16 YRS WIRELESS LEADERSHIP

RF design

engineering principles and practices

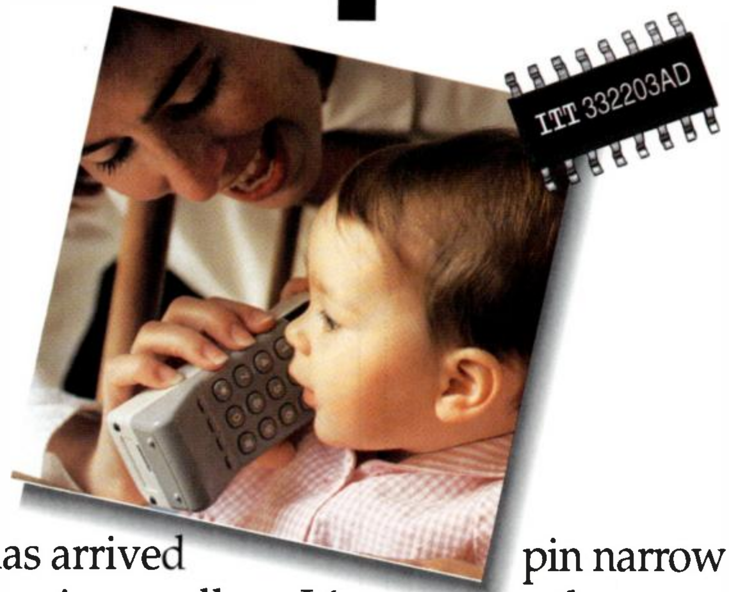
July 1995

Wireless Test Systems Benefit from New Synthesizer

Featured Technology —
Receiver Design

EMC Techniques
A Simple RF "Sniffer"

European Correspondent.



DECT has arrived and Europe's going cordless. It's a huge market and you can write yourself a great profit story...if you have the right correspondent.

And here it is: ITT's new 400 mW, 28 dB power gain RFIC power amplifier for DECT.

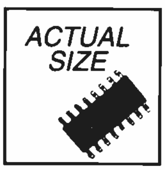
It requires only a single 3.6 volt battery, yet this 1880 -1900 MHz amplifier tolerates any mismatch in pulsed or CW operation. And, it produces an RF output signal strong enough to overcome filter and switch losses in the T/R path.

Like any good correspondent, it keeps a low profile. Its small 16-pin narrow body SOIC plastic package can fit into any design. It offers 50Ω input/output impedance. And it's tough and stable enough to handle any assignment.

It will make the most of your communications. With constant input VSWR in either the on or off state, it provides a constant load for your drive signal.

Don't risk getting written off in this competitive new market.

Call us at 703-563-3949 or fax us at 703-563-3935 for more information on this important new ITT correspondent.

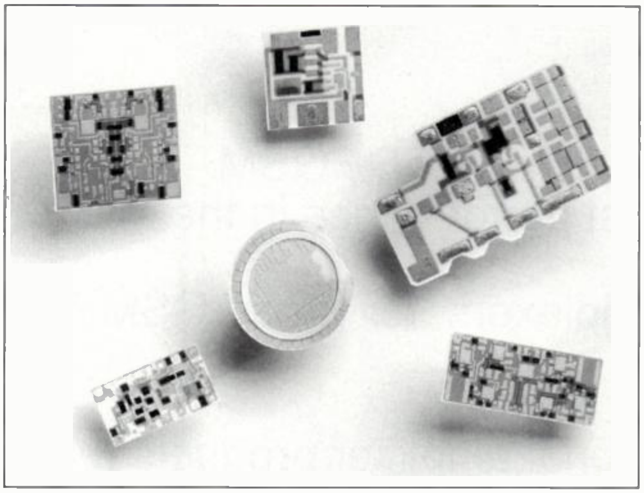


ITT GTC

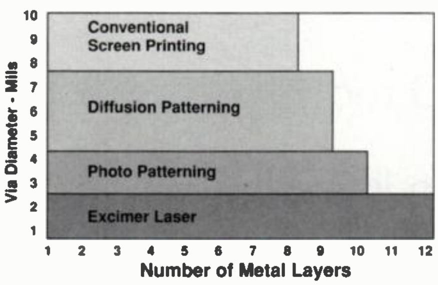
INFO/CARD 1

Custom Thick Film Circuits

Barry Industries is a leader in thick film technology. Because of our high degree of vertical integration, we are able to provide standard thick film processes, along with state of the art manufacturing capabilities, such as Diffusion Patterning, Photo Patterning and Excimer Laser Via Drilling. This enables us to attain extremely high circuit densities and up to 12 metal layers in production.



Via Design Guide



Design Guidelines

Standard Design Capabilities:

Number of Metal Layers	1 to 8
Thru Hole Metallization	1.5:1 Aspect Ratio
Edge Metallization	80% to 100%
Selective Plating	Gold and Nickel
Selective Soldering	Sn 62, 63, 96 Au/Ge Au/Sn Pb/In
Resistance Tolerance	1%, 2%, 5% and 10%
Resistance Range	.1 ohm to 100 gigohm
Minimum Via Diameter	.008"
Selective Edge Metallization	.050"/.050" Pitch
Line Width/Spacing	.005"/.005"
CAD Capability	

Advanced Design Capabilities:

Number of Metal Layers	8 to 12
Thru Hole Metallization	4.0:1 Aspect Ratio
Minimum Via Diameter	.001 - Excimer Laser Produced .002 - Photo Patterning Produced .004 - Diffusion Patterning Produced
Selective Edge Metallization	.030"/.030" Pitch
Line/Width Spacing	.002"/.002"

Standard Substrate Materials

Alumina 96% also 99%	Aluminum Nitride
Beryllium Oxide	Ferrite

Quality Assurance:

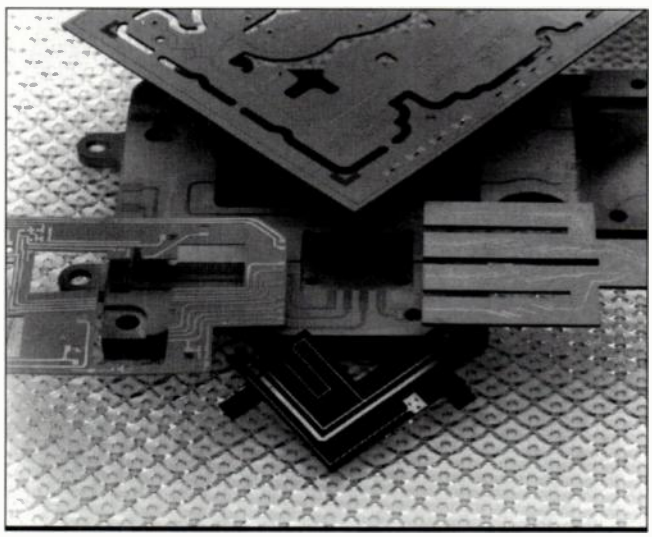
Inspection system complies with MIL-STD-45208. Calibration system complies with MIL-STD-45662. Test laboratory is capable of performing quality conformance inspection using the methods of MIL-STD-202, MIL-STD-883 and MIL-R-55342. Please consult the factory with your questions and your special design needs. We can solve your thick film problems.

Microwave PTFE (Teflon®) Circuit Boards

Barry Industries is a leading manufacturer of PTFE circuits for the microwave industry, using MIL-P-13949 specified material as well as specialty laminates for both military and commercial applications.

Commercial Grade & Specialty Laminates

TMM (Thermally Stable Microwave Material)
R04000 Series (Woven Glass, Ceramic, Thermoset)
R03000 Series (Ceramic Filled, Commercial Grade)
CLTE & TLE (Low Z-Axis CTE)
TLC (Low Cost Microwave Applications)



BARRY

Barry Industries, Inc.

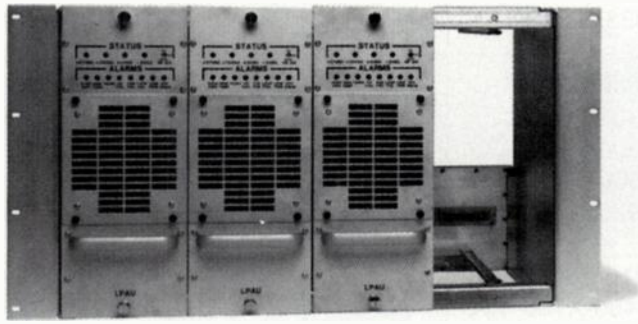
67 Mechanic Street, Attleboro, MA 02703
Tel: (508) 226-3350 Fax: (508) 226-3317

INFO/CARD 35

Milcom International MCA8000-250

High Power Multichannel Feedforward Amplifiers
Linear Technology For **CDMA/TDMA/Analog** Applications

- 25 Watt Average/250 Watt Peak Power
- Expandable (25W, 50W, 75W, 100W)
- Intermodulation Of -60dBc
- Hot Swap Capability/Redundancy
- Rack Mountable in 19" or 26" Racks
- Dimensions 14.0" x 5.5" x 16.0"
- Field Proven
- Remote Status/Fault Monitoring



FREQUENCY RANGE	869 - 894 MHZ
POWER OUTPUT	25 Watts Average Minimum/Per Module
INTERMODULATION DISTORTION	60 DBC Minimum
RF GAIN	58 DB Minimum
POWER OUTPUT STABILITY	± 0.6 DB @ 27 ± 1 VDC
OUTPUT PORT RETURN LOSS	18 DB Minimum
OUTPUT PROTECTION	Mismatch Protected (Isolator)
POWER INPUT	-10 DBM
INPUT PORT RETURN LOSS	14 DB Minimum
HARMONICS	-45 DBC Minimum
SPURIOUS	-60 DBC Minimum
DUTY CYCLE	Continuous
DC INPUT POWER	+27 VDC ± 1 VDC, 15 Amps (Typ) @ 25 W Operational +22 V to +30 VDC
OPERATING TEMPERATURE	+10° to +50°C
STORAGE TEMPERATURE	-40° to +85°C
OPERATING HUMIDITY	20% - 80% RH (Non-Condensing)
STORAGE HUMIDITY	5% - 95% RH (Non-Condensing)
CONNECTOR DC	STUD
CONNECTOR (RF OUTPUT)	N-Type
CONNECTOR (RF INPUT)	SMA
ALARMS Over Power, VSWR, DC Failure, High Temperature, Loop Failure, Low Power, Fan Failure	MONITORS Forward Power Reverse Power
FORCED AIR COOLING	Dual Fan

Milcom International Inc.

We Design and Manufacture RF Power Amplifiers

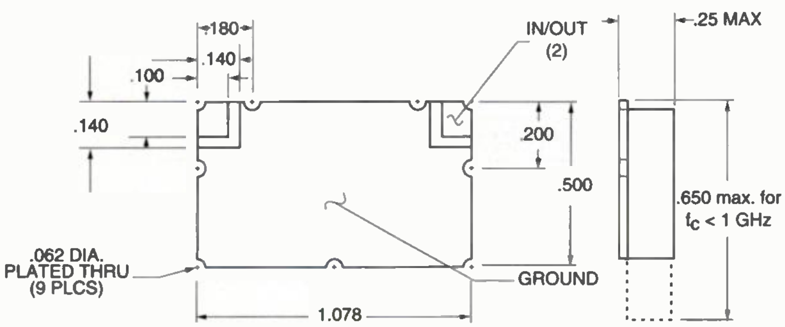
17500 Gillette Avenue, Irvine, CA 92714-5610 • 714-757-0530 • FAX 714-757-0941

INFO/CARD 37

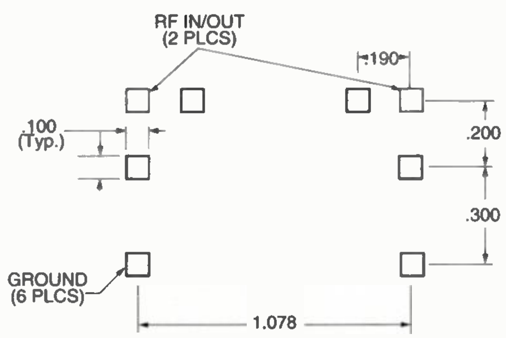
CERAMIC FILTERS

Part Number	Center Freq. (MHz)	BW (MHz)	BW I.L (dBa max.)	VSWR in BW	DELAY MIN/ MAX(ns)	Rejection dBc/MHz	Application
5SD836.5-X25-5CC	836.5	25	3.0	2.0	26/35	50 dBc@Fc+\-77.5	Cellular-AMPS
5SD881.5-X25-5CC	881.5	25	3.0	2.0	26/35	50 dBc@Fc+\-77.5	Cellular-AMPS
5SD964.0-X25-5CC	964.0	25	3.0	2.0	26/35	50 dBc@Fc+\-77.5	Cellular-AMPS
5SD902.5-X25-5CC	902.5	25	3.0	2.0	26/35	50 dBc@Fc+\-77.5	Cellular-AMPS
5SD947.5-X25-5CC	947.5	25	3.0	2.0	26/35	50 dBc@Fc+\-77.5	Cellular-AMPS
5SD888.5-X33-5CC	888.5	33	3.7	2.0	26/42	50 dBc@Fc+\-77.5	Cellular-TACS
5SD933.5-X33-5CC	933.5	33	3.7	2.0	26/42	50 dBc@Fc+\-77.5	Cellular-TACS
5SD886.0-X2-5CC	886.0	2	3.4	2.0	36/39	45 dBc@Fc+\-45	Cordless Phone
5SD931.0-X2-5CC	931.0	2	3.4	2.0	35/38	45 dBc@Fc+\-45	Cordless Phone
5SD904.0-X2-5CC	904.0	2	3.4	2.0	35/38	45 dBc@Fc+\-45	Cordless Phone
5SD906.0-X2-5CC	906.0	2	3.4	2.0	35/38	45 dBc@Fc+\-45	Cordless Phone
5SD926.0-X2-5CC	926.0	2	3.4	2.0	35/38	45 dBc@Fc+\-45	Cordless Phone
5SD915.0-X26-5CC	915.0	26	2.8	2.0	24/31	45 dBc@Fc+\-70	ISM
5SD2450-X100-5CC	2450.0	100	2.7	2.0	9/18	40 dBc@Fc+\-150	ISM
5SD1227-X10-5CC	1227.0	10	3.7	2.0	31/35	30 dBc@Fc+\-35	GPS
5SD1575-X10-5CC	1575.0	10	4.2	2.0	31/35	30 dBc@Fc+\-35	GPS
5SD1542-X34-5CC	1542.0	34	3.5	2.0	22/31	50 dBc@Fc+\-85	INMARSAT
5SD1643.5-X34-5CC	1643.5	34	3.5	2.0	21/30	50 dBc@Fc+\-85	INMARSAT
5SD1747.5-X75-5CC	1747.5	75	3.5	2.0	13/27	15 dBc@Fc+\-60	PCN
5SD1842.5-X75-5CC	1842.5	75	3.5	2.0	13/27	15 dBc@Fc+\-60	PCN
5SD1880-X60-5CC	1880.0	60	4.0	2.0	14/27	42 dBc@Fc+\-100	PCS
5SD1960-X60-5CC	1960.0	60	4.0	2.0	14/27	42 dBc@Fc+\-100	PCS
5SD2442.5-X90-5CC	2442.5	90	3.5	2.0	10/19	40 dBc@Fc+\-130	Wireless LAN

The size shown is a standard used by Lark to facilitate a low cost, easily reproducible unit. Should you require another size, please submit all of your requirements - both electrical and mechanical. This will enable Lark Engineering to quote the optimum design for your application.

