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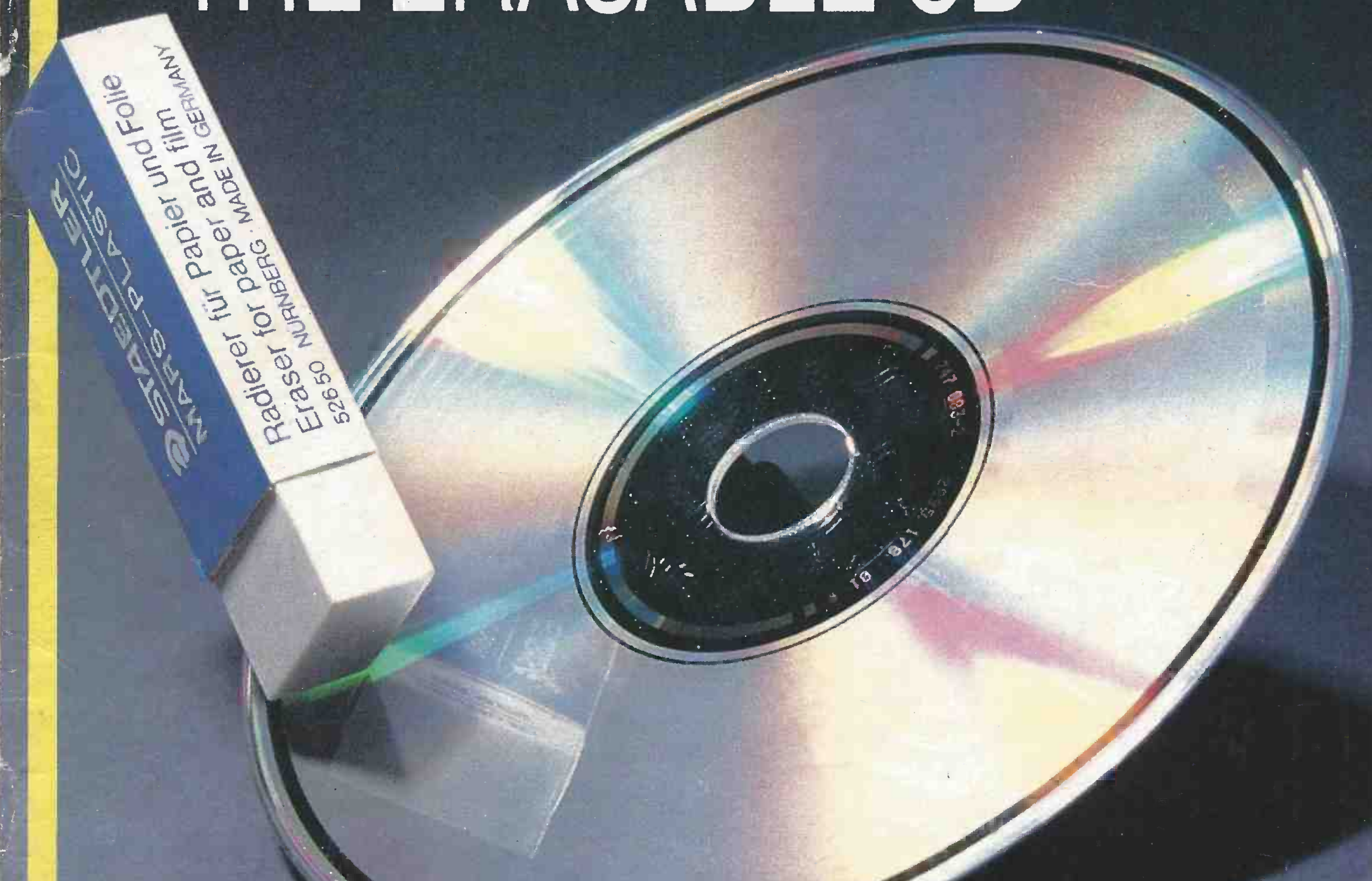
electronics today

INTERNATIONAL OCTOBER 1986 £1.20

CD MEMORY

Coming Soon...

THE ERASABLE CD



TO BUILD:

PLL AUTORANGING FREQUENCY COUNTER ▶

AUDIO ANALYSER

SPECIAL PULL OUT

STARTING YOUR OWN ELECTRONICS BUSINESS

PLUS: FREE READERS' ADS

AUDIO....COMPUTING....MUSIC....RADIO....ROBOTICS

electronics today INTERNATIONAL

OCT 1986 VOL 15 NO 10

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FEATURES

PROJECTS

Due to shortage of space, the Upgradeable Amp article scheduled for this month has been held over.

REGULARS

INFORMATION

74 SERIES

7400	30p
7401	30p
7402	30p
7403	30p
7404	30p
7405	30p
7406	40p
7407	40p
7408	30p
7409	30p
7410	30p
7411	30p
7412	30p
7413	50p
7414	70p
7416	30p
7417	40p
7420	30p
7421	60p
7422	30p
7423	30p
7425	40p
7426	40p
7427	40p
7428	43p
7430	30p
7432	30p
7433	30p
7437	30p
7438	40p
7439	40p
7440	40p
7441	90p
7442A	70p
7443A	100p
7444	110p
7445	70p
7446A	100p
7447A	100p
7448	120p
7450	30p
7451	35p
7453	30p
7454	30p
7460	55p
7470	60p
7472	55p
7473	55p
7474	60p
7475	60p
7476	45p
7480	60p
7481	150p
7483A	100p
7484A	120p
7485	110p
7486	42p
7489	210p
7490A	55p
7491	70p
7492A	70p
7493A	55p
7494	110p
7495A	60p
7496	60p
7497	290p
74100	150p
74107	60p
74109	75p
74110	75p
74111	55p
74116	170p
74118	110p
74119	170p
74120	100p
74121	55p
74122	70p
74123	70p
74125	55p
74126	55p
74128	55p
74132	75p
74136	70p
74141	70p
74142	200p
74143	270p
74144	270p
74145	90p
74147	175p
74148	140p
74150	175p
74151A	70p
74153	60p
74154	140p
74155	90p
74156	100p
74157	60p
74159	225p
74160	110p
74161	110p
74162	110p
74163	110p
74164	120p
74165	110p
74166	140p
74167	200p
74170	200p
74172	420p
74173	140p
74174	110p
74175	100p
74176	100p
74178	100p
74179	100p
74180	100p
74181	340p
74182	140p
74184	185p
74185A	180p
74190	130p
74191	130p
74192	110p
74193	115p
74194	110p
74195	80p
74196	130p
74197	110p
74198	220p
74199	220p
74221	110p
74251	100p
74259	180p
74265	300p
74273	200p
74276	140p
74278	170p
74279	90p
74283	100p
74285	320p
74290	90p
74293	90p
74298	180p
74351	200p
74365A	80p
74366A	80p
7436A	80p
74367A	80p
74368A	70p
74376	180p
74390	110p
74393	112p
74490	140p

74LS SERIES

74LS00	24p
74LS01	24p
74LS02	24p
74LS03	24p
74LS04	24p
74LS05	24p
74LS08	24p
74LS09	24p
74LS10	24p
74LS11	24p
74LS12	24p
74LS13	24p
74LS14	24p
74LS15	24p
74LS20	24p
74LS21	24p
74LS22	24p
74LS24	24p
74LS26	24p
74LS27	24p
74LS28	24p
74LS30	24p
74LS32	24p
74LS33	24p
74LS37	24p
74LS38	24p
74LS40	24p
74LS42	24p
74LS43	100p
74LS47	60p
74LS48	60p
74LS49	100p
74LS51	24p
74LS54	24p
74LS55	24p
74LS73A	30p
74LS74A	30p
74LS75	45p
74LS76A	30p
74LS83A	60p
74LS85	75p
74LS86	30p
74LS90	45p
74LS91	80p
74LS92	55p
74LS93	54p
74LS95B	75p
74LS96	90p
74LS107	30p
74LS109	40p
74LS112	40p
74LS113	45p
74LS114	45p
74LS122	70p
74LS123	80p
74LS124/	80p
	628/140p
74LS125	45p
74LS126	45p
74LS132	55p
74LS133	30p
74LS136	45p
74LS138	55p
74LS139	55p
74LS145	90p
74LS147	175p
74LS148	140p
74LS151	55p
74LS152	200p
74LS153	55p
74LS154	100p
74LS155	60p
74LS156	60p
74LS157	60p
74LS158	60p
74LS160A	70p
74LS161A	70p
74LS162A	70p
74LS163A	70p
74LS164	75p
74LS165A	110p
74LS166A	100p
74LS168	130p
74LS169	100p
74LS170	140p
74LS173A	100p
74LS174	75p
74LS175	75p
74LS181	200p
74LS183	100p
74LS190	75p
74LS191	75p
74LS192	80p
74LS193	80p
74LS194A	75p
74LS195A	75p
74LS196	80p
74LS197	80p
74LS221	90p
74LS240	80p
74LS241	80p
74LS242	90p
74LS243	90p
74LS 244	70p
74LS 245	90p
74LS247	110p
74LS248	110p
74LS249	110p
74LS251	75p
74LS253	75p
74LS256	90p
74LS257A	70p
74LS258A	70p
74LS259	120p
74LS260	75p
74LS261	120p
74LS266	60p
74LS273	120p
74LS279	70p
74LS280	180p
74LS283	80p
74LS290	80p
74LS 292	£14
74LS293	90p
74LS295	140p
74LS 297	£14
74LS298	180p
74LS299	220p
74LS321	370p
74LS323	300p
74LS324	320p
74LS348	200p
74LS352	120p
74LS353	120p
74LS356	210p
74LS363	180p
74LS364	180p
74LS365	55p
74LS366	55p
74LS367	55p
74LS368A	55p
74LS 373	70p
74LS 374	70p
74LS375	75p
74LS377	130p
74LS378	95p
74LS379	130p
74LS381	450p
74LS385	325p
74LS390	90p
74LS393	100p
74LS395A	100p
74LS399	140p
74LS445	150p
74LS465	120p
74LS467	120p
74LS490	150p
74LS540	100p
74LS541	100p
74LS608	700p
74LS 610	£25
74LS 612	£25
74LS624	300p
74LS626	225p
74LS628	225p
74LS629	125p
74LS640	200p
74LS640-1	
	300p
74LS641	150p
74LS642-1	
	300p
74LS643	250p
74LS643-1	
	300p
74LS644	350p
74LS645	200p
74LS645-1	
	400p
74LS668	90p
74LS669	90p
74LS670	170p
74LS682	280p
74LS684	350p
74LS687	350p
74LS688	300p
74LS 783	£16

74S SERIES

74S00	80p
74S02	80p
74S04	80p
74S05	80p
74S08	80p
74S10	80p
74S11	75p
74S20	80p
74S22	80p
74S30	80p
74S32	80p
74S37	80p
74S38	80p
74S40	80p
74S51	45p
74S64	45p
74S74	70p
74S 85	550p
74S86	100p
74S112	180p
74S113	120p
74S114	120p
74S124	300p
74S132	100p
74S133	80p
74S138	180p
74S136	180p
74S139	180p
74S140	180p
74S151	180p
74S153	180p
74S157	200p
74S158	200p
74S183	300p
74S169	500p
74S174	300p
74S175	320p
74S188	180p
74S189	180p
74S194	300p
74S195	300p
74S196	350p
74S200	400p
74S201	320p
74S225	520p
74S240	400p
74S241	400p
74S 244	400p
74S251	280p
74S257	280p
74S258	280p
74S260	180p
74S261	280p
74S263	270p
74S287	225p
74S288	220p
74S289	220p
74S 299	450p
74S373	400p
74S374	400p
74S387	225p

4000 SERIES

4000	30p
4001	24p
4002	24p
4006	70p
4007	25p
4008	60p
4009	40p
4010	40p
4011	24p
4012	25p
4013	30p
4014	60p
4015	70p
4016	40p
4017	55p
4018	60p
4019	60p
4020	60p
4021	60p
4022	70p
4023	25p
4024	40p
4025	24p
4026	60p
4027	40p
4028	50p
4029	75p
4030	40p
4031	125p
4032	100p
4033	125p
4034	250p
4035	70p
4036	70p
4037	110p
4038	100p
4039	250p
4040	60p
4041	55p
4042	60p
4043	60p
4044	60p
4045	100p
4046	60p
4047	60p
4048	55p
4049	40p
4050	40p
4051	60p
4052	60p
4053	60p
4504	60p
4055	80p
4056	60p
4059	450p
4060	70p
4063	85p
4066	40p
4067	230p
4068	60p
4069	24p
4070	24p
4071	24p
4072	24p
4073	24p
4075	24p
4076	60p
4077	25p
4078	25p
4081	24p
4082	25p
4085	80p
4086	75p
4089	120p
4093	30p
4094	90p
4095	80p
4096	80p
4097	270p
4098	75p
4099	60p
4501	30p
4502	60p
4503	30p
4504	95p
4505	300p
4506	80p
4507/4030	
	35p
4508	120p
4510	55p
4511	55p
4512	55p
4513	150p
4514	110p
4515	110p
4516	55p
4517	220p
4518	48p
4519	32p
4520	60p
4521	110p
4522	80p
4526	60p
4527	60p
4528	60p
4529	100p
4531	70p
4532	60p
4534	350p
4536	250p
4538	75p
4539	75p
4541	80p
4543	75p
4551	100p
4553	240p
4555	30p
4556	30p
4557	240p
4560	140p
4566	140p
4568	140p
4569	170p
4572	45p
4583	60p
4584	40p
4585	60p
4724	150p
14411	750p
14412	750p
14416	300p
14419	280p
14490	420p
14495	400p
14500	750p
14599	280p
22100	280p
22101	700p
22102	700p
40014/4584	
40106	
	40p
40085	120p
40097	30p
40098	40p
40100	150p
40101	125p
40102	150p
40103	200p
40104	120p
40105	120p
40106	40p
40107	60p
40108	320p
40109	20p
40110	225p
40114	225p
40147	250p
40163	100p
40173	120p
40174	100p
40175	100p
40192	100p
40244	150p
40245	150p
40257	150p
40373	150p
40374	150p
80C95	75p
80C97	75p
80C98	75p

LINEAR ICs

AD7581	£15
ADC0808	1100p
AM7910DC	£20
AN103	250p
AY-1-5050	100p
AY-3-1350	450p
AY-3-8910	450p
AY-3-8912	500p
CA3019A	100p
CA3028A	110p
CA3046	70p
CA3059	300p
CA3080	70p
CA3080E	210p
CA3086	70p
CA3089E	200p
CA3090AQ	375p
CA3130E	90p
CA3130T	130p
CA3140E	45p
CA3140T	100p
CA3160E	90p
CA3161E	150p
CA3162E	450p
CA3189E	270p
CA3240E	120p
CA3280G	270p
D7002	£8
DAC1408-8	200p
DAC0800	300p
DAC0808	200p
DG308	300p
HA1366	180p
ICL7106	675p
ICL7611	95p
ICL7650	400p
ICL7660	250p
ICL8038	325p
ICM7555	90p
ICM7556	140p
LC7120	300p
LC7130	300p
LC7137	350p
LF347	130p
LF351	50p
LF353	90p
LF355	90p
LF356N	110p
LF357	100p
LM10C	400p
LM301A	30p
LM307	45p
LM308CN	75p
LM310	200p
LM311	60p
LM318	150p
LM319	180p
LM324	40p
LM334Z	110p
LM335Z	120p
LM336	150p
LM339	40p
LM348	60p
LM358P	50p
LM377	300p
LM380N-8	150p
LM380	150p
LM381N	300p
LM382	200p
LM383	325p
LM384	225p
LM386N-1	150p
LM387	270p
LM391	180p
LM392N	110p
LM393	60p
LM394CH	400p
LM709	30p
LM710	40p
LM711	100p
LM723	50p
LM725CN	400p
LM733	60p
LM741	25p
LM747	70p
LM748	35p
LM1011	400p
LM1014	150p
LM1801	300p
LM1830	300p
LM1871	300p
LM1872	300p
LM1886	600p
LM1889	450p
LM2917	300p
LM3302	80p
LM3900	60p
LM3909	100p
LM3911	150p
LM3914	240p
LM3915	240p
LM3916	240p
LM13600	150p
MS1513L	230p
MS1516L	300p
MB3712	200p
MC1310P	150p
MC1413	75p
MC1458	40p
MC1485L	300p
MC1496	70p
MC3340P	200p
MC3401	70p
MC3403	80p
MF10CN	400p
MK50240	900p
ML920	500p
ML922	400p
MM6221A	300p
NE531	120p
NE544	100p
NE555	18p
NE556	50p
NE564	400p
NE565	120p
NE566	120p
NE567	100p
NE570	400p
NE571	400p
NE592	100p
NE5532P	120p
NE5533P	150p
NE5534AP	120p
NE5534AP	120p
OP-07EP	300p
PLL02A	500p
RC4136	60p
RC4151	200p
RC4558	60p
SAA1900	£16
SFF96364	800p
SL490	400p
SN76033N	300p
SN76489	400p
SN76495	400p
SP0256AL2	700p
TA7120	150p
TA7130	140p
TA7204	150p
TA7205	80p
TA7222	150p
TA7310	150p
TBA231	120p
TBA800	90p
TBA810	90p
TBA820	80p
TBA820M	75p
TBA920	200p
TBA950	220p
TC9109	600p
TCA940	175p
TDA1010	225p
TDA1022	600p
TDA1024	110p
TDA1170S	300p
TDA2002	325p
TDA2003	300p
TDA2004	300p
TDA2006	300p
TDA2020	300p
TDA2030	300p
TDA2593	300p
TDA3810	300p
TDA7000	300p
TEA1002	700p
TL081CP	30p
TL082	90p
TL084	90p
TL071	40p
TL072	70p
TL074	110p
TL081	30p
TL082	50p
TL083	50p
TL084	90p
TL094	75p
UA739	220p
UA2240	150p
UCN5801A	600p
ULN2003A	70p
ULN2004A	75p
ULN2068	100p
ULN2802	100p
ULN2803	100p
ULN2804	100p
UPC575	275p
UPC592H	200p
UPC1156H	300p
UPC1185H	300p
XR210	400p
XR2206	400p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	125p
ZN409	100p
ZN414	80p
ZN419P	175p
ZN423E	130p
ZN424E	130p
ZN425E8	300p
ZN426E	300p
ZN427E	600p
ZN428E	400p
ZN429E8	200p
ZN447E	£9.50p
ZN448	750p
ZN449E	250p
ZN450E	700p
ZN459CP	300p
ZN1034E	200p
ZN1040E	600p
ZNA134H	£23
ZNA234E	800p

COMPUTER COMPONENTS

CPU

1802CE	650p
2650A	1050p
6502	400p
6502A	450p
65C02A	£15
6800	250p
6802	300p
6809	650p
6809E	£8
68B09	£10
68B09E	£12
68000-LB	£36
8035	300p
8039	420p
80C39	700p
8080A	420p
8085A	300p
8087	120
80C85A	900p
8086	£22
8088	1750p
8741	£12
8748	£12
TMS9980	£14.50
TMS9995	£18
Z80	200p
Z80A	200p
Z80B	500p
Z80CMOS	750p
(CMOS Z80)	
808A	850p

8279	480p
8282	300p
8284	400p
8287	400p
8288D	650p
8755A	£16
TMS4500	£14
TMS9901	£14
TMS9901	500p
TMS9902	500p
TMS9911	£16
TMS9914	£14
Z80PIO	200p
Z80APIO	200p
Z80BPIO	500p
Z80CTC	200p
Z80ACTC	275p
Z80BCTC	500p
Z80DART	500p
Z80ADART	700p
Z80DMA	700p
Z80ADMA	700p
Z80ASIO-0/1/2	
/9	700p
Z80BP10	500p
Z80BCTC	500p
Z80DART	800p
Electrically programmable and erasable PROMS	
2816-30	£20

SUPPORT DEVICES

2651	£12
3242	600p
3245	450p
6520	200p
6522	300p
6522A	400p
6532	600p
6551	600p
6821	150p
68B21	300p
6829	£12.50
6840	375p
68B40	600p
6850	180p
68B50	300p
6852	300p
6854	600p
68B54	800p
6875	600p
8154	600p
8155	600p
8156	600p
8205	225p
8212	200p
8216	200p
8224	200p
8226	400p
8228	600p
8243	200p
8250	£12
8251A	300p
8253C-5	350p
8255AC-5	300p
8256	£16
8257C-5	400p
8259C-5	400p
8275	£28

EPROMs

2516+5v	300p
2516-35	500p
2532	400p
2532-30	500p
2564	£11
2708	400p
2716+5v	300p
2716-35	500p
2732	400p
2732A-2	500p
2732A-35	£7
2764-25	300p
27C64-25	£6
27128-25	250p
27256-25	£4
27512-25	£14
TMS2716	650p

CRT CONTROLLER

CRT5027	£16
CRT5037	£12
CRT6545	£8
EF9364	£8
EF9365	£25
EF9366	£25
EF9367	£25
MC6845	650p
MC6845SP	
MC6847	600p
EF 9369	£12
SFF96364	£8
TMS9928	£10

INTERFACE ICs

AD558CJ	775p
AD561J	£15

AD7581	£15
ADC0808	1100p
AM25S10	300p
AM25LS2521	
	300p
AM25LS2538	300p
AM26LS31	120p
AM26LS32	120p
D7002	£8
DAC80-CB1-V	
	£20
DM8131	600p
DP8304	450p
DS3691	300p
DS8830	150p
DS8831	150p
DS8832	150p
DS8833	220p
DS8835	225p
DS8836	150p
DS8838	225p
MC1488	60p
MC1489	60p
MC3446	300p
MC3459	450p
MC3470	475p
MC3480	800p
MC3418L	500p
MC3486	300p
MC3487	300p
MC4024	300p
MC4044	450p
MC6883	£16
MC14411	750p
MC14412	750p
ULN2068	300p
ULN2004A	
	75p
ULN2068	150p
ULN2802	150p
ULN2803	150p
ULN2804	150p
75107	140p
75108	140p
75109	120p
75110	140p
75112	140p
75113	140p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	120p
75160	650p
75161	650p
75162	750p
75172	400p
75182	150p
75188	150p
75189	60p
75365	60p
75450	150p
75451	60p
75452	60p
75453	60p
75454	60p
75480	150p
75491	70p
75492	70p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p

81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
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3.5795	150p
4.00	150p
4.194	150p
4.43	150p
4.608	150p
4.9152	150p
5.000	150p
6.00	150p
17.734	150p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.50	150p
10.70	150p
11.00	150p
12.00	150p
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18V		7818	50p	7918	50p
24V		7824	50p	7924	50p
5V	100mA	78L05	30p	79L05	45p
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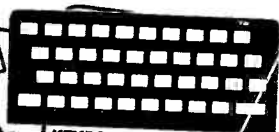

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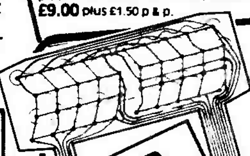

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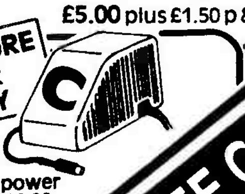

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DIGEST

New RS Components Distributor

Those of you who read ETI regularly will know how often our authors specify items from the extensive RS Components range for our projects.

Unforutnately, RS only supply to trade and professional customers, which makes life very difficult for those who are not employed in the industry or whose companies will not allow staff to purchase items on the company account.

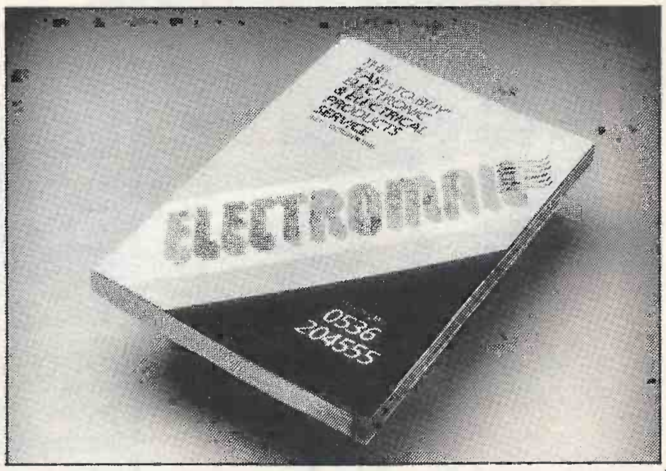
In the past, we have had to recommend companies who will act as intermediaries, obtaining RS parts for our readers.

Now with the launch of Electromail, anyone can order RS parts directly and receive a professional, fast-despatch service at minimal extra cost.

Electromail offer the full RS range of over 12,500 components and charge the usual RS price for each item. The only additional cost is a fixed charge of £2.00 per order for postage and packing plus an initial charge of £2.50 for their 688-page, A4 catalogue.

Orders can be made either by post or over the telephone and the company accept both Access and Visa credit cards.

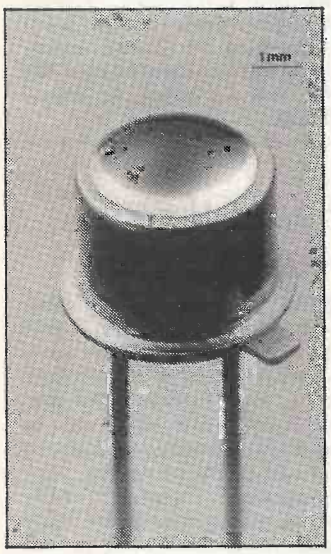
The catalogue is more-or-less identical to the standard RS catalogue (only the covers and the



pages containing the ordering information appear to be different) and contains the same mix of individual product data and general technical information. In addition, the range of RS Data Sheets containing more detailed product information will also be available free on request from Electromail.

To obtain a copy of the catalogue send £2.50 to Electromail, PO Box 33, Corby, Northamptonshire NN17 9EL, or telephone 0536-204 555 and quote your Access/Visa number.

Low-Power Gas Sensors



Plessy have introduced a range of single-wavelength LEDs and photosensors which can be used to detect and monitor gas and moisture contents using reflection or absorption techniques.

They claim that gas sensors using this system require far less power than existing gas sensors, making them ideal for use in portable and other battery-operated equipment.

The LEDs emit light in the infrared region, at wavelengths between 0.75um and 1.95um. The wavelength options available are tailored to suit the absorption bands of the various component elements or compounds which the sensors may be called upon to detect.

The LED chips are normally mounted on transistor-like headers with end windows. Alternatively they can be supplied with integral fibre-optic tails, allowing sensing to be carried out in unstable or combustible environments while associated electronic circuitry is mounted a safe distance away.

Plessey expect the new sensors to find applications in the food agriculture, medical and petrochemical industries.

Plessey Research (Caswell) Ltd, Caswell, Towcester, Northamptonshire NN12 8EQ, tel 0327-50581.

System A PCBs

A number of problems have come to light regarding the boards for this project. First, on some versions of all the System A boards, a number of the pads seem to have spread and created short circuits.

Second, some examples of the main preamplifier board (E8107-2) have Q12 base connected to Q8 collector, not Q9 as it should be and Q1 base similarly connected. We will happily replace faulty boards as soon as we have corrected boards available but you may prefer to tackle the fault yourself to save time.

Finally, some of the main amplifier boards (E8108-1) seem to be grossly corrupted. Please check carefully before applying power to your system.

● A new, 16-page A4 brochure from Hitachi describes their range of ROMs, EPROMs and EEPROMs. Both low-power and ultra-high-speed type are covered and the information given includes pin-outs, instructions for use, and advice on noise and static precautions. Contact Hitachi Electronic Components (UK) Ltd, 21 Upton Road, Watford, Hertfordshire WD1 7TB, tel 0923-46488.

● *Barrie Electronics have sent us a 4-page, A4 brochure which gives a brief guide to the range of components they stock. Among the items listed are valves, inverters and special-purpose lamps as well as the usual resistors, capacitors, semiconductors, etc, but the bulk of the space is taken up with details of some of their extensive range of transformers. Included are safety isolating, constant voltage, noise protection and audio transformers and they can wind to order if they don't have anything in stock to suit your needs. Barrie Electronics Ltd, Unit 211, Stratford Workshop, Burford Road, London E15 2SF, tel 01-555 0228.*

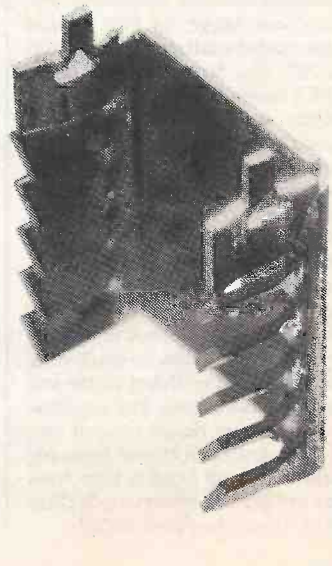
● **Concern over the shortage of recruits for the information technology industries has led the IEE and the National Computing Centre to propose a National Certificate in Software Engineering. As an initial step, a working party is being formed to devise a syllabus for the new course.**

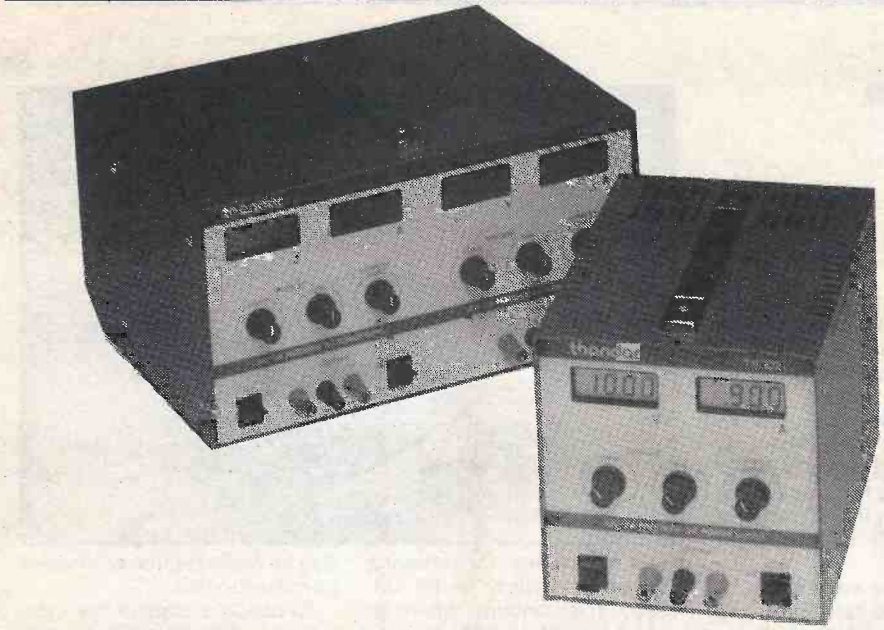
Solderable Heatsinks

New from Redpoint Ltd is a finned heatsink which can be soldered in the same was as other electronic components.

The TV905 Powerfin heatsink is manufacturerd from copper-plated aluminium, a material which combines the low cost and weight of aluminium with the soldering properties of copper. It is generally similar to Redpoint's popular TV1505 heatsink and is designed for direct PCB-mounting. Samples are available now and Redpoint have plans to introduce other models made from the same material.

Redpoint Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QN, tel 0793-37861.





Power Up

The TS3021 from Thandar Electronics is a laboratory quality variable linear power supply capable of providing up to 2A at up to 30V. Dual half-inch, 3½-digit LCD displays show output voltage and current at the same time and can be used to preset output voltage and/or current limit before connection to load.

The PSU can operate in constant current or constant voltage modes and voltage can be set to within 5 mV. The output is protected against forward and reverse voltages and the supply current is varied logarithmically to give accurate control at low values. Thandar claim 0.01% line and load regulation and ripple and noise figures better than 1mV. They also note that 'linear regulation and the use of LCD meters ensure that RF1 and interference generated by the display is minimised.' This seems to be an increasingly important consideration in the electronics industry. A dual version of the PSU features two identical and independent units in one case. The TS3021 single unit retails at £150 plus VAT while the TS3022 double unit is £240 plus VAT. Contact Thandar at London Road, St. Ives, Huntingdon, Cambs., PE17 4HJ (tel: 0480 64646).

