94,*R96 1 1k ohm " " *R90 1 Voltage Regulator Cooling Fin 1 100k ohm " " *R40 1 9308 FatMan Printed Circuit Board 1 500k ohm " " *R114 parte marked, * mount on the front panel				·					
8 10k ohm Panel Mount Pot *R34,*R56, 4 4-40 X 1/4" Machine Screws 8 10k ohm Panel Mount Pot *R69,*R71, 1 4-40 X 1/2" Machine Screws 6 1megohm " " *R74,*R102, 1 #4 Flat Washer 7 1Megohm " " *R32,*R82, *R34,*R92, *Bare Wire 8 Small Insulated Sleeving *R94,*R96 38' #22 insulated, stranded wire (4 ea. 9.5' lengths) 1 1 1k ohm " " *R40 1 9308 FatMan Printed Circuit Board 1 500k ohm " " *R114 parte marked, * mount on the front panel	3	1k ohm	PC Mount Trimmer	R18,R21,R24					
8 Tok onm Panel Mount Pot *R34, R56, *R34, R56, *R69, *R71, *R69,*R71, *R74,*R102, *R104,*R115 1 4-40 X 1/2" Machine Screw 6 1megohm *"" *R69,*R71, *R102, *R104,*R115 1 Wylon Cable Clamp 6 1megohm *"" *R34,*R92, *R82, *R84,*R92, *R94,*R96 1 Nylon Cable Clamp 1 1k ohm """<" *R90							Machina Sarawa		
61megohm"""*R74,*R102, *R104,*R115, *R104,*R15, *R104,*R15, *R84,*R92, *R84,*R96,1#4 Flat Washer 111#4 Flat Washer 11Nylon Cable Clamp 42" Bare Wire 8" Small Insulated Sleeving 38' #22 insulated, stranded wire (4 ea. 9.5' lengths) 111 kohm""*R84,*R92, *R94,*R968" Small Insulated Sleeving 38' #22 insulated, stranded wire (4 ea. 9.5' lengths) 111 kohm""*R901Voltage Regulator Cooling Fin 11100k ohm""*R4019308 FatMan Printed Circuit Board1500k ohm""*R114parte marked, * mount on the front panel	8	10k ohm	Panel Mount Pot	*R34,*R56,					
61megohm"""R104,"R102, *R104,"R1151Nylon Cable Clamp61megohm"""R32,*R82, *R84,*R92, *R94,*R96%Bare Wire11k ohm"""Small Insulated Sleeving 38'11k ohm"""R901100k ohm"""R401500k ohm"""R114				*R69,*R71,					
6 1megohm "R104,*R115" 1 Nylon Cable Clamp 6 1megohm "R104,*R115" 2" Bare Wire 8 "R32,*R82, *R84,*R92, 8" Small Insulated Sleeving 1 1k ohm """"""""""""""""""""""""""""""""""""				*R74,*R102,					
6 1megohm " " " "						•	Ciamp		
*R84,*R92, *R94,*R968°Small insulated Sleeving11k ohm""*R94,*R9638'#22 insulated, stranded wire (4 ea. 9.5' lengths)11k ohm""*R901Voltage Regulator Cooling Fin1100k ohm""*R4019308 FatMan Printed Circuit Board1500k ohm""*R114parts marked, * mount on the front panel	6	1megohm	" "						
*R94,*R9638° #22 insulated, stranded wire (4 ea. 9.5' lengths)11k ohm" " *R901100k ohm" " *R401500k ohm" " *R114	-	3							
1 1k ohm """ *R90 1 Voltage Regulator Cooling Fin 1 100k ohm """ *R40 1 9308 FatMan Printed Circuit Board 1 500k ohm """ *R114 parts marked, * mount on the front panel					38'			' lengths)	
1 100k ohm " *R40 1 9308 FatMan Printed Circuit Board 1 500k ohm " " *R114	1	1k ohm	" " "		1	1 Voltage Regulator Cooling Fin			
1 500k ohm """" *R114					1	1 9308 FatMan Printed Circuit Board			
narte marked * mount on the tront nanel			ee ee ee						
			66 66 66		part	s marked * n	nount on the front panel		
	1	SK UHITI		N119	, ,		,		

1/4W 5% resistors

Designations R50, R51and R87 are not used.

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FatMan Design and Tuning Analysis

As shown in fig 5a, the schematic of the digital circuitry, FatMan's brain is an 8031 MicroController (IC1). Firmware for the system is burned into the EPROM (IC3) which is attached to the uP's address and data lines with the Octal Latch IC2. The DIP switch S2 connects to five of the uP's input port lines. Four of the switches in this package are used to select MIDI Channel and the fifth is an unused input to the processor.

The receive (RxD) line of IC1 receives MIDI Data from the mandatory optocoupler IC6 which isolates the ground of the MIDI sending device from FatMan's ground. The output of the optocoupler is also buffered by a pair of Inverter stages (IC7:b & a) which drive the MIDI Thru output J2. A third Inverter stage, IC7:c, drives the LED D2 to give an indication of MIDI activity on the input J1.