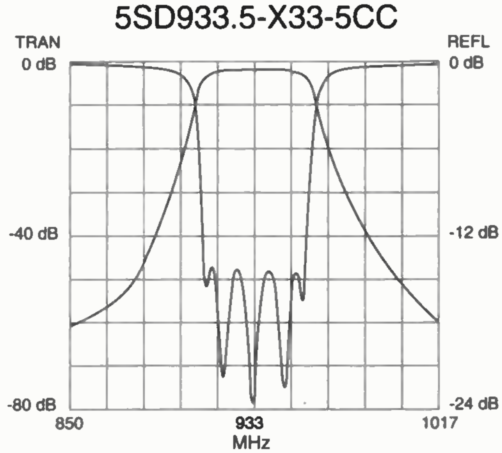


5SD FOOT PATTERN



PCB SOLDERING PATTERN LAYOUT

5SD933.5-X33-5CC



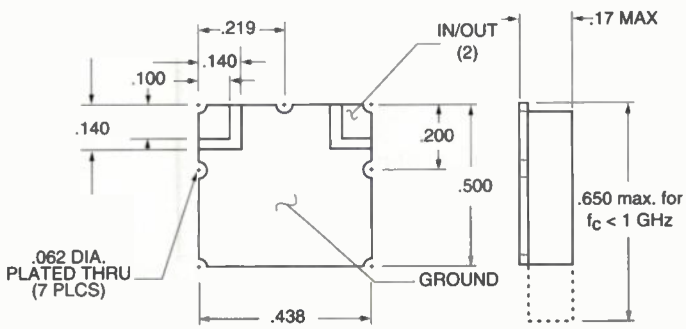
TYPICAL ELECTRICAL PERFORMANCE

Lark Engineering Company™
Div. Baier & Baier, Inc.
27282 Calle Arroyo
San Juan Capistrano, CA 92675
PHONE (714) 240-1233
FAX (714) 240-7910

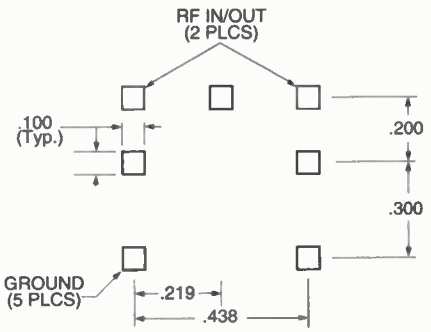
CERAMIC FILTERS

Part Number	Center Freq. (MHz)	BW (MHz)	BW I.L (dBa max.)	VSWR in BW	DELAY MIN/ MAX(ns)	Rejection dBc/MHz	Application
3SD836.5-X25-3CC	836.5	25	3.0	2.0	15/22	30 dBc@Fc+\-77.5	Cellular-AMPS
3SD881.5-X25-3CC	881.5	25	3.0	2.0	15/22	30 dBc@Fc+\-77.5	Cellular-AMPS
3SD964.0-X25-3CC	964.0	25	3.0	2.0	15/22	30 dBc@Fc+\-77.5	Cellular-AMPS
3SD902.5-X25-3CC	902.5	25	3.0	2.0	15/22	30 dBc@Fc+\-77.5	Cellular-AMPS
3SD947.5-X25-3CC	947.5	25	3.0	2.0	15/22	30 dBc@Fc+\-77.5	Cellular-AMPS
3SD888.5-X33-3CC	888.5	33	4.0	2.0	14/21	27 dBc@Fc+\-77.5	Cellular-TACS
3SD933.5-X33-3CC	933.5	33	4.0	2.0	14/21	27 dBc@Fc+\-77.5	Cellular-TACS
3SD886.0-X2-3CC	886.0	2	3.0	2.0	18/21	22 dBc@Fc+\-45	Cordless Phone
3SD931.0-X2-3CC	931.0	2	3.0	2.0	19/22	22 dBc@Fc+\-45	Cordless Phone
3SD904.0-X2-3CC	904.0	2	3.0	2.0	19/22	22 dBc@Fc+\-45	Cordless Phone
3SD906.0-X2-3CC	906.0	2	3.0	2.0	19/22	22 dBc@Fc+\-45	Cordless Phone
3SD926.0-X2-3CC	926.0	2	3.0	2.0	19/22	22 dBc@Fc+\-45	Cordless Phone
3SD915.0-X26-3CC	915.0	26	3.0	2.0	15/21	25 dBc@Fc+\-70	ISM
3SD2450-X100-3CC	2450.0	100	1.9	2.0	4/8	30 dBc@Fc+\-300	ISM
3SD1227-X10-3CC	1227.0	10	3.7	2.0	20/23	18 dBc@Fc+\-35	GPS
3SD1575-X10-3CC	1575.0	10	4.2	2.0	20/22	18 dBc@Fc+\-35	GPS
3SD1542-X34-3CC	1542.0	34	3.4	2.0	12/18	25 dBc@Fc+\-85	INMARSAT
3SD1643.5-X34-3CC	1643.5	34	3.4	2.0	12/18	25 dBc@Fc+\-85	INMARSAT
3SD1747.5-X75-3CC	1747.5	75	2.1	2.0	5.5/9.5	12 dBc@Fc+\-100	PCN
3SD1842.5-X75-3CC	1842.5	75	2.1	2.0	5.5/9.5	12 dBc@Fc+\-100	PCN
3SD1880-X60-3CC	1880.0	60	2.0	2.0	6/10	30 dBc@Fc+\-200	PCS
3SD1960-X60-3CC	1960.0	60	2.0	2.0	6/10	30 dBc@Fc+\-200	PCS
3SD2442.5-X90-3CC	2442.5	90	1.8	2.0	4.5/7	30 dBc@Fc+\-300	Wireless LAN

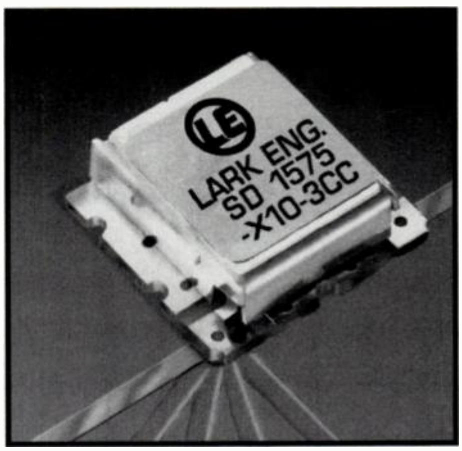
The size shown is a standard used by Lark to facilitate a low cost, easily reproducible unit. Should you require another size, please submit all of your requirements - both electrical and mechanical. This will enable Lark Engineering to quote the optimum design for your application.



SD FOOT PATTERN



PCB SOLDERING
PATTERN LAYOUT



INFO/CARD 39

Lark Engineering Company™
Div. Baier & Baier, Inc.
27282 Calle Arroyo
San Juan Capistrano, CA 92675
PHONE (714) 240-1233
FAX (714) 240-7910

T/R UHF POWER AMPLIFIER SUBSYSTEM
225 - 400 MHZ 100 WATTS

- **UHF HIGH POWER AMPLIFIER WITH PREAMPLIFIER**
- **CURRENT LIMITING**
- **THERMAL SHUTDOWN**
- **Tx/Rx SWITCHING BY BOTH PTT & RF SENSE**
  Switching speed ≤ 30 milliseconds.
- **HIGH EFFICIENCY (minimizes cooling requirements)**
- **RUGGED** o **SMALL SIZE**

Subsystem Specifications

Frequency:	225 - 400 MHz	Size:	9.0" X 5" X 1.5"
DC Supply:	22 - 30 VDC	Weight:	< 5 lbs
Altitude:	50,000 ft.	Temperature:	-54°C to +90°C.
Connectors:	One Power/Control Connector Type N,TNC or SMA input/output		
Cooling:	Conduction cooling.	Vibration, Shock:	110 G

High Power Amplifier (HPA) Specifications

Power: 100W CW typical Gain: 8 - 10 dB typical (Higher gain available)

Input/Out VSWR: Compatible with 50 ohm system.
(HPA is rugged and tolerant of mismatches.)

Pre-amplifier with integrated 1 W limiter

Gain: 10 dB minimum NF: 3 - 4 dB typical at 25°C

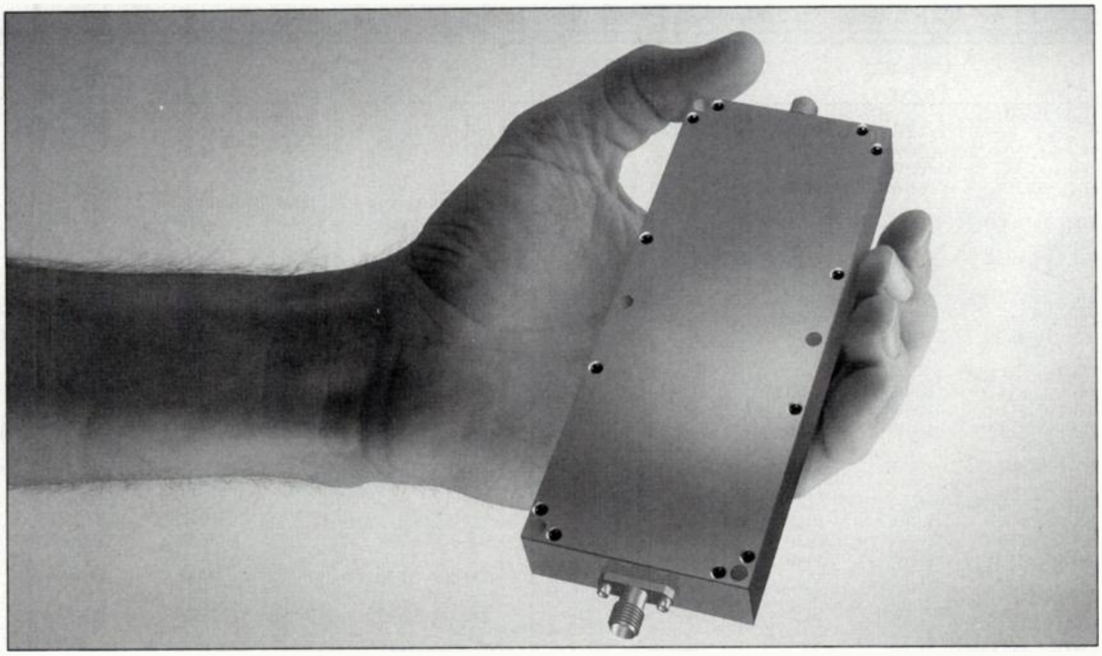
LCF ENTERPRISES
651 Via Alondra, Unit 712
Camarillo, CA 93012 USA

Phone: 805-388-8454
FAX: 805-389-5393

LCF ENTERPRISES

RF POWER AMPLIFIERS

30 WATT UHF POWER AMPLIFIER



- **ULTRA HIGH EFFICIENCY**
- **SMALL SIZE**
- **BATTERY-OPERATED**
- **RUGGED**

OUTPUT POWER:	**30 Watts cw**	**FREQUENCY:**	**340 - 370 MHz**
DC VOLTAGE:	12 VDC	GAIN:	40 dB
EFFICIENCY:	40% minimum	ENABLE/DIS:	0 to 5 VDC
CONNECTORS:	SMA Female	TEMPERATURE:	- 30 to 80 °C
SIZE:	**4.75" x2.0" x 0.5"**		

LCF ENTERPRISES
651 Via Alondra, Unit 712
Camarillo, CA 93012 USA

Phone: 805-388-8454
FAX: 805-389-5393

LCF ENTERPRISES

RF POWER AMPLIFIERS

(Standard or Custom)

1 MHz - 2 GHz • 1 W - 1 kW

Part No.	Output Power	Gain	MODULES DC Supply	PKG
2 MHz - 30 MHz				
30-2-5-35	5W	35dB	24/28V	E3
30-2-50-35	50W	35dB	24/28V	E3
30-2-100-35	100W	35dB	28V	E3
30-2-200-35	200W	35dB	28V	E3
30 MHz - 100 MHz				
100-30-5-35	5W	35dB	24/28V	E3
100-30-100-35	100W	35dB	28V	E3
50 MHz - 150 MHz				
150-50-2-40	2W	40dB	12/15V	C3
150-50-100-35	100W	35dB	28V	A3
150 MHz - 200 MHz				
200-150-100-10	100W	10dB	28V	A1
200-150-100-18	100W	18dB	28V	A2
200-150-100-35	100W	35dB	28V	A3
200-150-200-35	200W	35dB	28V	A3
50 MHz - 250 MHz				
250-50-200-10	160W	10dB	28V	A1
250-50-200-18	160W	18dB	28V	A2
250-50-200-35	160W	35dB	28V	A3
50 MHz - 400 MHz				
400-50-1-30	1W	30dB	12/15V	C3
225 MHz - 400 MHz				
400-225-1-35	1W	35dB	12/15V	C3
400-225-10-35	10W	35dB	24/28V	A3
400-225-30-10	30W	10dB	24/28V	A1
400-225-30-18	30W	18dB	24/28V	A2
400-225-30-35	30W	35dB	24/28V	A3, B3

Part No.	Output Power	Gain	MODULES DC Supply	PKG
400-225-50-10	50W	10dB	24/28V	A1
400-225-50-18	50W	18dB	24/28V	A2
400-225-50-35	50W	35dB	24/28V	A3
400-225-100-10	100W	10dB	28V	A1
400-225-100-18	100W	18dB	28V	A2
400-225-100-35	100W	35dB	28V	A3
225 MHz - 600 MHz				
600-225-30-10	30W	10dB	24/28V	A1
600-225-30-18	30W	18dB	24/28V	A2
600-225-30-30	30W	30dB	24/28V	A3, B3
400 MHz - 600 MHz				
600-400-30-10	30W	10dB	24/28V	A1
600-400-30-18	30W	18dB	24/28V	A2
600-400-30-30	30W	30dB	24/28V	A3, B3
925 MHz				
925-1-8	1W	8dB	12/15V	D1
100 MHz - 500 MHz				
500-100-5-30	5W	30dB	24/28V	A3
500-100-10-30	10W	30dB	24/28V	A3
500-100-100-30	100W	30dB	28V	A3
500 MHz - 1000 MHz				
1000-500-10-8	10W	8dB	24/28V	A1
1000-500-10-16	10W	16dB	24/28V	A2
1000-500-10-30	10W	30dB	24/28V	A3
10 MHz - 1200 MHz				
1200-10-10-30	10W	30dB	24/28V	A3

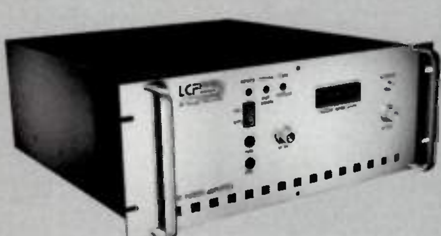
* Test Fixture (Option "B") includes heat sink, fan, thermal shutdown, and electrical fuse protection
** Rack-mount amplifiers: 120 Vac - 60 Hz / 240 Vac - 50 Hz

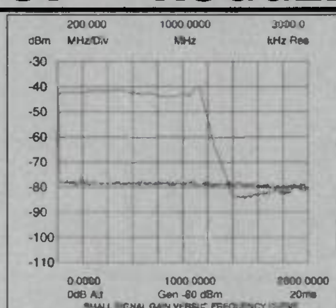
MODULES - SMALL SIZE • HIGH EFFICIENCY

- 200 watts
- 150 - 200 MHz
- 55% overall efficiency
- 35 dB gain
- 4.84" x 2.0" x 1.0"

- 100 watts
- 225 - 400 MHz
- 45% overall efficiency
- 10 dB gain
- 3.0" x 2.0" x 1.0"

SYSTEMS - LOW COST • RUGGED PROTECTION





- 10 MHz - 1200 MHz
- 10 watts CW
- 40 dB
- 19" x 7" x 18"
- 35 lbs maximum

LCF ENTERPRISES • 651 Via Alondra, # 712 • Camarillo 93012 USA • Phone: 805-388-8454 • FAX: 805-389-5393

TEMEX STANDARD 10.7MHZ MONOLITHIC CRYSTAL FILTERS CHANNEL SPACING FOR 12.5 • 20 • 25 AND 50KHZ

ELECTRONICS, INC.

CRYSTALS • CRYSTAL FILTERS • L/C FILTERS

NO.	TEMEX	PASSBAND		STOPBAND				LOSS	RIPPLE	ULT. REJ	TERM. (Rp//Cp)
POLES	P/N	dB	±KHz	dB	±KHz	dB	±KHz	dB	dB-MAX	dB-MIN	OHM/PF
2	TE5000	3	3.75	20	18.0	–	—	2	1.0	50	1800//+4
4	TE5010	3	3.75	30	14.0	–	—	3	2.0	60	1500//+3
6	TE5020	6	3.75	60	12.5	–	—	4	2.0	70	1500//+3
8	TE5030	6	3.75	60	10.0	90	12.5	5	2.0	80	1500//+3
2	TE5040	3	6.5	20	30.0	–	—	1	1.0	50	2700//0
4	TE5050	3	6.5	30	15.0	–	—	2	2.0	75	3100//0
6	TE5060	6	6.5	60	19.5	–	—	3	2.0	90	3100//0
8	TE5070	6	6.5	60	13.0	80	17.5	4	2.0	100	3100//0
2	TE5080	3	7.5	20	35.0	–	—	1	1.0	50	3000//0
4	TE5090	3	7.5	30	17.5	–	—	2	2.0	75	3300//0
6	TE5100	6	7.5	60	22.5	–	—	3	2.0	90	3300//0
8	TE5110	6	7.5	60	15.0	80	20.0	3	2.0	100	3300//0
2	TE5120	3	15.0	20	70.0	–	—	1	1.0	35	5000//-1
4	TE5130	3	15.0	30	35.0	–	—	2	2.0	60	5000//-1
6	TE5140	6	15.0	60	45.0	–	—	2	2.0	90	5000//-1
8	TE5150	6	15.0	60	30.0	80	40.0	3	2.0	100	5000//-1

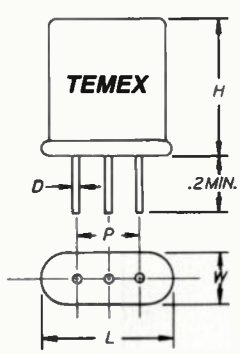
NOTES:

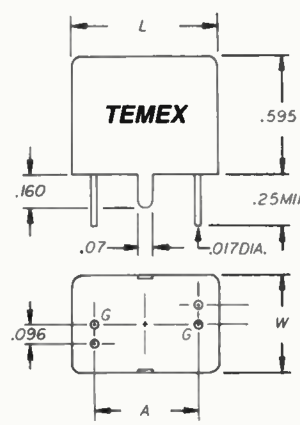
1. Maximum inband ripple over temp. range -20ºC to 70ºC.
2. Parallel termination capacity is adjusted for optimum filter response. Nominal parallel capacity, Cp: ±3pf. Impedance, Rp specified above.
3. A tandem set is a combination of matched 2 pole filter units making up multipole filters [example: 4 pole response; (2) 2 pole units-matches.]
4. These models available in other packages not shown below.