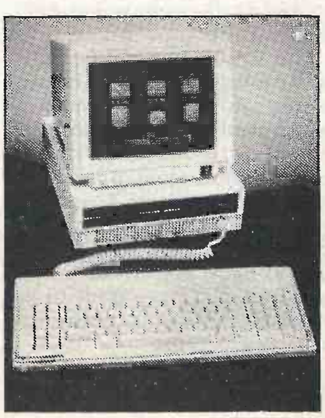
Digisound Advice

We're sorry to have to inform readers that Digisound of Blackpool — a company we've had a happy association with over the years — has ceased trading. A number of the projects Digisound was involved with will, fortunately, carry on. In particular, the PCBs for the ETI Project 80 synthesizer will now be available from Tim Higham, 16 Lauriston Road, Wimbledon, London SW19 4TQ (mail order only). Higham will also supply construction notes and some front panels — while ETI can, of course, supply photocopies of the original articles. Higham informs us that he has a price list available and is planning some new modules for the Project 80 (we'll keep readers informed). The Project 80 uses ICs from Curtis Electro-music, which Digisound had the exclusive rights to distribute. All these ICs are now available from Cicada Engineering, 54 Gibson Square, London N1 0RA (tel: 01-226 9778), who will be happy to supply details.

On The Surface

A new report from Electronic Trend Publications forecasts that usage of surface mounted devices will grow rapidly over the next few years. By 1990, says the report, 41% of all electronic components will be SMDs and 50% of all PCBs will utilise SMDs. The report claims that cost considerations combined with a felt need for improved reliability and higher performance underly the growth in SMD usage. 'Advances in design, assembly, and test equipment,' say the report's publishers, ETP, 'coupled with the availability of a complete range of SM devices have made board size reduction up to 70% and cost reduction up to 50% a reality.' The report, priced at $1250, 'represent a "hands on" guide to the application of SMT (surface mount technology) in new equipment design.' Although not completely ignoring the issue of smaller scale users of electronic components, who may find the capital cost of SMT prohibitive, the report has little to say about the long term implications of surface mounting for small manufacturers, the repair and servicing sector and home constructors. The eventual but inevitable dominance of surface mount devices will probably have a greater impact here than has the almost universal adoption of PCBs or integrated circuits.

Bigger Acorns — Small PCs

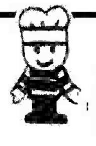


The forward march of MS-DOS and PC-DOS continues as the former bright hope of the UK computer industry, Acorn, unveils two new models designed to soften its maverick image. The Master 512 belongs ostensibly to the BBC range but is built around an 80106 processor (running at 10MHz) and comes bundled with a mouse, Digital Research's GEM software and DOS Plus which resembles MS-DOS. It is priced at £345.26 plus VAT. Somewhat more expensive is the Acorn M19, which is claimed to be 'a true (IBM) PC compatible'. This machine — designed by Acorn's parent company, Olivetti, but badged Acorn — features twin 360K 5.25" disc drives, a high resolution monochrome monitor and 256K of memory in the basic version (AIM 20), all of which makes it rather expensive at £1499. Numerous upgrades and the option of Econet compatibility suggest that Olivetti are still unwilling to commit Acorn completely to the MS-DOS/IBM route, but the prognosis is not good for UK computer design. Acorn may be contacted at Cambridge Technopark, 645 Newmarket Road, Cambridge CB5 8PD (tel: 0223 214411).

Seal Of Approval

Seal Electronics of Reading have produced a peripheral for BBC B and Spectrum computers designed to enable their use as logic analysers. The add-ons come in matching cream or black cases intended to be placed underneath the computers. They incorporate internal 10MHz clocks, offering a range of sample rates. An external clock can be used. There are inputs for up to 16 data lines (in two groups of eight) and the computers' own vdus or TV screens display all 16 lines under selectable cursors. Clock rate and data format (hex, octal, decimal or binary) can be selected and the analyser is capable of storing up to 1999 4-bit samples and displaying any chosen sequence. A preset 4-bit word triggers sampling according to the state of the four least significant data lines and results can be shown graphically or numerically. The analyser can also operate in real time.

The SL16 Logic Analyser costs £200 in the Spectrum version and £250 in the BBC version, inclusive of software, manual and p&p. Contact Seal at 1 Hagbourne Close, Woodcote, Reading, RG8 0RZ.



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30. 2 – Nicad battery chargers
31. 1 – key switch with key
33. 2 – aerosol cans of ICI Dry Lubricant
34. 96 – 1 metre lengths colour-coded connecting wire
39. 1 – long and medium wave tuner kit
41. 8 – rocker switch 10 amp mains SPST
45. 1 – 24 hour time switch mains operated (s.h.)
48. 2 – 6V operated reed switch relays
49. 10 – neon valves – make good night lights
50. 2 – 12V DC or 24V AC, 3 CO relays
51. 1 – 12V 2 CO miniature relay very sensitive
52. 1 – 12V 4 CO miniature relay
53. 2 – mains operated relays 3 × 8 amp changeover (s.h.)
54. 10 – rows of 32 gold plated IC sockets (total 320 sockets)
55. 1 – locking mechanism with 2 keys
56. 1 – miniature uniselector with circuit for electric jigsaw puzzle
60. 5 – ferrite rods 4" × 5/16" diameter aerials
81. 4 – ferrite slab aerials with L & M wave coils
83. 1 – Mullard thyristor trigger module
64. 10 – assorted knobs $\frac{1}{4}$ spindles
65. 5 – different thermostats, mainly bi-metal types
66. 1 – magnetic brake – stops rotation instantly
87. 1 – low pressure 3 level switch can be mouth operated
69. 2 – 25 watt pots 8 ohm
70. 2 – 25 watt pots 1000 ohm
71. 4 – wire wound pots – 18, 33, 50 and 100 ohm your choice
72. 1 – 1250 watt dimmer Ultra ref SE20
77. 1 – time reminder adjustable 1-60 mins clockwork
81. 2 – 30A panel mounting slyslok fuses
85. 1 – mains shaded pole motor $\frac{3}{4}$" stack – $\frac{1}{4}$ shaft
89. 1 – mains motor with gear box 1 rev per 24 hours
91. 2 – mains motors with gear box 18 rpm
96. 1 – thermostat for fridge
98. 1 – motorised stud switch (s.h.)
101. 1 – 2$\frac{1}{2}$ hours delay switch
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – 4$\frac{1}{2}$V DC
105. 1 – 5 pin flex plug and panel socket
107. 1 – 5" speaker size radio cabinet with handle
110. 10 – slider type volume controls
111. 2 – musical boxes (less keys)
112. 1 – heating pad 200 watts mains
113. 1 – FM front end with tuning condenser and data
114. 1 – 1W amplifier Mullard 1172
115. 1 – wall mounting thermostat 24V
118. 1 – teak effect extension 5" speaker cabinet
120. 2 – p.c. boards with 2 amp full wave and 17 other recs
121. 4 – push push switches for table lamps etc.
122. 10 – mtrs twin screened flex white p.v.c. outer
123. 100 – staples for thin flex
124. 25 – clear plastic lenses 1$\frac{3}{4}$ diameter
127. 4 – pilot bulb lamp metal clip on type
128. 10 – very fine drills for pcbs etc.
129. 4 – extra thin screw drivers for instruments
132. 2 – plastic boxes with windows, ideal for interrupted beam switch
134. 10 – model aircraft motor – require no on/off switch, just spin to start
136. 2 – car radio speakers 5" round 4 ohm made for Radiomobile
137. 1 – 6$\frac{1}{2}$" 4 ohm 10 watt speaker and 3" tweeter
142. 10 – 4 BA spanners 1 end open, other end closed
145. 2 – 4 reed relay kits 3V coil normally open or c/o if magnets added
146. 20 – pilot bulbs 6.5V.3A Philips
147. 1 – secret switch kit with data
149. 4 – socket covers (protect inquisitive little fingers) for twin 13A
152. 1 – air or gas shut off valve – clockwork operated
153. 1 – air or gas shut off valve – thermostat operated
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
158. 5 – 12 way connector blocks 2A 250V
159. 3 – 12 way connector blocks 25A 250V
162. 1 – 13A fused and switched spur for surface mounting or can be removed from box for flush mounting
163. 3 – 13A sockets good British make but brown
169. 4 – short wave air spaced trimmers 2-30f
171. 1 – shocking coi kit with data – have fun with this
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets $\frac{3}{8}$ hole size
182. 1 – short wave tuning condenser 50 pf with $\frac{1}{4}$" spindle
184. 1 – three gang tuning condenser each section 500 pf with trimmers and good length $\frac{1}{4}$" spindle
188. 1 – plastic box sloping metal front, 16 × 95mm average depth 45mm
   2 – double pole 20 amp 250V flush mounting switch – white
191. 8 – B.C. lamp holder adaptors white
193. 8 – 5 amp 3 pin flush sockets brown
195. 5 – B.C. lampholders brown bakelite threaded entry
196. 1 – in flex simmerstat for electric blanket soldering iron etc.
197. 2 – thermostats, spindle setting – adjustable range for ovens etc.
199. 1 – mains operated solenoid with plunger 1" travel
200. 1 – 10 digit switch pad for telephones etc.
201. 8 – computer keyboard switches with knobs, pcb or vero mounting
206. 20 – mtres 80 ohm, standard type co-ax off white
211. 1 – electric clock mains driven, always right time – not cased
218. 1 – stereo pre-amp Mullard EP9001
232. 2 – 12V solenoids, small with plunger
236. 1 – mains transformer 9V 1 amp secondary C core construction
241. 1 – car door speaker (very flat) 6$\frac{1}{2}$" 15 ohm made for Radiomobile
241. 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243. 2 – speakers 6" × 4" 16 ohm 5 watt made for Radiomobile
244. 1 – mains motor with gear-box very small, toothed output 1 rpm
245. 4 – standard size pots, $\frac{1}{2}$ meg with dp switch
249. 1 – 13A switched socket on double plate with fused spur for water heater
266. 2 – mains transformers 9V $\frac{1}{4}$A secondary split primary so ok also for 115V
287. 1 – mains transformers 15V 1A secondary p.c.b. mounting
289. 50 3.5V torch bulbs
290. 3 7" reel to reel tape spools
291. 1 ten turns 3 watt pot $\frac{1}{4}$ spindle 100 ohm
292. 5 two plate brown bakelite ceiling roses
293. 50 silicon diodes mixed unmarked
294. 50 Germanium transistors mixed and unmarked
295. 10 round pointer knobs $\frac{1}{4}$ spindle
296. 3 car cigar lighter socket plugs
297. 1 cover for 24hr time switch ref BO45
298. 2 15 amp round pin plugs brown bakelite
300. 1 mains solenoid with plunger compact type
301. 10 ceramic magnets Mullard 1" × 3/8 × 5/16
303. 1 12 pole 3 way ceramic wave charge switch
304. 1 stereo amp 1 watt per channel
305. 1 tubular dynamic microphone with desk rest
306. 1 module, speaker & battery to make musical card
307. 5 thermal fuses 15 amp woods metal
308. 1 T.V. turret tuner (black & white T.V.)
309. 12 adaptable legended knobs $\frac{1}{4}$" spindle
310. 2 oven thermostats
311. 1 Clare Elliot sealed relay 12V
312. 1 pressure pad switch 24 × 18 (Trigger Mat)
313. 5 sub miniature micro switches
314. 1 12" 8 watt min fluorescent tube white
315. 1 6" 4 watt min fluorescent tube white
316. 1 round pin kettle plug with moulded on lead

MULLARD UNILEX AMPLIFIERS

We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules – i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for **£6.00** plus £2 postage. For prices of modules bought separately see TWO POUNDERS.

CAR STARTER/CHARGER KIT

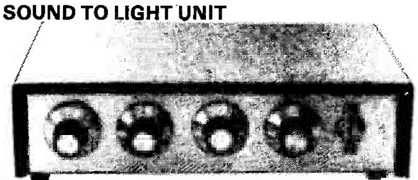
Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data **£16.50** or without case **£15.00** post paid.

Ex-Electricity Board. Guaranteed 12 months.

VENNER TIME SWITCH

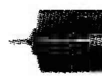
Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95** without case, metal case – **£2.95**, adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is **£2.30.**

SOUND TO LIGHT UNIT



Complete kit of parts of a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by $\frac{1}{4}$" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is **£14.95** in kit form.

12 volt MOTOR BY SMITHS



Made for use in cars, etc. these are very powerful and easily reversible. Size 3$\frac{1}{2}$" long by 3" dia. They have a good length of $\frac{1}{4}$" spindle –
1/10 hp **£3.45**
1/8 hp **£5.75.** 1/6 hp **£7.50**

25A ELECTRICAL PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. A beautiful unit at **£2.50**

THE AMSTRAD STEREO TUNER

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio – easy to carry about and which will give you superb reception. Other uses are a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.
Some of the features are: long wave band 115 – 170KHz, medium wave band 525 – 1650KHz, FM band 87 – 108 MHz, mono, stereo & AFC switchable, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or headphones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands). All made up on very compact board.
Offered at a fraction of its cost **only £4.95**

GOODS ARE ON APPROVAL

these notes are often hastily written and technical information sheets are seldom available about the items we have to describe, also advertisements sometimes go to press without our having a chance to correct any mistakes, however, everything we sell is supplied on the understanding that if it is not suitable for your project you may return it within 7 days for credit. If there was a definite error of description in our copy then we will pay postage. If not, then you pay the postage. Note this offer applies to kits, but only if construction is **not started.**

FANS & BLOWERS

Woods extractors
5" £5 + £1.25 post. 6" £6 + £1.50 post
4" × 4" Muffin equipment cooling fan 115V **£2.00**
4" × 4" Muffin equipment cooling fan 230/240V **£5.95**
5" Plannair extractor **£5.50**
9" Extractor or blower 115V supplied with 230 to 115V adaptor **£9.50** + £2 post.
All above are ex computers but guaranteed 12 months.
10" × 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow **£2.00** + £1.50 post or **£4.00** + £2.00 post for two.

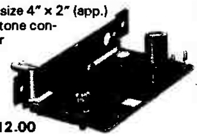
IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit, case included. **£11.95** plus £2.00 post.

TELEPHONE BITS

Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug **£3.95**
Extension socket **£2.95**
Dual adaptors (2 from one socket) **£3.95**
Cord terminating with B.T. plug 3 metres **£2.95**
Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 BT extension sockets **£11.50**

MINI MONO AMP on p.c.b. size 4" × 2" (app.)



Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of **£1.15 each,** or **13** for **£12.00**

J & N BULL ELECTRICAL

128 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QL Dept ETI

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/Card orders accepted. Brighton 0273 734648. Bulk orders: write for quote.

OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen pounds you spend on these packs. A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letters.

TWO POUNDERS*

2P2 –Wall mounting thermostat, high precision with mercury switch and thermometer
2P3 –Variable and reversible 8-12v psu for model control
2P4 –24 volt psu with separate channels for stereo made for Mullard UNILEX
2P6 –100W mains to 115V auto-transformer with voltage tappings
2P7 –Mini key, 16 button membrane keyboard, list price over £12
2P8 –Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
2P9 –Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
2P10 –12 volt 5 amp mains transformer – low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
2P11 –Power amp module Mullard Unilex EP9000 (note stereo pre-amp module Unilex 9001 is BD216
2P12 –Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
2P14 –Mug Stop kit – when thrown emits piercing squawk
2P15 –Interrupted Beam kit for burglar alarms, counters, etc.
2P17 –2 rev pr minute mains driven motor with gear box, ideal to operate mirror ball
2P18 –Liquid/gas shut off valve mains solenoid operated
2P19 –Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
2P20 –20 metres extension lead, 2 core – ideal most Black and Decker garden tools etc.
2P21 –10 watt amplifier, Mullard module reference 1173
2P22 –Motor driven switch 20 secs on or off after push
2P24 –Clockwork operated 12 hour switch 15A 250V with clutch
2P26 –Counter resettable mains operated 3 digit
2P27 –Goodmans Speaker 6 inch round 8ohm 12 watt
2P28 –Drill Pump – always useful couples to any make portable drill
2P29 –24 position Yaxley switch contacts rated 5A – $\frac{1}{4}$ spindle
2P31 –4 metres 98 way interconnecting wire easy to strip
2P32 –Hot Wire amp meter – 4$\frac{1}{2}$ round surface mounting 0–10A – old but working and definitely a bit of history
2P34 –Solenoid Air Valve mains operated
2P35 –Battery charger kit comprising mains transformer, full wave rectifier and meter, suitable for charging 6v or 12v
2P38 –200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
2P42 –Tubular heater, 60 watts per ft, unusued but slightly storage soiled, made by G.E.C. Perfect order (must be collected by appointment as 12ft long)
2P43 –Small type blower or extractor fan, motor inset so very compact, 230V
2P46 –Our famous drill control kit complete and with prepared case.
2P47 –Joy switch kit complete as previously sold.
2P48 –Telephone ringing unit reduces mains to 50 volts and changes frequency from 50 hz to 25 hz to give right ringing tone.
2P49 –Fire Alarm break glass switch in heavy cast case
2P51 –Stereo Headphone amplifier, with pre-amp
2P54 –2$\frac{1}{2}$kw. blow heater section of coal or log effect fire, this is a sheet metal assembly which holds the elements, the motor with fan, and the lamp holders and bits which give the flickering flame effect. Collect or add £3 to cover p&p
2P55 - Mains motor, extra powerful has 1½" stack and good length of spindle
2P62 - 1 pair Goodmans 15 ohm speakers for Unilox
2P63 - 1 5Kv 20 mA mains transformer ex-equipment
2P64 - 1 five bladed fan 6½" with mains motor
2P65 - 2 resettable trips 4.5A mains
2P66 - 1 2Kw tangential heater 115v easily convertible for 230V
2P67 - 1 12v-0-12v 2 amp mains transformer
2P68 - 1 15v-0-15v 2 amp mains transformer
2P69 - 1 250v-0-250v 60 mA & 6.3v 5A mains transformer
2P70 - 1 E.M.I. tape motor two speed and reversible
2P71 - 1 PAPST 240v 5hz motor
2P72 - 1 115v Muffin fan 4" × 4" approx
2P76 - 1 audax tweeter partner to 5P26 speaker
2P77 - 1 instrument box with key size 12" × 4½" wide 6" deep
2P82 - 9v-0-9v 2 amp mains transformer
2P83 - 25m .75 twin flat flex for mains appliances
2P84 - Modem board with press keys for telephone redialler
2P85 - 20v-0-20v ½A Mains transformer
2P88 - Sangamo 24 hr time switch 20 amp S.H.
2P89 - 120 min. time switch with knob.
2P90 - 90 min. time switch with edgewise engraved controller
2P91 - Panel meter size 2½" × 2" scaled power factor
2P92 - Bailey & Macky pressure switch 15 p.s.i.

Valve Pre Amp

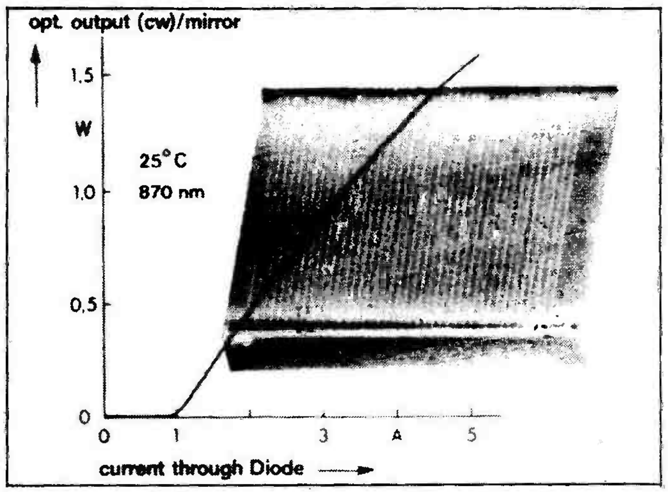
2P69 - We can supply the following mains transformer + £1.00 post
BD95 - Valve basis B9A 4 for £1.00
1P100 - Tag strips 3 lengths for £2.00

£5 POUNDERS*

1. 12 volt submersible pump complete with a tap which when brought over the basin switches on the pump and when pushed back switches off, an ideal caravan unit.
2. Sound to light kit complete in case suitable for up to 750 watts.
3. Silent sentinel ultra sonic transmitter and receive kit, complete.
4. 250 watt isolating transformer to make your service bench safe, has voltage adj. taps, also as it has a 115V tapping it can be used to safely operate American or other 115V equipment which is often only insulated to 115V. Please add £3 postage if you can't collect as this is a heavy item.
5. 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order and guaranteed.
6. Sensitive voltmeter relay, this consists of a 4$\frac{1}{2}$" dia moving coil meter with electronics (we will supply cct. dig.) over £120 each, they are new and still in maker's boxes.
7. Box of 25 fluorescent tubes 40 watt daylight or warm white ideal window pelmets, signs, etc. Please collect or add £2 postage.
8. Box of 25 18" fluorescent tubes assorted colours, please collect or add £2 postage.
9. 24 × 8 ft 85-120 watt warm white tubes. Ideal plant growing.
10. Collect or send open cheque to cover carriage. Equipment cooling fan – minin snail type mains operated.
11. Ping pong ball blower – or for any job that requires a powerful stream of air – ex computer. Collect or add £21 post.
12. Uniselector 360 degrees rotation, 5 poles, 50 ways, 50V coil.
13. Washing machine water pump, main motor driven so suitable for many applications.
14. Control panel case, conventional design with hinged front and finished metallic silver, easily arranged as lockable size approx. 15" × 10" × 5$\frac{1}{2}$", wall mounting.
15. Two kits: matchbox size surveillance transmitter and 2 FM receivers.

This months snip

Prestel units, brand new, complete except for some ICs with handbooks and keypads. Only **£5.00** + **£1.00** post.



Powerful Semiconductor Laser

Siemens have succeeded in integrating up to forty laser diodes on a single substrate to produce a semiconductor laser with more than thirty times the power of existing types.

The mirrors of conventional laser diodes are seldom able to handle more than 50mW of output power. The use of a laser array allows the individual diodes to operate at higher efficiencies, reducing the thermal stress on the mirrors. Siemens claim output powers of more than 1.5W using this system.

The arrays consists of optically-coupled laser diodes spaced 8-10um apart across a substrate. The wavelength of the light output is 0.88um with good coherence properties and the overall efficiency exceeds 30%.

Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS, tel 09327-85691.

● The Geiger-Mite is a pocket-sized Geiger ratemeter which flashes an LED to indicate ionizing events. It also has an output for a crystal earpiece and can be connected to a computer for count analysis. A complete kit including ZP1310 Geiger-Muller tube costs £46.92 inclusive from Becker Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED, tel 0689-37821.

● **Sifam's new dual movement panel meter allows you to keep an eye on both channels of a stereo system at the same time. Known as the Type 74, it is intended for use in peak programme meter (PPM) systems and meets all the relevant BBC and BS/IEC standards. Contact Sifam Ltd, Woodland Road, Torquay, Devon TQ2 7AY, tel 0803-63822.**

● *ITT-Cannon have extended their AXR connector range to include a type designed especially for use with loudspeakers. The AXR-PDN plugs and sockets are available in both cable and chassis-mounting form and feature rugged metal shells and a lock coupling to prevent accidental disengagement. The cable entries are designed to accept both round and figure-of-eight cables and the cable boot and insulating inserts are available in either blue or white to aid identification in stereo setups. Contact ITT-Cannon (UK), Jays Close, Viables Industrial Estate, Basingstoke RG22 4BW, tel 0256-473171.*

● B & R Electrical Products specialise in switches, relays, connectors and other electromechanical components and their 188-page, A4 catalogue contains a number of unusual items. It is also notable for the amount of information it gives, including photographs, detailed specifications and dimensioned drawings where appropriate. Contact them at South Road, Temple Fields, Harlow, Essex CM20 2BG, tel 0279-34561.

● **The new Cricklewood Electronics catgalogue is now available. Its 24, A5 pages list a wide range of components, from the commonplace through to more unusual items such as valves and VDRs, and it comes complete with a pre-paid envelope and mail order form. Credit card telephone orders are also accepted. Cricklewood Electronics Ltd, 40 Cricklewood Broadway, London NW2 3ET, tel 01-450 0995.**

NEWS:NEWS:NEWS:NEWS:

DIARY

Radio Amateurs' Examination Course — September 3-5th onwards
North Trafford College, Manchester. For details see September '86 ETI or contact the college, Talbot Road, Stretford, Manchester M32 0XH, tel 061-872 3731 extension 53.

The Evolving Local Telecommunications Network — September 7-12th
Aston University, Birmingham. For details see September '86 ETI or contact the IEE at the address below.

Electrical Measurements, DC to VHF — September 7-12th
Imperial College of Science and Technology, London. For details see August '86 ETI or contact the IEE at the address below.

Radio Amateurs' Examination Course — September 8-10th onwards
Paddington College, London. For details see August '86 ETI or contact the college, 25 Paddington Green, London W2 1NB, tel 01-402 6221.

ESSDERC '86 — September 8-11th
University of Cambridge. For details see September '86 ETI or contact the Institute of Physics, 47 Belgrave Square, London SW1X 8QX, tel 01-235 6111.

Commodore Horizons Show — September 13/14th
UMIST, Manchester. For details contact Database Exhibitions at the address below.

Television Engineering Course — September 17th onwards
The IBA, London. For details see September '86 ETI or contact the Royal Television Society at the address below.

People and Computers: Designing For Usability — September 22-16th
University of York. For details see September '86 ETI or contact the BISL Conference Department, The British Computer Society, 13 Mansfield Street, London W1M 0BP.

Electron & BBC Micro User Show — September 26-28th
UMIST, Manchester. For details contact Database Exhibitions at the address below.

Electromagnetic Compatibility — September 30th-October 3rd
University of York. See August '86 ETI or contact the Institution of Electronics and Radio Engineers, 99 Gower Street, London WC1E 2AZ, tel 01-388 3071.

Sound Comm '86 — October 1/2nd
New Century Hall, Manchester. For details see September '86 ETI or contact Brenda White on 06286 - 67633.

Wideband Communications — October 1/2nd
Tara Hotel, London. For details contact Online Conferences Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex MA5 2AE, tel 01-868 4466.

Amstrad Computer Show — October 4-5th
Novotel, London. For details contact Database Exhibitions at the address below.

Lighting Workshop — October 17-19th
BBC Engineering Training Centre, Woodnorton, near Evesham. A rare opportunity to learn lighting techniques from BBC and ITV broadcast lighting directors. The weekend course has been designed both for the newcomer and for those with some theoretical knowledge and the emphasis is on practical experience. For details contact the Royal Television Society at the address below.

Addresses
Database Exhibitions, Europa House, 68 Chester Road, Hazel Grove, Stockport SK7 5NY, tel 061-456 8835.
Institution of Electrical Engineers, Savoy Place, London WC2 0BL, tel 01-240 1871.
The Royal Television Society, Tavistock House East, Tavistock Square, London WC1H 9HR, tel 01-387 1970.

ETI

READ/WRITE

Micro Economics

Dear Sirs,
In your issue of December 1985 you indicate that the cost of the 6809-based microcomputer would be about £450 including twin disk drives, video monitor, keyboard and power supply.
Micro Concepts quote, for the bare PCB, case and operating system, £253. They advise that the cost of the components for the PCB would be approximately £290 — a total of £543. To that one has to add the cost of the units referred to in the first paragraph above. The realistic overall cost would seem to be more than double that which you suggest.
I cannot think that you would have been negligent to this extent, nor that you have intended deliberately to mislead. Can you please tell me how I may assemble the computer for anything like £450? And where is the evidence that the price "is coming down to less than £450"?
You also state that the computer's disk controller will support double-sided drives. Micro Concept's specification gives the disk interface as being for single-sided disks only, and at a maximum capacity of 700K bytes. Can you please say if it is possible to extend the system to a greater disk capacity?
Yours faithfully,
J.H. Eastaugh,
Chesham,
Buckinghamshire.

As we pointed out in the text, the £450.00 quoted was the cost of the prototype. This did not include a case (as mentioned elsewhere, the prototype board was simply screwed to the wall above the workbench!) and also took no account of the sum subsequent constructors would have to pay for the software and boards. Unfortunately, we didn't realise this at the time and quoted the £450.00 figure in the belief that others would be able to build the microcomputer for the same amount.
Having said that, we're not sure the costs are as high as you suggest. The boards and operating system cost £109.25 from Micro Concepts and our own estimate of the cost of the components is around £215.00, bringing the total cost of the fully-populated board to about £325.00. That includes VAT and postage, etc, and we arrived at our figure using prices quoted by Technomatic, CMC, Watford and Electromech in the September issue of ETI plus telephone quotes from the suppliers mentioned in Buylines for the more specialised components. No doubt anyone prepared to spend an evening or two going through all the amateur component catalogues available could trim this figure still further. If the disc drives, monochrome monitor, keyboard and power supply are all purchased as new, branded goods they may indeed cost as much again, but if you are prepared to consider surplus gear and shop around a little, you should be able to purchase the lot for around £200.00. That would bring the total to within £50-75 of the figure we quoted.
Regarding the disc interface, the WD1770 controller used on the 6809-based microcomputer does not include a side-select facility and therefore cannot handle double-sided discs. However, the kit supplied by Micro Concepts includes notes on using the PIA to select sides and the firmware supports this option. The formatted capacity available will then be 750K bytes per disc. — Ed.

A Bit Of A Stink About Ozone

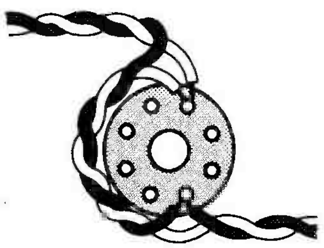
Dear sir,
You published an article in your July 1986 issue on an air ioniser.
I would have built an ioniser some time ago, but have been stalled by claims that they produce ozone. One article in an issue of Popular Science magazine claimed this to be one of the beneficial properties of the ioniser. However, I have read elsewhere that the ozone produced can be harmful to your health. I would like you to state if the design published in your magazine produces ozone and if it is in fact harmful.
I enjoy your magazine very much, keep up the diversity of your articles. I would like you to publish some on Dynamic Range Expanders and Electronic Crossovers, I can only locate a couple of these designs.
Yours truly,
O. Phillips,
St. Andrew,
Jamaica, W.I.

Many years ago, it was considered healthy to breathe ozone, and a number of gadgets (the 'Ozonette' springs to mind) were designed to produce ozone in the home. It is now generally agreed that high concentrations of ozone can be harmful, although the small quantities produced by electric motors, TV sets, electric train sets, and so on, are no cause for concern.
Modern ionisers aim to produce oxygen ions, which are not the same thing at all. Nobody has questioned the health-giving properties of negative ions, but for some reason the old ozone idea lingers on. If you are at all worried, it is easy to tell when ozone is present — it has a strong, pungent smell, like a sparking electric drill. The ions produced by the ETI ioniser are odourless.
As regards your final suggestions, we'll bear them in mind when planning future issues. — Ed.

Getting His Heaters In A Twist

Dear Sir,
I've just read your article on the Valve Preamplifier (ETI August 1986). Although you suggest that the layout shown in the photograph should not be followed too closely, the heater wiring should be done in a particular way and not as you've shown it. I enclose a diagram from Amateur Radio Techniques by Pat Hawker, published by the Radio Society of Great Britain.
Yours,
A. Moody,
BBC Radio Engineering Services,
Broadcasting House,
London.

We have received several letters regarding the heater wiring on the Valve Preamplifier. All make the point that the wires supplying the heater current should be twisted tightly together. In addition, the section on hum reduction in the book mentioned by Mr. Moody recommends arranging the wiring so that no complete loop is formed under a valve. The illustration shows how this can be done.



In fairness to Jeff Macaulay (the author of the Valve Preamplifier article) we should point out that the preamplifier shown in the photographs was a hastily-constructed replacement for the original prototype which went astray in transit. Hence our suggestion in the photo caption that readers should not follow the wiring too closely! — Ed.

AUNTIE STATIC'S PROBLEM CORNER

Dear Auntie,

Will you please inform me where I might purchase the following: A dictionary of electronic terms that is comprehensive, yet can be understood by a novice.