DAC TUNING

FatMan's VCOs are linear in the way their frequencies respond to Control Voltage changes. This means that CVs must change exponentially to produce proper pitches. For example, to produce a pitch an octave above the present pitch the CV must double; for an octave lower the voltage must be halved. Linear Digital to Analog Converters are generally no good at generating these kinds of voltage increments because if the DAC is scaled to produce the largest voltage necessary, a couple of octaves lower you're dealing with semi-tone voltage changes that are much smaller than the resolution of the Least Significant Bit.

FatMan gets around this problem by having the DAC (IC5) be responsible for only a single octave's worth of the CV. In tech-talk, the voltages for 12 equally tempered pitches are sparsely mapped along an exponential curve in the 256space of the 8-bit DAC. Octave changes are handled by the ranging network consisting of a 1/4 Multiplexer (IC9) that selects one of four taps on the voltage divider string R17-R26. These component values produce a voltage at each tap that is 1/2 the voltage of the tap above.

On the digital side of things, the DAC is glued to the uP data lines with the octal latch IC4. The ranging MUX is controlled by the processor's T0 and T1 lines. These signals are level shifted to 8V by discrete transistors Q1 and Q2.

In normal operation, the voltage generated by the DAC can be thought of as going from C down to C#, with octave ranging changes happening between C# and the C immediately below it. So that the maximum output range of the DAC can be used (for maximum error of less than one cent), the DAC is ranged to produce a voltage from a nominal 3V for C (FFh into the DAC) down to a nominal .177v for C# (0Eh into the DAC). The 3V offset introduced by the current flow through R12 and R14 causes the voltage from the DAC's output buffer (pin 7 of IC10) to go from a nominal 6V down to a nominal 3.177V.

Huh?

(c)2000 PAiA Electronics, Inc. Fair use copy with this notice only email info@paia.com What's this 3.177V business? Well, that is the voltage corresponding to the octave below 6V (which is 3V) plus the voltage required to produce the next semi-tone up. Since in equal temperament each semi-tone has a frequency 1.059 times the preceding semi-tone, and since our Voltage/Frequency response is linear, the next semi-tone above 3V is 3*1.059 =3.177V (if you think it's difficult to read, try explaining it some time.)

At the step between C# and the C below it, the DAC buffer output returns to 6V and the octave switching network switches to divide this in half so the CV to the VCOs becomes 3V, which as you now know is the voltage an octave below 6V.

During calibration the output of the DAC as set by R13 is adjusted so that it exactly matches the offset voltage from R12 and R14. When these conditions are met, the output of the buffer will be some voltage X in response to the maximum DAC output (FFh as data) and exactly X/2when the DAC is contributing no output at all (00h as data). We've stated the "nominal" value of x as 6V, which may seem sort of sloppy (the actual voltage may be as low as 5V.) until you realize that it's the ratio of 2:1 that matters, and not the exact value of the voltages.

The DAC must be tuned over the octave from C0 to C1 because C0 is the only C that causes 00h to be sent to the DAC. In firmware, this lowest C is an exception to the normal ranging that happens between C# and C.

Once the DAC is tuned, the trimmers that set octave intervals (R18, R21 and R24) are adjusted so that the pitch changes by octaves as you go down the keyboard by octaves. These adjustments do not interact between themselves or with the tuning of the DAC, so you usually only have to go through them once for them to be right, and the circuitry is simple and stable so they tend to stay right for a long time.

In the final calibration step, the two VCOs are made identical by adjusting the zero offset of VCO #1 so that it's the same as VCO #2. A subtlety of the tuning process is that it compensates for any zero offset in VCO #2 (which means that exactly zero voltage may not produce exactly zero frequency, trickier than it sounds). So as long as VCO #1 is the same, everything is wonderful.

The single output of the DAC and Octave Range Switcher is split into Pitch and Velocity CVs with the sample and hold circuits built using OpAmps IC12:a&b, CMOS switches IC11:a&b and capacitors C7 and C8. System firmware outputs values to the DAC and Range Switcher corresponding to the Pitch CV then turns on IC11:a to sample the voltage by charging capacitor C7. IC11:a is then turned off to isolate the voltage on C7. The processor then repeats these actions for the Velocity CV, turning on the second CMOS switch (IC11:b) to charge C8. The voltages on the capacitors are read out by their corresponding OpAmp buffers IC12:a & :b. Comparators IC8:a&b provide level translation from 5V to the higher voltage needed for the CMOS switches by tying their open collector outputs to the 8V rail through R29 and R30.

Leaving the bits and bytes behind, we turn our attention



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Fig 5a. An 8031 uProcessor provides the computing horsepower needed to decode MIDI and keep Control Voltages straight. Equally tempered Control Voltages are provided by the combination of the DAC and Octave Range switching.

to the analog sound generating and processing part of FatMan shown in fig 5b.

What would an analog synth be without a GLIDE control to grab and twist for really expressive portamento? FatMan uses the common approach of charging a capacitor (C12) through a variable resistor (R32). IC10:a buffers the voltage on the capacitor and drives the Master Pitch control R34 which is used to transpose both oscillators over slightly more than an octave range.