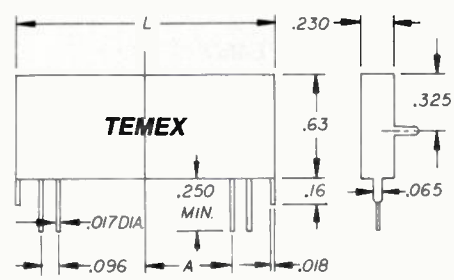
TO ORDER: TEMEX P/N and PACKAGE TYPE: Example: TE5100M5.

# POLES	PACKAGE SELECTION
2	M3 or 4
4	M3 or 4(x2)M5, 6, 7, 8 or 9
6	M3 or 4(x3)M5, 6, 8 or 9
8	M3 or 4(x4)M6 or 9

(x2)=2 cases (x3)=3 cases (x4)=4 cases







PKG	L	W	H	P	D
M3	.435	.185	.45/.53	.192	.017
M4	.750	.350	.750	.486	.030

HC-18/3:M3 HC-6/3:M4
HC-49/3:M3

PKG	L	W	A
M5	.590	.470	.354
M6	.745	.496	.528

PKG	L	A
M7	.89	.216
M8	1.32	.435
M9	1.75	.645

*Consult **TEMEX** for your custom crystal and filter requirements.*

3030 W. Deer Valley Rd. • Phoenix, AZ 85027 • 602-780-1995 • (FAX) 602-780-2431

TEMEX STANDARD 21.4 MHZ MONOLITHIC CRYSTAL FILTERS CHANNEL SPACING FOR 12.5 • 20 • 25 AND 50KHZ

ELECTRONICS, INC.

CRYSTALS • CRYSTAL FILTERS • L/C FILTERS

NO.	TEMEX	PASSBAND		STOPBAND				LOSS	RIPPLE	ULT. REJ	TERM. (Rp//Cp)
POLES	P/N	dB	±KHz	dB	±KHz	dB	±KHz	dB	dB-MAX	dB-MIN	OHM/PF
2	TE5180	3	3.75	15	12.5	–	—	2	1.0	50	850//+6
4	TE5190	3	3.75	30	12.5	–	—	3	2.0	70	850//+5
6	TE5200	6	3.75	60	12.5	–	—	4	2.0	90	850//+5
8	TE5210	6	3.75	60	10.0	80	12.5	5	2.0	100	850//+5
2	TE5220	3	6.5	15	20.0	–	—	2	1.0	50	1300//+2
4	TE5230	3	6.5	30	22.5	–	—	3	2.0	70	1400//0
6	TE5240	6	6.5	60	22.5	–	—	4	2.0	90	1400//0
8	TE5250	6	6.5	60	17.5	80	22.5	4	2.0	100	1400//0
2	TE5260	3	7.5	15	25.0	–	—	2	1.0	50	1500//0
4	TE5270	3	7.5	30	25.0	–	—	3	2.0	70	1600//0
6	TE5280	6	7.5	60	25.0	–	—	4	2.0	90	1600//0
8	TE5290	6	7.5	60	20.0	80	25.0	4	2.0	100	1600//0
2	TE5300	3	15.0	15	50.0	–	—	2	1.0	45	3000//0
4	TE5310	3	15.0	30	45.0	–	—	3	2.0	60	3000//-1
6	TE5320	6	15.0	60	45.0	-	—	3	2.0	90	3000//-1
8	TE5330	6	15.0	60	33.0	80	45.0	4	2.0	100	3000//-1

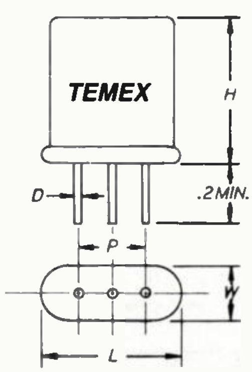
NOTES:

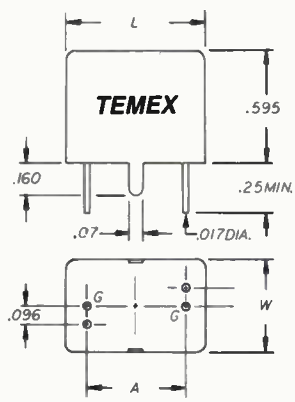
1. Maximum inband ripple over temp. range -20ºC to 70ºC.
2. Parallel termination capacity is adjusted for optimum filter response. Nominal parallel capacity, Cp: ±3pf. Impedance, Rp specified above.
3. A tandem set is a combination of matched 2 pole filter units making up multipole filters [example: 4 pole response; (2) 2 pole units-matched.]
4. These models available in other packages not shown below.

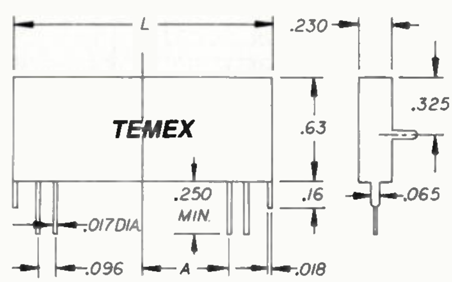
TO ORDER: TEMEX P/N and PACKAGE TYPE: Example TE5280M3

# POLES	PACKAGE SELECTION
2	M1, 2 or 3
4	M1, 2 or 3(x2)M5, 6, 7, 8 or 9
6	M1, 2 or 3(x3)M5, 6, 8 or 9
8	M1, 2 or 3(x4)M6 or 9

(x2) = 2 cases (x3) = 3 cases (x4) = 4 cases







PKG	L	W	H	P	D
M1	.300	.100	.310	.114	.017
M2	.310	.125	.320/.345	.148	.017
M3	.435	.185	.45/.53	.192	.017

HC-44/3:M1 HC-45/3:M2 HC-18/3:M3 HC49/3:M3

PKG	L	W	A
M5	.590	.470	.354
M6	.745	.496	.528

PKG	L	A
M7	.89	.216
M8	1.32	.435
M9	1.75	.645

All specifications subject to change without notice.

*Consult **TEMEX** for your custom crystal and filter requirements.*

3030 W. Deer Valley Rd. • Phoenix, AZ 85027 • 602-780-1995 • (FAX) 602-780-2431

TEMEX ELECTRONICS, INC.

STANDARD
45.0 MHz
MONOLITHIC CRYSTAL FILTERS

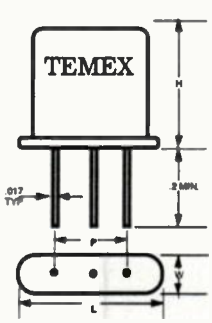
NUMBER OF POLES	MODE	TEMEX P/N	PASSBAND		STOPBAND		LOSS	RIPPLE	ULT.REJ.	TERMINATION Ohms/pF
			dB	± KHz	dB	± KHz	dB	dB-MAX	dB-MIN	
2	3-OT	TE9420	3	3.75	18	16	3	1	40	2000//-1.0
4	3-OT	TE9310	3	3.75	30	12.5	3	1	70	2000//-1.0
2	3-OT	TE7420	3	7.5	18	28	2	1	40	3000//-1.0
4	3-OT	TE7430	3	7.5	40	30	3	1	70	3000//-1.0
2	3-OT	TE7440	3	15	15	47	2	1	40	8000//-1.5
4	3-OT	TE7450	3	15	30	50	3	1	70	8000//-1.5
2	Fund	TE7730	3	15	15	50	2	1	40	1100//+1.5
4	Fund	TE7740	3	15	40	60	3	1	70	800//+1.0

NOTES:

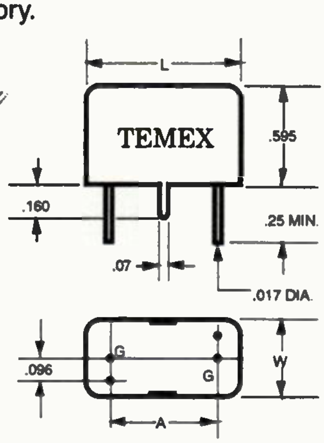
1. Maximum inband ripple over temp. range -20°C to 70° C.
2. Parallel termination capacity is adjusted for optimum filter response. Nominal parallel capacity,Cp: ± 3pf. Impedance, Rp specified above.
3. A tandem set is a combination of matched 2 pole filter units making up multipole filters [example:4 pole response:(2) 2 pole units- matched.]
4. These models available in other packages not shown below.
5. Standard package = M2.
6. 50 Ohms Z I/O available in our M5 or larger packages.
7. 3-OT =Third overtone crystals. Fund = Fundamental crystals.
8. Other models available, consult factory.

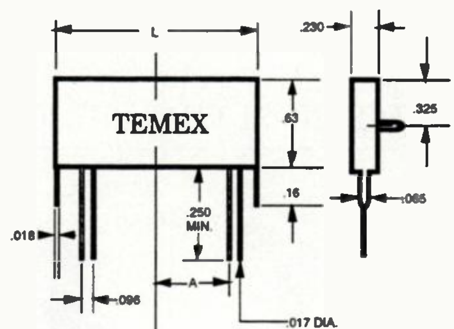
# POLES	PACKAGE SELECTION
2	M1, 2 or 3
4	M1,2 or 3(x2)M5,6,7,8,or9

(x2) = 2 cases



NOT TO SCALE





PKG	L	W	H	P
M1	.300	.100	.310	.114
M2	.310	.125	.32/.345	.148
M3	.435	.185	.45/.53	.192

HC-44/3:M1 HC-45/3:M2 HC-18/3:M3 HC-49/3:M3

PKG	L	W	A
M5	.590	.470	.354
M6	.745	.496	.528

PKG	L	A
M7	.89	.216
M8	1.36	.435
M9	1.79	.645

All specifications subject to change without notice.

Consult ***TEMEX*** for your custom crystal and filter requirements.

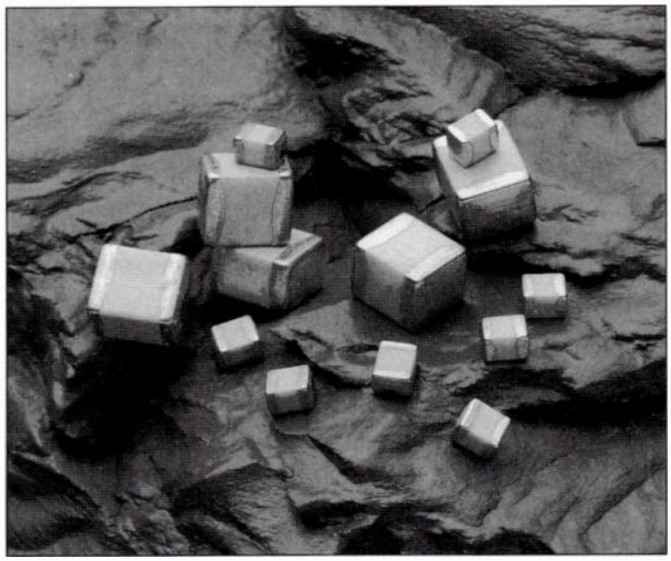
3030 W. Deer Valley Rd. Phoenix, AZ 85027 (602)780-1995 - FAX (602)780-2431

High-Q NPO
"Porcelain Replacement" Chip Capacitors

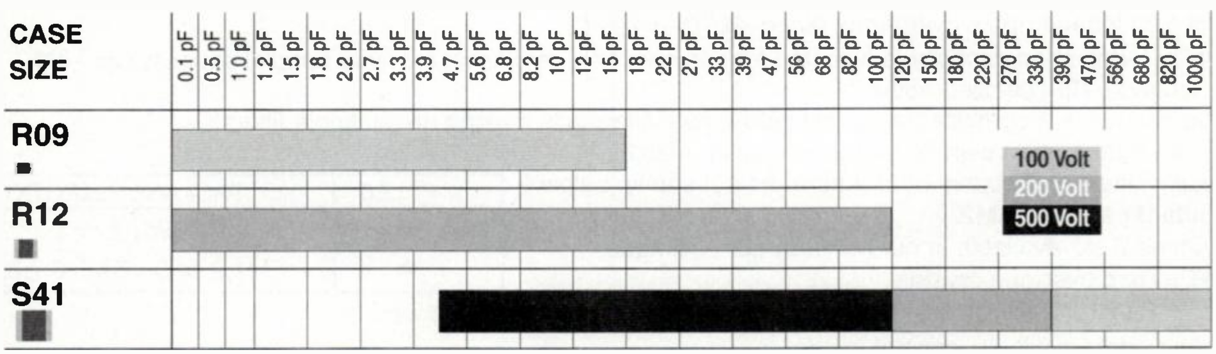
JOHANSON
TECHNOLOGY

DESCRIPTION

Johanson Technology offers these High-Q NPO capacitors as a low cost alternative to porcelain capacitors while maintaining the high quality factor associated with them. These chips are offered in ultra miniature size 0403, industry standard size 0505, and the extended range size 1210 which can replace the ".110 x ".110 size in most applications. Nickel barrier terminations plated with either Tin and Gold are standard. High-Q NPO capacitors are ideally suited for RF and microwave applications requiring high Q, low ESR, and high resonant frequency .

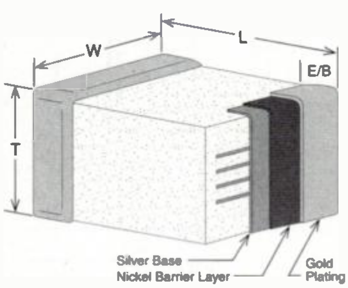


VOLTAGE AND CAPACITANCE SELECTION



Values shown above represent preferred values. High-Q capacitors are offered in 24 values per decade in the following significant digits: 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

MECHANICAL CHARACTERISTICS



PHYSICAL DIMENSIONS	R09 0403	R12 0505	S41 1210
LENGTH (Millimeters)	.040 ± .010" (1.00)	.055 ± .015" (1.40)	.120 ± .015" (3.05)
WIDTH (Millimeters)	.030 ± .010" (0.75)	.055 ± .015" (1.40)	.100 ± .015" (2.54)
THICKNESS MAX (Millimeters)	.035" (0.90)	.040" (1.02)	.060" (1.52)
ENDBAND MAX (Millimeters)	.012 (.350)	.015 (.380)	.025 (.640)

Stanford Microdevices

1.9 GHz Lineup

Low Noise PHEMTs

Part No.	Bias	Nf	Ga	P1dB	Package
SPF-884 *	2v @ 15mA	0.3dB	15dB	+10dBm	86
SPF-2084 *	5v @ 50mA	0.3dB	16dB	+20dBm	86

* Self-biased model available

Power PHEMTs

Part No.	Bias	Ga	P1dB	PAE	Package
SHF-0185 *	8V @ 150mA	15dB	+27.5dBm	+37dBm	85
SHF-0208S	8V @ 300mA	13dB	+30.5dBm	+40dBm	08S
SHF-0508S	8V @ 600mA	12dB	+33.5dBm	+43dBm	08S
SHF-1008S	8V @1200mA	10dB	+36.5dBm	+46dBm	08S

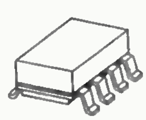
* Self-biased model available

MMIC Amplifiers

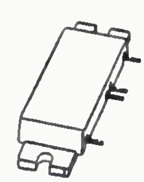
Part No.	Bias	Ga	P1dB	Features	Package
SMM-008S	12V @ 100mA	18dB	+15.0dBm	2dB Nf, AGC	08S
SMM-108	12V @ 70mA	18dB	+12.0dBm	3dB Nf, AGC	SO8
SMM-208S	5V @0.5A, -5V	25dB	+29.5dBm	30% PAE	08S
SMM-210	5V @0.7A, -5V	25dB	+30.5dBm	30% PAE	10
SMM-280-2	9V @1.4A, -5V	24dB	+34.0dBm	20% PAE	80
SMM-280-4	9V @2.8A, -5V	24dB	+36.5dBm	20% PAE	80


85


86


08S


SO8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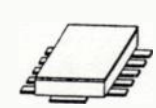
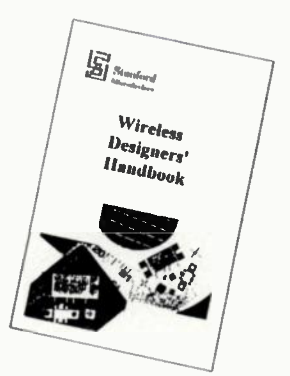

10

Call 1(800)SMI-MMIC for your free copy of Stanford's NEW 48-Page Wireless Designers' Handbook! Or fax your request at (408)496-4774.