A book that would allow me to build a 16-bit microcomputer which explains in detail how the microprocessor, ROM and RAM ICs work, and how to connect them together.

R. King,
Orpington,
Kent.

Every electronics dictionary seems to have its own little quirks, omissions and questionable definitions, and I have not yet come across one which I could recommend without reservation. For something cheap, readily available and fairly comprehensive, you could do worse than to choose the Penguin Dictionary of Electronics, which you will probably find in your high street newsagents. The definitions tend to be pedantic and are not always very enlightening, but it will cover most of the things you would want to look up. The Encyclopaedic Dictionary of Electronic Terms by John E. Traister and Robert J. Traiser (published by Prentice Hall) is a larger and more expensive book which covers every entry in much greater detail than the Penguin book. Another book we happen to have around the ETI Offices is the Encyclopaedia of Electronics, edited by Stan Gibilisco and published by Tab Books, which is similar in style to the last, but more comprehensive. Both of these books are good if you want a fairly detailed explanation rather than a definition. However, this is one case where I hope that you will not take Auntie's advice, but go to a bookshop with a good technical section and choose one that suits you.

To build a 16-bit computer, a book called 'How to Build Your Own Working 16-bit Computer' sounds like just the one you are looking for. It is available by post from Maplin, who advertise in ETI, and costs £4.95.

— Auntie

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10way	0.61	0.72	0.72	
16way	0.75	1.00	1.00	
20way	0.88	1.24	1.24	
26way	0.98	1.34	1.34	
34way	1.40	1.69	1.69	2.27
40way	1.62	1.88	1.88	
50way	2.08	2.93	2.93	

LINEAR ICs

555	0.20
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723	0.50
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AY-3-1014A	2.75
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BTT8124	3.00
CA3011	1.10
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6800	2.50
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68809P	12.00
68000P8	20.00
1793	12.00
1691	12.00
9216	12.00
1772	15.00
8271	45.00
2793	20.00
2797	20.00
L203B/4 ULN2003	0.70
L204B/4 ULN2004	0.70
MC1488	0.58
MC1489	0.58
SN75108	0.90
SN75189	0.70
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SN75480	0.99
SN76013	2.70
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SN76110	0.90
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27C64-25	8.00
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27128-250	2.21

27256-25	7.00
4116-3	0.75
27C256-20	15.00
27512-25	36.00
27C512-25	49.00
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41256-15	3.00
41416-15	3.90
4864P-2 150 N/S	1.50
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6116P4 200 NS	1.50
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HM6264LP15	3.00
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HM65256P-15	17.00
MB85101-A-10	46.00
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TC5516APL2	2.90
TC5517BP	2.95
TC5565PL15	3.55
TMM2016D	6.85
TMM416P-3	2.95
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UPD43256C-15L	55.00

DIODES

AA19	0.08
AA129	0.20
1N4001	0.04
1N4002	0.04
1N4003	0.05
1N4004	0.05
1N4005	0.05
1N4006	0.06
1N4007	0.06
1N4148	0.03
1N5401	0.09
1N5402	0.09
1N5404	0.12
1N5406	0.12
1N5408	0.14
1S44	0.08
1S920	0.07
1S921	0.08
6A600	0.40

74HC & 74HCT

HC00	0.28
HC02	0.28
HC03	0.28
HC04	0.28
HC08	0.28
HC107	0.35
HC109	0.40
HC10	0.28
HC112	0.40
HC113	0.40
HC11	0.28
HC125	0.40
HC126	0.40
HC132	0.70
HC133	0.28
HC137	0.70
HC138	0.70
HC139	0.70
HC14	0.70
HC15	0.70
HC153	0.50
HC158	0.50
HC160	0.80
HC161	0.80
HC162	0.80
HC165	0.85
HC173	0.80
HC174	0.80
HC194	0.80
HC195	0.80
HC240	1.00
HC241	1.00
HC242	1.00
HC244	1.00
HC245	1.00
HC257	0.80
HC266	0.70
HC273	1.00
HC32	0.35
HC390	1.00
HC393	1.00
HC42	0.50
HC51	0.28
HC534	1.00
HC540	2.00
HC541	2.00
HC74	0.50
HC75	0.50
HC85	1.00
HCT240	1.75
HCT241	1.75
HCT244	1.50
HCT245	2.20
HCT640	2.40

CRYSTALS

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100.0 KHz	4.00
1 MHz	2.65
1.8432 KHz	2.00
2.0 MHz	2.10
2.4576 MHz	1.90
2.5 MHz	1.80
3.0 MHz	2.10
3.2768 MHz	3.00
3.579545 MHz	1.25
3.6864 MHz	1.70
4.00 MHz	1.20
4.194304 MHz	1.50
4.433619 MHz	1.00
4.9152 MHz	1.20
6.00 MHz	1.30
6.144 MHz	1.30
6.4 MHz	1.30
6.5536 MHz	1.50
7.159 MHz	1.30
7.3728 MHz	1.50
8.0 MHz	1.40
10.0 MHz	1.70
12.00 MHz	1.50
15.00 MHz	1.80
16.0 MHz	2.00
18.432 MHz	1.50
20.0 MHz	1.50
32.00 MHz	1.30
36.00 MHz	1.30
48.00 MHz	1.30

DIL SOCKETS

TP = Turned Pin LP = Low Profile

	LP	TP
8 PIN I.C. SOCKET	0.05	0.20
14 PIN I.C. SOCKET	0.07	0.35
16 PIN I.C. SOCKET	0.08	0.38
18 PIN I.C. SOCKET	0.09	0.43
20 PIN I.C. SOCKET	0.10	0.48
24 PIN I.C. SOCKET	0.13	0.52
28 PIN I.C. SOCKET	0.14	0.55
40 PIN I.C. SOCKET	0.18	0.85
24 PIN ZIF	4.16	
28 PIN ZIF	4.87	
40 PIN ZIF	7.02	

VOLTAGE REGS

7805	0.35
7808	0.35
7808CK	0.56
7812	0.35
7815	0.35
7815CK	0.56
7818	0.35
7824	0.35
78L05	0.20
78L08	0.20
78L12	0.20
78L15	0.30
78L24	0.30
7905	0.40
7908	0.40
7912	0.40
7915	0.40
7918	0.40
7924	0.40
79L05	0.33
79L08	0.40
79L12	0.33
79L15	0.40
79L24	.60

CMOS

4000B	0.18
4001B	0.18
4001UB	0.18
4002B	0.18
4002UB	0.18
4006B	0.50
4007UB	0.18
4008B	0.50
4009UB	0.25
40103B	3.00
40104B	0.75
40105B	1.50
40107B	0.40
40108B	2.35
40109B	0.87
4010B	0.25
40110B	1.65
4011UB	0.18
40114B	2.10
4011B	0.18
4012B	0.18
4012UB	0.18
4013B	0.25
40147B	0.85
4014B	0.40
4015B	0.40
40160B	1.25
40161B	1.25
40162B	0.50
40163B	0.50
4016B	0.25
40174B	0.50
40175B	0.50
4017B	0.40
40181B	1.80
4018B	0.40
40192B	0.50
40193B	0.60
40194B	0.60
4019B	0.35
40106B	0.35
40208B	2.10
4020B	0.50
4021B	0.50
4022B	0.50
4023B	0.18
4023UB	0.18
4024B	0.30
40257B	1.50
4025B	0.18
4025UB	0.18
4026B	0.80
4027B	0.25
4028B	0.32
4029B	0.50
4030B	0.18
4031B	1.00
4033B	1.00
4034B	1.10
4035B	0.50
4038B	0.60
4040B	0.45
4043B	0.40
4044B	0.45
4045B	1.00
4046B	0.50
4047B	0.50
4048B	0.30
4049B	0.25
4050B	0.25
4051B	0.50
4052B	0.45
4053B	0.45
4054B	0.60
4055B	0.60
4056B	0.80
4060B	0.50
4063B	0.70
4066B	0.25
4067B	2.00
4068B	0.18
4069UB	0.18
4071B	0.18
4072B	0.18
4073B	0.18
4075B	0.18
4076B	0.50
4077B	0.18
4078B	0.18
4081B	0.18
4082B	0.18
4086B	0.45
4089B	0.95
4093B	0.25
4094B	0.80
4095B	0.75
4096B	0.75
4097B	2.25
4099B	0.75
4502B	0.50
4503B	0.33
4508B	0.90
4510B	0.40
4511B	0.40
4512B	0.40
4514B	1.00
4515B	1.00
4516B	0.40
4517B	2.25
4518B	0.40
4520B	0.40
4522B	1.10
4526B	0.45
4527B	0.50
4532B	0.50
4536B	2.00
4538B	0.60
4543B	0.55
4555B	0.30
4556B	0.45
4584B	0.40
4585B	0.40
4724B	1.00

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SN74LS123	0.40	SN74LS165	0.75	SN74LS247	0.55	SN74LS352	1.00	SN74LS645	1.20	SN7402	0.22
SN74LS125	0.30	SN74LS166	0.75	SN74LS248	0.90	SN74LS353	0.80	SN74LS668	0.80	SN7404	0.25
SN74LS126	0.30	SN74LS168	1.10	SN74LS249	0.90	SN74LS365	0.35	SN74LS669	0.80	SN7406	0.38
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HARDWARE DESIGN CONCEPTS

Mike Barwise considers ways of performing high speed arithmetic operations in small microprocessor systems.

Eight bit microprocessors can only handle very small numbers in any single operation (from 0 to 255 or -128 to +127), and can only perform very limited operations upon them. About the most complex arithmetic instruction available on any eight bit microprocessor is the ADD WITH CARRY.

As a result, in order to perform even basic arithmetic to reasonable precision, many repetitive operations have to be performed, and one calculation must be complete before the next can be started. This means that software arithmetic is *slow*. This becomes very obvious when we ask the poor micro to calculate something horrid like the 67th power of 13.5.

Alternatives

There is a range of alternatives open to the micro user in mathematics. The cheapest one is to run the program now and come back next week for the results. However, the more realistic options are:

- buy a very high speed micro or mini computer (prohibitively expensive);
- install a standard arithmetic chip set (a so called *arithmetic co-processor*);
- find a cheaper alternative.

The arithmetic co-processor is a dedicated micro which accepts instruction codes and data from the host and goes away to calculate answers, with which it returns after a while. Typical devices are the Intel 8231A APU and 8232 FPU. These chips both cost in the region of a hundred pounds in small quantities, and they are designed to operate with 8080 family systems using the 8237 DMA (direct memory access) controller. They are both extremely fast but they are remarkably complex to implement in both hardware and software terms unless you design a microsystem around them. I hasten to add that these problems are not exclusive to Intel, but inherent in all standard hardware arithmetic.

The Cheaper Alternative

In spite of the foregoing reservations, the concept of the co-processor can be carried across to establish a much cheaper solution.

It is very important to understand the significance of speed in micro arithmetic. If you have a single calculation to perform, albeit a complex one, the total run time increase in your program will proably be acceptable even if the maths is done in host software. The real snag materialises when you want to raise every value in the 9th column of your spreadsheet to the power (sin A). If each operation takes 30ms (quite realistic at, say, 400 KIPs on a 3MHz 6502), you multiply this by the number of values after adding a factor for the data transfer time to and from the spreadsheet file. The result is *exactly lots*.

However, we could transfer quite a number of bytes from the spreadsheet file to some other hardware in 30ms, so the immediate thought which springs to mind is *buffers*.

Suppose we create a dedicated micro from a CPU, RAM, ROM and interfaces (our buffer of last month), and provide it with a set of maths calculation routines fronted by an evaluation handler. To use this, maths statements are transferred to it by the host, which then waits for an interrupt from this co-processor which indicates an answer is available. Obviously there will be no time saving when a single calculation is performed, but there is still the advantage, that the maths software is not in the host map, so there is more user memory available.

Maximum efficiency is realised when the input of a complete expression for evaluation takes just a little less time than the calculation of the result. The host has then just finished loading the co-processor with the second expression when it receives an interrupt saying 'first result ready', and so on to the penultimate expression. Beyond this point, results will be coming back to the host but there is nothing more to send.

Implementation

The starting point for the arithmetic co-processor (ACP) is a buffer system similar to that described last month. It differs, though, in two ways. Firstly, both ports open onto the same bus, since the output is mapped to the same host CPU as the input. Secondly, the buffer can be smaller than last month's printer buffer.

In fact it consists of two such buffers (Fig. 1). The first transfers input data (expressions for evalution) between the ACP input port and the evaluation/calculation scratchpad; the second transfers results from the scratchpad to the ACP output port.

Between the two buffers is the essence of the ACP: the evaluation and calculation software. The evaluation section interprets incoming expressions and decides what information to pass to which calculation section, and recombines the various elements of the problem into a result for output.

Using this dual-buffer method, it is perfectly feasible to supply the ACP with (and recover results in) straight ASCII decimal expressions, greatly simplifying the problems of data format associated with integrated arithmetic chips. Of course, any other format you choose is also possible, but all operations internal to the ACP must be performed in conventional twos-complement arithmetic.

the string. Having done this, the interpreter just has to pass each element to the correct calculation routine.

The calculation routine set should include as a minimum:

- the four primary arithmetic functions (add, subtract, divide, multiply;)
- log and antilog;
- the basic trig functions (sin, tan, cos), and their inverse functions (arcsin, arctan, arccos).

This set will allow most general maths up to A-level standard to be performed. The provision of constants (π, e, and so on) is optional, but very easy.

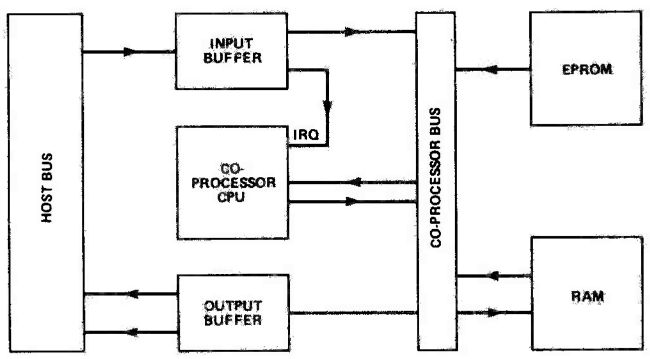


Fig. 1. Block diagram of the arithmetic co-processor.

The expression input buffer will have to be considerably larger than the result output buffer, as expressions can usually be up to 256 characters in length, whereas even real numbers are normally represented in five bytes (twos complement) or about nine digits (ASCII decimal integer) on eight bit systems.

Performing calculations

The first process is the analysis of the input problem by the input interpreter. If the problem is entered as ASCII, it can be scanned as a literal string and interpreted element by element. A slightly more sophisticated system would be to pre-scan the whole string and enforce conventional maths hierarchy. This can be done either by setting pointers to the required interpretation sequence, or by creating a rearranged copy of

Of course, there is nothing to stop you installing encryption/decryption algorithms, or anything else you fancy. This could prove interesting as, in spite of the recent publication of information and tips about NBS encryption chips, these remain impossible to obtain except under ridiculously stringent licensing agreements.

The four primary arithmetic operators can be performed adequately by software routines, in view of the 32 bit precision generally required. It does not look unduly efficient to implement trigonometry or logarithms as software routines too. An alternative (considering that nearly 32 Kbytes of our ACP map should still be free) is to provide EPROM look-up tables for these functions.

Whichever method you choose, it is best to use the fastest processor (CPU) you can get. The restriction on processor speed in most small micros is mainly due to the limits imposed by peripheral interfaces of the LSI and VLSI variety (programmable parallel port chips, video controllers, and so on). Our design approach uses RAM, EPROM and TTL, all of which are able to run at much greater speeds. The real limitation is going to be the EPROM, which is currently the slowest of the three.

The fastest processors (in terms of operation execution rate versus clock speed) are the 6500 and 6800 families, the 6502 and 6809 being the standard choices. The 6809 is available in the 2MHz version, and the 65C02 (CMOS) can be obtained in a version capable of an incredible 4MHz! This latter CPU will improve throughput in your ACP, not 'arf!

Of course, at 2MHz and beyond you must be more fussy about system timings. Sloppy design and marginal timings are much more apparent at these higher speeds, and will manifest themselves as intermittent random behaviour or 'crashing'. Particularly at 4MHz, you must ensure that every critical timing is given at least a 30% safety margin. Thus, at 2MHz (6502) the total machine cycle is 500ns, divided into two equal halves, for the address set-up time and data set-up time. You must ideally choose a memory device which can handle data transfer within 175 to 200ns of a stable address being applied, and your address path must stabilise within the same time limits.

These requirements are *much* more important during write operations than reads, due to the risk of writing to the wrong location. During a read operation, transient passage through an incorrect address at the start of the data half cycle is unimportant, as the output data are sampled by the processor at the *end* of the cycle, whereas during a write, the address is latched in the memory at the beginning of the second half cycle. If this address is not yet stable, the address latched will not be the one you wanted.

A realistic compromise is the use of 150ns RAM and 250ns EPROM at 2MHz, and 120 to 150ns RAM and 150 to 200ns EPROM (this means CMOS) at 4MHz.

Maximum efficiency is realised when the input of a complete expression takes just a little less time than the calculation of the result. . .

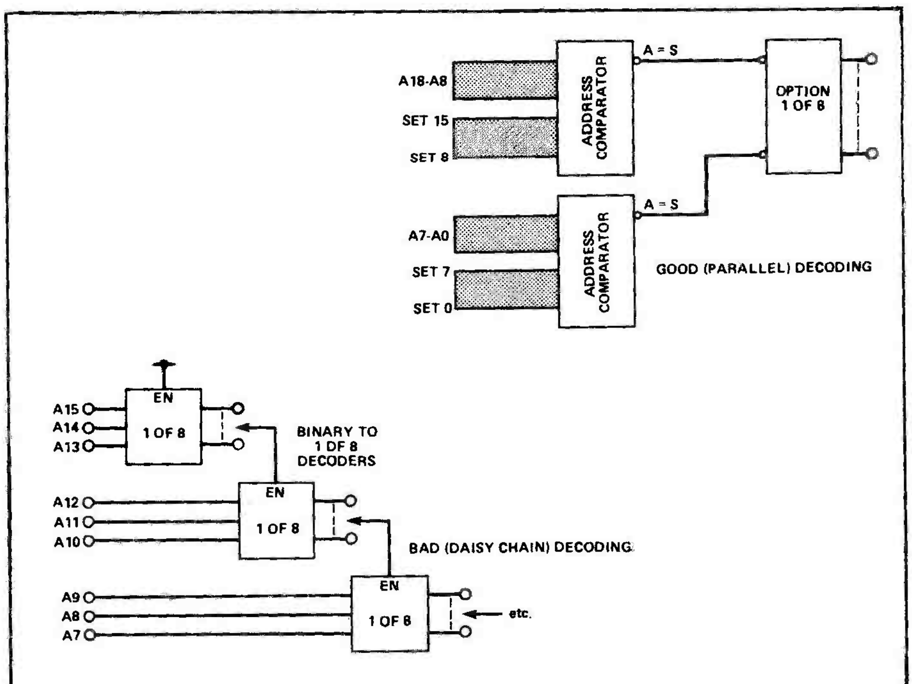


Fig. 2 Good and bad decoding.

Note that the 200ns EPROM in the 4MHz is 'pushing it' just a little: the data nominally become stable 200ns from a stable input address, and must be stable within about 30ns of the end of the 250ns cycle. This allows you 20ns *maximum* to stabilise the primary addressing (memory chip select). You will probably find FAST or AS TTL essential here.

The TTL interfaces, unless really messy in design, will always come up to expectations, but in all cases decoding should be as *parallel* as possible. The beginner (and many an unthinking professional, too) may be tempted to daisy chain decoders, which leads to very long cumulative propagation delays(Fig. 2).

Now for the shock: we have just drafted a design for a generalised co-processor. What it does between the output of the host input buffer and the input of the host output buffer is entirely up to you. This mechanism can be used time and time again to handle almost any slow non-real-time task.

Next month I will go into more detail on the implementation of the host/co-processor interface.

Whichever method you choose, it is best to use the fastest processor you can get . . .

ETI

MICRO-COMPUTER AIDED CIRCUIT DESIGN

Julian Burt's series concludes with an investigation of Fourier Transforms.

The idea of splitting a complex waveform into its constituent sine waves is a familiar one — whenever we talk of a signal's frequency spectrum or a circuit's frequency response, we are implicitly referring to the *sine wave* spectrum or response. If a waveform can be described by a mathematical function of time, there is a simple integral transform, similar to the Laplace transform described in previous articles, which can be used to calculate the frequency spectrum: the Fourier transform. For computer analysis, we are faced with two difficulties: firstly that it is often well nigh impossible to give a reasonable analytic expression for many waveforms which occur in electronic circuits; secondly, that computers are notoriously bad at dealing with integration of arbitrary functions.

Discrete Fourier Transform

If the waveform can be sampled, a reasonable approximation to the frequency spectrum can be obtained by means of the *discrete Fourier transform* (DFT). As this involves summation rather than integration, it is much easier to implement in software; the accuracy of the result will depend on the number of sample points used. For electronic waveforms, samples can easily be generated with an A-to-D converter.

The main drawback of the standard DFT is that it is slow. The number of calculations that the computer must perform is proportional to the square of the numner of sample points, and for large samples the time taken to produce a result can become unacceptably long. Much time and energy has been devoted in recent years to improving the basic algorithm and producing *fast Fourier transforms* (FFTs). Listing 1 is based on a FFT developed by Cooley and Tukey in 1965. For a set of sample points which fill 1 K of your computer's memory, this is about 100 times faster than the standard DFT.

Graph Plotting

The output from the analysis programs can conveniently be produced in tabular form, but often a graph is more revealing and easier to interpret. A simple way to produce graphs uses the PRINT TAB(B) statement. This avoids dedication of a large area of RAM to a graphics mode print routine, and eliminates the problems involved in transferring graphics output to certain types of printer.

```
1000  DEF PROCfft
1010  FOR I=0 TO N-1
1020  X(I)=X(I)/N
1030  NEXT I
1040  C1=N/2:C2=1:W=2*3.14159/N
1050  FOR I=1 TO P2
1060  D1=0:D2=C1
1070  FOR J=1 TO C2
1080  BF=INT(D1/C1)
1090  PROCbit_reverse
1100  C=COS(W*BR):S=-SIN(W*BR)
1110  FOR K=D1 TO D2-1
1120  A1=X(K):A2=Y(K)
1130  B1=C*X(K+C1)-S*Y(K+C1)
1140  B2=S*X(K+C1)+C*Y(K+C1)
1150  X(K)=A1+B1:Y(K)=A2+B2
1160  X(K+C1)=A1-B1:Y(K+C1)=A2-B2
1170  NEXT K
1180  D1=D1+2*C1:D2=D2+2*C1
1190  NEXT J
1200  C1=C1/2:C2=2*C2
1210  NEXT I
1220  PROCtabulate
1230  ENDPROC
1240
1250  DEF PROCbit_reverse
1260  BR=0:NN=N
1270  FOR L=1 TO P2
1280  NN=NN/2
1290  IF BF<NN THEN GOTO 1320
1300  BR=BR+2^(L-1)
1310  BF=BF-NN
1320  NEXT L
1330  ENDPROC
1340
1350  DEF PROCtabulate
1360  INPUT"How many lines do you want printed
for each screen";ML
1370  CLS:LL=0
1380  PRINT"Harmonic";TAB(15)"Real"
;TAB(30)"Imaginary";TAB(45)"Magnitude"
1390  FOR I=0 TO N/2
1400  BF=I
1410  PROCbit_reverse
1420  PRINTI;TAB(15) X(BR);TAB(30) Y(BR)
;TAB(45)SQR(X(BR)^2+Y(BR)^2)
1430  LL=LL+1:IF LL=ML THEN LL=0
:INPUT"Press a RETURN to continue";QWE
1440  NEXT I
1450  ENDPROC
```

Listing 1 Routine to implement the Cooley and Tukey fast Fourier transform algorithm.

The plotting method used in Listing 2 is simply to print a '*' on the screen or printer at a position proportional to the value of the function. The data points to be plotted are held in the array RESULTS(N,2), where N is the number of data points. RESULTS(i,1) will be the x co-ordinate of the ith sample point, and RESULTS(i,2) will be the corresponding y co-ordinate. The graph is printed with the y-axis running across the paper to allow any number of data points to be plotted along the length of the paper.

The program first searches for the largest value of RESULTS(i,2) to choose a suitable scaling factor so that there is room across the width of the paper or screen to accommodate all the points to be plotted. The y-axis is then printed and numbered. Next, the program prints the numerical value of the first x-co-ordinate, prints the x-axis, and then the corresponding data point, the y co-ordinate being adjusted by the scaling factor. This is repeated until the contents of the array are exhausted.

Conclusion

This series has, of necessity, covered only a small portion of an ever growing subject. If you wish to follow up any of the ideas without further reading, it would be well worth considering a visit to your local college or university library. Most of them will issue readers' tickets during vacations.

Many of the books about computer aided circuit design were written with the users of large computers in mind, so you may find that the algorithms involve the use of more memory than you have available on your home micro. Often, increased speed has been achieved at the expense of memory, so it is not practical to modify the program without losing the benefits. Having said that, there are many algorithms that can be implemented on home computers, or programs (often in FORTRAN) which can be translated into BASIC.

```
 90  PROCplotter(Y)
100  MAY=0
110  FOR X=0 TO 21
120  IF D(X,2)>MAY THEN MAY=D(X,2)
130  NEXTX
140  DY=65/(((MAY DIV10)+1)*10)
150  GOTO 160
160  Z=0
170  FOR X=0 TO ((MAY DIV10)+1)*10
STEP (((MAY DIV10)+1)*10)/Y
180  PRINTTAB(10+X*DY);INT(X);:T(Z)=10+X*DY
190  Z=Z+1
200  NEXT
210  FOR X=10 TO 78:Q=0
220  FOR Z=0 TO Y
230  IF INT(T(Z))=X PRINTTAB(X);"+";:Q=1
240  NEXTZ
250  IF Q=1 THEN GOTO260 ELSE PRINTTAB(X);".";
260  NEXTX
270  FOR X=1 TO 21
280  PRINTTAB(0);D(X,1);TAB(10);"."
;TAB(10+D(X,2)*DY+1);"*"
290  NEXT
```

Listing 2 A graph plotting routine.

Two books which I have found particularly useful are:

1) Fiddler, J.K. and Nightingale, C. 'Computer Aided Circuit Design', Nelson, 1978.
2) Kassab, V. 'Technical BASIC', Prentice Hall, 1984.

CD-ROMS — THE FUTURE OF MASS STORAGE?

Gary Herman looks at the past and future of optical memory.

There can be little doubt that the single most important issue in the development of computing, post-microprocessor, is that of mass storage. Computing speed only becomes an issue at all when large amounts of data need to be handled or when complex, memory-expensive, tasks need to be undertaken. And, despite all the ballyhoo, memory size (or, more particularly, address space) is rendered an almost marginal question in a virtual memory machine. Even 64K can cope with most demands if it has fast access to capacious enough mass storage devices.

If mass storage has never yet seemed to be an issue of singular importance, it is because it has — in a sense — been circumvented. The mass storage devices most associated with microcomputers are either inherently very slow (cassette tape) or quite limited in capacity (floppies and ROMs). Improvements in performance have tended to focus on more obvious and manageable areas of technological progress — processor speed and address space.

Now that micros of 1Mb core storage and more are routinely appearing on the market, we may confront situations in which a machine can hold more data than it can store in a single operation. For mainframes and minis, able to use expensive hard discs and tape streamers as back-up and constructed for the most part as tailor-made systems to fit a particular use, storage has never seemed to be a problem. The developing micro has thrown the issue into relief, however, and now the talk is all of mass storage and the way in which it can create flexible small systems of unimagined sophistication.

Optical Illusions

Optical devices have long been front-runners in the race to find the perfect medium of mass storage. Because light is — in theory — capable of much finer resolution than even a beam of single electrons, an optical medium should be able to store data much more densely than any straightforward electronic, electrical or electromagnetic medium. (The obverse is also true, that it requires vast amounts of memory to store a visual image with all the detail we have come to expect of, say, an ordinary colour photograph).

Of course, the theory meant nothing until there was a practical way to store and recover data using light. Once again, that old 'solution in search of a problem' — the laser — came to the rescue.

Visions Of The Future

In July, 1967, a small group of researchers under the leadership of Dr. Pieter Kramer began what was to become a massive and far-reaching programme at Philips Research Laboratories in Eindhoven, Holland. The object was to record and recover video and audio signals using laser light in conjunction with a permanent storage medium. The system that the Philips' researchers imagined would have had several advantages over the then emerging videotape devices.

It was to use a disc, which is easier to move at speed than tape (an important consideration for the recording and replay of large bandwidth video signals). A disc is also easier to reproduce in quantity if the information on it can be stored in the form of surface features. While a tape has to be copied piece by piece, such a disc can be mass reproduced using a die and a stamping machine. This is an important commercial consideration.

The use of a laser was another advantage — especially for reading the disc. The laser — a heterojunction semiconductor device of a type developed by Philips towards the end of the sixties — could be used to read a disc without physical contact since its reflected light could be modulated by surface features. This immediately eliminated the problems of wear which made video recorder head design and videotape manufacture so difficult. It also meant that the disc could travel with significantly less friction. The laser disc system would be more reliable, longer lived and qualitatively superior to tape systems.

By 1972, Philips were able to give the first public demonstration of a video disc using the LaserVision system. In 1978, LaserVision was introduced commercially into the USA and in 1982 it reached Europe. The system faced unbeatable competition from videotape, which was good enough for most consumers and had the added bonus of 'recordability', but few could deny its potential.

Visions Of The Past

Dr. Kramer recently commented that the idea for the LaserVisiion formwat was already present in telegraph-type punched tape using Morse code and even in the slotted and folded cardboard strips (known as 'books') which encode the music played on a barrel organ. 'It is,' said Kramer, 'just another set of dimensions.'

LaserVision discs contain picture information as tiny pits on their surfaces. These pits represent the positive peaks of an FM signal. The video signal is modulated on a carrier of 7MHz and the pits have dimensions in the order of one micron.

About an hour's worth of video material can be recorded on one side of a 12" video disc in a tight spiral of pits making some 54,000 turns to cover the disc surface. Track separation is 1.6 microns, which means that the video disc has a density of about 16,000 tracks per inch (tpi). The pit density corresponds to a data density of about 25,000 bits per inch, all of which gives the video disc about ten times the capacity of any practical magnetic disc, including a Winchester.

From the outset, LaserVision was seen as a technique for storing more than old movies. The problem was that a slightly irregular or scarred disc surface could effectively destroy invaluable data, although old movies might survive.

Even so, the technology associated with video discs achieved a great deal. Techniques used in IC manufacture were adapted to get the precision and resolution required to make a master disc using blue laser light on a polished glass disc coated with photosensitive lacquer. A nickel mould was made from the master using an electroplating process developed from that used in gramophone record pressing. The plastic discs have to be made quickly and cheaply from the nickel stampers, with the result that they are neither very regular nor very flat. To read them, powerful servo-motors are used to control the tracking and focus of the laser read head.

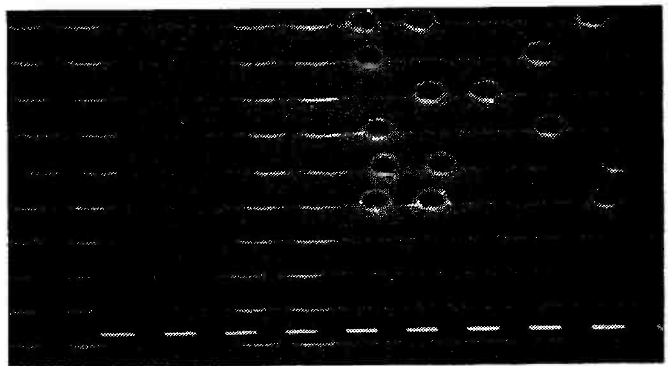
So bad are some video discs that they are known as 'potato chip' discs. Yet the lens of the read head must be kept within about ¼ micron of its fixed distance from the disc surface and the laser beam must be kept to the centre of the track with a margin of only 1/10 micron. The lens itself is a minor miracle, being a single-element aspheric piece of plastic manufactured by a simple pressing process and with a depth of focus of 2 microns. The servos, sensors, correcting motors and controlling logic — which owe quite a lot to robotics and magnetic disc drive technology, but which require almost instantaneous responses — are really the supports on which the whole LaserVision system rests.