The two VCOs are identical except for the Offset control (R40) which allows the pitch of VCO #1 to be raised and lowered an octave relative to VCO #2. VCO #1 also has a trimmer that allows it's zero intercept to be adjusted to match that of VCO #2.

Taking VCO #1 as being otherwise typical, the Pitch CV drives a voltage to current converter (V/I) consisting of IC10:c, transistors Q3 and Q4 and the associated resistors. The current output of this circuit, from the collectors of the transistors, charges capacitor C14 and produces a linear voltage ramp which is read out by the buffer amp IC10:d. IC16 is a 555 type timer that senses when the voltage ramp at the output of the buffer exceeds a threshold at which point an internal transistor is turned on to short out the capacitor and quickly discharge it. When the capacitor discharges to a lower threshold the transistor is turned off and the capacitor can once again charge and repeat the cycle.

The result of this relatively slow charging and quick discharging is a ramp (sawtooth) waveform and in the interest of simplicity this is the only oscillator waveform available. A ramp is the most harmonically rich of the common waveforms, having both the even harmonics of a triangle and the odd harmonics of a pulse. The filter can be used to track the pitch of the oscillators and reject all harmonics in the ramp leaving only the fundamental sine wave.

Potentiometer R56, the Osc1/Osc2 Mix control, allows the VCF to be driven by either VCO1 or VCO2 or a mix of the two. The VCF design is a State Variable Filter which has been configured to give a low-pass response with resonance, adjustable with R114, at the corner frequency. The filter is built around IC17, an LM13600 type Dual Operational Transconductance Amplifiers (OTA) with C20 and C21 as the tuning capacitors. Two control currents for setting the gain of the two OTAs in IC17 are produced by the V/I consisting of IC13:d, Q8, Q9 and associated resistors. Four separate voltages are summed to set the corner frequency of the filter; a static voltage that sets the initial frequency is adjustable with R74, Velocity CV adjustable by R69, Pitch CV adjustable by R71, and finally the output of the filter's dedicated transient generator adjustable with R115.

The filter's AR transient generator works by charging C22 through R83 and R84 for the Attack portion of the cycle and discharging it through R81 and R82 for the Release section. Charging and discharging currents are steered by D3 and D4 as Q7 is switched on and off by the TxD line of the uP. Voltage on the capacitor is buffered by IC12:c and the comparator IC8:c monitors the buffer's voltage and switches the processor's INT1 input when the peak voltage is reached. The firmware's response to this is to switch from Attack to Release. Closing the Sustain switch

S3 prevents this "peak reached" signal from getting back to the uP so that the Release portion of the cycle won't happen until the key that initiated the response is released. The result is to switch the transient from a nonsustaining AR to an Attack / Sustain / Release (ASR) response.

FatMan's Voltage Controlled Amplifier uses one OTA from IC18. The main components of the V/I that control this element are IC13:c and Q12. This voltage to current converter is unlike the others in that it must be stable for zero control voltage (so the VCA can turn off completely). Adding D9 to the circuit clamps the output of IC13:c and keeps it from going negative and C24 provides frequency compensation for the high loop-gain state that exists at near-zero control voltages

The Attack/Decay/Sustain/Release (ADSR) transient generator dedicated to the VCA is similar to the filter's A(S)R. Under control of a pair of the uP's output lines (P12 & P13), capacitor C19 charges and discharges though steering diodes D6-D8 at rates set by R92, R94 and R96. The Sustain control R90 sets the voltage level to which the Decay portion of the cycle falls. IC12:d buffers the voltage on the capacitor and comparator IC8:d signals the processor when the peak of the Attack is reached.

When the Punch switch S1 is closed the combination of C34 and R98 add a slight delay (about 20 ms.) between the time that the ADSR reaches its Attack peak and the time that this information reaches the uP. The result is a short Sustain interval that adds punch to sounds with fast Attack and Decay dynamics. When S1 is open, the ADSR behaves in the normal, technically correct way.

FIRMWARE

The FatMan firmware is responsible for recognizing MIDI Note On and Off messages and breaking them down into Note number and Velocity values. Note number is checked for being in the range of 36-84 and then converted into octave ranges by division and the data required to drive the DAC by look-up table.

The Velocity data from Note On and Off messages are handled in much the same way, except that the 0 to 127 step range of this data is first scaled to range from 36-84.

Pitch Wheel messages are also supported. In the FatMan, Wheel data modulates the Pitch data before it gets to the DAC. This is possible because only 12 of the 256 possible values of the DAC are used for pitch and the space between these values is available for modulation. Musical range of FatMan's Pitch Wheel is +/- a semi-tone. Since there are no pitches available above the highest C or below the lowest, wheel data is ignored on these bends.

The firmware is also responsible for turning on and off the proper sample and hold at the proper time to produce Pitch and Velocity CVs. It manages the A(S)R and ADSR transient generators, turning on their Attack cycle when a note is played and managing Decay, Sustain and Release as appropriate for the status of the transient and any Note Off messages which may be received.



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Fig 5b. The FatMan analog circuitry comporises two VCOs, low-pass VCF with AR Transient Generator, and VCA with ADSR Transient Generator