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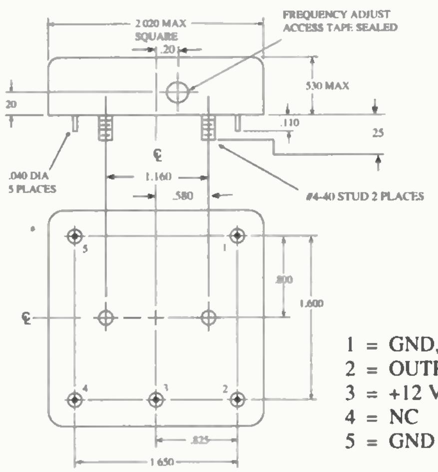
10.0 MHz SATCOM/BASE STATION TCXO's

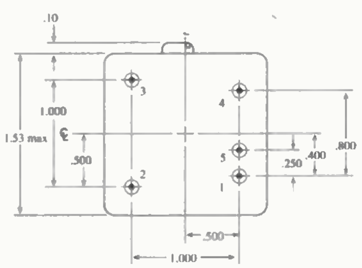
Stabilities to ±0.1 PPM! ±1 x 10^{-9}/second Peak to Peak

Oscillatek has introduced an entire family of 10 MHz TCXO's designed to bridge the gap between OCXO's and TCXO's. These parts have been optimized for excellent short-term stability and ***LOW AGING.*** With over 100,000 units produced and units in constant production we can offer ***LOW PRICE*** and ***QUICK DELIVERY.***



1 = GND, CASE
2 = OUTPUT
3 = +12 VDC
4 = NC
5 = GND

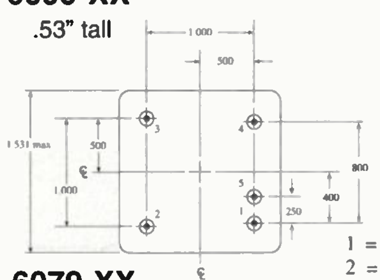
6024-XX



1 = OUTPUT
2 = + 12 VDC
3 = CASE
4 = CASE
5 = GND, CASE

Pin Dia. = .030

6099-XX
.53" tall



6079-XX
.53" tall

1 = OUTPUT
2 = +12VDC
3 = GND, CASE
4 = VCO
5 = GND, CASE

Pin Dia. = .030

6024-XX 6099-XX 10.0 MHz SINEWAVE

STABILITY OPTIONS		6024 - XX	6099-XX
-01	0° to +70°C	±0.1 PPM	±0.2 PPM
-02	0° to +70°C	±0.3 PPM	±0.5 PPM
-03	0° to +70°C	±0.5 PPM	±1.0 PPM
-04	-40° to +85°C	±1.0 PPM	±1.0 PPM
-05	-55° to +85°C	±1.0 PPM	±1.5 PPM
-XX	CALL FOR OTHER OPTIONS		

ALAN VARIANCE:

-01	±1 x 10^{-10} at tau = 1 second
-02 thru -05	±2 x 10^{-10} at tau = 1 second

AGING:

-01 thru -02	<0.2 PPM/year <1.0 PPM/10 years	< 0.25 PPM/year < 1.5 PPM/10 years
-03 thru -05	<0.5 PPM/year <2.0 PPM/10 years	< 0.5 PPM/year < 2.5 PPM/10years

PHASE NOISE:

-100 dBc at	10 Hz
-130 dBc	100 Hz
-150 dBc	1.0 KHz
-155 dBc	>10.0 KHz

+12.0 VDC ±5% Input   +6.5 to +10 dBm Output into 50Ω

6079 - XX 10.0 MHz HCMOS

STABILITY OPTIONS		AGING/YEAR	10 YEARS
6079 -01	0° to +70°C	±0.2 PPM	±1.5 PPM
6079 -02	0° to +70°C	±0.5 PPM	±1.5 PPM
6079 -03	0° to +70°C	±1.0 PPM	±2.0 PPM
6079 -04	-40° to +85°C	±1.0 PPM	±2.5 PPM
6079 -05	-55° to +85°C	±1.0 PPM	±2.5 PPM
6079 -XX	CALL FOR OTHER OPTIONS		

SHORT TERM and ALAN VARIANCE PER ABOVE

+12.0 VDC ± 5% INPUT   HCMOS 15mA Max

VOLTAGE TRIM   +0.5 to +4.5 VDC Positive Slope

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The AN900 family of spectrum analyzers are designed to help you quickly track down system problems. Even intermittent problems can be detected and captured automatically with the AN900's unique unattended monitoring feature.

Other built-in AN900 features including a sensitive AM/FM receiver, high speed sweep, digital oscilloscope, and FFT analyzer provide powerful diagnostic capabilities that enable you to effectively analyze the source of problems.

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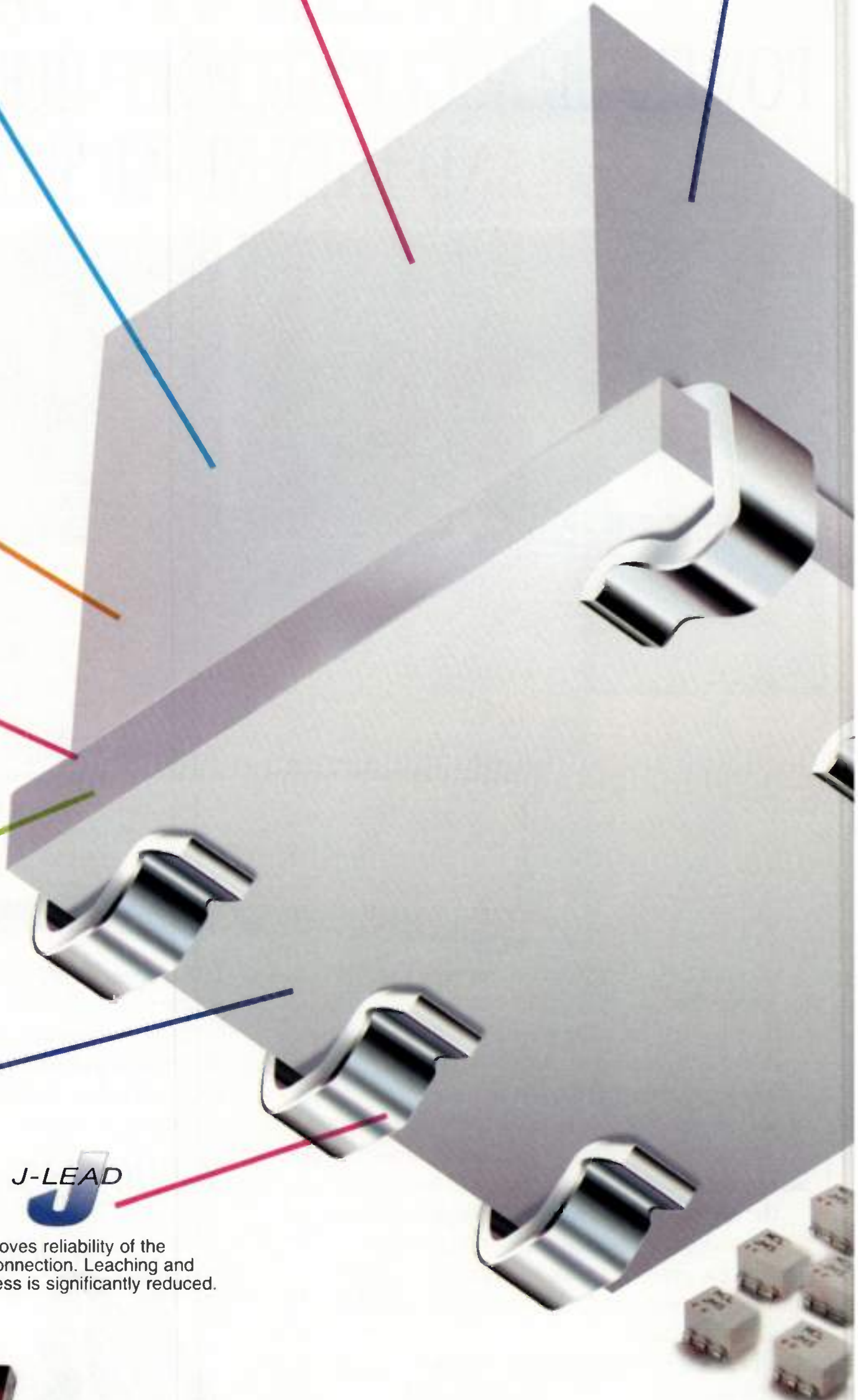

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J MIXERS UNPRECEDENTED IN VALUE.

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from $4.25 (qty. 10-49)

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From cellular to satellite applications, this is the tough, reliable surface mount mixer you demand! JMS...from Mini-Circuits!

Mini-Circuits...we're redefining what VALUE is all about!

SPECIFICATIONS

Model	LO (dBm)	Freq. (MHz) LO/RF	Freq. (MHz) IF	Midband (dB, Typ.) Conv. Loss	Isol. L-R	Isol. L-I	$ea. (qty. 1-9)
JMS-1	+7	2-500	DC-500	5.75	45	45	4.95
JMS-1LH	+10	2-500	DC-500	5.75	55	45	8.45
JMS-1MH	+13	2-500	DC-500	5.75	60	45	9.45
JMS-1H	+17	2-500	DC-500	5.90	50	50	11.45
JMS-2L	+3	800-1000	DC-200	7.0	24	20	7.45
JMS-2	+7	20-1000	DC-1000	7.0	50	47	7.45
JMS-2LH	+10	20-1000	DC-1000	6.5	48	35	9.45
JMS-2MH	+13	20-1000	DC-1000	7.0	50	47	10.45
JMS-2H	+17	20-1000	DC-1000	7.0	50	47	12.45
JMS-2W	+7	5-1200	DC-500	6.8	60	48	7.95
JMS-11X	+7	5-1900	5-1000	6.7	35	37	4.25*

Note: *10-49 qty.

Mini-Circuits®

P.O Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718)332-4661

or detailed specs on all Mini-Circuits products refer to • THOMAS REGISTER • MICROWAVE PRODUCT DATA DIRECTORY • EEM • MINI-CIRCUITS' 740- pg. HANDBOOK.

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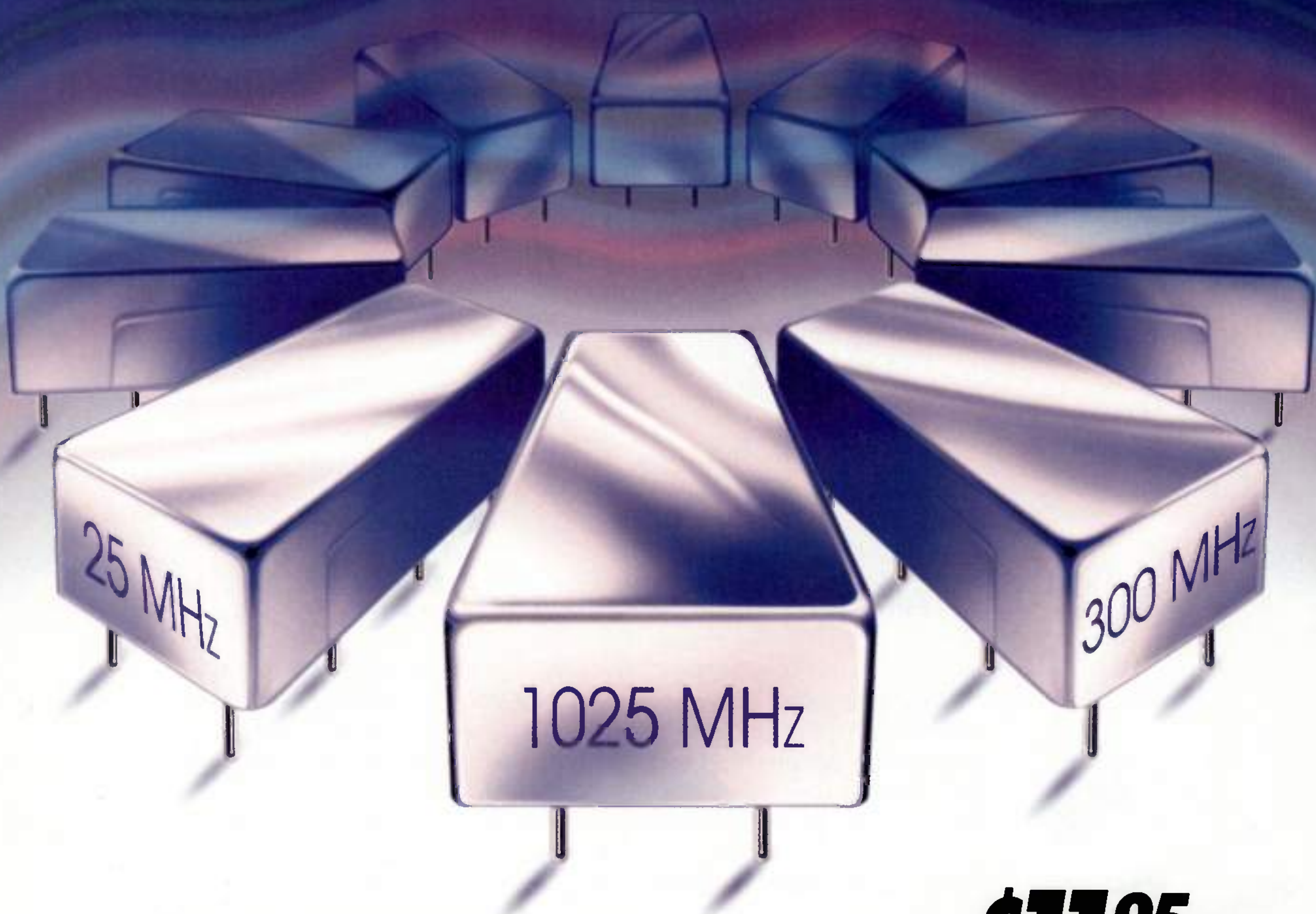
F 181 Rev A

INFO/CARD 3

VOLTAGE CONTROLLED OSCILLATORS



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POS-150	75-150	-103	-23	18	11.95
POS-200	100-200	-102	-24	18	11.95
POS-300	150-280	-100	-30	18	13.95
POS-400	200-380	-98	-28	18	13.95
POS-535	300-525	-93	-26	18	13.95
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POS-1025	685-1025	-84	-23	22	16.95

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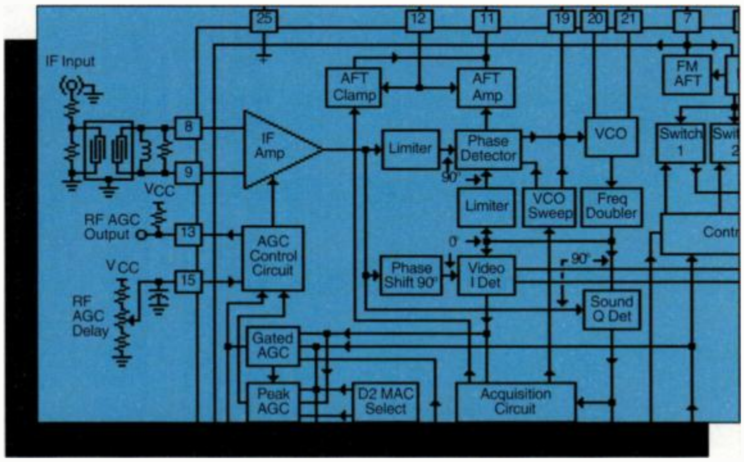
featured technology



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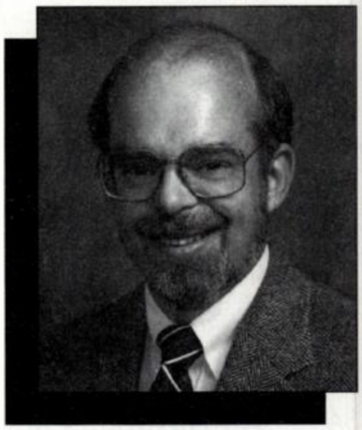
Argus Integrated Media — A New Name, an Ambitious Mission



Dear *RF Design* readers:

A new powerhouse in the information market is devoted to maximizing the efficiency of the flow of information you rely on for your professional development and decision-making.

Argus Integrated Media was formed in June to focus the entire strength of a major communications company on the information market. Our basis is seven publications in various segments of the information technology industry, five annual directories, three trade shows and a host of seminars and conferences, but Argus Integrated Media also brings you information generated by our divisions involved in international market research, electronic publishing, custom publishing, printing and mailing services, data base marketing and more.

Argus Integrated Media combines the very best that all the divisions and subsidiaries of Argus Inc. have to offer. Now, all those talents and services are devoted to creative approaches to developing and delivering information to the RF industry.

As you know, *RF Design* has been a leader in the larger world of information that reaches beyond the pages of our magazine — through our RF Expo trade shows and conferences, our unique software distribution service, and the valuable technical article collections that make up the *RF Design* Handbook Series.