Thanks For The Memory

LaserVision technology provided the mechanisms by which digital optical recording (DOR) could be made workable, but it didn't provide the motivation nor the required degree of reliability. In fact, the realibility problem and the motivation were interlinked.

The motivation was really quite simple, and that was the desire to store large amounts of data as cheaply as possible. The video disc offered the possibility of extraordinary bit densities combined with extreme cheapness of manufacture and the ability to replace discs within a drive. It was versatile as a floppy while being more capacious than a Winchester and probably cheaper to produce in the long term than a cassette tape. It was, of course, limited by its read-only nature, but then there have always been plenty of uses for ROMs and, in any case, the video disc might provide the perfect medium for database storage.

Just as the floppy was first developed as a short-term storage medium for loading programs on to mainframes,



The surface of a tellurium DOR disc showing 1um pits.

so DOR systems were first considered as long-term storage media for reference data: dictionaries, maps, mailing lists, device libraries for circuit design packages and so on. These could all be stored permanently on a DOR device and data transferred to programs or short-term storage media as necessary. The discs themselves would be cheap enough to throw away if information on them became obsolete. If, on the contrary, you were faced with a growing volume of discs in one database, there was a ready solution in copying the familiar jukebox. DOR discs, unlike hard discs, could easily be swapped around within a single drive.

Shortly after the introduction of the video disc, Sony very noisily dropped out of the market saying that they intended to concentrate on non-domestic applications of the technology. By 1980, they had become involved with Philips in the development of the laser based digital audio system which was to become known as Compact Disc or CD. Almost certainly, the two companies calculated that the domestic market for quality audio would be big enough to bring down unit prices within this technology. Indeed, CD Players have fallen to something like 20% of the price with which they greeted the world in 1982-83 (although the discs themselves remain fairly expensive *for an audio medium*).

The vision of gigabytes of data brought with it a nightmare in the form of uncorrectable errors. With the sort of data density to be expected from a DOR and given the goal of cheap mass production, data errors became extremely likely — particularly block errors caused by physical defects in the disc or read devices. In a system operating at a data rate of 1Mbit/sec, it only requires an error rate of 10^{-6} to ensure an average of one error every second. This is unacceptable in data processing applications, although an audio system can simply mute if an uncorrectable error comes along and the result will be no worse than a scratch on an ordinary vinyl disc.

This may have been another consideration leading Philips and Sony to develop CD technology for audio applications first. The point, however, is that the audio and data storage applications use exactly similar techniques so that CDs and CD-ROMs (as the data storage discs have come to be called) can exploit the same manufacturing plant and can share economies of scale.

Constant In A Different Way

CDs are in many ways similar to video discs. The most noticeable difference is that the CD is smaller at 12cm, not 12", in diameter. Even at this size, a CD can store up to 74 minutes of near-perfect audio programme material on one surface.

Data are stored in the form of pits along a 1.6 micron track spiralling out from the centre. With a CD, these pits represent binary numbers not FM signals. Unlike magnetic, video or vinyl discs, the CD rotates with constant linear velocity (CLV) to maximize storage capacity (Fig. 1). Information is stored as serial data in blocks which all have the same physical length. This results in a much more efficient form of storage than with, say, a floppy but means the process of actually finding a piece of information (the seek operation) is compromised.

Each block is addressed using a time code: 0–73 minutes for a CD or 0–59 for a CD-ROM, 0–59 seconds and 0–74 blocks. Because of the CLV, each block is read in exactly the same time, although the disc itself will be spinning at anything from 200 to 500 rpm depending on which block is being read. Seek time is increased by the need to turn the address into a physical location (with a floppy this is simplified by the track/sector sort of co-ordinate system) and by the process of adjusting the disc's rotational speed to maintain the CLV. The data rate for an audio CD is 176.4Kbytes/sec while for a CD-ROM it is 153.6Kbytes/sec.

The standard CD read laser scans the surface of the disc at just over 1m/s and operates from a clock of 4.3218MHz. Each data bit read is represented by the state of the disc surface in one clock cycle. A single feature is 0.3 microns in length and may or may not be along the bottom of a pit. Actually the coding system ensures that no features of less than 0.9 microns (and none of more than 3.3 microns) will be present. That is, the coding system — called 'eight-to-fourteen modulation' (EFM) — is run-length limited, as with high quality magnetic drives.

In fact, the coding system is quite complex. The basic unit of data is a frame, consisting of 24 8-bit bytes plus 1 byte of disc identification, timing and similar data plus 8 bytes of error correcting code computed from the 24 bytes of user data. Ninety eight of these frames form a block and, with CD-ROM only, 288 block bytes are used for further error correction, while 12 block bytes are used for synchronization and four hold the absolute address of the block to enable random memory access. There are 270K blocks on a CD.

Each 8-bit byte of each frame (33 in all) is converted into a 14-bit code by the EFM encoder, which then adds a further 24 bits for synchronization and a 3 bit merging sequence following the 24-bit and 14-bit sequences. Each frame provides 192 user bits but actually consists of 588 channel bits. Channel bits are, in effect, coded instructions to the recording laser: a one representing a change of state (begin making pit or finish making pit) and a zero representing no change (Fig. 2). During a read operation, the channel bits are demodulated and appear at the output as data bits. In the course of the read operation, a sophisticated set of error detection and correction systems come into play.

Audio CDs and CD-ROMs use the same error correction techanique on each frame — a cross-interleaved Reed-Solomon code (CIRC) based on a system developed in 1960 by Irving S. Reed and Gustave Solomon specifically to correct block (rather than single bit) errors in data transmission and reception. RS codes are widely used in satellite and deep space links, the basic technique relying on a result of the arithmetic of Galois fields, a rather arcane branch of mathematics invented by the French mathematician Evariste Galois (1811–1832) shortly before he was killed in a bar brawl. In short, RS codes allow an error affecting any subsequence of up to a specified length of any sequence of specified length to be corrected.

With the CD, each sequence of 24 bytes of user data is used to produce a 4 byte error code. These 28 bytes are then interleaved to break up block errors (Fig. 3) and a further 4 bytes of error code are produced. On replay, the processes are reversed. The first decoder accepts 32 bytes and can correct one byte only. Other errors are flagged but not corrected. The four error correcting bytes are stripped from the sequence and the 28 bytes are 'de-interleaved'. The second decoder accepts this sequence and, using the 4 byte error code and the flags produced by the first decoder, it can correct up to four bytes in sequence. This system is capable of dealing with error bursts of up to 450 bytes, which are most likely to result from easily visible physical defects. If longer error bursts occur, the CD will either mute itself or calculate a reasonable interpolation for the unreliable data.

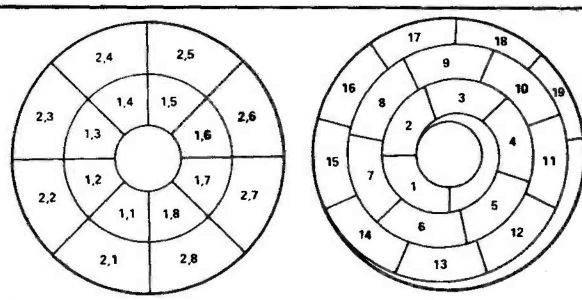


Fig. 1 CAV and CLV disc formats.

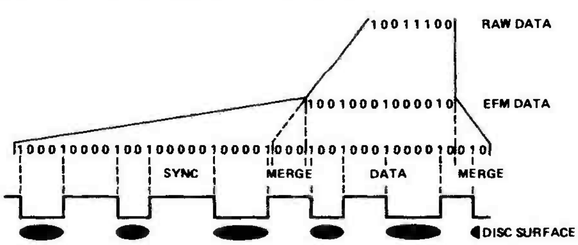


Fig. 2 CD and CD-ROM encoding system.

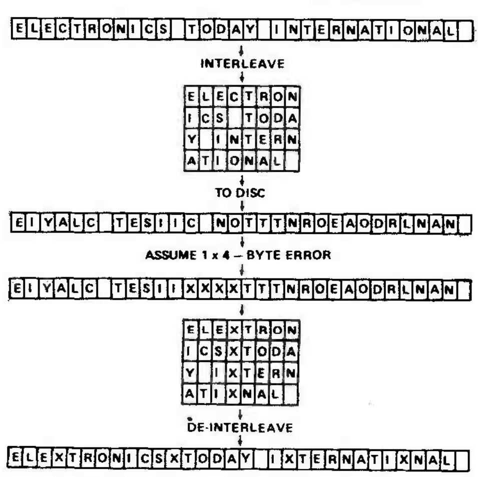


Fig. 3 Interleaving breaks up block errors.

To perform all this decoding on a CD player requires an IC which is the largest logical circuit in any item of consumer equipment. The CD-ROM has a further level of error correction operating on whole blocks of data. The theoretical incidence of uncorrectable errors for a CD-ROM is below 10^{-15}, or roughly once in every 200 years. The observed rate is actually better than 10^{-13} or once in 2 years.

The WORM Turns

Writeable DORs have been around since 1983. The first types used 12" discs with a capacity of around 1Gbyte per surface. The drives cost around £5,000 each and were aimed at the minicomputer market. Like all the writeable discs currently available, these were 'write-once' devices (or, more colourfully, WORMs — standing for, 'write-once read-many-times'). This means that any part of the disc can be written to once (and once only) enabling users to store their own data. With 1Gbyte capacity, these discs make plausible alternatives to hard discs.

The surface of the discs consists of a metal film, maybe 0.03 microns thick, deposited under a vacuum. A powerful laser is used to heat a pinpoint of metal rapidly to beyond melting point so that it forms a tiny rimmed hole in the surface on cooling. These surface features are used to represent data. A considerably less powerful laser is used to scan the features and read the data.

To heat even a tiny area by several hundred degrees Celsius in a few nano-seconds requires a power density in the order of 1MWatt/cm^2. Fortunately, suitable semi-conductor lasers were being developed at around the same time as the discs themselves. The write lasers need to be powerful to avoid heat diffusing into the substrate of the disc. On the other hand, the read lasers (usually aluminium gallium arsenide types) must be low powered to avoid degrading the surface. Any heat generated during the read operation tends to be dissipated by the metal surface, which makes sure that the surface will maintain its integrity during reading.

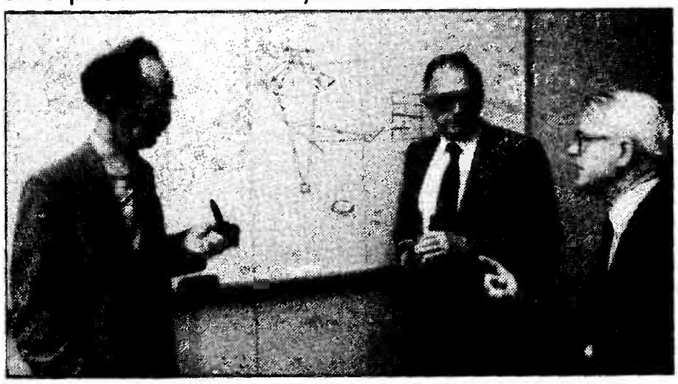
But metals do not necessarily provide the best surface for alterable or erasable optical discs. To remove surface features means that the metal would have to be left smooth and that no metal be evaporated in the write or erase operation.

Read, Write

Three possibilities are currently being investigated in research on erasable optical discs: tellurium-selenium alloys, organic compounds and magneto-optical materials. Atlhough many predict that magneto-optical materials will prove to be the eventual winners, comparatively little practical progress has been made with them or with organic compounds. By far the most is known about tellurium-selenium alloys. In fact, a tellurium disc is currently in commercial use in Philips' Megadoc document storage system.

In all cases, the best results have been obtained using infrared GaAs lasers operating at about 800nm with a writing power of 10mW overall and a 50ns pulse length. (By comparison the reading power is about 0.5mW).

Tellurium-selenium is a polycrystalline alloy usually compounded with small quanities of other elements (for example, arsenic which gives better control of melting point and the stability of the material). Holes can be made in the alloy by local heating to 1100°C for a period of one pulse. By heating the alloy to 450°C for a period of about two pulses, the surface is melted and rendered amorphous. No holes are formed, although the amorphous area reflects differently on read-out and can register as erased data. The alloy may be heated again to about 400°C for about two pulse periods to return an amorphous area to its crystalline state.



The Philips' team — Gys Bouwhuis, Kramer and Klaas Compaan.

Amorphous magnetic gadolinium-iron-cobalt has been known about for some time. This is a magneto-optical material which utilises the phenomenon of phase change. Several companies are currently involved in researching it and similar substances.

A laser is used to heat the material locally which reverses the magnetic polarity of a small area and freezes it in that state. Polarised laser light can then be used to read the pattern of magnetized areas due to a phenomenon known as the Kerr effect whereby the magnetic field rotates the direction of polarisation of the reflected light. To erase the data, the area is heated again while an external magnetic field is applied in the original direction of polarization.

With both tellurium alloys and magneto-optical materials the main problem is simply that it is at present impossible simply to overwrite data. Also, fatigue occurs after some thousands of erase-rewrite cycles, although that may not be a problem if there is enough capacity on the disc in the first place and if suitable algorithms can be developed to handle reading and writing.

Organic compounds do not as yet offer erasability. Research is based on dyes that absorb a great deal of light and have a high reflectivity even when applied in very thin layers. The dyes presently being investigated can be melted locally rather like tellurium alloys. Less energy is involved since the dyes are only superficially melted, the memory effect being obtained by registering difference in reflectivity due to the reduced thickness of the dye layer. The dyes can be very easily applied by spin-coating and are apparently resistant to heat and moisture.

The future for mass storage may be glimpsed in the vision of the CD-ROM jukebox. Already, NEC have shown a prototype jukebox using writable optical discs. It holds two stacks of 100 discs each and two separate drives. With a capacity of 120Gbytes and a physical volume of only 5 cubic feet, this is surely the prototype of the memory devices of the future. **ETI**

TRIGGER HAPPY

In March, we invited readers to send in their ideas for circuits to build on your free PCB. From the entries received, we've chosen a variable hysteresis schmitt trigger, sent in by Michael Harris, as the best taking into account Michael's age — 17 at the time of the competition — as well as the usefulness of the design. What follows is based on that design with afterthoughts by Paul Chappell

It must be said, as a prelude, that the level of entries for our free PCB competition was disappointing. We looked in vain for the fabled ingenuity of ETI readers. In the past, such competitions have inspired clever designs and outrageous designs (including the never-to-be-forgotten caged lion constructed from an IC and a few odds and ends in response to our request for the most original application of the IC in question).

This time we were moved to wonder whether anybody had actually *understood* the competition — we asked for a design based on the PCB and we got designs based on the PCB *and* the LM358 IC. A bit lacking in originality. For this reason alone, we have felt unable to offer a first prize to anybody. The design which follows has the virtues of simplicity and usefulness and for these it wins a runner-up prize of £20.

The Circuit

The circuit is a voltage controlled switch and is shown in Fig. 1. Switching levels are set by choosing appropriate values for R1, R2 and R3. If the input voltage begins at 0V and rises the output will be low until V_{in} reaches the voltage at the junction of R1 and R2, whereupon it will go high. Once high, the output will not go low again until the input falls to the voltage at the junction of R2 and R3.

If R1, R2, and R3 are all of the same value, the upper switching point will be at ⅔ of the supply voltage, and the lower point will be at ⅓ of the supply. Reducing the value of R2 will bring the two switching points closer together, keeping them symmetrical about $\frac{1}{2}V_{cc}$. Adjusting the values of R1 and R3 will raise or lower both switching points together.

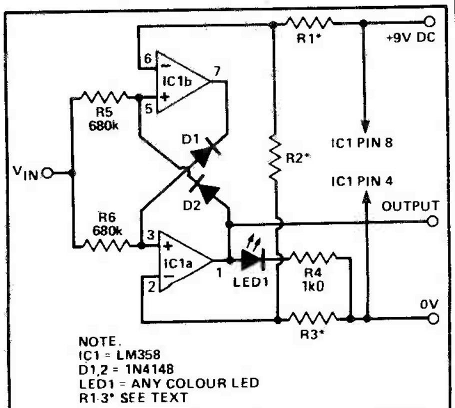


Fig. 1 Circuit of the voltage controlled schmitt.

Applications

The circuit can be used to clean up digital wafeforms — the variable switching points allow the circuit to be matched with almost any line driver, or any logic system. It can be used to provide logic pulses from various transducers, for instance the variable reluctance magnetic transducer shown in Fig. Fig. 2

Another application is to prevent overheating in, say, a transformer. The upper switching point would be chosen to trigger when the highest allowable temperature was reached. The output would operate a relay to disconnect the load from the transformer. The other switching point would be set to a lower temperature to allow the transformer to become reasonably cool before loading it again (Fig. 2).

Layout

The suggested layout for the circuit on the free PCB is shown in Fig. 3. The LED is optional — you may wish to have a visible indication of the circuit's status for some applications; in others it would not be necessary. The resistor and LED can be replaced by a resistor and 4V7 zener to give a TTL logic output. In this case, the resistor would be about 470R and would connect to the output of IC1a. The zener would go from the free end of the resistor to ground. The TTL output would be taken from the junction of the resistor and zener.

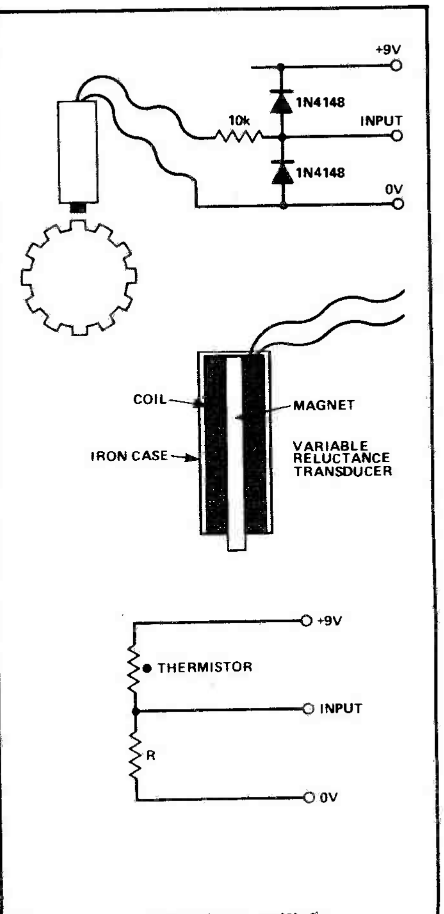


Fig. 2 Two applications utilising a variable reluctance magnetic transducer and a thermistor. A suitable variable reluctance sensor is available from RS Components or Electromail — see the item in this month's News Digest.

HOW IT WORKS

Suppose the input voltage rises from 0V. Initially, the outputs of both IC1a and IC1b will be at 0V. As the input rises, pin 3 of IC1a will be held low by the low output of IC1b, via D2, so nothing will happen until V_{in} reaches the voltage at pin 6 of IC1b — the upper switching voltage. When this happens, the output of IC1b will go high, allowing pin 3 of IC1a to go high too. The ouptut of IC1a will go high, and hold pin 5 of IC1b high via D1. If the input voltage now falls, it will have no effect on IC1b, which is now held on by D1. Nothing will happen until it reaches the voltage at pin 2 of IC1a — the lower switching point. When it reaches this level, the circuit will once again switch to its 'low' state.

PARTS LIST

RESISTORS (all ¼W, 5%)

R1, 2, 3	see text
R4	1k0
R5, R6	680k

SEMICONDUCTORS

IC1	LM358
D1, 2	IN4148
LED1	standard LED (but see text)

MISCELLANEOUS

PP3 battery connector, PP3 battery, sensors as required.

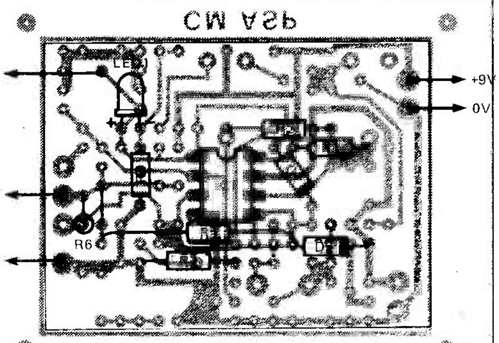


Fig. 3 Component overlay for the schmitt.

ETI

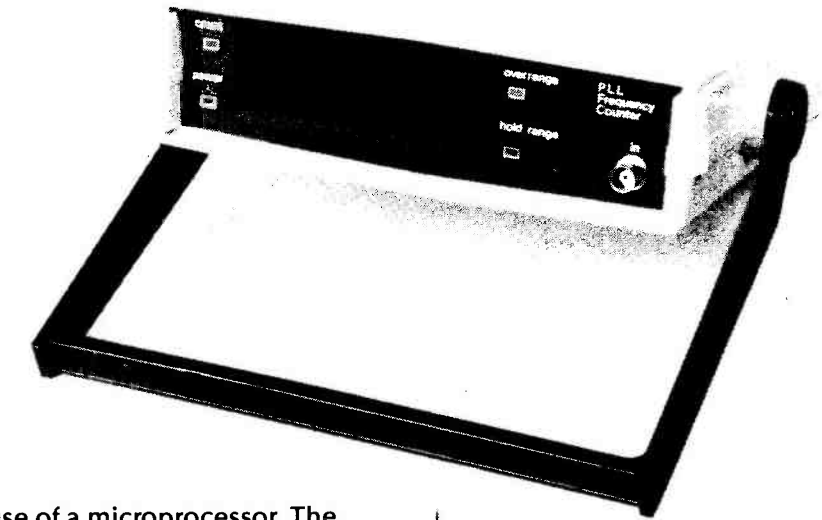
PLL FREQUENCY COUNTER

Graeme Durant describes a fully-autoranging, 10MHz frequency counter which is pretty nifty when it comes to measuring low frequencies.

Over the past few years there have been numerous designs for digital counters published in various electronics magazines, many based on a certain Intersil wonderchip and all boasting roughly the same features and facilities. Like so many of the others, the design described here has a four digit display. It is also fully autoranging, which is not too rare. However, the feature which sets it apart from the rest can be deduced from the title — the use of phase-locked loop (PLL) circuitry to reduce updating time.

The minimum updating time is normally dependent upon the measurement resolution required. The frequency to be measured is first converted into an equivalent train of logic pulses, then fed to a digital counting circuit for a fixed period of time. If a frequency of 1kHz must be measured to four digits of accuracy, the counting time must be one second and the circuit will count up to one thousand. For a 100Hz input, the counting time must be ten seconds to achieve the same measurement resoltution. For a 10Hz signal the counting time will be one hundred seconds. Should you wish to tune a signal generator to an exact frequency under 100Hz or measure the bass resonance frequency of a loudspeaker, this delay is likely to prove very awkward.

Two different methods can be used to reduce the updating time without losing measurement resolution. One system involves measuring the time taken for one wavelength of the input signal to occur and then calculating the reciprocal of this period. This method obviously requires much computational hardware or the use of a microprocessor. The alternative is to use a phase-locked loop to multiply the input frequency by some exact integer value prior to measurement. This is the approach taken here.



A phase-locked loop uses the principles of feedback control systems to lock a variable frequency oscillator onto the same frequency as an input signal, or if desired, to some predetermined multiple of it. In this design, low frequency inputs are multiplied by some power of ten prior to measurement. In this way, the counting time to achieve a particular resolution can be divided by the same power of ten and the speed of updating dramatically increased.

This design will measure frequencies from 10Hz to 10MHz with four digit resolution and it updates its display two-and-a-half times per second on all ranges. The counter is fully autoranging, the current range being displayed as an exponent to the right of the main readout. For example, a figure two would indicate that the main reading should be multiplied by x10^2. A 'hold range' feature is also provided, allowing users to avoid the disturbing flicker which results when an input signal frequency is wavering undecided just between ranges.

The Circuit

Figure 1 shows the internal workings of the frequency counter in block diagram form. Incoming signals are first amplified and then squared-off by a Schmitt trigger to produce clean, logic-compatible pulses. The circuit will operate correctly from input signal levels as low as 35mV at moderate frequencies.

The output from the squaring circuit is split several ways. It is fed to a detector which provides a logic-low signal to the rest of the circuitry whenever there is an input signal. It also goes to the range-setting circuitry built around the phase-locked loop, the frequency dividers and the two electronic switches.

The function of the range-setting circuitry is to adjust the

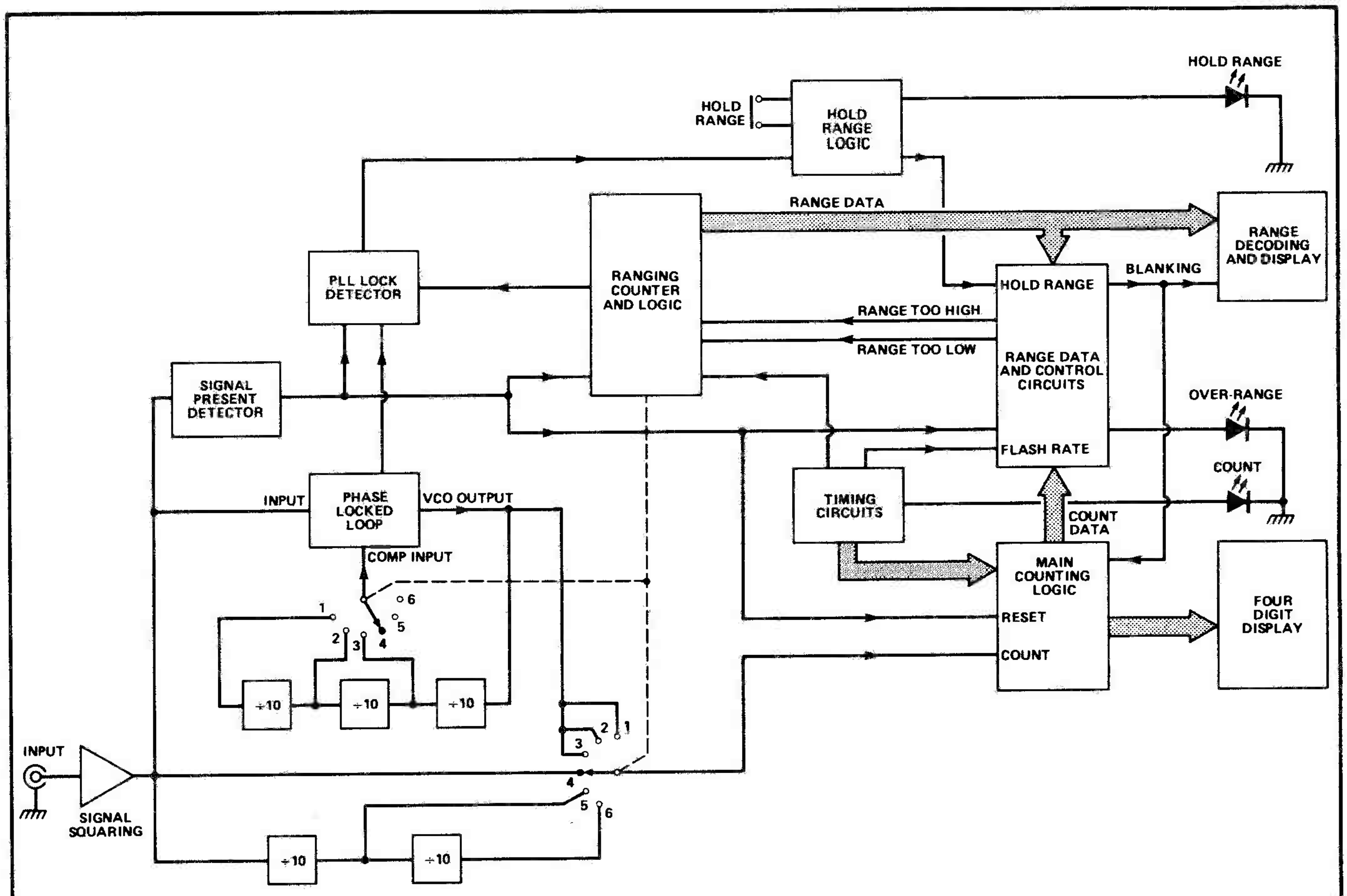


Fig. 1 Block diagram of the PLL frequency counter.

frequency of the incoming signal so that the ouput of the main counting logic always lies between 10kHz and 99.99kHz. When the incoming frequency is already within these limits, no adjustment is necessary and the output from the signal squaring circuit can be passed directly to the main counting logic (position 4 of the switches). If the input frequency is above 99.99kHz, the output from the squaring circuit will be passed either through one or both of the two ÷10 stages, allowing measurement of input frequencies up to 999.9kHz and 9999kHz (9.9MHz) respectively (positions 5 and 6 of the switch).

If the input frequency is below 10kHz, a phase-locked loop is used to multiply it. Under conditions of lock, the VCO output frequency will be n times the input frequency where n is the division ratio between the VCO output and the comparator input. By using one, two or three ÷10 stages, the VCO output frequency can be made 10, 100 or 1000 times higher than the input frequency. This allows frequencies down to 10Hz to be multiplied-up to the 10kHz minimum required by the counting logic.

The counting logic takes the ouput selected by the range switching and counts the number of pulses arriving during a 100ms period. This period is set by the timing circuits, which also drive an LED when the count is taking place. The count at the end of the period corresponds to the signal frequency and is fed to the main, four-digit display. If no input is connected to the counter, the signal detector mentioned earlier provides a logic-low on the reset line and sets the display to zero.

Count data from the main counting logic is passed to the range data and control circuits. These perform a number of functions, one of which is to produce 'range too high' and 'range too low' signals when the input to the main counting logic lies outside of the acceptable frequency range. These signals are used to control a ranging counter which sets the positions of the two electronic range switches. The output of the counter is decoded to produce the single-digit range display. The range data and control circuits are also responsible for blanking both the main display and the range display while counting is in progress.

Data from the counter is also fed back to the range data and control circits and compared with the count data coming from the main counting logic. If the count rate is too high and the ranging has already selected the highest range, an 'over-range' LED is illuminated on the front panel. This indicates that the frequency of the input signal is too high for the instrument to measure. Like other indicators on the instrument, this LED is flashed slowly using the 'flash rate' output from the timing circuits.

The hold-range facility is designed to over-ride the autoranging circuitry and 'freeze' the instrument on whatever range it happens to be on at the time the button is pressed. Another flashing LED is used to indicate that this facility has been selected. A lock detector monitors the state of the phase-locked loop circuits and resets the hold if the input signal goes out of the circuit's frequency range.

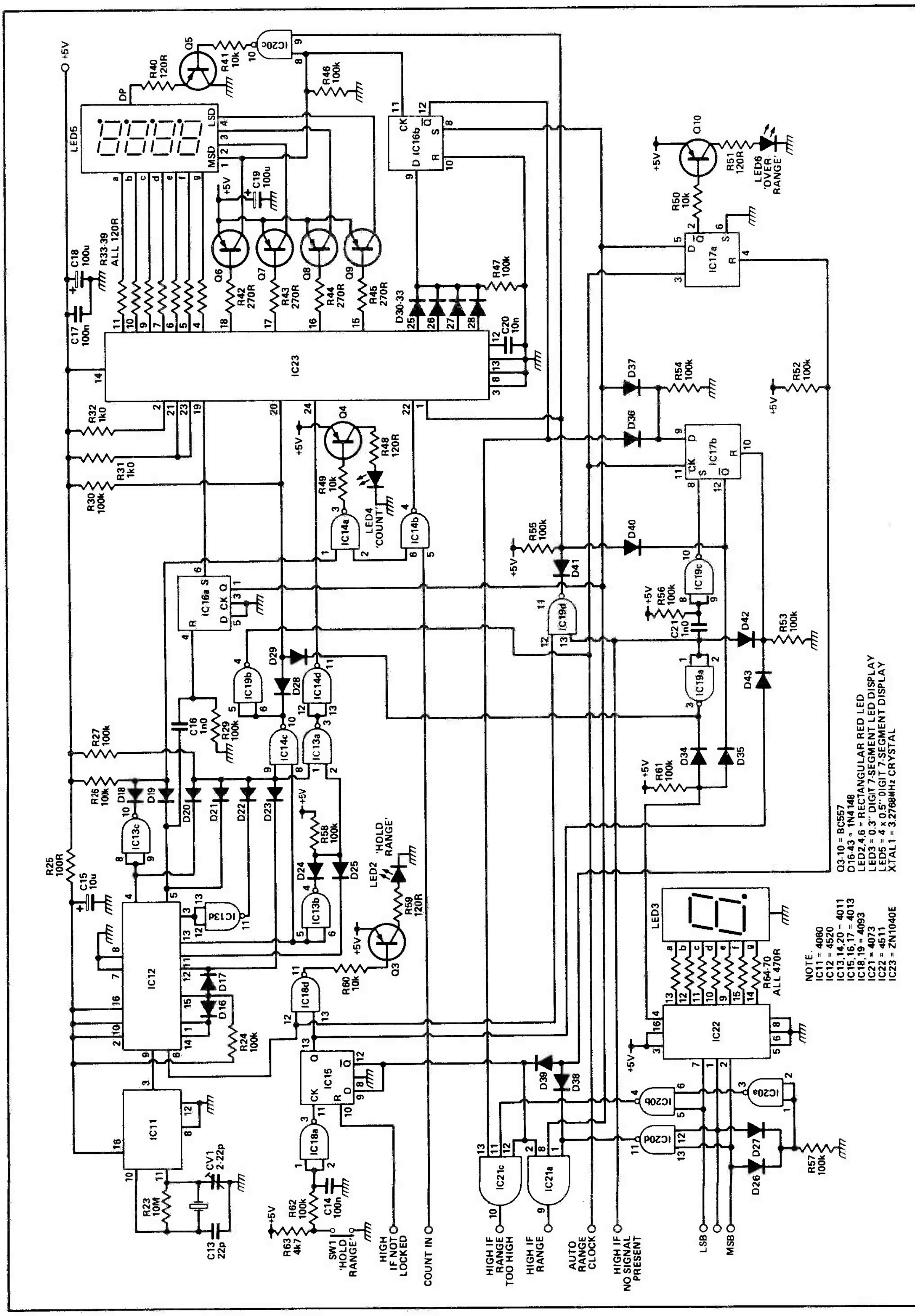


Fig. 2 Diagram showing the counting and display circuits.

HOW IT WORKS — COUNTING AND DISPLAY CIRCUITS

IC11 and IC12 form the heart of the counter's timing circuit. They provide a precise 100ms gate pulse during which counting takes place, a latch pulse soon after to latch the count and display circuits, and finally a reset pulse to start the whole sequence off again. IC11 is a 4060 CMOS oscillator and divider which is driven from a 3.2768 MHz crystal. A variable capacitor, CV1, is included to allow fine adjustment of the oscillator frequency. The reference frequency is divided down by 2^{14} to give a 200 Hz clock which is passed to IC12, a 4520 dual binary up-counter.

The first half of this IC consists of input pin 9 and the output pins 11, 12, 13 and 14. It is configured as a decade counter by D16, D17 and R24 which reset the counter via pin 15 when the count reaches 10. The output from Q3 (pin 14) drives the input of the second counter stage (pin 1) which is configured as a standard 4-bit binary counter. The output from Q1 (pin 4) of this stage will have a frequency of 5 Hz.

The gate signal is produced by inverting the Q1 output (by means of IC13c) and combining it in a diode gate (D18, D19, R26) with the Q2 output from pin 5 of IC12. The result is a pulse of 100ms (the period of the 'low' half of the 5 Hz signal) which recurrs at 400ms intervals. This signal enables IC14b which carries the main count input from the range switching circuitry. It also drives LED4 which indicates that the count is being updated.

The latch signal must occur some time after the end of the gate pulse and is produced by combining six of the outputs from IC12 in a diode gate. The outputs from pins 4, 5, 11 and 12 are used directly whilst those from pins 3 and 13 are inverted before use, producing a pulse with a period of 5ms. It is fed to the transfer input (pin 24) of IC23 where it causes the result of a recently-completed count to be latched into the display drivers.

Once the count result has been passed on to the displays, the counter in IC23 can be reset ready for the next count. The reset pulse must occur soon after the latch pulse so that the auto-ranging circuitry has as much time as possible to settle before the next count takes place. Again,. the required pulse is produced by combining several of the outputs from IC12, this time using the NAND gate IC14c. The pulse is passed to the reset input of IC23 (pin 20) via D28.

IC23 is a ZN1040E, a four-digit counter and display driver which can drive LEDs directly and which incorporates a BCD output system and display banking. The display is multiplexed, which means that each of the four digits is illuminated in turn instead of all four being illuminated all the time. The benefits of this include a significant reduction in current consumption, and thanks to our persistence of vision the flicker is not visible and the display appears quite stable. The seven driver outputs from the IC (pins 4-7 and 9-11) are loaded with segment data for each of the digits in turn, and at the right moment the appropriate digit is illuminated by turning on the associated transistor in the common-anode circuit (Q6-9). C19 is included to decouple the supply line at this point so that the rapid switching does not produce spikes. The decimal point is fixed, always appearing after the first digit. It is driven by Q5 from the common-anode line of the most significant digit (MSD), so every time that digit is strobed the decimal point will be illuminated as well. R46 pulls the line low when the digit is not being strobed.

The MSD common-anode line also clocks a D-type latch, IC16b, whose function is to provide a signal for the ranging circuits when the digit is zero. It does this by means of a diode OR-gate (D30-33) connected to the BCD output pins of IC23. A pull-down resistor, R47, is included to ensure the line drops to 0V when the BCD outputs are low. When a zero is detected, the Q output of IC16b will go high.

The other half of this device, IC16a, is used to check for overflows and functions as a simple set-reset latch. It is set by the overflow output of IC23 (pin 19) and reset by the leading edge of the signal on pin 5 of IC12 which will occurr at the start of every count period. The Q output of the latch will go high when an overflow occurs and will drive both the ranging circuits and also the 'set' input (pin 8) of the latch formed around IC16b. This means that the counter will always be described as overflowed when there is no leading zero; however, since it is the overflow latch which sets the leading zero latch, the overflow condition will take priority.

The outputs from these two latches provide the basic 'range too high' and 'range too low' signals for the autoranging circuits. If there is a leading zero the count range is too high, and if there is an overflow the count range is too low. Rather than being fed directly to the autoranging circuits, the two signals are fed to IC21a and IC21c where they are gated with other signals. This allows them to be overridden when it is not appropriate for the counter to try and change ranges.

This will happen when the overflow latch goes high to indicate that a higher range is needed but the counter is already on its highest range, or when the leading zero latch goes high to indicate that a lower range is needed but the instrument is already on its lowest range. These conditions are catered for by using IC20a, b and c and D26, D27 and R57 to interrogate the range data lines and indicate when the counter is on its highest or lowest range. Only when the counter is set to one of the intermediate ranges and the outputs of IC20b and IC20d are high will the triple-AND gates be able to go high in response to a leading zero or overflow signal.

The other condition in which the autoranging facility is not required is when the 'hold range' function is selected. This mode is entered by pressing the non-latching pushbutton, SW1, which clocks the D-type latch, IC15. This IC is configured as a divide-by-two counter, so successive pushes of SW1 will cause it to switch on and off. When hold-range is selected, the Q output of IC15 will be low and the outputs of the two triple-AND gates will not go high whatever the signals on the other inputs. The counter will then remain on the same range regardless of the input frequency. If, however, the input signal subsequently moves a long way out of the held range, the phase locked loop will not be able to lock and any figures displayed will be meaningless. To overcome this, a 'high if not locked' signal is used to reset the hold range latch via pin 10. This will leave the autoranging circuits free to operate once more and the correct range and lock will be regained.

The Q output of IC15 will be high when hold range is selected and is used to drive the hold range indicator, LED2, via IC18d. The other input of this gate is taken from a low-frequency output on the timing counter, IC12, causing the LED to flash slowly when in use.

IC22 is a 4511 BCD-to-7-segment decoder-driver which produces the range display. It takes its input from the range data lines and directly drives LED3 via the individual segment limiting resistors, R64-70.

IC17a is the 'over-ranging' indicator which illuminates LED6 when the counter is presented with an input frequency too high for it to measure. The latch is clocked by the reset signal which occurrs each time a count is made. The Q output of IC16a is then interrogated to see if the count overflowed. Provided the reset input is low, the LED will then light up. The reset line will be pulled low by diodes D38 and D39 when the coutner is on its highest range and/or when the hold-range facility is selected. At all other times, the reset line will be pulled high by R52 and the latch will then ignore any overflow signals it receives.

The reset pulse from IC16a is also used to clock IC17b which blanks the display whilst ranging is taking place. Its data input is connected via D36 and D37 to the leading zero latch, IC16b, and the overflow latch, IC16a, one or other of which will be high during ranging. Under these conditions, the main display (via pin 1 of IC23), the decimal point (via pin 9 of IC20c) and the range display (via D35) will all be blanked by the Q output of IC17b.

Blanking can be inhibited by taking the reset of IC17b (pin 10) high via D42 or D43. D43 is driven by the Q output (pin 13) of the hold-range latch, IC15. This prevents the display being blanked when hold-range is selected, even though the range may technically be incorrect. The other situation in which display blanking must be inhibited is when no signal is present at the counter's input. In this condition, the 'high if no signal present' line drives D42 to reset IC17b while IC19a inverts this signal to blank just the range display via D34. The output of IC19a is also uased to reset the main display to zero via D29. The 'high if no signal present' line also enables IC19d whose other input is connected to the low-frequency output from the timing counter, IC12. The output of IC19d is connected to the blanking pins on the main display and the decimal point via D41. The result is that, when no signal is present at the input to the counter, the range display will not be illuminated and the main display will show four zeros and will flash slowly along with the decimal point.

HOW IT WORKS —

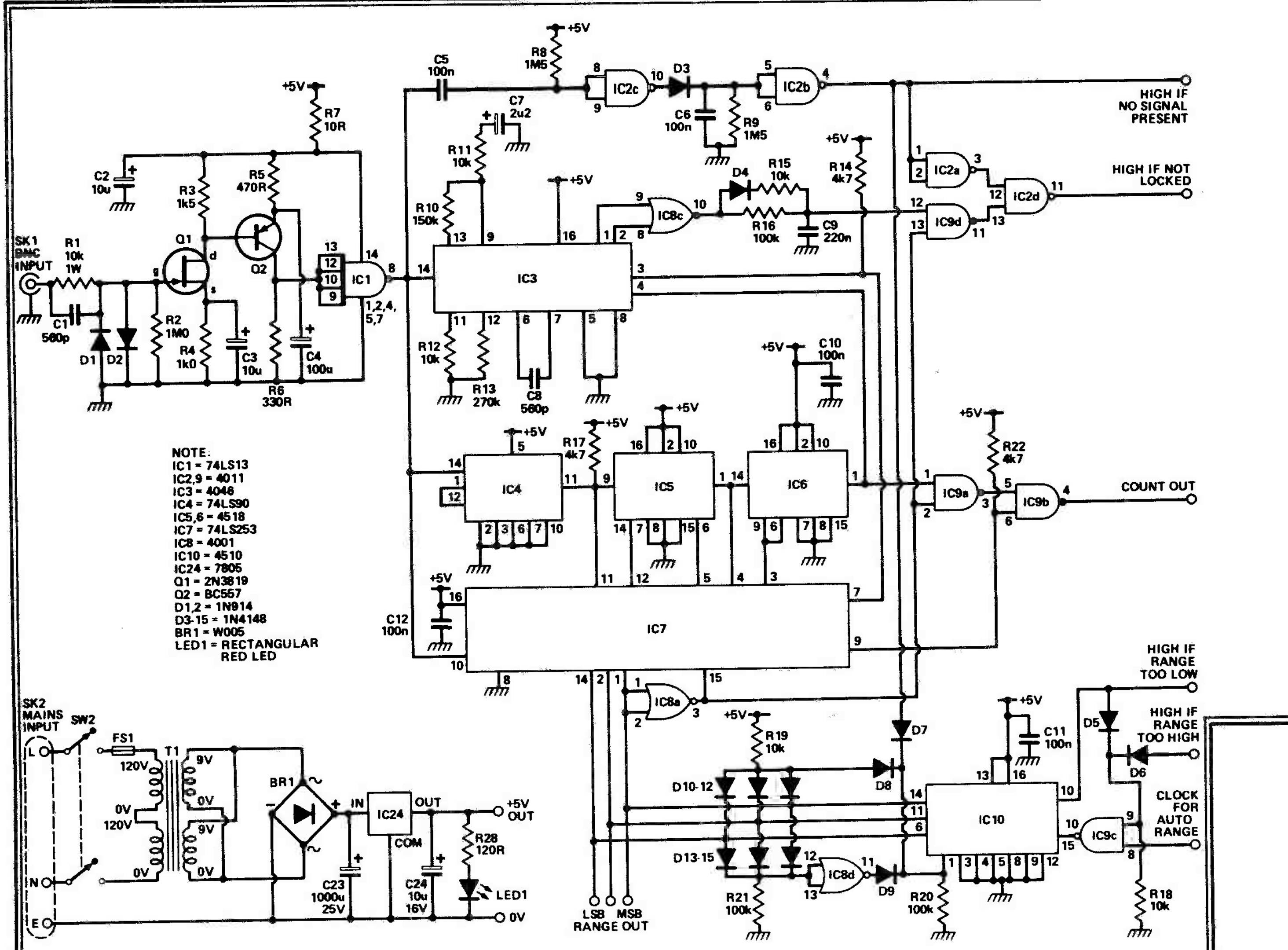


Fig. 3 Diagram showing the PLL and autoranging circuits.

Incoming signals are applied to the voltage-limiter consisting of R1, D1 and D2 which reduces the input to a maximum of ±600mV. R1 is rated at 1W so that large input voltages can be handled safely and C1 is included to ease the passage of high-frequency signals.

The input amplifier and squarer is based around Q1, Q2, and IC1. The FET, Q1, is used in a self-biasing arrangement with a 1M0 resistance, R2, tying the gate to ground. This ensures that the counter has a high input impedance. R4 provides the necessary negative source bias and is decoupled to AC by C3 so as to roll-off the frequency response below about 20Hz. Q2 shifts the level of the signal to drive IC1, a TTL NAND gate with Schmitt trigger inputs. This ensures that the logic-compatible output pulses have fast-rising edges. R7 and C2 provide a smoothed supply or the input circuitry.

The output from IC1 drives all of the other sections of the circuit, including the 'signal present' detector built around IC2b, IC2c and D3. These components form a monostable with a normally high output which goes low for about 200ms when triggered. The mono-stable is triggered by falling edges and is retriggerable, which means that an incoming frequency of more than 5Hz will cause it to remain permanently in the low state.

The input signal from IC1 also goes to IC7, a 74LS253 dual data selector which performs the function of an electronic switch. This is controlled by the ranging counter, IC10, a 4510 BCD dual up/down counter. The three least signficant bits of its data output (pins 6, 11 and 14) form the range signal which controls IC7.

Just after every count period, IC10 will receive a 'clock for autorange' pulse from the reset circuitry and will check the 'range too high' and 'range too low' lines. Both signals will increment the counter via the clock input, pin 15, passing through D5 and D6 and then IC9c. In addition. 'range too low' signals will pass directly to the UP/DOWN input, pin 10, forcing this pin high and causing the counter to increment upwards rather than downwards.

IC10 has a preset facility which is used here to return the counter to range four when no signal is being measured. This is useful because range four is around the middle of the instrument's measuring range and is therefore a good place for the autoranging circuits to start from when adjusting to a new signal. When no input is applied, the signal present detector will reset IC10 pin 1 via D7. The counter will also be reset should it accidentally stray onto a non-existent range. This is achieved by using D10-12, R19 and D8 to reset IC10 when all the data lines are high (range seven) and by using D13-15, R21, IC8d and D9 when all the lines are low (range 0).

When the ranging circuitry has settled upon a suitable range, IC7 responds by selecting the appropriate input and passing it on to the counting circuitry. IC7 contains two, four-into-one selectors, one of which handles the lower three ranges while the other handles the upper three ranges. When one of the upper three ranges is required, the most significant bit of the data input will be high and pin 15 of IC7 will be taken low by IC8a. This enables one half of the

PLL AND AUTORANGING CIRCUITS

selector which has pins 10, 11 and 12 as its inputs and pin 9 as its output.

When range four is required, IC7 routes the signal from IC1 directly through from pin 10 to pin 9. When range five is required, the singal is taken via IC4 and pin 11 of IC7. IC4 is a 74LS90 decade counter which is used here to divide the incoming frequency by ten. A TTL device is used because CMOS would not be able to cope with the highest frequencies handled by the instrument; R17 is included to convert the TTL level so that it is CMOS compatible. When range six is required, the signal is taken via IC4 and the first half of IC5 and into pin 12 of IC7. IC5 is a 4518 dual BCD up counter which divides the signal by ten again. A CMOS device is quite adequate here because incoming signals will aready have been divided by ten by the TTL device.

When the ranging counter selects one of the lower three ranges, the most significant bit of the data lines will be low and the first section of the electronic switch will be disabled via pin 15. Pin 2 of IC9a will also be driven high by the output of IC8a, and in the absence of a signal from IC7, R22 will pull pin 6 of IC9b high. This allows signals from pin 4 of IC3, the phase locked loop, to be passed directly to the counting circuitry via IC9a and b.

IC3 also takes its input from IC1. The VCO output passes both to the counting circuitry and to a chain of three counters, each arranged as a divide-by-ten stage. One of these is the second half of the 4518, IC5, and the others are the two halves of a second 4518, IC6. The second of the two four-into-one selectors in IC7 routes one of the outputs on this chain of dividers to the comparator input of IC4 (pin 3). By selecting a suitable division ratio between the VCO output and the comparator input, the phase locked loop can be made to multiply the input signal by 10, 100 or 1000 as required. R14 ensures compatibility between CMOS and TTL levels. R12, R13 and C8 set the operating frequency of the phase locked loop VCO and R10, R11 and C7 form a two-pole, lag-lead low pass filter. This allows faster locking on step changes in frequency than other filter types.

The circuitry around IC8c is a detector which provides the first indication of locking in the PLL. When the PLL is locked, the output of the unused phase comparator (pin 2) will be low except for some very short duration pulses which result from the inherent phase difference between the signal and comparator inputs. The phase pulses output, pin 1, will be high except for some short duration pulses which arise for the same reason. In this condition the output of IC8c will go low and the unwanted pulses are then filtered out by R15, R16, D4 and C9.

This 'low when locked' signal passes to the circuit consisting of IC2a, IC2d and IC9d where it is compared with the 'high if no signal present' line and the output of IC8a. This latter line will be high when the counter is on one of the lower ranges and the phase locked loop is in use. Using this data, the 'high if not locked' output will reflect the condition of the lock detector provided a signal is present. If the counter is used on one of the higher ranges where the phase locked loop is not needed, the ouput will still indicate lock so long as there is a signal present.

The power supply is perfectly conventional and uses the two secondary windings of 9-0-9V mains transformer to feed a full-wave rectifier. The output is then smoothed by C23 and an IC regulator, IC24, provides a steady output voltage regardless of loading. A power-on indicator, LED1, is driven from the supply via R28.

This project will be concluded with a further article on the construction, testing and setting-up of the frequency counter.

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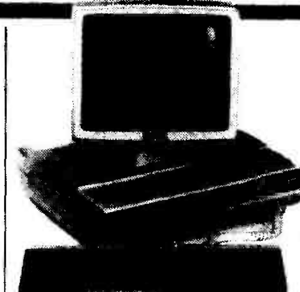

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SPECIAL PULL-OUT

TAKING CARE OF BUSINESS

From now until the end of the year, we'll be taking a close look at the subject of starting your own business in the electronics field. The possibilities for the group or individual with determination and energy are great: component supply, specialist equipment supply or manufacture, circuit design, PCB design, prototype manufacture, small run PCB manufacture, consultant engineering, equipment repair, hiring out and operating PA systems, technical writing and more.

You could design a particular piece of equipment — an audio amplifier, say, or a computer peripheral. You could sell it as a built unit or as a kit, or you could sell the rights to an established manufacturer or kit supplier. You could provide technical services at a price — consultancy, taping up PCB artwork, writing documentation and manuals, even training. You could buy and sell components or second-hand equipment or just open a retail shop. Electronics offers opportunities in practically every kind of business enterprise.

These days, lots of people are thinking about starting small businesses and thinking seriously. Most of them will have no experience of business at all and despite an apparent commitment to supporting new enterprise from banks, government, local authorities, and the EEC and the local Chambers of Commerce, starting up in business is still a difficult and risky undertaking.

The new entrepreneurs will be greeted by a veritable jungle of regulations and restrictions. They will have to face the realisation that the small electronics business is, in practice, no more encouraged today than it was ten years ago. Researchers at Edinburgh's Heriot-Watt University have demonstrated that small companies and the job creation that is supposed to go along with them have not been noticeably stimulated or encouraged during the past five years in Scotland's loudly-trumpeted Silicon Glen. The Small Business Bureau have pointed out how the possible merger (as I write) of GEC and Plessey may destroy over 150 small firms. Others have argued credibly that the British electronics industry's dependence on military contracts is actually crippling to small businesses. For the start-up company and the would-be entrepreneur, the road is not easy.

We hope to smooth the journey a little with this short series. Each month you will be able to pull-out the business section to provide a handy information pack for you to refer to as and when you need it. We'll tell you how to get financial backing and what to do about tax. We'll try to enlighten you on the murky topic of protecting your inventions, ideas, designs and trade names. We'll cover partnerships, sole-traders, co-operatives and limited companies and we'll give you an invaluable list of addresses and contacts as well as offering easy-to-use advice on research, planning, marketing and the law.

On top of all that, we'll be profiling some of the people who've set out on that hazardous road to self-employment, starting this month with a success story to gladden the hearts of even the most pessimistic. In short, if you think you might like to start a small business, or if you've already started one, we'll help you.

The Editor

Helen Armstrong profiles the men who made Maplin — and carry on building the company even against the odds.

Doug Simmons is one of those familiar names you can't quite place. Add 'of Maplin', and you probably have the face as well as the place. Mr. Simmons confronts his public from the pages of Maplin Electronic Supplies' catalogue, but they might be forgiven for missing him between the epic sci-fi covers and 450 pages of components and data within. More elusive still, co-director Roger Allan appears only as one of 100 postage-stamp staff portraits.

Greater exposure is given to a scaled-down version of the cover painting, and its story '.. sprinkled like grains of sand among the stars are the outposts of mankind; drawn together over the unimaginable distances by the giant trading fleets that cross and re-cross the galaxy...'. At the foot of this most conspicuous page are the all-important phone numbers: 'Sales only... Trade Sales... Cashtel... Sales desk open 9 am to 5.30pm Monday to Friday' and the addresses of the company's five shops.

At a time when electronic construction by private

MAPLIN MANAGED IT

individuals is beginning to look like a vanishing craft of old England, Maplin have expanded their services resolutely in precisely that market as well as in the professional sector. Yet they had a classic 'small beginning', with Allan and Simmons starting business in a converted bedroom at Roger Allan's home in 1972. Serious hobbyists, they were unhappy with their component suppliers, and believed they could do better.

Simmons had been working for the Post Office (now British Telecom) with the Special Projects Planning Group, and Allan was a service engineer at a newspaper print works, but Simmons stresses that the blueprint for Maplin came from their spare time interests, particularly electronic music.

'We started doing electronic organ and synthesizer kits. None of them are left now, but the first really good seller we had was the Practical Electronics synth kit in 1973, and then the ETI 4600 synth, which was an enormous seller over the years. They went like hot cakes. I don't know how many we sold, but I remember packing them evening after evening. Fortunately, we had our own premises by that time.' Business was good enough to extend to a shopfront by Christmas 1974, but real expansion came with a new approach some years later.

'We didn't make a decent profit until the first classic Maplin-style catalogue appeared in 1978. After that, turnover doubled every year for some years.

'The catalogue came out at Christmas. We advertised it, and mailed out about 30,000. We couldn't physically move until they were gone. Then it just went mad. We were working nights and weekends, we doubled staff. It took three months to get back to same-day service. We had complaints, all right. At the worst point, we were a week behind. We had to put a computer in, a PDP11/70. Before that, two or three people were just looking up orders, full time. It could take two days to find one order.'

Doug Simmons — the serious hobbyist made good.

The Maplin computer took a year to set up. At first, the company employed an outside consultancy to write the software but, characteristically, they eventually took over the job and finished it themselves.

The impetus behind the catalogue was 'to give hobby electronics a more professional image. We wanted a catalogue which looked like a mail order catalogue — not like another electronics catalogue. Electronics had a "junk shop" image. Some of it still does, but if the hobby market has changed at all in the last ten years, it's insomuch as people are more technically knowledgeable. Component quality used to be very poor; now people are more quality conscious. Otherwise, the demand for types of components hasn't altered that much.'

'The things they build have changed, though. Whenever ready-made products come from the east, a market dies. Synthesizer and organ kits aren't viable any more. We did very well with microcomputers at first, but that collapsed when they went into the shops. Why build something you can buy ready-made for less?'

'Burglar alarms and any kind of novelty projects are popular now,' says Simmons.

Maplin's other venture has been into publishing. The quarterly *Electronics — The Maplin Magazine* has drawn fully on their company machinery.

'The magazine started in November 1981, and we're up to issue 20. Fifty per cent go through newsagents and 50% by subscription, which is very cheap and our subscriber base is very high. There is no advertising, and the production and distribution costs are paid for by the cover price. Project development is costed against the sale of kits.'

'All our projects are developed in-house, or by one or two reliable writers. Project writers aren't very practical people: they tend to come up with hard-to-obtain parts, or projects where only the prototype ever works. We can build all our prototypes here, and they very rarely need amending, unless a component goes out of production. It's a self-regulating system — our project service chap is here, and he keeps a close eye on the designers so that they don't make more work for him!'

Roger Allan — a postage-stamp portrait is more usual.

Electronics is Maplin's second venture into publishing. *Electronics and Music Maker* (now *E&MM*, published by Music Maker Publications in Cambridge) was another Maplin project.

'We decided to try a monthly as a new production area, and chose music because we liked music,' explains Simmons. 'It didn't work out because we didn't get the money in from the advertisers efficiently enough. We really weren't interested in that aspect of publishing, so we sold it to the present owners. They were very committed to it, and have done a great job.'

Home constructors are still Maplin's main customers but Simmons admits, the growth area is in trade sales. Maplin's trade desk, MPS, has up till now been something of a sideline. The new year will see a more concentrated effort, with MPS being split off and set up as a separate company — if it grows.

'We have had a 20% increase this year, mostly trade,' says Simmons. 'A lot of it is from small businesses starting up, but we have had some big accounts from around the country changing to us.'

'We sat down and said, "we're going to be millionaires"...'

Maplin have managed to keep expanding steadily while others have drawn in their tentacles. How does Doug Simmons think they have achieved this?

'The change of catalogue had a lot to do with it, with the new sense of professionalism. Another thing was keeping up with the times. Some of our competitors have had a hard time when markets collapsed just as they invested in them. It could have happened to us if we hadn't got out of computers when we did. There's still a good trade in add-on bits, but overall it's dropping steadily.'

'Also, we've never really taken money out. I'm still on a working wage rather than a Director's wage. Everything has been reinvested in the business. Perhaps in a few year's time we can get the company on to the Stock Market to generate more capital, and we can take some of the profits out. The Unlisted Securities Market would be the first stage. We're a long way from that, yet, but we're still expanding. The shops do ever so well — 20% of retail and trade business is over the counter — so we're looking for two more sites at the moment. There's a new computer going in, because the old one is too slow now, and we'll be running Unix with C, instead of Extended Basic.'

When Simmons and Allan started, did they realise that their bedroom business would be a full-time living? 'Oh yes,' Simmons says immediately, 'We sat down and said "We're going to be millionaires," and we thought we'd still be sitting in the bedroom. We never thought of ourselves as managers.'

'We've fallen for all the pitfalls — most of them, anyway. We did lots of silly things, we despaired a few times.' Would they do it again? 'If I was at the same age, yes. Not again at my age. It can be very traumatic, and it affects your personal life. You have to be completely committed.'

'And it has got more difficult. You need a new angle, not necessarily a new idea, but a new way of approaching something. It's all been done now, hasn't it?'

Doug Simmons and I did not discuss the 'right' age for starting up a new business. The 'right' age is the age when you can see the new angle, and find the commitment. Right?

ETI

Amanda Hopkinson asks a few pertinent questions — starting with 'Why begin in business?'

So you think you want to set up in business. Why? Because you can't stand another week of subsisting on the dole, odd jobs or redundancy money? Because the kid's granny or the workaholic-but-unemployed-DIY-maniac-next-door are driving you out? Or because being a cog in the wheel, servant to a master or exploited employee has lost its compensatory lustre?

Wrong answers, the lot of them, however commonplace. Wrong because they're negative, about knowing what you want freedom from not freedom for, and taking escapism as your prime motivation. Appropriate answers would be positive but not fantastical, showing a realistic awareness of the business world and a capacity for self-evaluation. A sense of independence needs to ride with a sense of responsibility, moral as well as financial.

If you don't believe your product or service is a thing of beauty or usefulness, it'll be all the harder to believe in its commercial viability. And as for yourself.. you may be convinced of how healthy and hard-working you are already, but can you combine financial shrewdness with flexible management? The stolidity of an ox with the delicacy of a diplomat? A grasp of the necessary complexities of business life with the ability for simplifying priorities?

A BUSINESS-LIKE APPROACH

If the opening questions seemed appealing and the latter prissy, then perhaps setting up in business is not for you. Much better to find out beforehand with a bit of careful questioning and foresight than later, in some spectacular fiasco. And the first questions to ask yourself are, of course: Why? Why now? What do I want to put in to and get out of the project? Where do I see myself in six months, a year and five years time? (If the last answer involves stashing the loot away down in Malaga, you get a double disqualification.)

Get Rich Slow

For a start, getting-rich-quick is not necessarily an example of sound business sense. In the early years, your business is likely not to show a paper profit, since everything you make should be ploughed back into its development and expansion. Part of your realistic outlook is dropping the bit about the dazzling rise to rapid millionaire-dom: there's only one Richard Branson, but thousands of well-upholstered stockbrokers. If your devotion is to making a quick buck, maybe you should consider changing your line of enquiry.

On the other hand, no-one goes into business to lose money. A subsequent article in this series will examine the types of assistance available for obtaining and administering start-up capital and for handling the subsequent cash-flow. But before entering into the practicalities of business management, it's worth assessing your reasons for going into it, and ways of staying sane while you do.

Make a checklist of the qualities you imagine are necessary to your success. Tenacity, determination, commitment, common sense and tolerance should appear near the top. The ability to seek and take advice and to delegate competently need to feature in bold type. This means you need the humility to find recommended professionals to instruct you in fields you find boring or thought you knew all about already. Just because you personally undertook the conveyancing on your house purchase, don't assume you don't need advice on how to set about obtaining business premises, or planning permission for a change of use of your home.

You will have to be prepared to figure out how you yourself are best used: Dynorod may be an expensive means of unblocking drains, but is it really the most profitable use of your skills to spend the morning with an arm jammed up the outflow?

Finally, if you can't delegate, then you need the consitition of a Martian or an angel, and so there will never be a holiday or an illness in your life. There's an arguable correlation here. The cemetery, as they say, is full of indispensable people — make sure you're not one of them.

Making Time

It's essential to plan, programme and organise your time with care. I'm instinctively opposed to theses such as that of James Noon, author of **'A' Time**, proposing that new business managers prepare themselves for a minimum 80-hour-a-week workload; for regular late week-nights at the office; and for bringing work home at weekends. This sounds like the perfect recipe for breakdown — on the part of the business person, his or her marriage and, sooner or later, the entire enterprise.

How do you evaluate arguing with the driver who delivered the wrong order, or trying to get through to directory enquiries?