Now, we will be able to expand our delivery of information beyond those successful efforts. The opportunity to provide Gary Breed, our editor, with a whole new brace of tools for gathering and distributing information is indeed exciting. To many of you, the changes won't seem revolutionary, and that's as it should be. Keeping *RF Design* in the leadership position of delivering the information you need in your profession is a constant evolution.

David Premo
Vice President / Group Publisher

This month's editorial column was given over to our Vice President and Group Publisher, David Premo, who has given you the big news about our new company name and our expanded mission. The evolutionary changes he describes are exciting to us all, because they give us greater access to all kinds of information technologies — for your benefit — in an expanded role as a resource for your technical information needs. Watch for a series of announcements regarding the delivery of information for the RF specialty in new venues and media.

Gary A. Breed
Editor

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713FC	15W CW	20-1000 MHz	42dB	$ 5,680
225LC	25W CW	.01-225 MHz	40dB	$ 3,295
*737LC	25W CW	.01-1000 MHz	45dB	$ 9,995
712FC	25W CW	200-1000 MHz	45dB	$ 6,950
714FC	30W CW	20-1000 MHz	45dB	$ 9,350
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715FC	50W CW	200-1000 MHz	47dB	$ 14,990
707FC	50W CW	400-1000 MHz	50dB	$ 10,990
716FC	50W CW	20-1000MHz	47dB	$ 17,950
*747LC	50W CW	.01-1000 MHz	47dB	$ 18,550
116FC	100W CW	.01-225 MHz	50dB	$ 9,500
709FC	100W CW	500-1000 MHz	50dB	$ 16,990
717FC	100W CW	200-1000 MHz	50dB	$ 19,500
718FC	100W CW	20-1000 MHz	50dB	$ 29,800
7100LC	100W CW	80-1000 MHz	50dB	$ 19,500
*757LC	100W CW	.01-1000 MHz	50dB	$ 29,950
122FC	250W CW	.01-225 MHz	55dB	$ 19,950
723FC	300W CW	500-1000 MHz	55dB	$ 29,995
LA500V	500W CW	10-100 MHz	56dB	$ 12,900
LA500UF	500W CW	100-500 MHz	57dB	$ 46,000
LA500G	500W CW	500-1000 MHz	57dB	$ 55,000
LA1000V	1000W CW	10-100 MHz	60dB	$ 22,500
LA1000UF	1000W CW	100-500 MHz	60dB	$ 75,000
LA1000G	1000W CW	500-1000 MHz	60dB	$ 99,000
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134C	500W CW	.01-220 MHz	57dB	$ 20,500
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Letters should be addressed to: Editor, RF Design, *6300 S. Syracuse Way, Suite 650, Englewood, CO 80111. Letters may be edited for length and clarity.*

Rethinking Path Loss Calculations

Editor:

I have recently discovered a mistake in concept in my article "Path Loss and Antenna Gain, Elementary Calculations" [Feb. 1995]. On page 63, under the subheading "Where are the Losses?", the antenna factors were used in the loss calculations. In this instance, the antenna gains in dBi should have been used.

The dB path loss equation 8: dBPL = 10 log G_t + 10 log G_r – 20 log f – 20 log R + 27.558 clearly shows that the antenna gains in dBi are to be used in path loss calculations. Since 10 log G_t = gain dBi where G_t is a power gain as used in the circuit parameters of the article, the final equation should read –2.57 dBi for the transmitter and –10.33 dBi for the receiver for a total antenna path loss of –12.9 dB. This leaves an over the air path loss of –78.734 dB. This over the air path loss is the FSPL (free space path loss) and is calculated using equation 8, omitting 10 log G_t and 10 log G_r.

Frank L. Egenstafer

Contact Correction

The correct address/telephone/fax numbers for information about the technologies mentioned in the June 1995 article, "DSP Implementation of GFSK, GMSK and FQPSK Modulated Wireless Systems" are:

For technology transfer and license of patented technologies:

Digcom, Inc., c/o Dr. Feher and Associates, 44685 Country Club Drive, El Macero, CA 95618, Tel: (916) 753-0738, Fax: (916) 753-1788.

For general technical inquiries:

Kamilo Feher, University of California, Davis, Davis, CA 95616, Tel: (916) 752-8127, Fax: (916) 752-8428.

We apologize to readers who heard an unpleasant fax tone instead of getting a telephone response

Kamilo Feher, Ph.D.
Vice President, Digcom, Inc.

Antenna Matching Errors

In Robert Dehoney's May article, "Program Synthesizes Antenna Matching Networks for Maximum Bandwidth," the following corrections should be made:

The formulas for C_A and L_A on page 74 should read

$$C_A = 2H\left\{0.89075 / \left(L_S^{0.8006} - 0.861\right) - 0.02541\ \text{pF}\right\}$$

$$L_A = 2H\left\{148.13 L_S^{1.012} - 61.88\ \text{nH}\right\}$$

In Figure 2, C_m should be M.

In the formulas for C_2 (on page 76) and C_3 (on page 77), M2 should multiply the expressions, not divide.

The formula for L_3 should read

$$L_3 = \left(C_3 \omega_0^2\right)^{-1}.$$

RF calendar

July

30-1 **Electrex and Instrumentation**
Johannesburg, South Africa
Information: Reed Exhibition Companies, 383 Main Avenue, Norwalk, CT 06851. Tel: (203) 840–5398. Fax: (203) 840–9398.

August

15-17 **Advanced Technology Acquisition, Qualification, and Reliability Workshop**
Newport Beach, CA
Information: Dorthy Connor, General Technical Services, Inc., 3100 Route 138, Wall Township, NJ 07719. Tel: (908) 544–3231. Fax: (908) 389–3992.

27-31 **Surface Mount International '95**
San Jose, CA
Information: Yolanda White. Tel: (415) 905–4994.

September

5-7 **International Conference on 100 Years of Radio**
London, UK
Information: HYR95 Secretariat, Conference Services, IEE, Savoy Place, London WC2R 0BL UK. Tel: 071 344 5477. Fax: 071 497 3633.

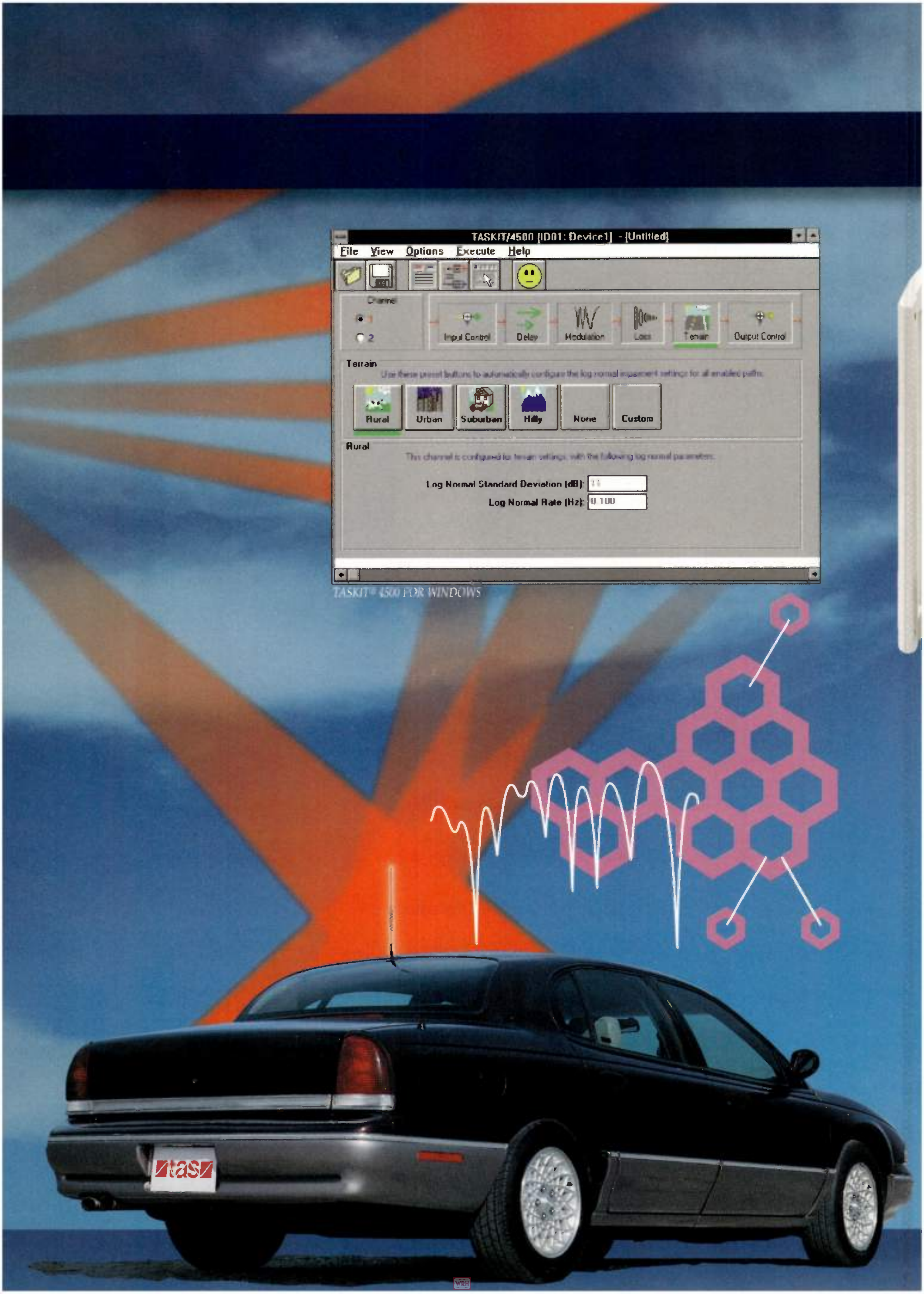
12-15 **International Conference on Electromagnetics for Advanced Applications**
Torino, Italy
Information: ICEAA 95, c/o Dipartimento di Elettronica, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 TORINO, Italy.

19-20 **The Canadian High Technology Show**
Toronto, Canada
Information: Reed Exhibition Companies, 383 Main Avenue, Norwalk, CT 06851. Tel: (203) 840–5398. Fax: (203) 840–9398.

20-22 **17th Annual Piezoelectric Devices Conference**
Kansas City, MO
Information: Components Group, Electronic Industries Association, 2500 Wilson Boulevard, Arlington, VA 22201–3834. Tel: (703) 907–7500. Fax: (703) 907–7501.

26-28 **Sixth International Conference on Radio Receivers and Associated Systems**
University of Bath, UK
Information: RRAS'95 Secretariat, IEE Conference Services, Savoy Place, London WC2R 0BL UK. Tel: +44 (0) 71 344 5477. Fax: +44 (0) 71 497 3633.

26-29 **ComNet Fenasoft Brazil**
Sao Paulo, Brazil
Information: IDG World Expo, 111 Speen Street, P.O. Box 9107, Framingham, MA 01701–9107. Tel: (508) 879–6700. Fax: (508) 872–8237.



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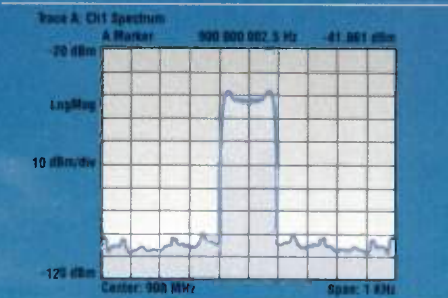

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Microwave Tubes, High-Power Transmitters, and Microwave Systems: Basic Principles
July 24-28, 1995, Washington, DC
The Cellular Telephone System
August 8-10, 1995, Washington, DC
Digital Cellular Telecommunications and PCS
August 16-18, 1995, Washington, DC
Analyzing Communications System Performance
August 21-24, 1995, Washington, DC
Global Positioning System: Principles and Practice
September 11-14, 1995, Washington DC
Antennas and Antenna Systems: Practical Design, Implementation, and Testing
October 23-26, 1995, Washington, DC
Information: The George Washington University, Continuing Engineering Education, Academic Center, Room T-308, 801 22nd Street, N.W., Washington, DC 20052. Tel: (202) 994–6106 or (800) 424–9773. Fax: (202) 872–0645.

Technical Cellular
July 31-August 3, 1995, Madison, WI
Radio System Design for Telecommunications
August 21-24, 1995, Madison, WI
Information: Department of Engineering Professional Development, University of Wisconsin-Madison, 432 North Lake Street, Madison, WI 53706. Tel: (800) 462–0876. Fax: (608) 263–3160.

Microwaves and RF Measurements & Applications
October 2-5, 1995, Washington, DC
Information: University Consortium for Continuing Education, 16161 Ventura Boulevard, M/S C-752, Encino, CA 91436. Tel: (818) 995–6335. Fax: (818) 995–2932.

Wireless Communication Systems
August 2-4, 1995, Ann Arbor, MI
Information: Engineering Conferences, 400 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109–2092. Tel: (313) 764–8490.

DSP Without Tears
September 20-22, 1995, Washington, DC
October 9-11, 1995, Dallas, TX
Information: Z Domain Technologies, Inc., 325 Pine Isle Court, Alpharetta, GA 30202. Tel: (800) 967–5034, (404) 587–4812. Fax: (404) 518–8368.

Kalman Filtering
August 28-31, 1995, Los Angeles, CA
Wavelet Transform Applications to Data, Signal, Image and Video Processing
September 11-15, 1995, Los Angeles, CA
Information: UCLA Extension, Engineering Short Courses, 10995 LeConte Ave., Ste. 542, Los Angeles, CA 90024. Tel: (310) 825–1047. Fax: (310) 206–2815.

Rewards Offered for Vintage Thruline Wattmeters

Bird Electronic Corporation has launched QUEST 43 to locate the oldest working Model 43 Thruline wattmeter. QUEST 43 will help celebrate Bird's recent production of the 250,000th Model 43. Rewards for vintage Bird test instruments include a 24 KT gold plated Model 43, new wattmeters and $250 to $1000 gift certificates. Winners will be announced at the 1996 International Wireless Communications Expo (IWCE).

The production of the first Model 43 Thruline wattmeter in the early 1950s heralded a major breakthrough in RF power measurement. Bird anticipates finding many working units with low serial numbers. Rewards will be offered to owners of the 10 lowest serial number Model 43 wattmeters in working condition.

Entries must be received by January 31, 1996. All Model 43 owners are encouraged to contact Bird Electronics for an entry form to participate in QUEST 43.

Metrology Advancements for the Americas

All 34 nations of the Organization of American States have agreed to participate in the Interamerican Metrology System (SIM), a recently re-established organization seeking to harmonize measurement standards among the countries of the Western Hemisphere. The rebirth of SIM marks the first successful inter-american effort toward realizing two major goals: increasing cooperation in science and technology within the Americas and promoting prosperity and free trade by eliminating technical trade barriers. SIM members focus on improving their national measurement and standards activities, and then harmonizing these activities with each other and the SIM as a whole.

Apple Petitions for High-Speed Wireless NII Band

Apple Computer, Inc. has filed a Petition for Rulemaking with the FCC, asking the FCC to create an "NII Band" – a radio spectrum allocation that would permit high-speed data communications for schools, libraries, community groups, individuals, businesses and institutions. The proposed NII Band radio service would be accessible by equipment from any supplier, available to anyone without licensing or air-time charges, and would facilitate wireless participation in the National Information Infrastructure.

Compared with the capacity and local nature of Data-PCS, the NII Band would provide much larger bandwidths (data rates), be extensible to longer distances, and occupy higher frequencies protected from unpredictable interference. One portion of the NII Band comprises radio frequencies (5150-5300 MHz) already earmarked in Europe for local area wireless networks. The second portion of the band (5725-5875 MHz) is already available for low-power, unlicensed spread spectrum devices under Part 15 of the FCC rules.

Digital Radio in Canada

The commercial launch of L-Band digital radio in Canada is expected during 1996, using Eureka 147/DAB technology, recently recommended as a world standard by the radio study group of the International Telecommunications Union. Digital Radio Research Inc. (DRRI) already operates permanent experimental digital transmitters in Toronto and Montreal, and two new transmitters will be installed in Vancouver and Ottawa during the summer of 1995. The addition of these new facilities means that about 35 percent of Canadians will be covered by terrestrial L-Band DR signals by mid-1995.

Growth Expected for RFID Equipment Sales

U.S. sales of radio-frequency identification (RFID) equipment will grow by more than five times, from $144 million in 1994 to $782 million by the year 2000, at a 33 percent compound annual rate, projects a new study by Frost & Sullivan. The revenue share of tags will increase from 46 percent of the total market in 1994 to 49 percent in 2000 while that of readers falls from 36 to 31 percent and that of antennas and other equipment rises from 18 to 20 percent.

RFID will be viewed increasingly as a replacement for barcode technology as the former's prices fall. RFID systems are being integrated increasingly with other technologies like barcode and smart cards and the combination of RFID technology with portable terminals is moving the industry into mobility applications.

Rapid Growth Reported in Wireless Communications

BIS Strategic Decisions' Mobile and Wireless Communications Service has determined that the number of subscribers using cellular telephones in the United States in 1994 grew by 51 percent to reach 24.2 million. In its latest report, BIS forecasts that cellular voice services generated more than $17 billion in revenue in 1994, growing to $26 billion by 2000. BIS also predicts that almost 60 million Americans will be subscribing to cellular voice services.

One of the primary drivers contributing to the phenomenal growth in the cellular market is the "consumerization" of wireless products and services. This concept refers to BIS research findings indicating that the mass market consumer segment will be the single largest contributor to growth in both the cellular and paging installed bases. Cellular carriers are now rolling out service plans aimed at offering consumers only what they

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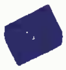

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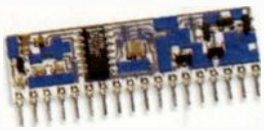

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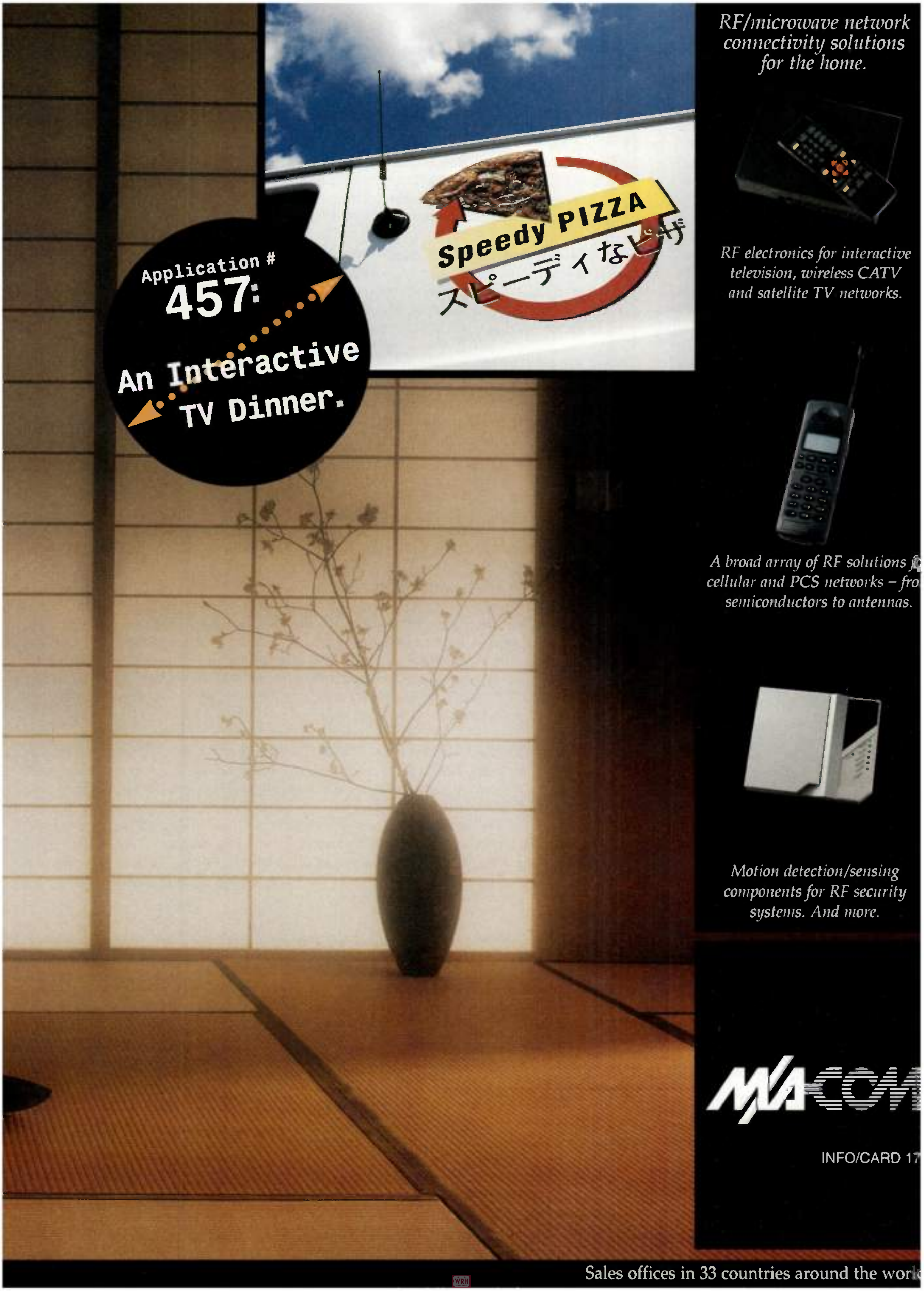

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need at a price commensurate with their service needs. The broader deployment of the next generation digital network, combined with continual improvements to the existing analog network, will ensure long-term attraction to cellular technology.

Growth is also expected in the Canadian markets for cellular, paging, and wireless data. The markets are anticipated to grow to a combined installed base of almost 12 million subscribers by the year 2000. According to BIS, this represents a penetration of the Canadian population of 43 percent, achieved by a compound annual growth rate of 28 percent over the next five years. This will grow from just under 3 million wireless subscribers at the end of 1994.

CATV Distribution Products Reach $1.1 billion

The U.S. market for CATV outside plant products totaled more than $1.1 billion in 1994, according to a recent report entitled *CATV Cable and RF Distribution Products: U.S. Markets, Competitors, and Opportunities: 1995-2000 Analysis and Forecasts*, published by World Information Technologies, Inc. According to the study, U.S. demand for CATV cable will grow about 21 percent annually between 1995 and 2000, while demand for CATV apparatus will grow about 15 percent each year.

The study provides detailed statistical information, analysis, and forecasts on more than 30 products used in CATV outside plant including coaxial and fiber cables, coaxial active and passive products, fiber active and passive products, and new products.

Motorola to Aid Users Affected by PCS Licenses

Motorola's Land Mobile Products Sector will provide wireless communications system design and integration consultation to users affected by the recently completed FCC licensing of PCS technologies. The FCC's objective is to clear the 1.8 GHz to 2.1 GHz spectrum, currently used by fixed radio systems throughout the United States, and eliminate interference with new PCS systems. Incumbent users on this spectrum may be relocated to other microwave frequencies, or provided with alternative means of interconnection for their systems at the expense of the forthcoming PCS users.

Business Briefs

Champion Completes Renovation — Champion Technologies has completed the $2.0 million renovation of their facility. The project created and upgraded key areas in manufacturing, engineering and laboratory/prototype space. The facility is scaled to approximtely 63,000 square feet of space.

Avista Announces New Source for Analog EDA — Avista Design Systems is a new EDA software firm specializing in design tools that advance the art of analog circuit design. Avista will integrate accurate electrical analysis with the familiar environment of Microsoft Office to provide a qualitative advance in tools for analog circuit design.

Schaffner Gains Recognition for Instrumentation Calibration — The calibration laboratory at Schaffner's headquarters in Luterback, Switzerland has gained approval from EAM (Swiss Federal Office of Metrology) as a Calibration Center for electrical values to the European Standard EN 45001. This accreditation allows the laboratory to offer full calibration and certification of EMC instrumentation.

Toko and Sager Expand Partnership — Toko America, Inc. has completed the franchising to all locations of Sager Electronics. The addition of these locations will bring the total to 16 regional branch locations and 4 satellite locations served by Sager. Toko's complete product offering of RF/microwave, low power conversion/EMI and bi-polar ICs will be featured and promoted throughout the entire Sager organization.

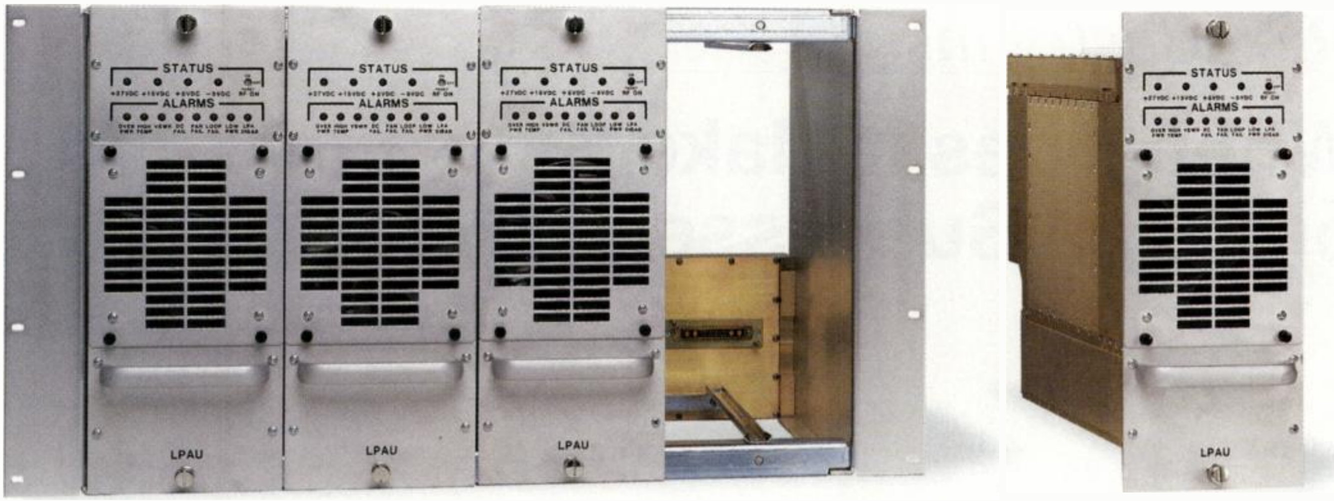
Pineapple Technology Expands Product Line — Pineapple Technology Corp. has expanded its product line within the domestic and international TV and broadcast markets. The product line consists of solid-state amplifiers and subassemblies designed and manufactured for OEMs in the domestic and international TV and FM broadcast markets, including a new line exclusively devoted for the "wireless cable" markets.

Agreement Signed to Develop RFID Technology — Four Japanese corporations and British Technology Group (BTG) signed an agreement that will develop all the components needed for commercial systems emphasizing the "Supertag" identification technology. The Supertag technology comprises an electronic label system that uses radio frequency to identify and count grouped objects. BTG has also signed an agreement with Semaphore Asset Management Systems Inc., Canada to commercialize the Supertag technology. Semaphore will act as a centralized marketer of labeling and identifications solutions that incorporate the technology.

Noise Com Moves — Noise Com has recently moved and expanded its manufacturing facility by 50 percent to meet the increasing demand for wireless test equipment. The new location is in the same building complex, therefore the address and phone/fax numbers remain unchanged.

Mexico Communicaciones Opens Warehouse in Mexico City — Mexico Comunicaciones, S. de R.L. de C.V. has opened a stocking wireless communications warehouse in Mexico City. The warehouse and sales offices are located at Calle Camino De Minas #501 Local #2, Col. Lomas De Becerra, Deleg. Alvaro Obregon, Mexico D.F. 01279, tel (5) 615–15–50, fax (5) 615–15–54.

Proxim and Digital Announce Alliance — Proxim, Inc. and Digital Equipment Corporation have announced a strategic technology alliance designed to provide significant benefits to the emerging wireless LAN marketplace. Under the agreement, Digital has licensed the use of Proxim's RangeLAN2 core technology allowing Digital to include frequency hopping technology as part of their future RoamAbout wireless LAN product offerings.



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When Does It Make Sense to Build or Buy a Sub-Assembly?

By Andy Kellett
Technical Editor

Every company has to decide at what point in its manufacturing process it will stop buying parts from other manufacturers and start putting those parts together – that is – when to stop buying and when to start building. The inflection point between building and buying is a function of many variables. This report will map out those areas where manufacturers tend to buy and where they tend to build the sub-assemblies that make up their final product.

The Buy Zone

There are certain situations where the advantages of buying a module are clear. For instance, a company that has little or no expertise in the manufacture of a particular product will probably spend little time deciding to purchase that product. Before Tim Nolan joined K&L Microwave, where he is now Vice President of Engineering, he purchased K&L filters. "It was awful hard for me, even internally, to compete against the pricing they were giving," says Nolan, "I was not a filter designer, but when I called K&L I got the best product possible."

The hard part for a company can be realistically assessing its own capabilities. "Quite often engineers may think it is easier for them to design it," says Meta Rohde, President of Synergy Microwave. Many customers have come to LCF Enterprises, an amplifier specialist, after unsuccessfully trying to make a particular amplifier themselves, says LCF President Dr. Lorna Finman.

Even if a company has the expertise, other facts can make an assembly manufactured outside a company more attractive. "Big systems require buying many parts and doing lots of assembly," says K&L's Dolan, "subsystems decrease the number of buys and reduces the amount of assembly required." Synergy Microwave's Rohde agrees, "If you buy a module, it's finished and tested, you can rely on the data and just put it in – much simpler."

The Build Zone

Of course there is a point at which a manufacturer has to stop buying parts and start putting them together.

When a company agrees to buy an assembly from another company, they put part of the success of their product in the hands of another company. This has been one of the major concerns of military and aerospace contractors in the past. Though Lockheed-Martin is using more commercial off the shelf products, they still maintain a "must-make" list says O.J. Moore, Manager of Subcontract Management and Integration at Lockheed-Martin. LCF's Finman notes that many of her military and aerospace customers are buying more "best commercial" products instead of Mil-spec. "They have a little trouble culturally adapting to that," says Finman, explaining that some customers have the habit of sending Mil-spec paperwork, while still expecting commercial prices.

However, that concern exists throughout the industry. "I will not sell a product if it has too high a quantity of 'buy-product' in it because you don't have control over it," says K&L's Dolan.

The cost effectiveness of buying is eliminated at a certain point. Dolan points out that his company's sub-assembly group produces switched filter banks because that is where their expertise lies. However, Dolan says he would discourage a customer from asking them to integrate an amplifier, because K&L would buy the same $50 amplifier the customer could buy and have to charge them another $50 to put the amplifier in a K&L enclosure.

The low cost of a purchased sub-assembly can tempt even companies with adequate talent to build it to buy. However, some companies pass up those opportunities to buy in order to retain their engineering and manufacturing talent. "They want to keep their people employed," says Finman.

Trends

The number of sub-assemblies being bought seems to be increasing, say several vendors. "We've noticed it for one or two years," says LCF's Finman, "It's very obvious to us."

Two factors may be responsible for this. Synergy's Rohde says, "Engineering costs more today than it used to, and there's more pressure because the commercial market moves so fast."

However, the company that can recognize its own strengths and build products that play to those strengths will have no trouble keeping up with a fast changing market. *RF*

More Options in the Manufacturing Spectrum

There are manufacturing options between completely building an assembly in-house and simply buying a completed component off the shelf.

Kitting – a manufacturer designs the assembly, purchases the components and then contracts with an outside company to do the actual assembly.

Turnkey manufacturing – The manufacturer supplies the design, and leaves everything up to an outside contractor to deliver a completed subassembly.

Mike Cook, Purchasing Manager for Giga-tronics, Inc. points out that his company uses kitting to produce many of their circuit boards, and that some sub-assembly designs which are originally built in-house at Giga-tronics are eventually considered stable enough to be sent out for turnkey manufacturing.