The issue is to work out realistically what time is available to you after discounting that spent in sleeping, eating and travel to and from work. You may not be left with more than 12 out of every 24 hours. These can then be further divided into 'must', 'ought to' and 'renewal' times, *all three of which are equally important even when not of equal length.*

The 'must' time might occur between 9am and 4pm — especially if, as with myself, you work from home and have school or nursery age children. The 'ought to' hours I use to catch up on work I may have been unable to do during 'must' time. These hours extend from after 8.30pm to — theoretically, at least — before 7.30am. Between 4pm and 8pm on weekdays and all of most weekends is time often taken up with family. This partly counts as 'renewal' time since at least some of it is delightful, but it's crucial to define a time for being alone.

This may sound strange counsel to someone whose principal problem of adaptation could be the isolation of becoming established as a sole trader after years of happily thronging along as one of the crowd. But it's important not to fall for the fallacy that 'a change is as good as a rest'. The maxim simply doesn't apply when you've emerged from the rut of routine work and to fill each evening and weekend with family picnics or swapping bar tales may give a transitory stimulus of companionship but doesn't relieve you of the responsibility of replenishing your own inner reserves.

Keep a record, if only for a day, and you'll be surprised at how much time gets wasted or spent on nondescript endeavours. (Well, how *do* you evaluate arguing with the driver who delivered the wrong order, or trying to get through to directory enquiries?)

Some of that time could be relocated to learning how to enjoy a walk alone, get into the lotus position, even how to practise relaxation or meditation techniques. If this sounds foreign to you, it's probably because there's an oriental theory underlying it. But we all know how well the Japanese succeed in their business enterprises, don't we?

ETI

USEFUL ADDRESSES

STARTING OFF... GET ADVICE!

Small Firms Service

The service operates a network of Small Firms Centres and helps both new and established businesses. They offer information, advice and training. They also publish useful booklets and a pack. If you are at the 'thinking' stage of setting up they will help and there's no limit on the type of business. They can also help to put you in contact with people in local authorities, government departments, and chambers of commerce. More complex and individual enquiries are dealt with by counsellors. They give three counselling sessions free and there's a nominal charge for subsequent sessions.

The London branch is at
Ebury Bridge House
Ebury Bridge Road
London SW1 8QD
Telephone 01 730 8451 or ring the operator and ask for Freephone 2444 or Freephone Enterprise.

Bristol 0272 294546
Birmingham 021 643 3344
Cambridge 0223 63312
Cardiff 0222 396116
Edinburgh 031 337 9229
Glasgow 041 248 6014
Liverpool 051 236 5756
Leeds 0532 445151
Manchester 061 832 5282
Newcastle 0632 325353
Nottingham 0602 5821205
Reading 0734 591733

Enterprise Agencies

They offer a variety of services to small firms on a free or subsidised basis. Their activities include training programmes, small firms counselling and promotion, advise on premises and a service to link small firms with new investors and partners. There are many agencies throughout England and space limits us to giving the London address only. If you experience difficulty finding your local Enterprise Agency contact your local council's Industrial Development Officer.

LENTA (London Enterprise Agency)
69, Cannon St.
London EC4N 5AB
(01 236 2676)

COSIRA (Council for Small Industries in Rural Areas)

This is an agency for the development commission which aims to help small firms in rural areas where the population is declining or disadvantaged. It offers help in areas of up to 10,000 population. Local information, professional consultancy and advice and training are offered. There is no charge for preliminary discussion with an organiser. The address below is for the central office in England. For Wales contact the Welsh Development Agency, Scotland the Scottish Development Agency and N. Ireland the Department of Economic Development.

141, Castle St.
Salisbury
Wiltshire SP1 3TP
(0722 336255)

Local Councils

What they do to help the development of small businesses varies. To find out what is happening in your area talk to your council's Industrial Development Officer. The ways in which local authorities can help are:

Premises: Some develop disused buildings into seed bed premises, offering workshops for new business to use until they can expand and move out.

Advice and Information.

Loans and Grants: Some local authorities also provide loans and grants to certain types of new and small businesses.

Finance: Help with premises and advice is often available for Co-operatives.

ARC (Action Resource Centre)

This was set up in 1973 by a group of businessmen to research and demonstrate how business skills can be used to benefit the community. Since 1976 they have concentrated more on helping to create employment opportunities and work on selected projects. There are Action Research Centres throughout the country, to find out if they can help you contact the regional manager.

ARC (Greater London)
CAP House
3rd Floor
9-11 Long Lane
London EC1 9HD
(01 726 8987)

BSC (Industry) Ltd. (British Steel)

They concentrate on industrial regeneration in areas of steel closure. They have centred activity on providing small industrial workshops and offices. They also have a consultancy service to assist in examining the market viability of a business plan. They have access to special EEC funds and a detailed knowledge of UK grants. Their help is available to anyone setting up in one of the

designated areas.
British Steel Corporation (Industry) Ltd.
NLA Tower.
12, Addiscombe Rd.
Croydon CR9 3JH
(01 686 0366)

National Federation of Self-employed and Small Businesses

Membership £18 pa. The federation is a pressure group which acts on behalf of the self-employed and small business. Amonst other benefits, membership includes VAT tribunal representation, and defence in any Health and Safety prosecution.
32, St. Annes Rd.
West Lytham St. Annes
Lancashire FY8 1NY
(0253 720911)

Alliance of Small Firms and Self-employed people.

Membership £15 pa. For additional fee, insurance is available in the event of legal prosecution in relation to business activities. Advice on VAT, company law, planning legislation, tax and insurance.
33, The Green
Calne
Wiltshire SN11 8DJ
(0249 817003)

Small Firms Information Service

British Institute of Management
Parker St.
London WC2B 5PT

The Small Business Bureau

Membership £15 pa. Gives you access to an advisory service and a copy of its monthly newspaper 'Small Business'.
32, Smith Square
London SW1P 3HH
(01 222 9000)

Ideas and Resource EXchange (IREX)

A computer-based exchange which offers members a service through which they can offer or seek ideas, finance, skills etc.
Snow House
103, Southwark St.
London SE1 0JF
(01 633 0424)

Paul Bogle Enterprise Trust

Helps new black businesses. Advice on finance, training and help with accountancy, advertising, tax and law.
189, Kentish Town Rd.
London NW5 2JU
(01 267.6476)

UK-Caribbean Chamber of Commerce, Business Advisory Service

99, Stoke Newington Church St.
London N16 0UD
(01 254 4532)

Project Fullemploy

Self-employment resource centre for those who want to work for themselves. Tutorials and one-to-one advice as well as use of resources.
Unit 120
31, Clerkenwell Close
London EC1 0AT
(01 251 4083)

Head Start in Business

A scheme to help young people set up in business.
Robert Hyde House
48, Bryanston Square
London W1H 7LN
(01 723 4075)

Manpower Services Commission

Operates Youth Training Schemes and similar work experience programmes.
Head Office:
Moorfoot
Sheffield S1 4PQ
(0742 753275)

The Small Firms Technical Information Service

The production Engineering Research Association operates this service for the Department of Industry. Ring PERA (0644 64133 ext. 444) for more details.

The Technology and Innovations Exchange Ltd.

Aims to bring together inventors and developers of new products and those with the money and technical expertise to support them. Inventors contact the company with their idea which is assessed by legal and technical experts. If an idea is accepted it is placed on the TIE listing.
TIE Listings
13 Golden Square
London W1
(01 734 8341)

Exchange Resources

An agency dedicated to helping firms and individuals working in non-military areas of electronics and computing. For details of annual fee etc., write or phone:
Townsend House
Green Lane
Marshfield
Nr. Chippenham
Wiltshire SN14 8BR
(0225 891710)

CO-OPERATIVES

National Co-Operative Development Agency

Represents the interests of the co-operative sector and offers advice and information. Local CDAs can offer a variety of services. They can offer assistance with finding premises, developing your business plan, drawing up a structure for your co-op and advice on funding and grants. Your local town hall can give you information, or contact:
Broadmead House
21, Panton St.
London SW1 4DR
(01 839 2988)

Industrial Common Ownership Movement (ICOM)

Advice available on all aspects of running a common ownership business is available through ICOM. It can provide 'tailor made' constitutions and has a network which contains lawyers and accountants. It also organises a database of workers' co-ops and has training schemes.
The Corn Exchange
Leeds LS1 7BP
(0532 461737/8)
London ICOM
7, Bradbury St.
London N16
(01 249 2837)

ICO Womens' Link Up

For women in co-ops.
City Road
London EC1
(01 837 7020)

Industrial Common Ownership Finance

Formed by ICOM but now operating independently it provides short to medium term loans.
4, St. Giles St.
Northampton NN1 1AA
(0604 37563)

The Co-operative Union

The Co-operative College is based here and courses are run. Full time and part time education secretaries of the union are available for advice and help and are based throughout England.
Education Department
Stanford Hall
East Leake
Loughborough
Leicestershire LE12 5QR
(050982 2333)

Greater London Enterprise Board (GLEB)

GLEB may offer assistance and investment capital but only in cases where the group have already prepared a business plan. A local CDA may help with this.
Co-ops Unit
Structural Investment Division
63-67 Newington Causeway
London SE 6BD
(01 403 0300)

Mutal Aid Centre

Research and development work on Co-ops.
18, Victoria Park Square
Bethnal Green
London E2 9PF
(01 980 6263)

Job Ownership Ltd. (JOL)

JOL is an independent non-profit making consultancy unit for the promotion of worker owned businesses.
9, Poland St.
London W1.
(01 437 5511)

Co-operative Advisory Group

272-276, Pentonville Rd.
London N2 9JY
(01-833 3915)

Community Accountancy Services

An accountancy service for co-ops.
The Works
105A, Torriano Avenue
London NW5 2RX
(01 482 2866)

Registry of Friendly Societies

Information about legal requirements of forming a co-op.
15-17, Great Marlborough St.
London W1V 2ZX
(01 437 9992)

Assistant Registrar of Friendly Societies

58, Frederick St.
Edinburgh EH 2NB
(031 226 3244)

Each month we'll bring you more useful addresses to create your own directory of opportunities.

(List compiled by C.M. Herman).

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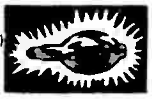

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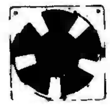

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6522	3.30	2.80	74LS541	.45	.35	27256-250	3.70	3.30
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19×5.25	17×5×12	27.50	32.50
19×5.75	17×5.5×12	28.50	33.50
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* 17×3.5	15.5×3×9	17.00	—
* 19×3.0	17×2.5×10	—	20.50
* 19×4.0	17×3.5×10	16.50	19.50
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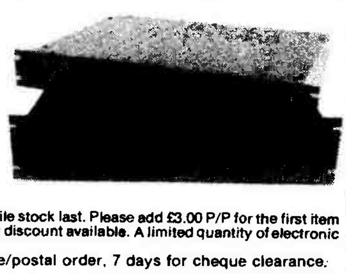

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AUDIO ANALYSER

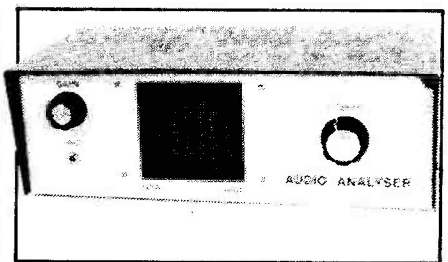
A multiplexing circuit drives the display on this useful audio accessory of considerable educational value.

The drawbacks of top notch analysers are that they cost more than most hi-fi systems, and are not really the type of equipment that many people would build or buy if (as is likely) they will need them no more than occasionally. On the other hand, a relatively simple type can be built at reasonable cost, and represents an interesting and useful constructional project. The unit described in this article is a straightforward design which has an eight bargraph display with ten LEDs per bargraph and logarithmic scaling. Each bargraph corresponds to an audio band approximately one octave wide. In order to reduce the cost and complexity of the unit the display is a mulitplexed type having just a single bargraph driver, but this does not compromise results in any way. This section of the unit could easily act as the basis for other projects which require a multiple bargraph display.

System Operation

At the input there is a high gain amplifier which enables the unit to be fully driven from practically any microphone, including low and medium impedance dynamic types, and crystal microphones. The sensitivity is adjustable, and it can be backed off to the point where the unit will operate properly with line level input signals.

Eight bandpass filters are used



The audio analyser

to split the amplified signal into octave bands (actually each band has to be marginally more than one octave in order to cover the full audio range in eight bands). The blocks marked as bandpass filters in Fig. 1 also provide rectification and smoothing so that the output signals are DC levels proportional to the AC input. In common with other types of audio level indicator, the smoothing circuit has a fast attack time of a few milliseconds, and a slow decay time of a few seconds. This gives a stable and easily read display, and it also ensures that brief transients do not pass unnoticed.

An eight-way analogue switch is used to feed the DC signals through to the input of the bargraph driver one at a time, and is continuously cycled by a clock oscillator at over 100Hz via three stages of a seven-stage binary counter.

Multiplexing the input signal is only half the problem solved, and the eight bargraphs must somehow be driven from the single bargraph driver. They must also be synchronised properly with the analogue switch so that each analogue input consistently drives the right bargraph.

This is achieved by driving the cathodes of the bargraphs from a one-of-eight decoder which provides a path to the negative supply for one bargraph at a time and is itself driven from the same clock used for the analogue switch. A common reset pulse for the binary counter and the one-of-eight decoder sets them at a predictable and repeatable starting point, so that each channel always drives the appropriate bargraph.

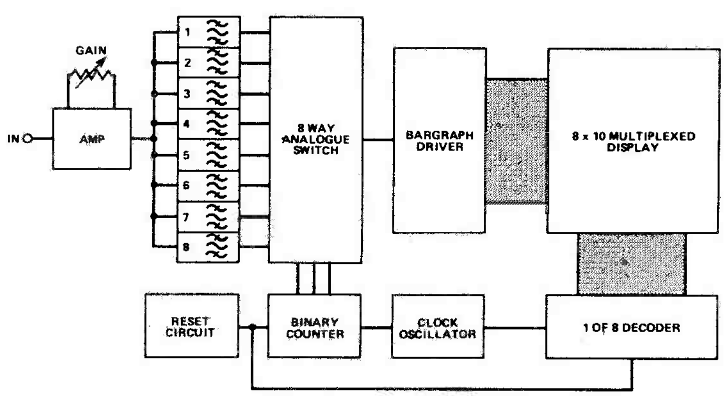


Fig. 1 Block diagram of the analyser.

Construction

Apart from the input socket, mains transformer and controls, the components are all fitted on to four PCBs. The display driver and filter boards (Figs. 2 and 3, respectively) are the two most complex boards, but offer little out of the ordinary as far as construction is concerned. Bear in mind that ICs 2, 3 and 4 on the display card are CMOS types, and require normal antistatic handling precautions. IC1 is not a particularly cheap device, and it is worthwhile fitting this on a socket even if none are used for the other non-MOS types.

There is a complication with the filter board in that some components are repeated in each filter, and appear on the board in eight different locations. These components have been given numbers on the overlays to indicate which channel they are in, and channel 1 is the lowest frequency channel.

Table 1 indicates the value of the filter components themselves which vary from channel to channel. To avoid confusion over the right quantities, the parts list shows the total number of each value or type required in brackets, while Table 1 lists the components not individually itemised in the parts list.

Details of the power supply board are shown in Fig. 4. Fuse FS1 is mounted on the board in a pair of 20mm fuseclips, and you should

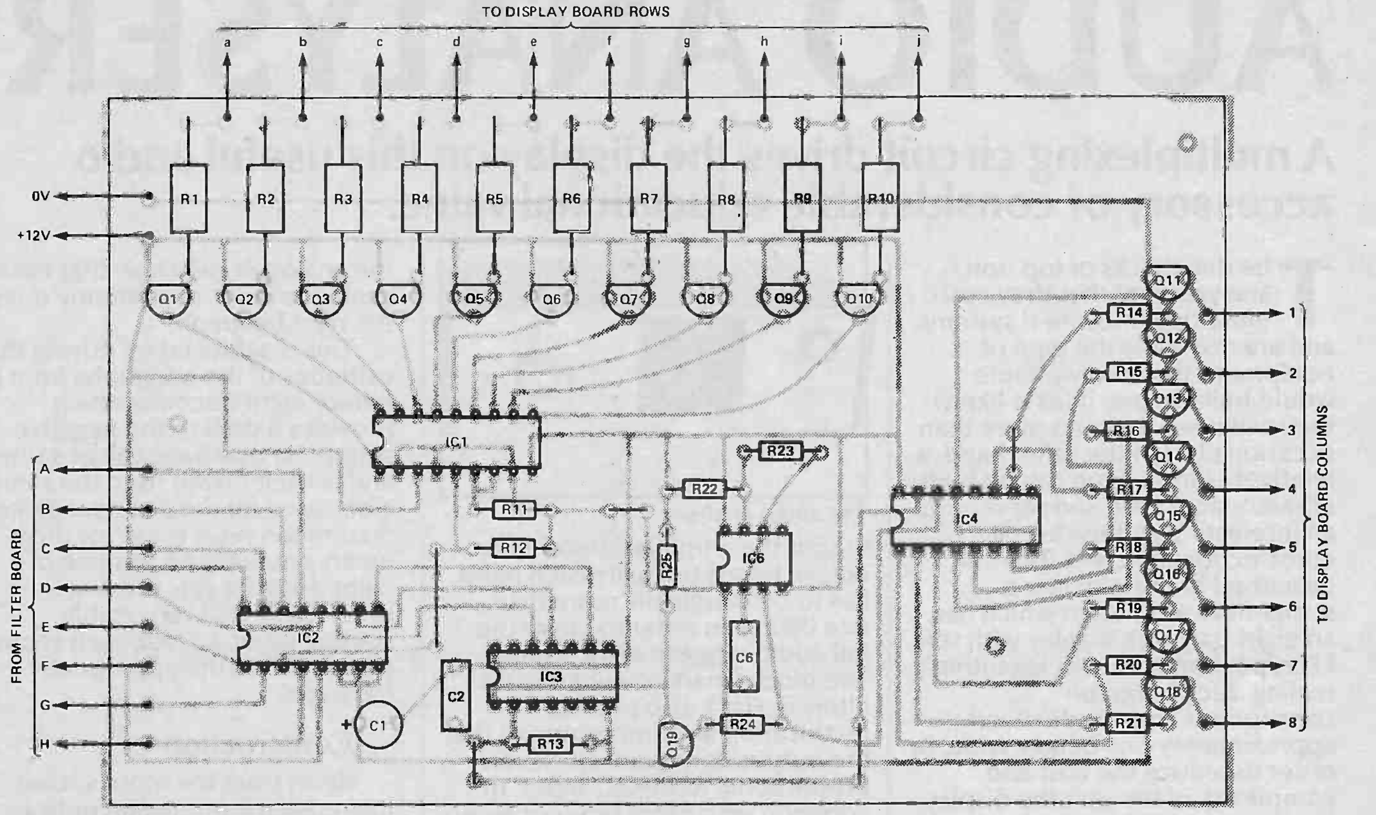


Fig. 2 Component overlay for the display driver board (clock included)

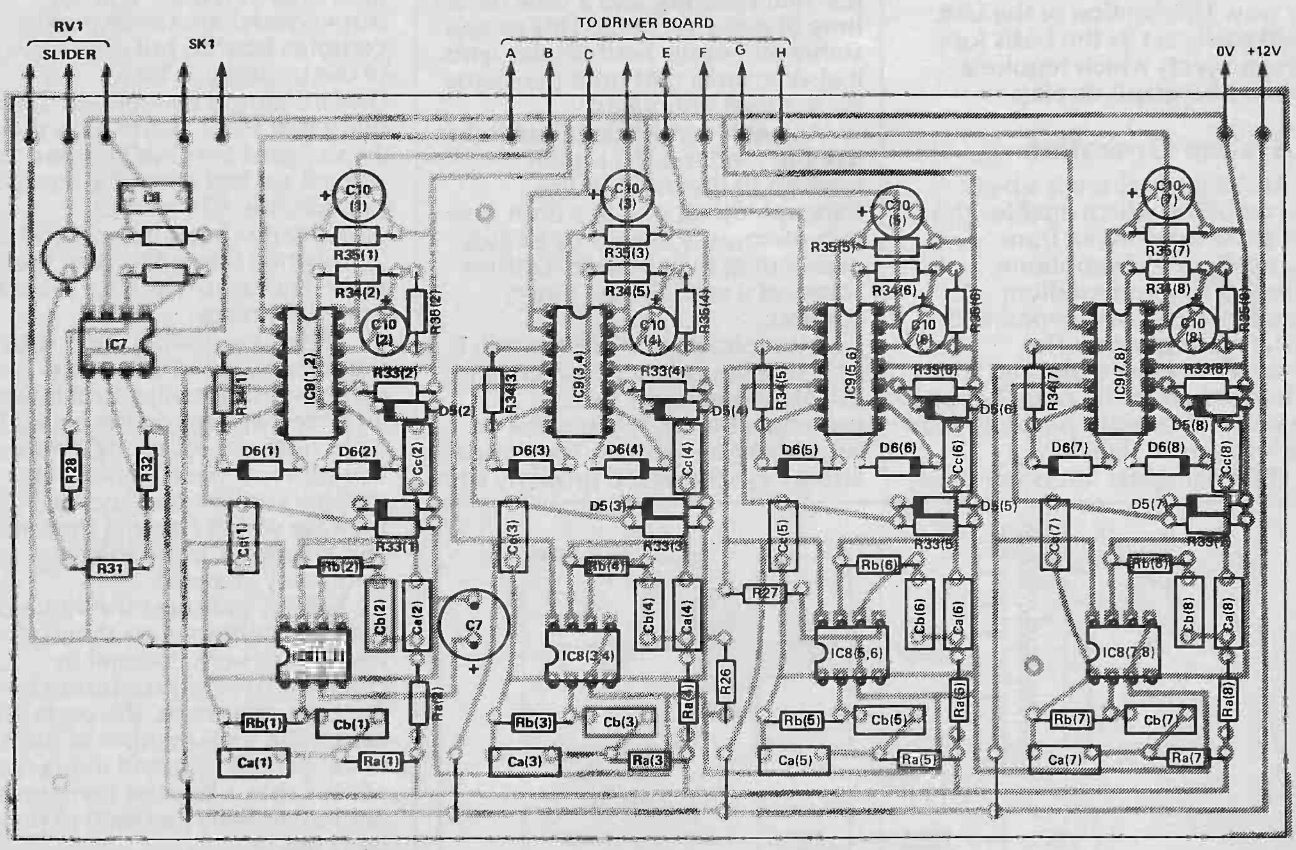


Fig. 3 Component overlay for the filter board (note the number of repeated components).

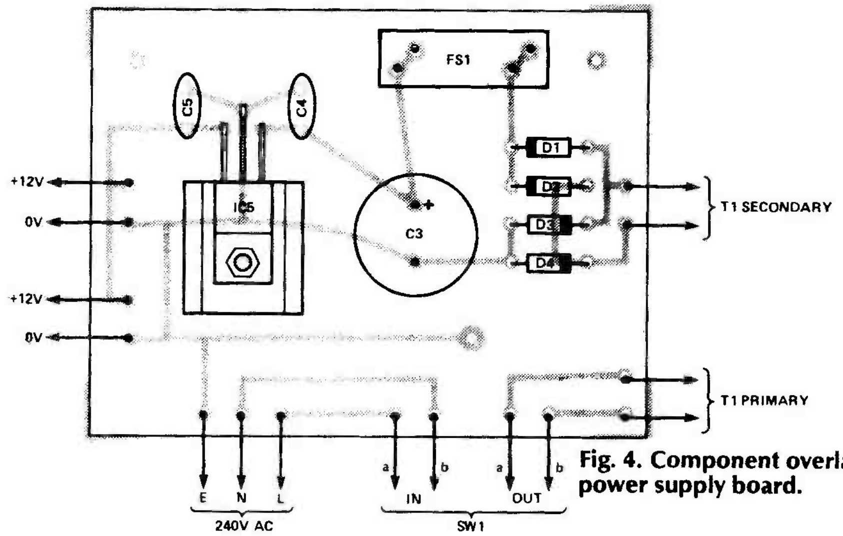


Fig. 4. Component overlay for the power supply board.

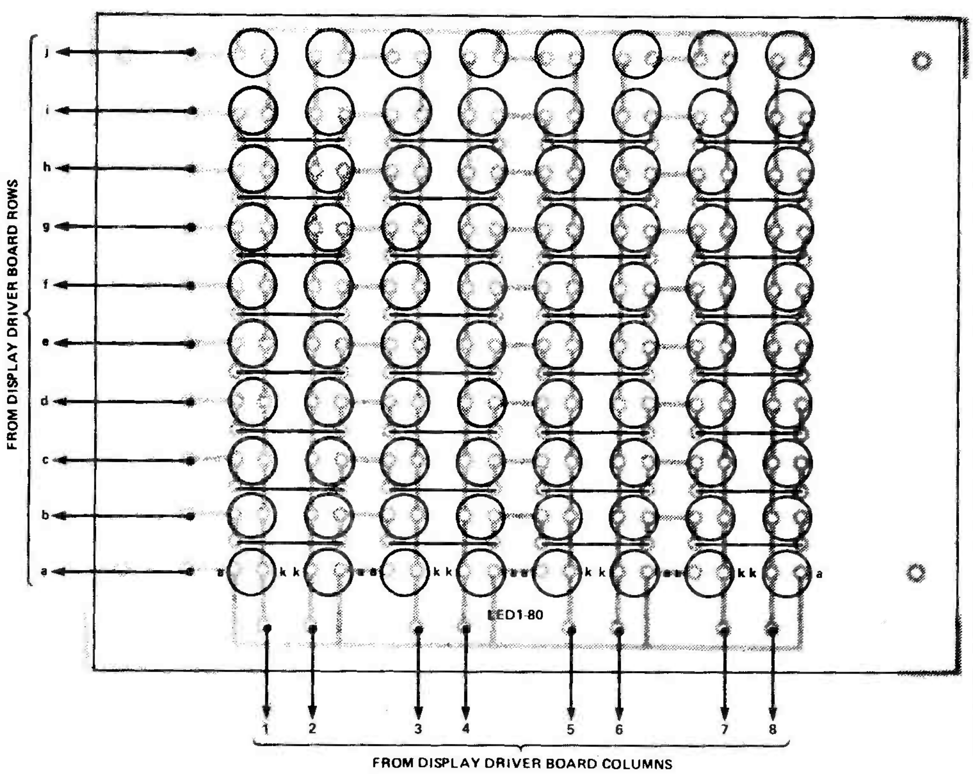


Fig. 5. Component overlay for the LED display.

FREQUENCY	Ra	Rb	Ca	Cb	Cc	CHANNEL
50HZ	33k	330k	33n	33n	330n	1
10HZ	33k	330k	15n	15n	150n	2
225HZ	33k	330k	6n8	6n8	100n	3
500HZ	33k	330k	3n3	3n3	33n	4
1kHZ	33k	330k	1n5	1n5	22n	5
2.2kHZ	22k	220k	1n0	1n0	10n	6
4.8kHZ	10k	100k	1n0	1n0	4n7	7
10kHZ	10k	100k	470p	470p	2n2	8

RESISTORS
2x10k, 1x22k, 5x33k, 2x100k, 1x220k, 5x330k

CAPACITORS
2x470p (polystyrene); 4x1n0, 2x1n5, 1x2n2, 2x3n3, 1x4n7, 2x6n8, 1x10n, 2x15n, 1x22n, 3x33nf, 1x100n, 1x150n, 1x330n (all polyester layer).

PARTS LIST

RESISTORS (all 0.4W 1% metal film unless stated)

R1 - R10	180R 1W 5% carbon (10 off)
R11, 12, 23, 24, 30	18k (5 off)
R13	100k
R14 - R21	1K0 (8 off)
R22	4k7
R25	3k9
R26, 27	3k3 (2 off)
R28, 31	10k (2 off)
R29, 32, 35	1M0 (10 off)
R33	220k (8 off)
R34	6k8 (8 off)
Ra, Rb	See Table 1
RV1	10k log pot

CAPACITORS

C1	10μ 16V radial elect
C2	100μ polyester layer
C3	2200μ 25V radial elect
C4, 5	100n ceramic (2 off)
C6	47n polyester layer
C7,8	220μ 16V radial elect. (2 off)
C9	2μ2 63V radial elect
C10	1μ 63V radial elect. (8 off)
Ca, Cb, Cc	See table 1

SEMICONDUCTORS

IC1	LM3815N
IC2	4051BE
IC3	4024BE
IC4	4022BE
IC5	uA7812
IC6	NE555
IC7	LF353
IC8	1458C (4 off)
IC9	LM324 (4 off)
Q1 - Q10	BC327 (10 off)
Q11 - Q18	BC337 (8 off)
Q19	BC547
D1 - D4	IN4002 (4 off)
D5, 6	IN4148 (16 off)
LED1 to 80	5mm red LEDs (80 off)

MISCELLANEOUS

SW1	Rotary mains switch
SK1	3.5mm jack socket
T1	Mains primary, 12V 1A secondary
FS1	20mm 1A quickblow

Metal instrument case about 300 x 150 x 100m; PCBS; two control knobs; six 8-pin DIL IC holders; five 14-pin DIL IC holders; two 16-pin DIL IC holders; one 18-pin DIL IC holder; pair of 20mm fuse clips; small finned heatsink (plastic power type); ribbon cable, mains lead.

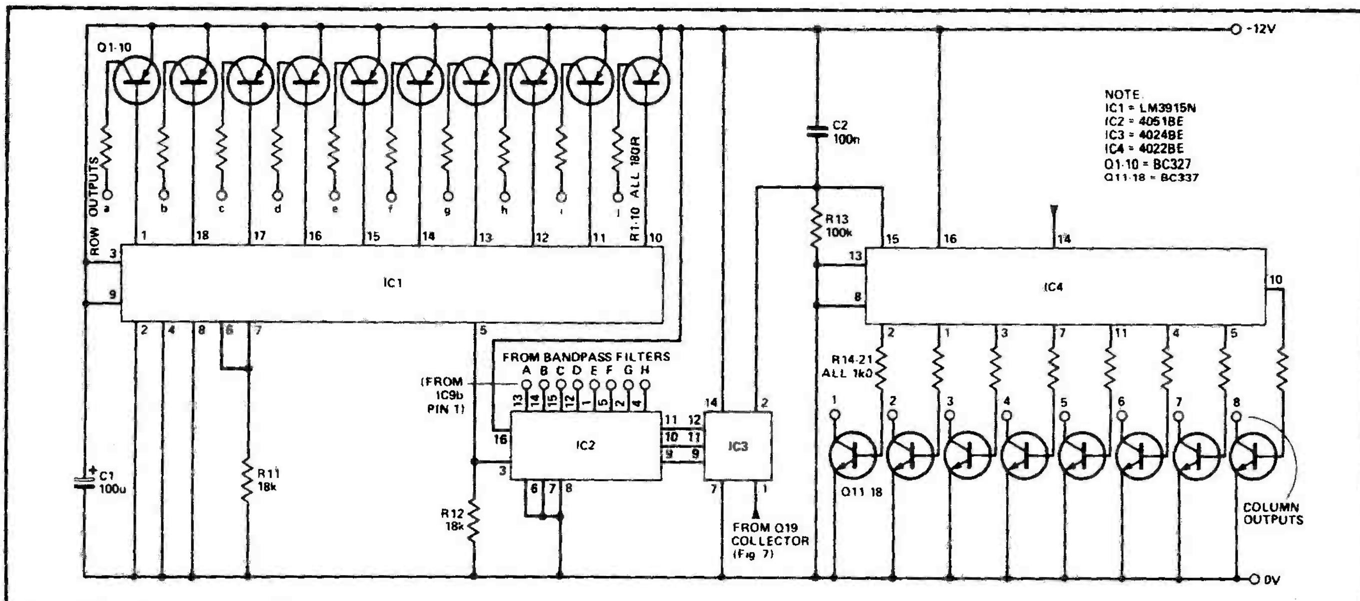
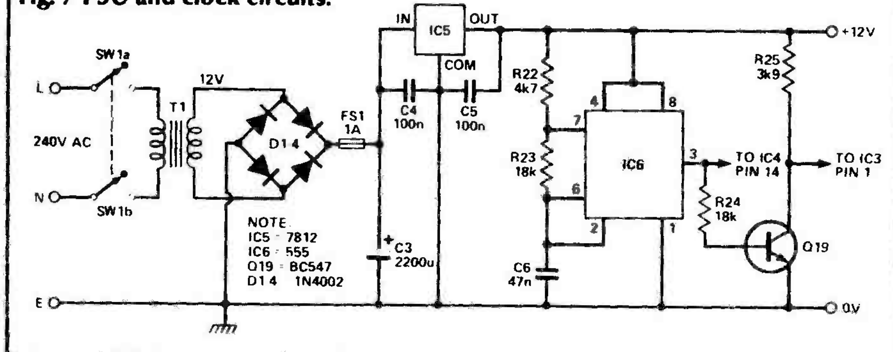


Fig. 6 Circuit diagram of the display driver.

Fig. 7 PSU and clock circuits.



ensure that these are properly inserted before soldering them in place. IC5 — the 12 V regulator — must be fitted with a small heatsink.

The display board is probably the most difficult from the construction point of view, and details of this board are provided in Fig. 5.

It is best to start by fitting the 32 necessary wire links. The LEDs are then fitted, taking great care not to fit any the wrong way round (note the alternate anode — cathode, cathode — anode orientation of the columns). It is probably best to work through the LEDs one column at a time, checking each completed column for errors using a multimeter before progressing to the next one. It could be a little awkward to correct errors in the middle of the board after completion. Try to make the board as neat as possible, including keeping the LEDs at a consistent height above the board. The LEDs should not be allowed to protrude any further above the board than is really necessary or it might be difficult to find sufficient space to accomodate the completed board inside the case, and mounting it could be difficult.

All the boards are fitted with pins at the points where interconnections will be made. Connections are made to the rear (copper) side of the display board, and so double-sided pins should be used on this one.

Case

A metal instrument case having approximate outside dimensions of 300 x 150 x 100mm will comfortably take the four boards and other components. The prototype has the power supply at

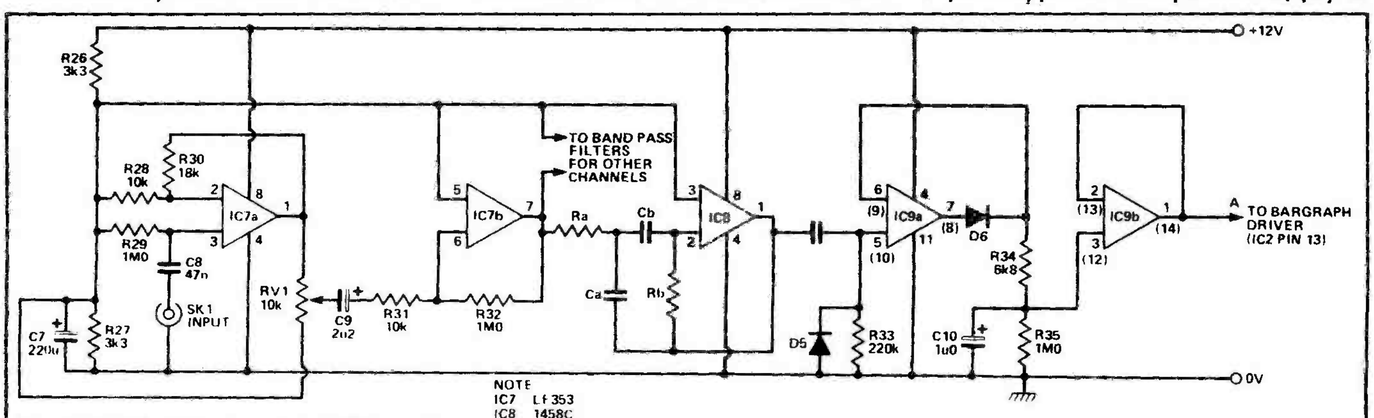


Fig. 8 Circuit of the input amplifier and one filter channel.

HOW IT WORKS

The display driver circuit is shown in Fig. 6, and is built around IC1, an LM3915N bargraph driver (the logarithmic version of the popular LM3914N device). The logarithmic scaling provides indications at 3dB intervals, and enables a reasonably wide dynamic range to be covered with a ten LED display. The device supports both dot and true bargraph operation. The latter is used here, giving a relatively high level of current consumption. Bar mode provides a much clearer form of display, especially in a multiple bargraph application.

IC1 can sink up to 30 mA per output, which is inadequate in this case as the current may be shared between eight LEDs — giving only 3.75 mA per LED. Q1 to Q10 are used to roughly double the drive current, and they also effectively convert IC1 from a current sink to a current source.

IC2 is the 8-way analogue switch, and IC3 the binary divider which controls it using three of its seven stages. IC4 provides the one-of-eight decoder action, but provides an inadequate ouput current capability and is therefore buffered to the display by switching transistors Q11 to Q18. C2 and R13 form the common reset circuit for IC3 and IC4.

The power supply and clock circuits are shown in Fig. 7, and these are both quite conventional. The power supply uses bridge rectification and a monolithic voltage regulator IC5 to give a well smoothed and stabilised 12 volt output. A current of over 500mA can be drawn when all 80 LEDs are turned on, but the supply is well capable of providing this.

The clock oscillator is a standard 555 astable circuit. Since IC3 and IC4 require antiphase clock signals in order to achieve proper synchronisation, Q19 acts as an inverter which generates the second clock phase.

The input amplifier circuit (Fig.8) consists of a low gain non-inverting amplifier ahead of gain control RV1, and a high gain inverting type following it. The voltage gain ahead of RV1 has to be kept low in order to maintain reasonable headroom for high level signals, and the main purpose of the input stage is to act as a buffer to give the unit a high input impedance of 1MO.

IC8 operates as a bandpass filter and is repeated eight times for each channel. The circuit is a standard op-amp configuration and gives reasonable performance without needing large numbers of components. The Q value of the filter is made quite low so that there is no significant variation in gain over its frequency range, a factor which is crucial if the unit is to give good results. An inevitable consequence of this is that there is some overlap between one filter and the next, and with a signal at the centre of one passband the adjacent channels will respond to it to some extent. This is something that has to be tolerated in a low cost design, but with about 16dB or so of attenuation (equivalent to a range of about 5 or 6 display LEDs) from the centre of one pass and to the next, the level of performance compares quite well with other low-cost analysers.

Each filter feeds into a separate precision half-wave rectifier (IC9a) and buffer amplifier (IC9b). The values in these provide the required fast attack and slow decay times. Note that the LM324 is suitable for single supply rail operation — an essential feature of this circuit.

The LED display circuit (Fig. 9) is an ordinary 8 x 10 diode matrix built up from individual 5mm diameter red LEDs (suitable ready made displays seem to be unobtainable).

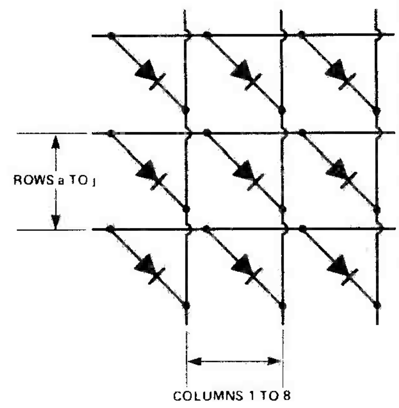


Fig. 9 A section of the LED display circuit.

the right, looked at from the front. The display is to left of centre on the front panel with RV1 and SK1 to its left. The display driver board is on the base panel to the left of the power supply, and the filter board is on the rear panel adjacent to the display driver board. Wiring up is quite easy with this arrangement and it keeps the sensitive wiring at the input of the unit well separated from the mains power supply.

The display board must be mounted behind and looking through a window cut in the front panel, about 77mm wide by 74mm high. This can be cut using a fretsaw or a miniature round file. Spacers are used over the board's 6BA or M3 mounting bolts so that the tops of the LEDs are brought flush with the front panel. Red display window material could be fixed in place in front of the LEDs to give a neat finish.

The unit is completed by hardwiring the boards using multicoloured ribbon cable except for the lead to SK1 which must be a screened type and the mains lead.

In Use

When the analyser is switched on, some of the bargraphs will show a strong initial indication, soon falling back to zero. As a quick check of the unit, connect an input lead to SK1 and touch the non-earthy side. This will probably cause all the display LEDs to light up at first. By carefully backing off RV1 it should be possible to obtain a strong indication from the two lowest frequency channels, with little or no response from the others (since the signals picked up in your body will be predominantly low frequency mains hum).

With each bargraph having ten LEDs at 3dB intervals the unit covers a fairly wide dynamic range, but for optimum results in some applications it is still necessary to adjust RV1 carefully. Best use of the available dynamic range is made by advancing RV1 just far enough to cause the top LED in one of the bargraphs to light up on signal peaks. Of course, in some applications the idea is to adjust things so that an equal response is obtained from all eight bargraphs, and RV1 can then simply be given any setting that results in a few LEDs in each bargraph lighting up.

The unit will operate well with most types of microphone, but with some types the high input impedance of the unit is less than ideal. However, this is easily corrected by adding a resistor across SK1 to shunt the input impedance to the required figure. Operation with line level inputs is possible, but an external attenuator will be needed for signal levels of more than about 3V peak-to-peak in order to avoid overloading the input amplifier.

BUYLINES

Most of the components are standard, readily available items. The case is available from Maplin — who advertise in this issue — order code XY49D. Probably the cheapest way of buying the 80 LEDs is to buy 100 from a supplier who offers a quantity discount and to keep some spares. The mains transformer can be a type having a 12V, 1A secondary, but types with twin 6V, 1A secondaries are suitable if the two secondary windings are wired in series.

ETI

LOW COST FRAMESTORE

Dan Ogilvie discusses the ADC/DAC and video circuitry

In the last exciting episode I looked at the desing of a real-time storage video framestore, and in particular at the logic and memory interfacing. This month I shall describe the video input and output stages and the external synchronizing circuit.

I mentioned briefly last month that the analogue-to-digital conversion has to be performed within 200ns and that a new and cost-effective integrated circuit from STC will be used for this. It will be pertinent to look in more detail at this IC — the UVC3101 — now (see Fig. 5).

High Speed ADC

Flash converters, or parallel converters as they are sometimes called, have been covered in ETI recently so I shall only briefly mention the principle involved.

An n-bit flash converter will contain 2^n comparators. One input to these comparators will be the analogue input, the other input will be a tap on a resistor ladder. The resistor ladder is connected in this case beteen ground and a voltage reference of 2V, provided on the chip.

The higher the analogue input the more comparators that change state so the output from the converter is a kind of bar graph. Our converter has 8-bit resolution, so 256 comparators are used. The 256 outputs are fed to a priority encoding network which converts them to 8-bit binary form.

One useful feature of the UVC3101 is the provision of an input amplifier for the ADC. The input to a flash converter usually sees a large number of comparator inputs and hence a large capacitance. Worse still, the impedance changes depending on the state of the comparators which, in turn, depends on the voltage input. We therefore normally need to provide a low impedance output driver for the ADC capable of charging and discharging the

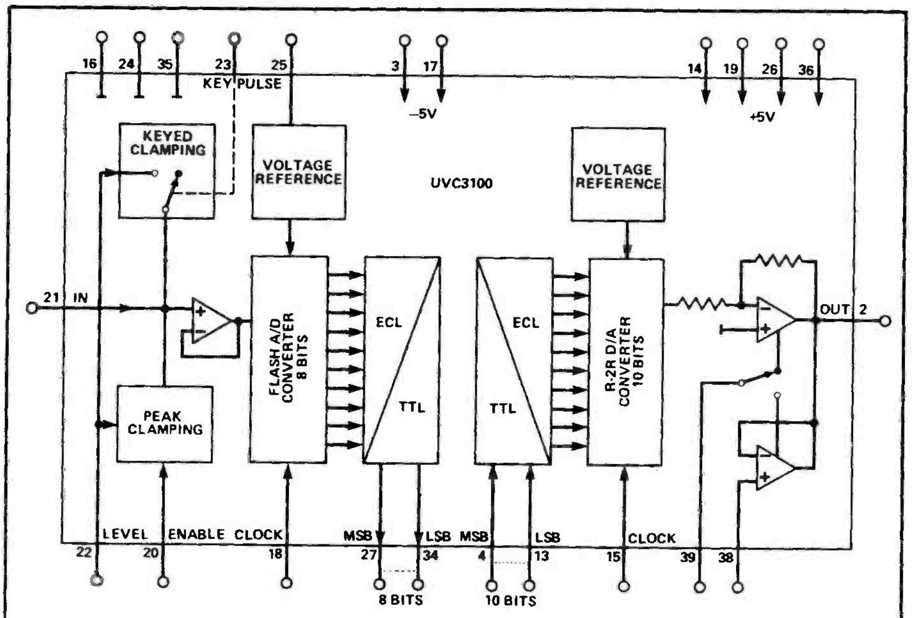


Fig. 5 Block diagram of the combined ADC-DAC.

100pF or so input capacitance at 5MHz.

The input amplifier saves us the trouble, its input impedance being 100k in parallel with 10pF. This can be comfortably driven from most op-amps.

The input amplifier also allows us to black-level clamp the input signal. We mentioned last month that the back porch of the line sync is defined as black. By generating a pulse in this part of the signal and using it to DC restore the incoming video we can ensure that the black in the image is always stable.

Jumping DAC Flash

The UVC3101 is not finished yet. Also fabricated on chip is a 10-bit R-2R DAC. An internal 2V reference for this is also provided as are two output amplifiers. One provides buffering for the DAC, the other allows us to mix in an additional video signal. Switching between amplifiers is accomplished by a TTL level signal on pin 39.

Genlock

A composite sync output is provided from the framestore board. It is meant to drive the genlock input to a video camera. This input will synchronize the camera to the framestore and ensure stable pictures are obtained when loading. Switching between internal and genlock mode may be automatic or manually achieved.

Camera genlock is the preferred mode of operation, but not all cameras have a genlock input, while video tape recorders and TV broadcasts never have the facility. The BBC are unlikely to accept a request to synchronize all their studio equipment from your framestore, so provision has been made for the framestore to lock to the incoming video. Switching is performed by pulling low pin 1 of IC41, the select input of a 2:1 multiplexer (see Fig. 2, p. 38, ETI September, 1986).

The incoming video has the sync pulses stripped from it. Mixed sync and blanking signals are derived from it and replace the

HOW IT WORKS

IC34 (Fig. 6) is a high speed op-amp which amplifies the incoming video from 0.7V to 2V. This is AC coupled into the ADC by C5. The video input is terminated in 75R by R65, but this may be removed if necessary. R63 and C6 form a low-pass filter to reduce the amplitude of high frequency signals and prevent aliasing. The AC coupled input to the ADC is clamped internally by a pulse on pin 23. IC38 generates this pulse which is arranged to lie in the back porch of the line sync pulse — black by definition. This ensures the blacks in the picture do not shift with changing light levels or with different camera iris settings. The top 4 bits of the 8-bit converter are used and are present on pins 27-30 of IC39. Pin 27 is the MSB.

The top four DAC bits are on pins 4 to 7 of IC39 (MSB first). Resistors R58-R61 pull these inputs low when their driver, IC17, is tristated. This occurs in the blanked areas of the picture. The DAC has two output amplifiers which are selected by a pulse on pin 39 — the mixed sync signal. One of these amplifiers buffers the DAC output while the other buffers an input on pin 38 of the IC which, in this case, forms a variable sync pulse level. The mixed sync pulses are used to switch between the DAC output (video) and the sync pulse level — set by RC1. The resulting composite output is on pin 2 which is buffered by Q3 to enable it to drive 75R.

The video input is also presented to one quarter of IC35 which amplifies and inverts it. The output is sent to the +ve input of a comparator IC36 and also to a peak detector formed by D5 and C9. C9 holds the peak level of the signal, in this case the voltage corresponding to the sync pulse tips. R68 and R69 discharge C9, forming the time constant of the peak detector. They also form a potential divider allowing some 90% of peak detector output to form the -ve input or reference input to IC36.

One further quarter of IC35 buffers the high impedance of the peak detector. The comparator inputs see both the sync pulses and a reference voltage derived from them at some 90% of their peak value. By using this as the comparator, the derived sync pulses are formed on pin 1 of IC36. These are inverted by Q4 to form the genlock sync input. They are also used to trigger half of IC37 to form the line sync blanking pulse, and are integrated by R74 and C10 which, with IC36, detect the field sync pulses. The line and field blanking signals are then mixed by D6 and D7 and inverted by Q2 to form the external blanking signal.

These two pulses are switched in to replace the internally generated signals when pin 1 of IC41 (a 2:1 multiplexor) is pulled low (see Fig. 2, p.38, ETI September 1986). The crystal oscillator is then also replaced by IC40 (a VCO) which is locked by the inhibit signal on pin 6 to ensure it starts in the same position in its cycle every line. RV2 sets the oscillator frequency for IC40 — which should be 10MHz. If you have no oscilloscope, set the picture width equal to that of a non-genlocked signal.

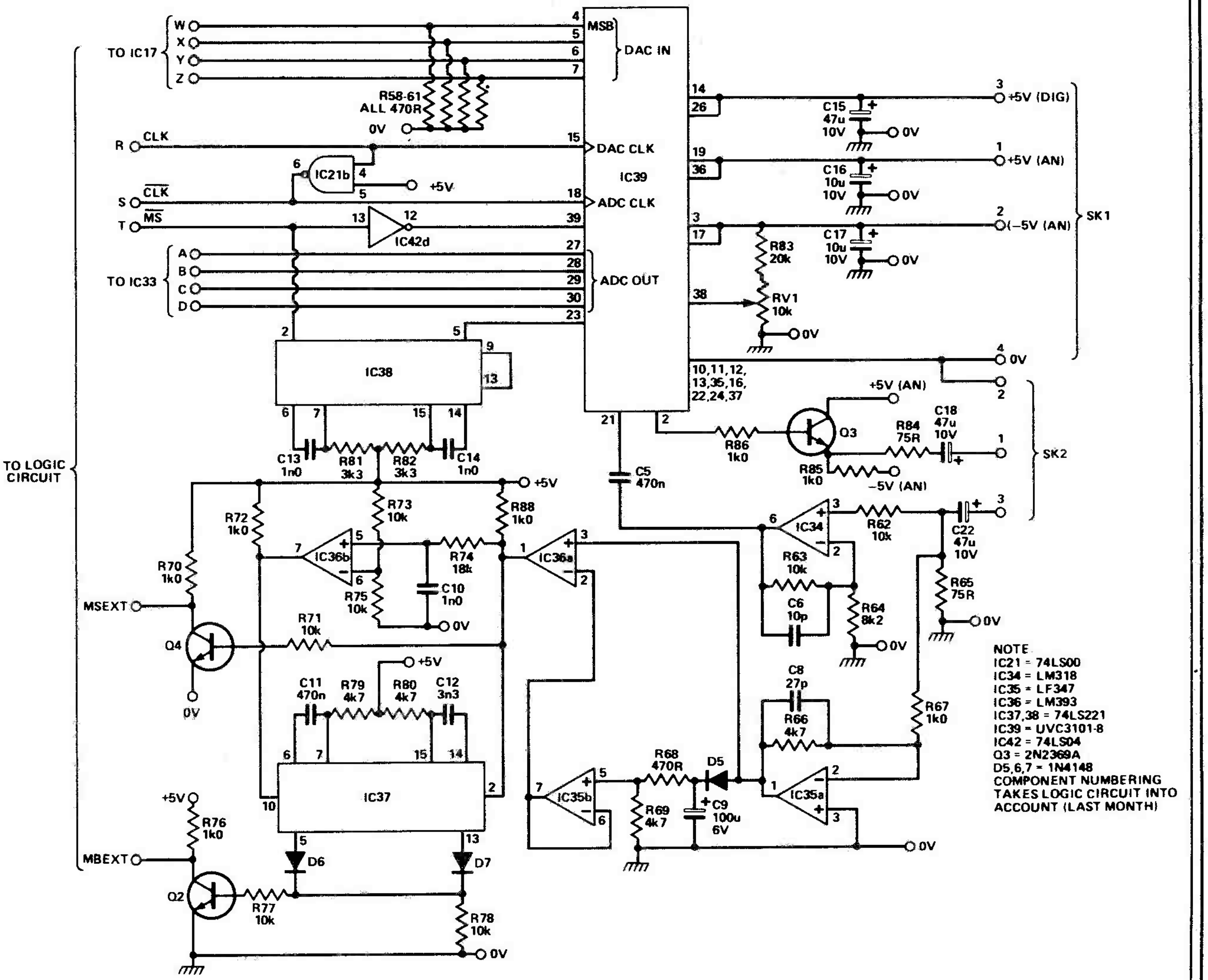


Fig. 6 The video circuit.

normal internally generated signals. The clock oscillator is also locked to the incoming video, ensuring that it starts at the same point with every line. (Incidentally, Fig. 2 fails to show the connection between pin 14, IC29, and the CLK line. This was an oversight.)

This circuit will provide a stable lock from nearly all video inputs. However, because the switching between the two modes of operation is not automatic if the input is removed in genlock mode, refresh to the memory is not guaranteed and picture corruption may occur if this condition persists.

Construction

It is recommended that the plated-through-hole PCB provided with the kit (see below) is used to construct the framestore, although a wirewrapped prototype performed satisfactorily. The board has a silk screen legend to aid component location. The components can be inserted in any order you desire. Sockets are not required for the ICs and are not provided with the kits, although sockets can be used for any of the components without problems. If you do not have a bench power supply available a simple PSU can be built using the ubiquitous 7805 for the digital +5V and a further 7805 and a 7905 for the analogue ±5V. Current consumption for the framestore is about 700mA for the digital supply and 150mA for each analogue supply.

Once all the components have been positioned check the orientation of ICs, diodes and transistors and wire up to a power supply. Although a solder resist is provided on the PCB a quick check for solder bridges would not be wasted.

Two links must be made on the board before you switch on. Both pin 1 of IC28 and pin 5 of IC32 must be taken to 0V with a short piece of insulated wire. These two inputs are normally controlled from an external microprocessor, but are not required yet and must be linked.

You are now ready to switch on. If you are still with us and have access to an oscilloscope it is worth checking the oscillator output (10MHz at pin 6 of IC15), mixed sync and blanking (IC22 pins 3 and 4) and the RAS and CAS signals. If all is well (or if you were unable to check) switch off and

The framestore will reveal differences between two images.

POWER	
SK1/1	+5V analog
SK1/2	-5V analog
SK1/3	+5V digital
SK1/4	OV
FUNCTION	
SK2/5	OV (ground one of PL2/6-PL2/13 or PL2/17 via 9 way rotary switch to select function)
SK2/6	clear function (all zeroes = black)
SK2/7	live minus store
SK2/8	store minus live
SK2/9	live plus store
SK2/10	live EXOR store
SK2/11	live OR store
SK2/12	live AND store
SK2/13	preset (all '1's = white)
SK2/17	Norm. Store image.
All the function switch results will only be seen when the load switch is pressed.	
LOAD, IMAGE SELECT AND VIDEO I/O	
SK2/14	single pole C/O
SK2/15	load switch, common to OV.
SK2/16	A/B image select. Ground for second image to be displayed or loaded to.
SK2/18	ext. sync out
SK2/1	video out, IV composite output into 75 ohms
SK2/2	OV
SK2/3	video input, terminated in 75 ohms
SK2/4	Ground for external sync mode

Table 1 Socket connections

wire up the load switch, PL2 pin 17, to 0V and the video output to a TV monitor. Switch on again. If possible use a scope to set the sync pulse amplitude on the output to 0.3V into 75 ohms with RV1. Alternatively set it to obtain a stable lock on the monitor.

If necessary use the horizontal and vertical hold controls on the monitor to obtain a stable picture. Some form of fixed pattern should be obtained on the screen. This is the random data held in the memory on switch on. Press the load switch. The random pattern should be replaced with a black or near black image. If this is so, the other switches may be wired up in accordance with Table 1.

If you have been unlucky and none of what should have happened has, but you have access to an oscilloscope, you should check the circuit methodically for correct signals. The timing diagram given on p. 40, ETI September 1986, should help. Check that all the links and switches have been correctly wired up and that the supplies are delivering the right voltages.

If you still have no success, the author offers a repair service on the boards supplied by Oggitronics that have been assembled with due care and attention. A charge of £25 + parts + VAT will be made.

Next month we will look at interfacing the framestore to a microprocessor and some of the uses for the TTL arithmetic unit.

We've had to hold over the parts list and overlays until then, too.

BUYLINES

No problems should be found in purchasing any of the components for the framestore. The only special component, the ADC, can be obtained from STC Mercator, Telephone 0493-844911. The PTH, silk screened PCB is available from Oggitronics at 7, Saywell Brook, Chelmsford Essex CM1 6RJ for £25.00 + VAT but including postage. A complete kit of parts including the PCB is available for £170 + VAT, also from the above address.

A complete framestore, boxed and with its own power supply is available also for £395 + VAT, again from Oggitronics.

ETI

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INTELLIGENT CALL METER

Chris Ranklin describes the software which drives his all-singing, all-dancing telephone call charge meter.

In the first article on the call meter in ETI August '86 we looked at the basic facilities offered and the hardware. In this article we will look at the operation of the meter in more detail as we consider the functions performed by the software.

The software consists of the main programme stored in EPROM (0000-07FF) and the system parameters and other data which are stored in RAM as required (0800-0FFF). The system memory map is shown in Table 1 and a separate list of the data stored in the top 62 bytes of RAM is given in Table 2.

At switch-on, the hardware resets the programme counter to memory location 0000. The code at this location instructs the microprocessor to zero the RAM in the stack area and set the stack pointer at 0856.

The software then jumps to the main area of the programme, a short loop extending from 0103 to 0115. This causes the time to be displayed on the LCD (using time data from the RAM) and also monitors data bits 0 and 3 on the input port to see if the 'phone has been lifted or the user switch pressed.

At 1/50th of a second intervals, the NMI will interrupt the programme and direct the processor to memory location 0066. The code there produces the 7-day clock data and is illustrated in Table 3. Each interrupt causes the value stored at 0FFE in RAM to be increased by one, and the total is then checked. If it is less than 50, the R and C counters are incremented to update the display and the code then returns to the main area of the programme. If the total is more than 50, the code passes through the next instructions (zero 1/50ths second and increment seconds) and then updates the RAM, checks the total and increments the counter as before. The procedure is repeated for minutes, tens of minutes, hours, tens of hours, and days. At the end of each update, the programme returns to the main area of the code at 0103.

If, whilst the main programme loop is running, data bit 3 on the input port goes high to indicate that the USER switch has been pressed, the processor will execute the code beginning at line 0116. This allows the user to read and alter the data stored in lines 0857-0FFF of the RAM. The record of the last 135 calls made

EPROM	0000 – 07FF	Software program
RAM	0800 – 0801	not used
	0802	unit cost of call in 1/10p
	0803	unit cost of call in pence
	0804 – 0855 – 0856	Stack: 82 bytes
	0857 – 085F	not used: 10 bytes
	0860 – 0FC1	135 numbers and costs stored in 14 byte blocks: 1890 bytes
	0FC2 – 0FFF	RAM list: 62 bytes

Table 1 System memory map.

FFF	Not used	FDF	1/10p this call cost
FE	1/50 sec	DE	1p this call cost
FD	Seconds	DD	10p this call cost
FC	Minutes	DC	Pounds this call cost
FB	Tens of minutes	DB	10 pounds this call cost
FA	Hours	DA	100 pounds this call cost
F9	Tens of Hours	D9	1st digit this number dialled
F8	Total hours	D8	2nd digit this number dialled
F7	Day	D7	3rd digit this number dialled
F6	Holidays	D6	4th digit this number dialled
F5	Not used	D5	5th digit this number dialled
F4	1/10 p total cost	D4	6th digit this number dialled
F3	1p total cost	D3	7th digit this number dialled
F2	10p total cost	D2	8th digit this number dialled
F1	Pounds total cost	D1	9th digit this number dialled
F0	10 pounds total cost	D0	10th digit this number dialled
EF	100 Pounds total cost	CF	10 pounds last call cost
EE	Not used	CE	pounds last call cost
ED	C/counter	CD	10p last call cost
EC	R/Counter	CC	1p last call cost
EB	Fast flag	CB	1st digit last numbers dialled
EA	Slow flag	CA	2nd digit last numbers dialled
E9	User number	C9	3rd digit last numbers dialled
E8	Phone down flag	C8	4th digit last numbers dialled
E7	Units	C7	5th digit last numbers dialled
E6	Clock period	C6	6th digit last numbers dialled
E5	Band index	C5	7th digit last numbers dialled
E4	Tot H	C4	8th digit last numbers dialled
E3	Tot L	C3	9th digit last numbers dialled
E2	Index	C2	10th digit last numbers dialled
E1	Counter		

Table 2 Contents of the top 62 bytes of RAM.

(number dialled and cost) can be read or reset, the 7-day clock data can be checked and altered, and the unit cost charges can be adjusted to take account of changes in BT's rates. In addition, this area of RAM can be reset to zero (as would be required immediately after switching on) and the charging software can be instructed to take account of a bank holiday. The 7-day clock obviously cannot cope with holidays, so if calls are to be metered at the correct rate, the user must set the appropriate bit before using the 'phone. At the end of any user adjustments the programme is returned to the main loop.

If the telephone line becomes active, the main programme will detect data bit D0 going high and will jump to line 0248 (Table 4). This causes the area of RAM reserved for current call data to be zeroed and the software then monitors both D0 and D1. If D1 goes high, the activity on the line is caused by an incoming call and no charge need be calculated. The software returns to the main loop. If D1 is low and D0 remains high, the receiver has been lifted to make an outgoing call and the system proceeds to identify the number dialled by counting the pulses.

If D0 goes low for more than 700ms, the programme will revert to the main loop. Otherwise, the incoming pulses will be counted, the counter returning to zero and starting on the next digit after each 400ms interdigit pause. When eight digits have been counted, they will be compared with a table of numbers in the software so as to identify the relevant charge band. Data bit 1 is also monitored; this line will be high when a local call causes reverse battery voltage to appear on the line.

The table of numbers in software is stored between lines 0400 and 04FC. Up to 73, 3 and 4-digit STD codes are used, these being entered by the user when the EPROM is programmed. The codes are all obtained from the local code book, and where codes of more than four digits are given the final digits are ignored since they shouldn't affect the charge rate. International dialling codes will, of coures, be the same from any part of the country, so these codes are already included in the main software (100 numbers stored between 049A and 04FC).

0066	Exchange Registers			
	Does user wish to alter the time			YES
	Increment 1/50 sec	is it less than	50	YES
	Zero 1/50 sec			
	Increment Seconds	is it less than	60	YES
	Zero Seconds			
	Increment minutes	is it less than	10	YES
	Zero Minutes			
	Increment 10 minutes	is it less than	6	YES
	Zero 10 minutes			
	Increment hours	is it less than	10	YES
	Zero hours			
	Increment 10 hours			
	Increment total hours	is it less than	24	YES
	Zero total hours			
	Increment day	is it less than	7	YES
	Zero day			
	Increment R/counter			
	Increment C/counter			
	Exchange registers			

Table 3 The NMI routine which produces the 7-day clock data.

0248 Zero Telephone parameters
Port in A
D 1 high ringing in Jump to MAIN
D 0 high = phone up

COUNT PULSES
(number being dialled)

Port in A
Phone down for 700ms Jump to MAIN
Bit 0 low
Increment pulse counter
Port in A
Interdigit pause 400ms YES
Bit 0 high
Start of next pulse
8 numbers stored YES
Port in A
Bit 1 high = negative on line Jump to LOCAL
Bit 0 high
Start of next pulse

CODE
(sort code on present numbers)

Check for International	Yes	Jump to INTERNATIONAL	
Check for B1	Yes	Set B1	in Band Index
Check for B	Yes	Set B	in Band Index
Check for A	Yes	Set A	in Band Index
Check for Local	Yes	Set Local	in Band Index
Check for Spurious	Yes	Set Local	in Band Index

033A Jump to CHECKLINE

Table 4 The call check, pulse counting and code identifying routine.