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2	TE5000	3	3.75	20	18.0	-	-	2	1.0	50	1800//+4
4	TE5010	3	3.75	30	14.0	-	-	3	2.0	60	1500//+3
6	TE5020	6	3.75	60	12.5	-	-	4	2.0	70	1500//+3
8	TE5030	6	3.75	60	10.0	90	12.5	5	2.0	80	1500//+3
2	TE5040	3	6.50	20	30.0	-	-	1	1.0	50	2700//0
4	TE5050	3	6.50	30	15.0	-	-	2	2.0	75	3100//0
6	TE5060	6	6.50	60	19.5	-	-	3	2.0	90	3100//0
8	TE5070	6	6.50	60	13.0	80	17.5	4	2.0	100	3100//0
2	TE5080	3	7.50	20	35.0	-	-	1	1.0	50	3000//0
4	TE5090	3	7.50	30	17.5	-	-	2	2.0	75	3300//0
6	TE5100	6	7.50	60	22.5	-	-	3	2.0	90	3300//0
8	TE5110	6	7.50	60	15.0	80	20.0	3	2.0	100	3300//0
2	TE5120	3	15.0	20	70.0	-	-	1	1.0	35	5000//-1
4	TE5130	3	15.0	30	35.0	-	-	2	2.0	60	5000//-1
6	TE5140	6	15.0	60	45.0	-	-	2	2.0	90	5000//-1
8	TE5150	6	15.0	60	30.0	80	40.0	3	2.0	100	5000//-1

21.4 MHz

NO. POLES	TEMEX P/N	PASSBAND dB	PASSBAND ±KHz	STOPBAND dB	STOPBAND ±KHz	STOPBAND dB	STOPBAND ±KHz	LOSS dB	RIPPLE dB-MAX	ULT. REJ. dB-MIN.	TERM.(Rp//Cp) OHM/PF
2	TE5180	3	3.75	15	12.5	-	-	2	1.0	50	850//+6
4	TE5190	3	3.75	30	12.5	-	-	3	2.0	70	850//+5
6	TE5200	6	3.75	60	12.5	-	-	4	2.0	90	850//+5
8	TE5210	6	3.75	60	10.0	80	12.5	5	2.0	100	850//+5
2	TE5220	3	6.50	15	20.0	-	-	2	1.0	50	1300//+2
4	TE5230	3	6.50	30	22.5	-	-	3	2.0	70	1400//0
6	TE5240	6	6.50	60	22.5	-	-	4	2.0	90	1400//0
8	TE5250	6	6.50	60	17.5	80	22.5	4	2.0	100	1400//0
2	TE5260	3	7.50	15	25.0	-	-	2	1.0	50	1500//0
4	TE5270	3	7.50	30	25.0	-	-	3	2.0	70	1600//0
6	TE5280	6	7.50	60	25.0	-	-	4	2.0	90	1600//0
8	TE5290	6	7.50	60	20.0	80	25.0	4	2.0	100	1600//0
2	TE5300	3	15.0	15	50.0	-	-	2	1.0	45	3000//0
4	TE5310	3	15.0	30	45.0	-	-	3	2.0	60	3000//-1
6	TE5320	6	15.0	60	45.0	-	-	3	2.0	90	3000//-1
8	TE5330	6	15.0	60	33.0	80	45.0	4	2.0	100	3000//-1

45.0 MHz

NO. POLES	TEMEX P/N	MODE	PASSBAND dB	PASSBAND ±KHz	STOPBAND dB	STOPBAND ±KHz	LOSS dB	RIPPLE dB-MAX	ULT. REJ. dB-MIN.	TERM.(Rp//Cp) OHM/PF
2	TE9420	3-OT	3	3.75	18	16.0	3	1	40	2000//-1.0
4	TE9310	3-OT	3	3.75	30	12.5	3	1	70	2000//-1.0
2	TE7420	3-OT	3	7.50	18	28.0	2	1	40	3000//-1.0
4	TE7430	3-OT	3	7.50	40	30.0	3	1	70	3000//-1.0
2	TE7440	3-OT	3	15.0	15	47.0	2	1	40	8000//-1.5
4	TE7450	3-OT	3	15.0	30	50.0	3	1	70	8000//-1.5
2	TE7730	FUND	3	15.0	15	50.0	2	1	40	1100//+1.5
4	TE7740	FUND	3	15.0	40	60.0	3	1	70	800//+1.0

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Designing an AM Receiver for Low Power Wireless Systems

By Jim Wang
California Eastern Laboratories

A wide variety of low power wireless communication systems have surfaced in recent years. Automotive keyless entry, home security, bar code readers, and child monitors are just a few of the many applications for this technology. Most low power wireless systems operate in the FCC PART 15 band (260-470MHz) where licensing is not required for transmitters producing less than 1mW of power. Operating range varies from just a few feet (bar code readers) to a few hundred feet (garage door openers) depending on the application. Naturally, many of these systems must be lightweight and battery driven to meet portability requirements. Most importantly, however, cost must be highly competitive to survive in demanding commercial markets.

When designing low power radio receivers for systems such as those described above, management of performance, size, and cost tradeoffs can be complicated. The NEC UPC2768GR downconverter IC was developed to simplify system design. The chip combines solid performance with high functionality in a very small 20-pin SSOP package. By integrating the UPC2768GR IC into a receiver design, total parts count is reduced and manual tuning of reactive elements is eliminated. In the next sections, a brief description of the UPC2768GR circuit will be presented followed by an example of the UPC2768GR in an automotive keyless entry receiver application.

Circuit Description

The UPC2768GR is a frequency converter IC manufactured in the NESAT-III 20 GHz Si bipolar process developed by NEC. The IC contains a downconverter and a limiting amplifier (Figure 1).

The downconverter consists of an RF input amplifier, Gilbert cell mixer, local oscillator, and IF amplifier. The RF input stage is a differential amplifier which has 15 dB of gain when driven single-ended. The input stage also features good noise performance for improved sensitivity and excellent reverse isolation to minimize LO re-radiation. The Gilbert cell mixer generates 8 dB of conversion gain. Due to the double-balanced nature of the Gilbert cell, excellent suppression of LO and RF is achieved at the output. The local oscillator uses an external tank circuit to set the oscillation frequency and can be operated beyond 500 MHz. In applications where an external oscillator is used, the local oscillator stage can serve as a 10 dB gain buffer. The differential IF amplifier with 15 dB of gain completes the downconverter. In all, 38 dB of conversion gain is available. From a 3V supply, the downconverter typically draws 5.6 mA.

The five stage IF limiting amplifier provides an additional 44 dB of gain from DC to 25 MHz. Global feedback is employed to maintain DC stability. The limiting amplifier draws only 1.4 mA from a 3 V supply.

The UPC2768GR is also equipped with a power save circuit. By grounding the power save pin, the chip can be put in an OFF state where it draws less than 200 µA of current.

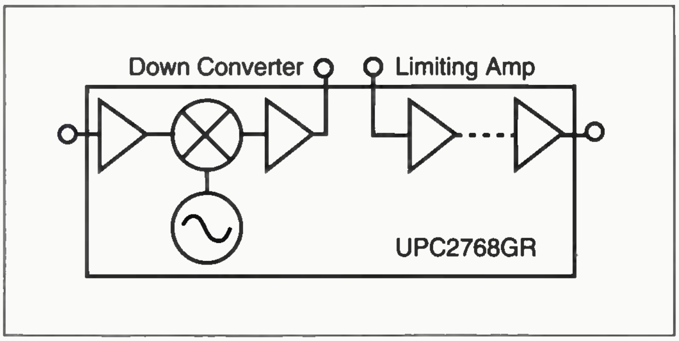

Figure 1. UPC2768GR functional block diagram.

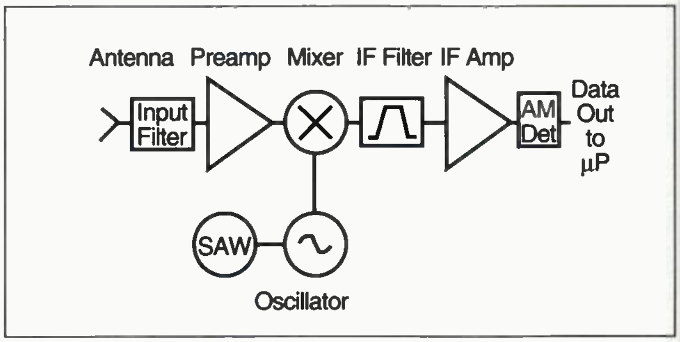

Figure 2. Superheterodyne receiver block diagram.

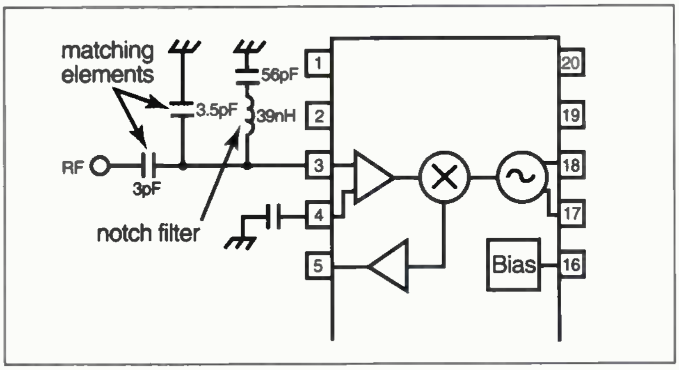

Figure 3. Input notch filter.

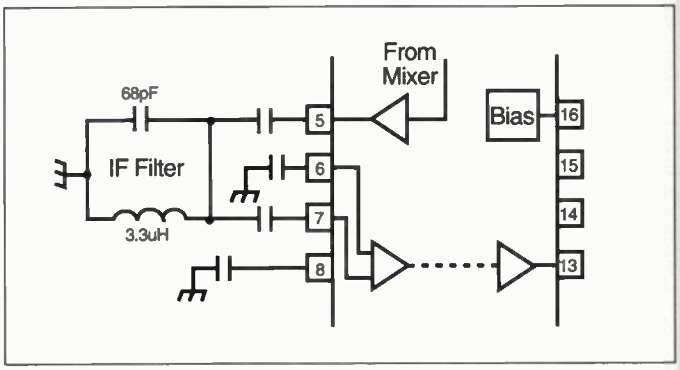

Figure 7. Shunt LC filter (IF=10.7MHz).

Keyless Entry Receiver System

Remote entry receivers for automobiles are one of the largest and fastest growing applications for low power wireless technology. Receivers for this application generally fall into two broad categories; superregenerative and superheterodyne. Although earlier receiver designs were predominantly superregenerative, the current trend is toward superheterodyne because it meets more demanding system requirements. A typical superheterodyne receiver block diagram is shown in Figure 2.

Notice that with the exception of the filters, SAW resonator, and detector, the UPC2768GR can replace the entire receive block. The following sections will describe how the remaining elements can be implemented around the UPC2768GR to form a complete receiver.

Input Filtering

Due to strong interference from signals in the FM radio band (87 MHz - 107 MHz), filtering is required at the input. Received signals in the FM band can be as high as +10 dBm in areas where a transmitter is nearby. The most problematic interferences in this band are harmonics of the desired RF input frequency. For example, in U.S. automotive keyless entry applications where the input signal is at 315 MHz, an interfering harmonic at 105 MHz ($f_{RF}/3$) can severely degrade the receiver sensitivity if adequate filtering is not present at the input. In extreme cases, the receiver can actually be jammed by such signals.

Narrowband interference problems such as this can be effectively eliminated with notch filters. Notch filters possess excellent rejection characteristics and are easy to implement in the FM band. In Figure 3, the UPC2768GR is shown with a series LC notch filter at the RF input. The notch frequency is determined by this equation:

$$f_{notch} = \left(2\pi\sqrt{LC}\right)^{-1}$$

The values of L and C were chosen to produce a notch at 105 MHz, the frequency where the interference occurs.

Input Matching

Impedance mismatch at the input can significantly degrade overall system sensitivity. In order to minimize the effects of mismatch loss a matching network can be added. In most receiver systems, the UPC2768GR should be preceded by an antenna or perhaps a SAW filter. Typically, these elements have impedances in the 50-75 range. The input impedance (pin 3) of the UPC2768GR, on the other hand, is quite high and capacitive as shown by the S_{11} plot in Figure 4.

Inclusion of the notch filter rotates the impedance to the inductive half of the Smith chart as shown in Figure 5.

Now the impedance shown in Figure 5 must be matched to 50 at the system frequency. This can be accomplished by first inserting a shunt capacitor to rotate S11 clockwise toward the unit circle. Then, a series blocking capacitor can be inserted to bring the impedance back to 50. This is all shown graphically in Figure 6.

IF Filtering

An IF frequency of 10.7 MHz is

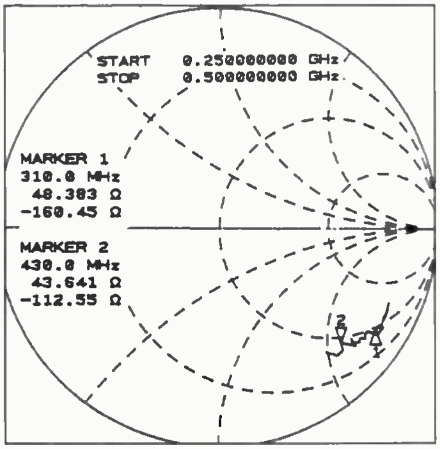

Figure 4. UPC2768GR input S_{11}.

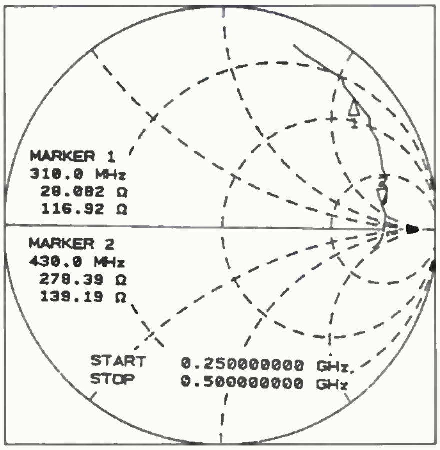

Figure 5. Input S_{11} of UPC2768 and notch filter.

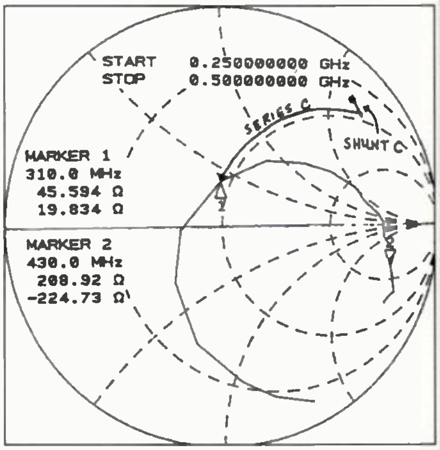

Figure 6. Results of matching procedure shown on Smith Chart.

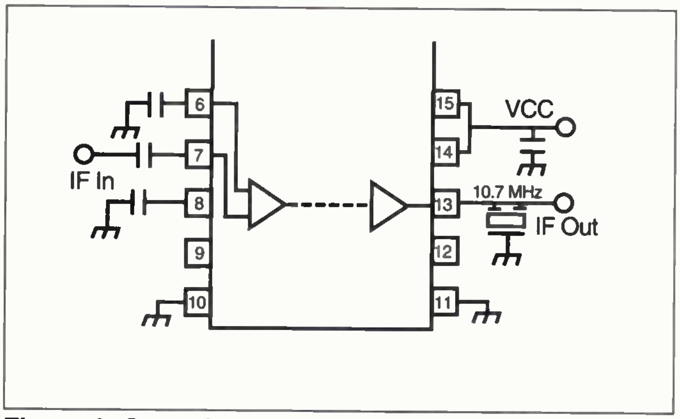

Figure 8. Ceramic IF Filter (IF = 10.7MHz).

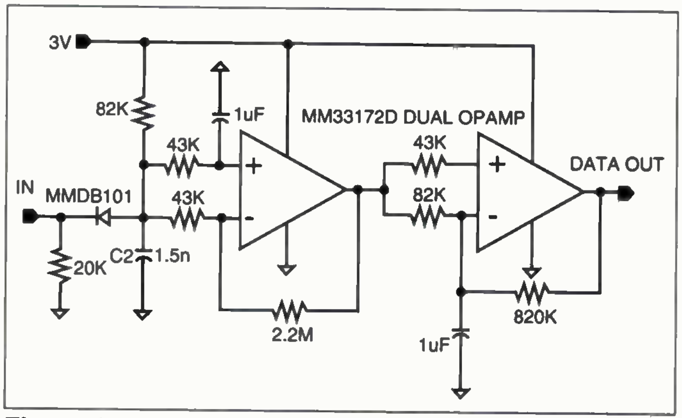

Figure 10. Diode detector circuit.

widely used because ceramic filters are commonly available (e.g. Murata SFE10.7MA). Ceramic filters are typically very narrowband (< 500 kHz) and also possess excellent rejection characteristics. In high gain receiver systems such as automotive keyless entry, sharp filtering is essential in minimizing overall noise power.

When using the UPC2768GR, IF filtering is recommended between the mixer and IF amplifier (pins 5 and 7) to prevent undesired harmonics generated by the mixer from saturating the IF amplifier. A shunt LC filter is effective here because of its low insertion loss and zero group delay characteristics (Figure 7). Ceramic filters are not recommended here because poor group delay could potentially introduce instabilities in the system.

IF filtering is also required at the output of the IF amplifier (pin 13). At this point, a ceramic filter should be applied in order to effectively eliminate higher order harmonics generated by the limiter and also to minimize noise bandwidth (Figure 8).

Local Oscillator and SAW

In most modern, low power, wireless systems, superheterodyne receivers employing SAW resonators are used.

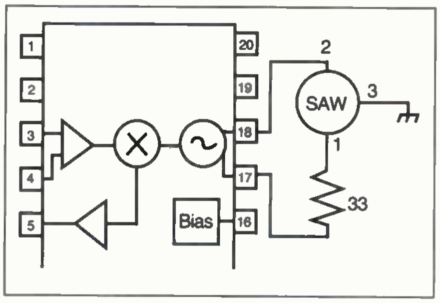

Figure 9. UPC2768GR SAW oscillator.

In addition to having excellent frequency stability, SAW resonators eliminate the need for manual tuning. The UPC2768GR contains an oscillator which can be easily configured with a SAW resonator (Figure 9).

The SAW resonator is used in a two-port configuration. Notice that R_{osc} is the only additional element required to complete the oscillator circuit. R_{osc} is placed in series with the SAW resonator to provide an appropriate matching impedance.

Detector Circuit

In AM systems, data recovery can be accomplished by the addition of a diode-based detector circuit. A typical detector circuit is shown in Figure 10.

The diode bias is established at approximately 30 μA by the 20k and 82k resistors.