033B Port in A
Check band index if local bypass ringing
Bit 2 high means ringing
Bit 1 high means -ve
Bit 0 high means phone is up
Last 2 numbers Yes Jump to COUNT PULSES
Port in A
Bit 0 high means end of pulse
Phone down 700ms means phone down Jump to MAIN
Port in A (is it a proper ring?)
Bit 2 low
Less than 0.28 sec high means not a proper ring
Port in A (wait for ring to stop)
Bit 2 high
Port in A (check line again)
Bit 2 high
Bit 1 high means local -ve
Bit 0 low for 700ms Jump to MAIN
Bit 2 low = less than 2.4 secs
Through (all calls except local or international)
Set clock 1 sec period Jump to TIMER

LOCAL
(local -ve on line not operator call)
Set clock to 5 second period Jump TIMER

INTERNATIONAL
(calls beginning with 010)

Set clock to 1/10 sec clock period
Port in A
Bit 4 low = top button pressed Jump to TIMER
Bit 0 low for 700ms Jump to TRANSFER
03EF Return

Table 5 The checkline routine which sorts calls not immediately identified.

00D4	Return
0640	Add 1 unit to this call cost (0FDF to 0FDA)
	Add 1 unit to the total cost (0FF4 to 0FEF)
	Fetch band index 0FE5 and use it as a list pointer.
	If today is a holiday or Saturday or Sunday load the cheap rate, else add time to list pointer then point to the rate and load rate for time of day
	Port in register A
	Bit 0 low for 1 sec = phone down
	Increment D register using clock period in 0FE6
	1/10 second is International, 5 second is Local
	1 second is the rest.
	If D register is not equal to the rate counter
	If D register is equal to the rate counter, then another time period begins
	→ TRANSFER
	(saves costs and numbers)
	Move costs and numbers down in memory 14 places
06CF	Jump to MAIN

Table 6 The timing and transfer routines which increment the call cost and then save the data.

A full listing of the program will be published along with the constructional details of the call meter in a later article.

If the call is identified, the program will jump to the appropriate point on a table in the software (beginning at 0500). The table gives the amount of time paid for by one unit of charge for each period of the day in each of the charge bands: local, A, B, B1, Ireland, and international charge bands A to G. The value found will then be loaded into the RAM.

If the call is not identified, the program moves on to a sequence known as CHECKLINE (beginning at line 033B — see Table 5) It checks each of the major line parameters and takes the appropriate action, either returning to the main loop if the receiver has been put back on its rest or returning to count pulses if a number is still being dialled. If the number is finally found to contain a local or international code, the programme will jump to the appropriate section where a clock period will be set (five seconds for local calls, 0.1 seconds for international calls). The programme will then jump to the timer sequence. If the call is found to be to a number in any of the other charge bands, a period of one second will be set and the programme will then jump to the timer as before.

The timer sequence begins at line 0640 (Table 6) and is responsible for setting a final charge rate according to the time of day, day of week, etc, then incrementing the cost values in the RAM. This information forms the basis of the value displayed on the LCD as the call progresses. The timing sequence continues until data bit 0 goes low to indicate that the receiver has been put back on its rest. The total cost recorded and the number dialled are then transferred to the RAM, the numbers already there being moved down 14 bytes each to make space. The program then reverts to the main loop, awaiting further outgoing calls or user instructions.

To be continued... **ETI**

TECH TIPS

Over Voltage Indicator

Andy Fiore,
Maldon, Essex.

Although this is a simple circuit, it does combine high input impedance with full-wave response.

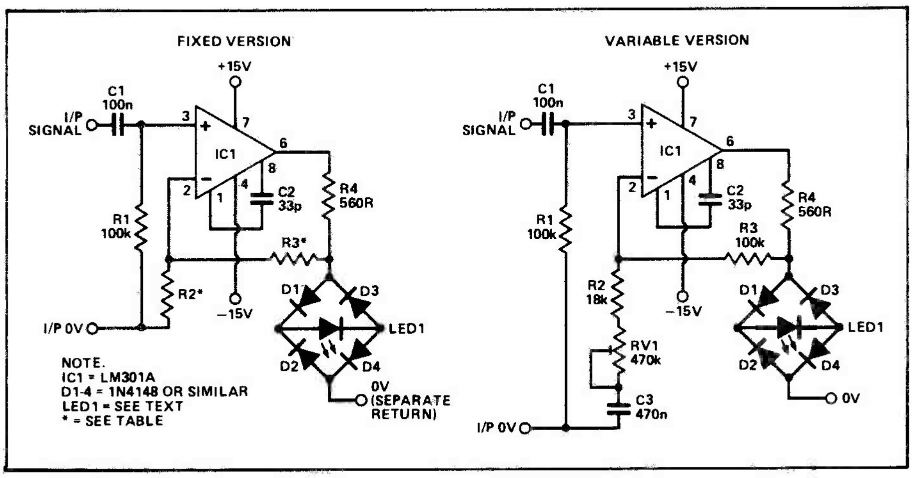
For output signals below the threshold of about ±2.9V (for the low-current LED used in the prototype, or ±3.3V for a standard red LED), the op-amp acts as an ordinary non-inverting amplifier with its gain determined by R3+R4/R2. At the threshold level, the bridge rectifier and LED combination start to conduct, clamping the negative feedback and hence the voltage on the inverting input. The op-amp begins to act as a comparator as the input voltage level rises, and the output is driven into clipping at the supply rails, turning the LED fully on all the time the threshold is exceeded.

The use of a separate return for the 0V connection to the LED/bridge connection is necessary because the switching current can cause interference with sensitive audio circuits. For the same reason, dual or quad op-amps should be avoided — I used an LM301A because it's cheap, it can supply enough current to light the LED, and because I like it!

A table of preferred E24 resistor values is given so that you can adjust the input sensitivity to your needs. The values assume the use of the same type of LED as in the prototype (a low-current red LED as sold by RS); as already noted, different types and colours of LED will have different forward bias voltages, so you will have to re-calculate the R2 and R3 values to suit.

As an alternative, a version with sensitivity adjustable between −62dBm and +6dBm is also shown.

R2	R3	Sensitivity (dBm/VRMS)
430k	130k	+6/1.55
220k	180k	+3/1.10
160k	270k	0/0.775
130k	390k	−3.8/0.5
120k	820k	−10/0.25
110k	1M0	+14/0.15



Power Booster For MOSFET Amplifiers

E. A. Harrington
Sheffield

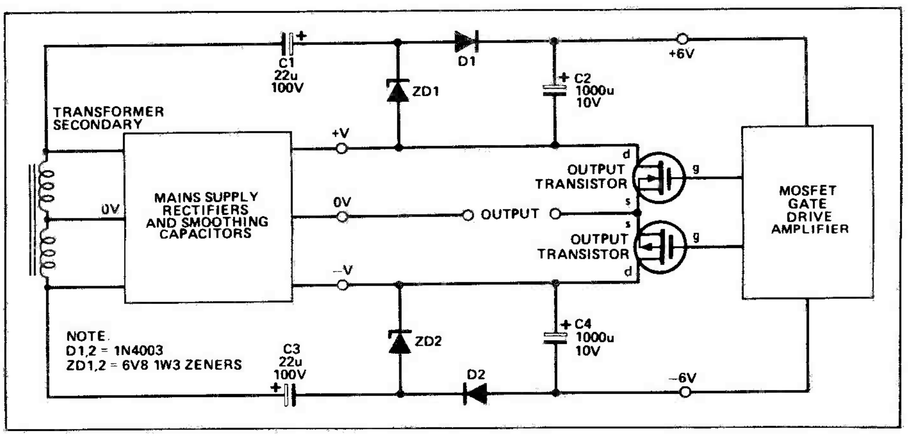
Many MOSFET power amplifiers are designed in such a way that the gates of the output transistors cannot be taken beyond a point about two volts away from either supply rail. If the output voltage does get close enough to a rail, the reduced gate-source and drain-source voltages will limit the output current to less than that necessary to properly drive the load. This is the point at which the amplifier begins to clip. However, if the gate voltages were able to go higher, the output current and voltage, and hence the output power would be increased.

To achieve this, the MOSFET drive amplifier is powered by a supply with higher voltages than the main supply. These voltages are derived from the main supply by means of charge-pump circuits.

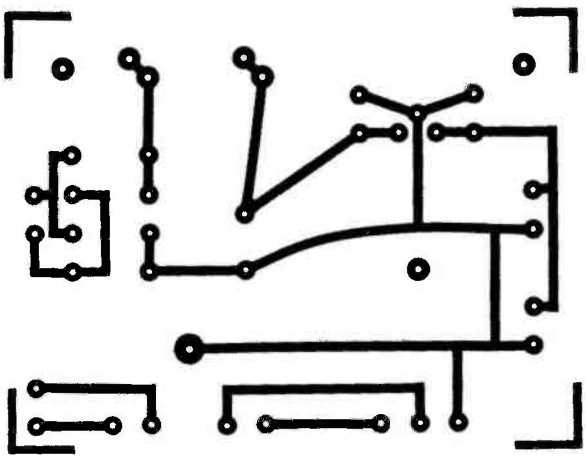
Consider the circuit ont he positive rail. As the transformer voltage rises, C1 charges the smoothing capacitor, C2, through D1. The voltage on C2 is limited by the Zener diode ZD1. When the transformer voltage is falling, ZD1 becomes forward biased and C1 recharges from the positive rail through it. A similar circuit provides the negative voltage from the negative rail.

The extra voltage produced is such that, at clipping, the output current is limited by the MOSFET drain-source voltage only. There is no more to be gained by creating a higher voltage.

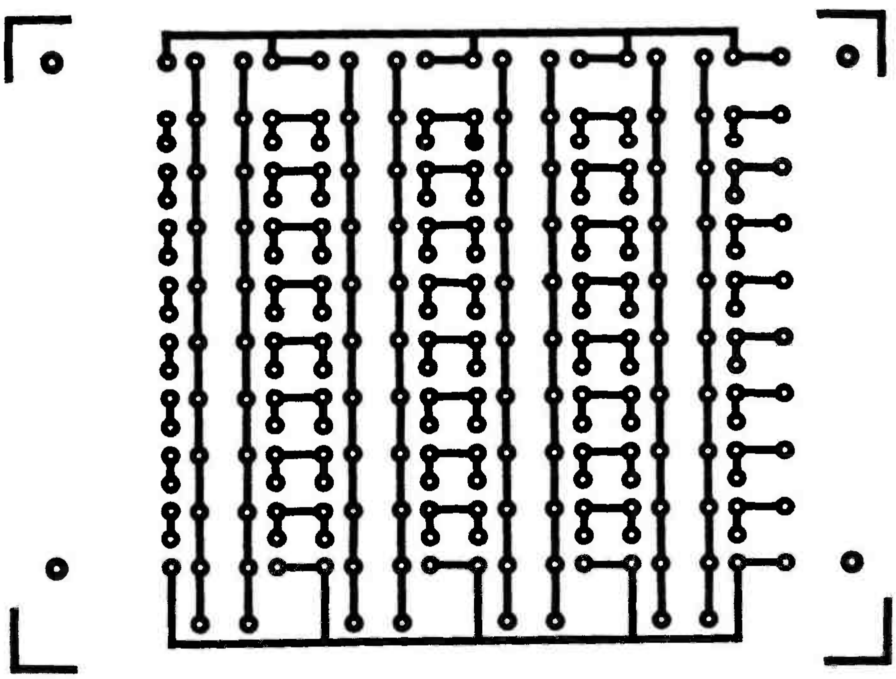
With a main supply of ±30 volts, the output power into 8 ohms is increased from about 35 watts to 45 watts, and from 55 watts to over 75 watts into 4 ohms. Remember that the drive transistors are now operating at a higher voltage and should be suitably rated, and that the power supply must be able to deliver the extra current.



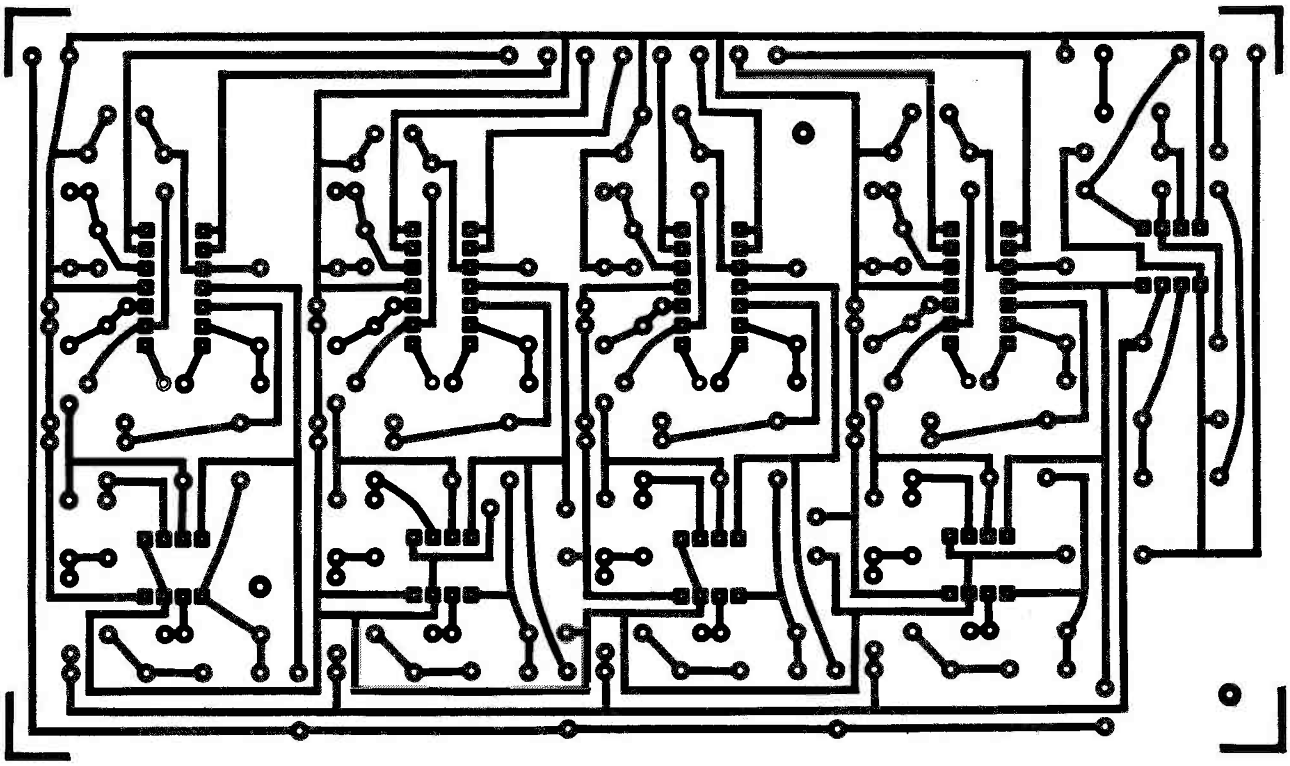
PCB FOIL PATTERNS



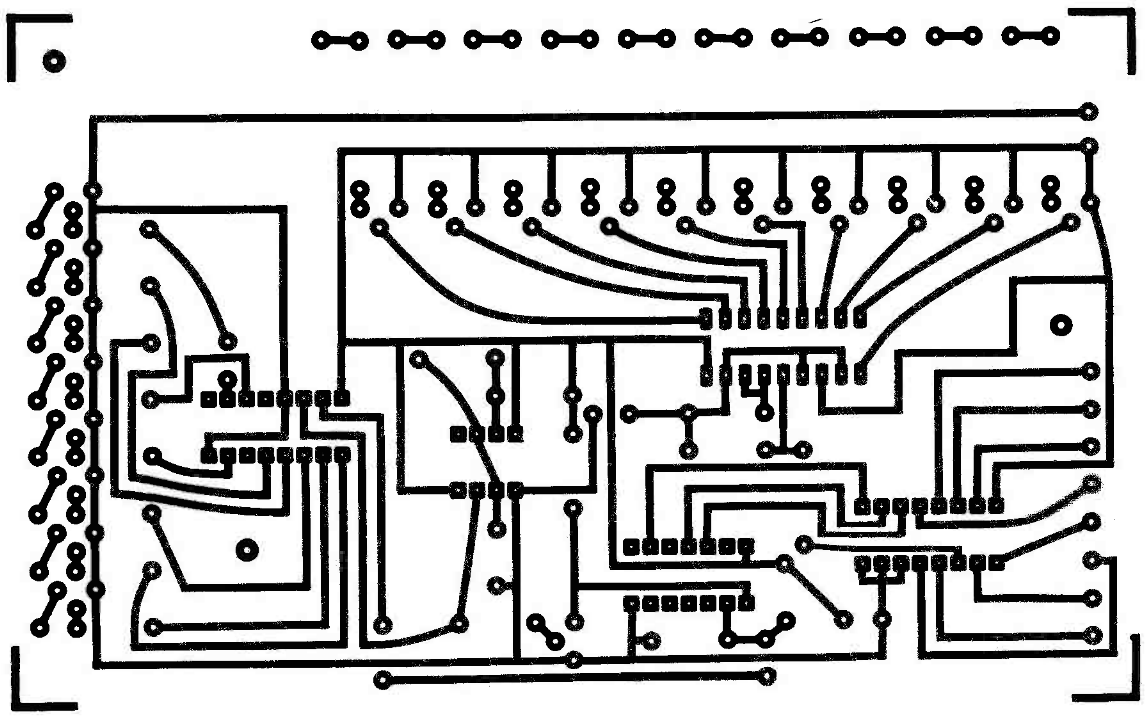
Audio Analyser PSU.



Audio Analyser display.



Audio Analyser filter board.



Autio Analyser display driver.

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E8406-8 AD Power Amp PSU .... J
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E8408-2 EPROM Emulator .... N
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E8411-9 Stage Lighting Interface ...... F
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E8504-3 Framestore Control .... N
E8504-4 Buzby Meter .... E
E8504-5 CCD Delay .... F
E8505-5 Stereo Simulator .... F
E8506-1 Audio Mixer Main .... J
E8506-2 Audio Mixer PSU .... F
E8506-3 Audio Mixer RIAA .... D
E8506-4 Audio Mixer Tone Control ... D
E8506-5 EPROM Prog MKII .... O
E8508-1 RCL Bridge .... N
E8508-2 EX42/BBC Interface .... E
E8508-3 EPROM Emulator L
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E8512-1 Specdrum connector .... F
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E8603-2 Programmable Logic Evaluation Board .... H
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E8605-1 Microlight Intercom .... E
E8605-2 Baud Rate Converter .... M
E8605-3 Baud Rate Converter PSU Board .... G
E8605-4 Portable PA .... H
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E8606-3 Troglograph .... F
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E8610-1 Audio Analyser Filter Board L
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E8610-3 Audio Analyser Display .... H
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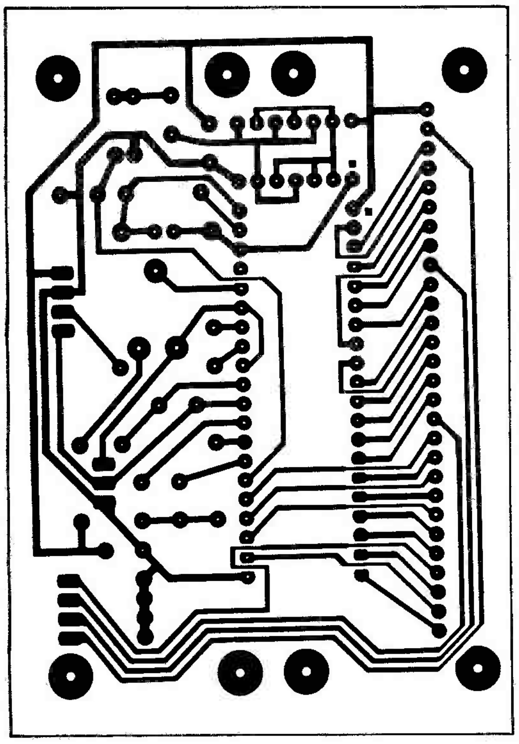

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OOPS!

PA Amplifier (May 1986)
Although text, diagrams and parts list specify a TL071 for IC102 in the preamplifier stage (pp. 45-47), the component overlay and PCB foil (Fig. 7, p.47) actually show IC102 to be one of half of a TL072 dual op-amp. This is perfectly acceptable.

Digibaro (February 1986)
Capacitors C1, C3, C5 and C7 should be 470u 25V types as shown on the circuit diagram, not 47u 25V types as stated in the parts list. We have also been told that one of the companies mentioned in Buylines, Hawke Electronics, no longer supply the MPX100a pressure transducer. The other company recommended, Macro Marketing, should still be able to help.

LED5 on Fig. 7, page 28, the component overlay, is shown as having 16 pins. It should have 18 pins and be extended rightwards to the two pads shown. In the author's prototype the LED displays used were both MAN6710 2-digit types, LED4 having pins 16, 17 and 18 removed.

RS232-Centronics Converter (March, 1986)
On the circuit diagram (Fig. 2, p. 53), pin 11 of IC2d should be marked pin 13. Pin 10 of IC3 is missing and should be shown connected to ground. Pin 9 of IC7f becomes pin 8 and vice versa. Also, in Table 1, the figure '8' in column SW1b should be a zero and the '8' belongs in the 'DATA BITS' column. The specification of 74LS121 and 74LS07 is wrong, since LS types do not exist for these devices. They should be replaced with standard TTL. Finally, some confusion seems to have been generated over XTAL1. Although not mentioned in the text, a simple calculation should demonstrate that XTAL1 needs to be 6.144 MHz to produce the baud rates shown.

Microlight Intercom (May, 1986)
In Fig. 1 (p.29) the link between pins 2 and 3 of PL3 is not shown. C13 is shown as a polarised capacitor. The battery check contact on SK1 should be shown as normally closed. the PCB foil pattern on p.59 is shown as from the component side. It should be reversed. The miniature loudspeakers mentioned in the article cost £2.50 each, not per pair as incorrectly noted in Buylines, p.32. The author of the article suggests that it may be advisable to insert a suitable capacitor between R9 and IC3, pin 3.

Baud Rate Converter (May, 1986)
In Fig. 4 (p. 35), some confusion has crept in to the ins and outs of the circuit diagram. IC6a and IC5c need to be turned round and pins 20 and 25 of IC2 swapped round. In Fig. 5 (p.36), D4 and D3 are shown the wrong way round on the overlay. This could of course lead to the destruction of C10 as well as the presence of a second +12V rail instead of the required −12V. In Fig. 6 (p.37), SK4.3 and SK3.3 must be swapped over. In the Parts List, C10 should be 1000uF, not 100uF.

RF Oscillators (June, 1986)
Fig. 12 (p.23) does not, in fact, show a working oscillator. For a series fed arrangement, take the link from CV1a,b junction to R3 and Q1 emitter junction and not 0V, remove C1 and move C2 to shunt R2. For a shunt-fed arrangement, break the link between L1 and Vcc and take Q1 collector to Vcc via a 4k7 resistor.

Speaking Alarm Clock (August, 1986)
In the circuit diagram, Fig. 2 (p.53), diode D3 and resistor R14 should be in parallel not series as shown. The link from IC10, pin 1, to battery positive should be removed.

electronics today INTERNATIONAL

READERS SERVICES

OPEN CHANNEL

Britain's very own computer giant, ICL, is joining forces with Mercury Communications in a venture designed to obtain a 20% stake in the business communications market by 1990 — estimated, in total, to be around £1 billion. The venture will provide computer networks which, ICL hopes, an awful lot of companies worldwide will take advantage of. Apparently, Mercury was ICL's first choice as co-producer of the networks before British Telecom, because BT has less experience of operating international data networks and charges more for services too. The aim is high, but if it's on target, to mix metaphors, the pot of gold at the end of the rainbow is there for the taking. I wish the venture success.

Talking of BT

If you think my use of English is bad, at least it's not as bad as the service I've recently suffered in the hands of Grittish Smellycom, when for a total of four days my 'phone was up the Swannee, and not a sight of an engineer was to be had. Finally, after numerous calls on my patient neighbour's telephone apparatus to report the fault, an engineer arrived and repaired the fault within an hour.

I wouldn't normally go into print about technical problems with products because it gives an unfair advantage over the product provider who can't easily answer back. But, in this case, I feel I am justified. Over the last year I have reported problems to BT on five occasions. Prior to the latest debacle, I'm the first to admit, prompt service has always been effected. But it's not really the length of time which it takes to repair faults which I'm annoyed at — it's the frequency of occurrences! Furthermore, I don't have what I would regard as an adequate quality of line: what with all the crackles and pops and hisses and whines, it is difficult to hear and be heard. Also, data communication via modem is virtually impossible.

According to Mercury Communications' plans, it should be possible to hook-up to its rival telephone network service by the end of this year, thus effectively not using BT's network. It is a possibility I'm looking into.

Open The Box

A recent decision by Yorkshire Television to commit itself to 24-hour television broadcasts, okayed by the Independent Broadcasting Authority, has resulted in the use of Richard Branson's top video channel, Music Box, as an experimental all-night programme. If successful it is likely that similar deals will be negotiated with other independent television companies — the possibility of nationwide coverage of Music Box has even been suggested.

Music Box, of course, is already available to those few cable viewers in the country, and also to those of us with satellite reception equipment, but regrettably they are in a minority. By using the all-night slot which may become available on existing land-based television channels, however, the audience will be far greater. One more nail in the DBS coffin, as far as I'm concerned.

One To Watch

As of late, there has been a seemingly new name being bandied around the telecommunications world and indeed in the financial world — Vanderhoff. The company — not new (about ten years old) and definitely British (despite its name) — is well and truly on the up and up.

Although until recently Vanderhoff has simply been a supplier of specialised telecommunications equipment to buyers such as British Telecom (there they are again) and Mercury, with a series of takeovers of companies such as Eagle Telecoms, Elcom Systems and Recordacall (from Thorn Ericsson), they now become retail suppliers with an extensive network of dealers, acquired automatically through the takeovers. All the names of companies recently taken over by Vanderhoff are well known, particularly Recordacall and no doubt will boost the organisation's turnover considerably.

When I first had business dealings with Vanderhoff, some four or five years ago, turnover was, if I remember correctly, somewhat below £1m. This year's turnover is around £11 and is expected to be boosted to over £16m next year by another takeover, yet to be announced. Such rapid growth is typically only precedented by companies in the computer market, and we all know what happens to them — what goes up ... and all that! Let's hope the telecoms market is more stable, and that Vanderhoff continues to rise in a controlled fashion. If plans to join the stock market come to fruition, shares will be worth looking at.

Keith Brindley

ALF'S PUZZLE

Alf's been reading up on cryptography. The other day he devised a secret alphabet with 32 characters and started rifling through his stores cupboard for a chip set capable of encoding messages in his secret alphabet and decoding them at the other end. There were no suitable ICs to hand, so he devised an encoder and decoder which scrambled the messages at random and tried to put them together again by trial and error at the other end. He used 17½ chips, two transistors, 15 resistors, a crystal and several short lengths of wire. Then he strung a few feet of five-way ribbon cable between the stores cupboard and his workbench and started sending himself secret messages.

'What's all this?' demanded Jean-Paul Eno, the head janitor, when he saw the shambles (or breadboard, as Alf calls it). 'You can't make a mess like this. You haven't got permission.' 'It is within my power,' said Alf loftily, 'to make this circuit work with only two ICs. Furthermore and notwithstanding,' he continued, warming to his theme, 'I shall use the same IC for encryption and decryption.'

'It's probably against regulations,' muttered Jean-Paul as he swept out with vigorous strokes of the broom. After Jean-Paul Eno had left, Alf regretted his rash claim. How on earth was he going to do it?

To Alf, ICs are either 741s, 555s or CMOS logic, and as the first two didn't seem too promising he started leafing through his 'Penguin Guide To CMOS' book in search of something that would do the trick. He eventually came up with an IC that would do for both encryption and decryption — it left one of the five data lines unencrypted, but to Alf that was a minor point. On further study of his book, he came to the conclusion that the IC he had chosen was also the only one that would work.

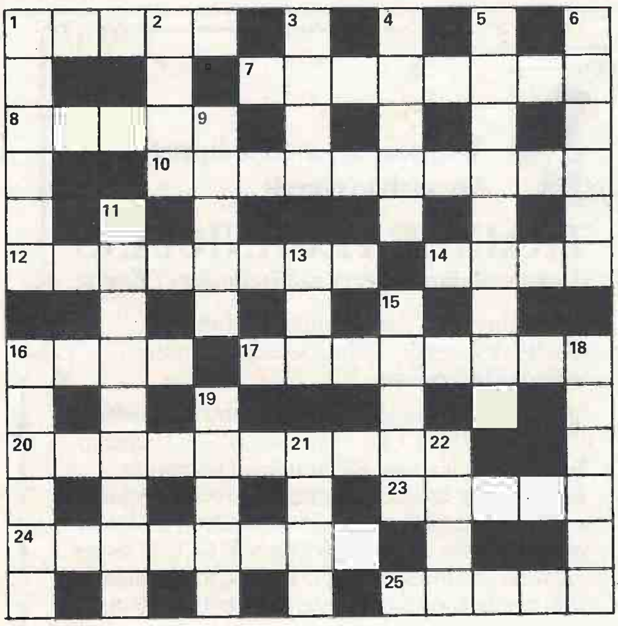
'You're almost right,' said Auntie. 'There's another similar IC that would also work.'

Which ICs were they?

The answer to last month's puzzle:

LED7 and LED8 would light up first. LED6 would never light at all because LED3 drops about 1.7V and LED6 requires about 1.9V to light.

CROSSWORD
No. 9



ACROSS

1) The colour which represents zero (5).
7) Metallic element, the oxide of which is used in the production of magnetic tape (8).
8) The space in whcih a force such as electricity or magnetism exerts its influence (5).
10) An IC socket in which the height above the PCB is kept to a minimum (3,7).
12) A write-protected disc or memory (4,4).
14) In computer terms, a complete block of data to which a directory name has been given (4).
16) Critical ______ Analysis (4)
17) You call him out when the television blows up (8).
20) The restoration of a signal to its original frequency/amplitude relationship following, say, the phono or tuner input of a pre-amplifier (2-8).
23) A resistor used to preset a load to the open collector output of an IC (3-2).
24) One of Acorn's home computers (8).
25) BASIC command which loads a program without destroying the program already resident (5).

DOWN

1) Area of computer memory used for temporary storage of input/output data, strings, etc (6).
2) In machine code, a direct jump with a return address stored on the stack (4).
3) A type of aerial, or means of flogging (4).
4) Print CHR$(58) and this will appear on the screen (5).
5) Peripheral which converts an analogue value into digital form (9).
6) To resist AC signals (6).
9) An element which when added to pure silicon produces an excess of electrons, giving an N-type semiconductor (5).
11) Instrument for measuring power (9).
13) Linear (abbreviation) (3).
15) Prevent a voltage or current exceeding a preset value (5).
16) A small variable capacitor in series with and for adjusting the value of a larger tuning capacitor (6).
18) the AC component of a DC voltage, such as the 50 Hz signal found across a power supply (6).
19) Marks on the phosphor of a CRT, or is it acne? (5).
21) A collection of neutrons, protons and electrons (4).
22) Short term for sinusoidal (4).

Solution to Crossword No. 8

ACROSS

1) In phase
8) Arcing
9) Blurred
10) BASIC
12) MSDOS
13) Dry
15) Sink
16) Isolate
17) Disc
18) AND
19) Atari
20) Ghost
24) Pointer
25) Static
26) Utility

DOWN

2) Null string
3) Harmonic
4) Slew
5) Array
6) Hi-fi
7) AGC
10) Break
11) Concurrent
14) Count
15) Sentinel
18) ASCII
21) Head
22) Port
23) SSB

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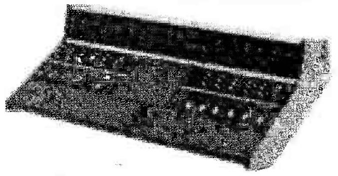

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