A 1500 pF shunt capacitor to ground (C1) is used at the output of the diode detector to filter out the IF carrier leaving just the detected data. The detected data is then amplified through two opamp stages (MM33172 dual opamp IC or equivalent) to yield the final data output.

Board Layout

The layout of a PC board which can accommodate the UPC2768GR, all of its associated external components, and an AM detector circuit is shown in Figure 11. The design was fabricated on 28 mil thick epoxy glass material and measures only 1″ × 1.5″.

Finished Receiver

A schematic of the completed receiver is shown in Figure 12. Input sensitivity and dynamic range of this receiver were measured. Data was succesfully recovered for input ranging from –100 dBm to 0 dBm.

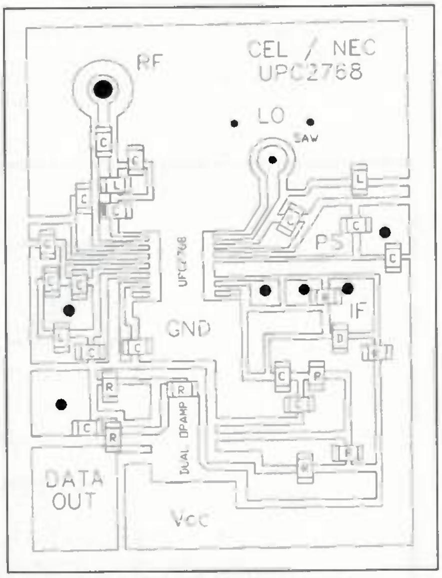

Figure 11. PC board layout.

Conclusion

The receiver described in this article is just one of many possible applications for the NEC UPC2768GR. By integrating the UPC2768GR into a receiver, design is simplified, total parts count is reduced, and costly tuning of reactive elements is eliminated. In short, the UPC2768GR offers solid performance and high functionality in a small, affordable 20-pin SSOP package. It is these characteristics which make it ideally suited for low power wireless systems. *RF*

About the Author

Jim Wang is a Product Development Engineer at California Eastern Laboratories where he is currently designing Si MMICs for RF communication systems. His previous experience includes an 18 month assignment at the Compound Semiconductor Device Division of NEC in Japan and five years with Anadigics developing GaAs ICs for the DBS marketplace. He received his BS degree from Columbia University in 1986 and his MS degree from Rutgers University in 1990. He can be reached at 4590 Patrick Henry Drive, Santa Clara, CA 95054, or by telephone at: (408) 988-3500.

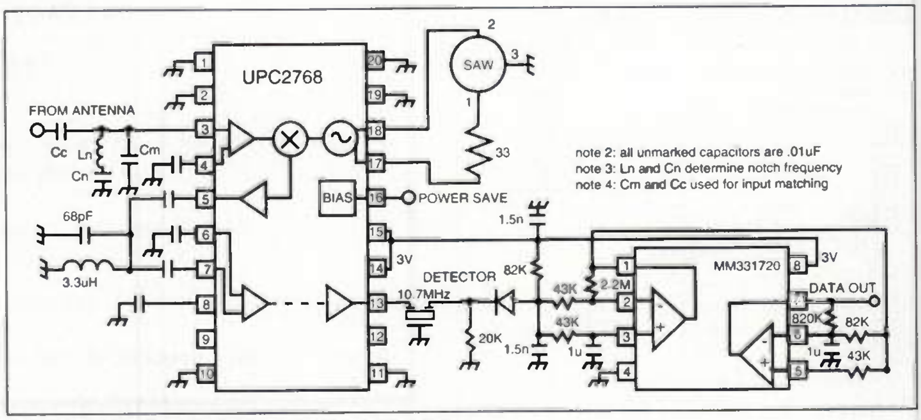

Figure 12. Complete receiver design.

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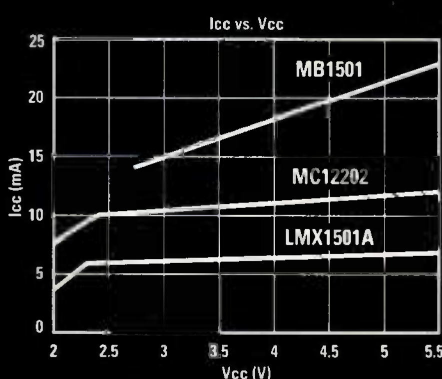

	LMX1501A	LMX1511	LMX2314/15	LMX2320	LMX2325	LMX2330A	LMX2331A	LMX2332A	LMX2335	LMX2336	LMX2337
RF Input-Main PLL	1.1GHz	1.1GHz	1.2GHz	2.0GHz	2.5GHz	2.5GHz	2.0GHz	1.2GHz	1.1GHz	2.0GHz	550MHz
RF Input-Aux PLL						510MHz	510MHz	510MHz	1.1GHz	1.1GHz	550MHz
I_{cc} (typ) @3V	6mA	6mA	6mA	10mA	11mA	15mA	14mA	8mA	9mA	11mA	9mA
Powerdown (typ)	N/A	N/A	30µA	30µA	30µA	1µA	1µA	1µA	1µA	1µA	1µA

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INFO/CARD 24

An Advanced Multi-Standard TV Video/Sound IF

By Jade Alberkrack and Mike McGinn
Motorola Inc., Analog IC Division

This article describes a circuit which performs the functions of IF amplification, AGC, AFT, and demodulation of a TV video and sound IF signal for PAL, NTSC, SECAM, and AM D2MAC.

This new device is an advanced high performance multistandard IF system specifically designed for use with all of the world's major television modulation techniques including NTSC, PAL, SECAM, and AM D2MAC. It performs the function of intermediate frequency (IF) amplification, automatic gain control (AGC), automatic frequency tuning (AFT) and signal demodulation for transmitting systems that use either positive or negative amplitude modulated video along with frequency modulated (FM) or amplitude modulated (AM) sound. The television designer is offered a new level of circuit simplicity along with enhanced system performance when compared to present day television IF amplifiers. Numerous unique design techniques are incorporated resulting in only a single tuned circuit adjustment for a completely aligned video and sound IF system with tuner AFT output. Special design attention was given to enhance noise performance and to reduce differential gain and phase distortion. Additional internal circuitry is provided to meet the European Peritel socket requirements along with a means for descrambling video signals that use either or both amplitude modulated sync and alternate line video inversion. A detailed block diagram of the internal architecture is shown in Figure 1, and a description and operation of the major circuit blocks is given below.

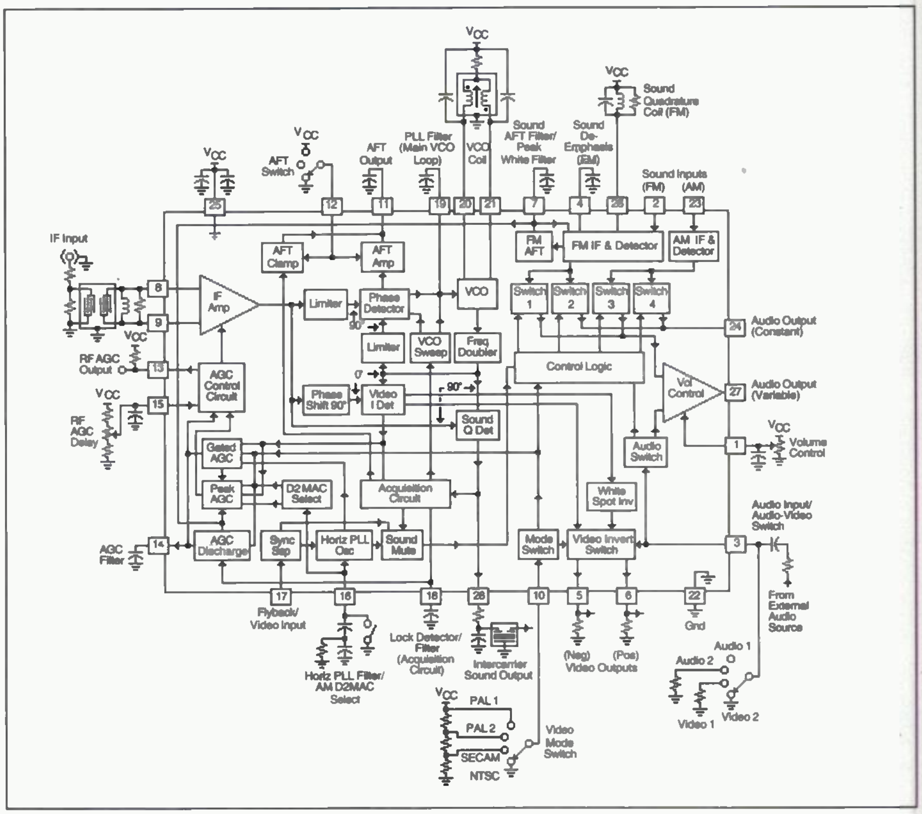

Figure 1. Representative block diagram.

IF Amplifier and AGC

The IF amplifier consists of four cascaded AC coupled gain stages yielding an input sensitivity of 40 μV for a full video output swing of 2.2 $V_{p\text{-}p}$. This level of sensitivity allows the use of a single IF block filter without incurring the additional cost of a preamplifier. A quite acceptable level of signal to noise performance is achievable by utilizing a tuner with a gain of 33 dB to 36 dB combined with a low insertion loss (≤18 dB) surface acoustic wave (SAW) filter. The first three stages of the IF amplifier are gain controlled to provide an AGC range of 80 dB. This improves the signal handling capability while reducing differential phase and gain distortion. AGC of the first stage is internally delayed so as to preserve the amplifier's low noise figure characteristics.

An on-chip sync separator and horizontal phase locked loop oscillator is provided for noise-immune AGC gating in self contained applications where a horizontal scan signal may not be available. A positive going sync source connected to the flyback/video input at pin 17 is used to lock the PLL and generate an internal AGC keying pulse. The sync separator allows direct use of the negative video output at pin 5 as a source for the keying pulse. If horizontal scan circuitry is available, a positive going flyback pulse can also be used to set the keying pulse.

The video level is established by the AGC system using an internal voltage

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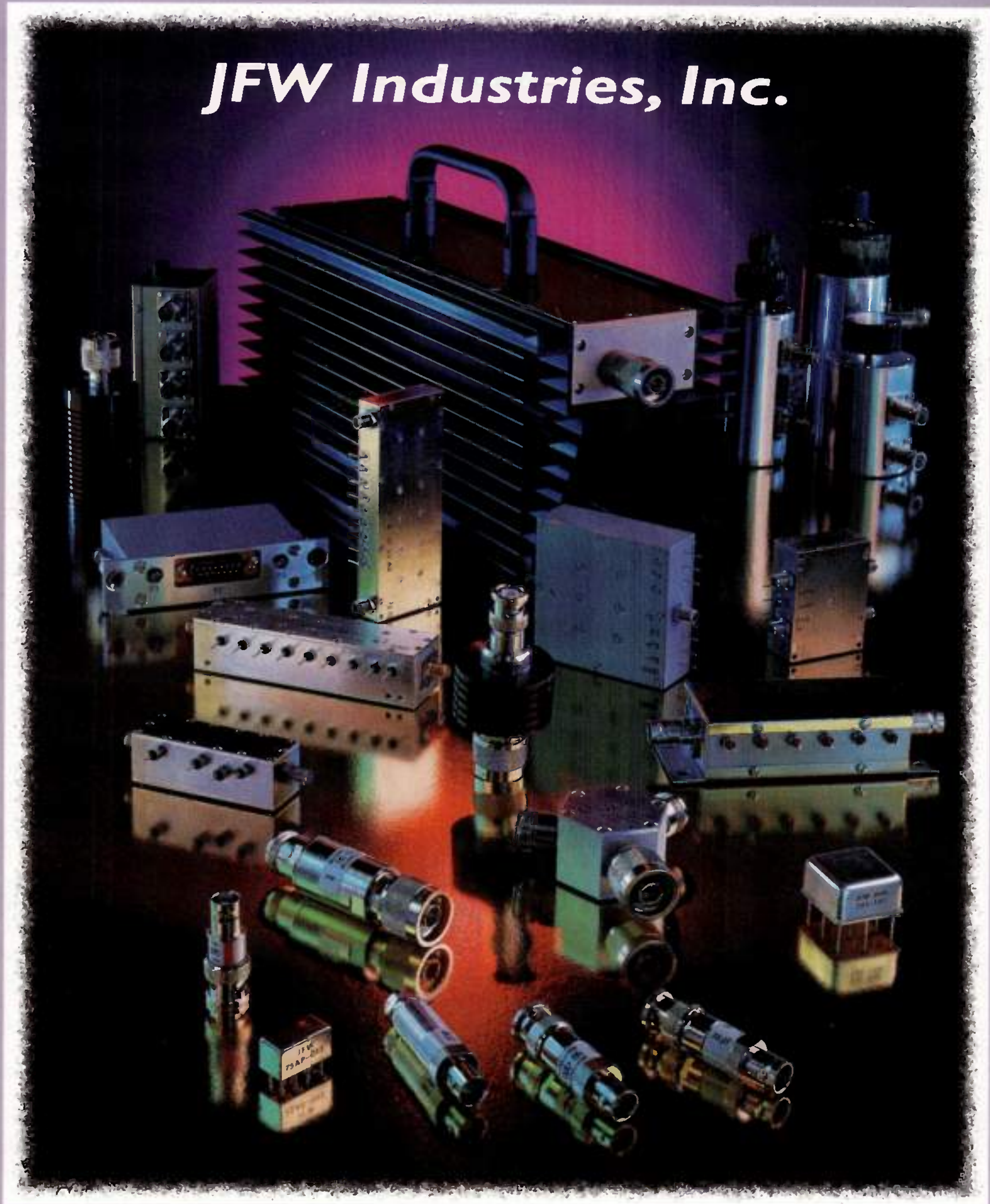

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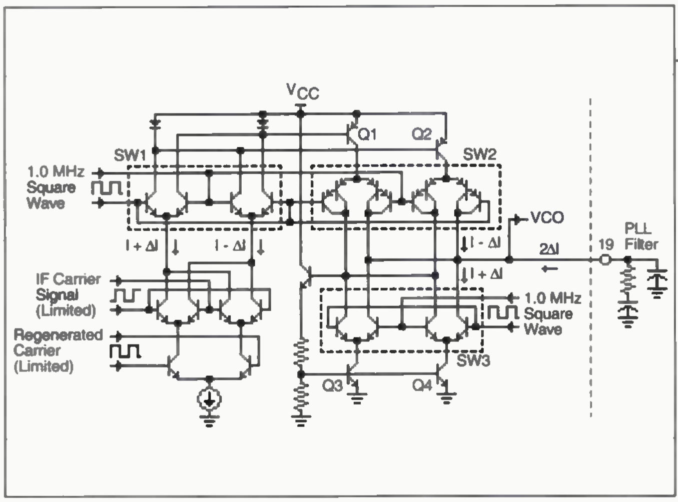


Figure 2. Phase detector.

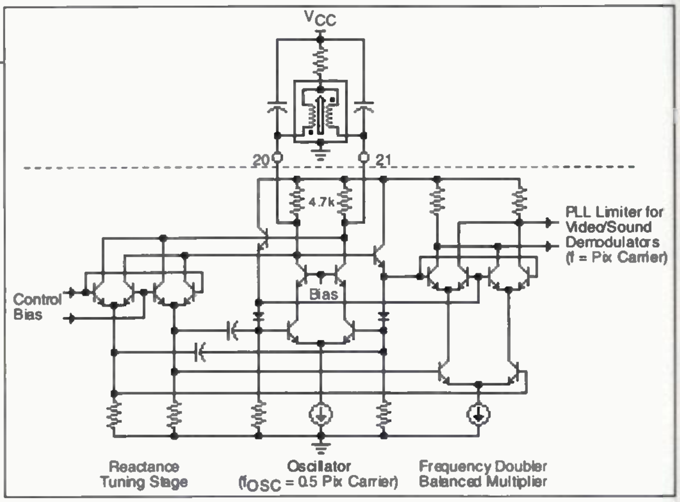


Figure 3. VCO and frequency doubler.

reference. The reference is selected for a specific modulation standard by the mode switch voltage setting at pin 10; see Table 1. With PAL 1, PAL 2, or NTSC mode selected, a black level reference is established by AGC keying during the tip of sync. With SECAM mode selected, a black level reference is established by AGC keying during the back porch. In order to correct for the inconsistent back porch level that is common between SECAM transmitters, a long time-constant, non-keyed peak white reference level is also established, and is used in conjunction with the black level reference to control the video output level. The peak white level is used in effect to slowly readjust the black level reference threshold over a limited range of ±10 percent. With this dual reference approach, the accuracy associated with a typical peak white detecting system is maintained without the usual sacrifice of speed, thus allowing a quick AGC response to airplane flutter and channel changes. With AM D2MAC selected, a long time constant non-keyed peak black reference is established and used to control the video output level.

The tuner AGC control function consists of an RF AGC delay adjustment at pin 15 and an RF AGC output at pin 13. The delay adjustment sets the threshold where tuner gain reduction is to begin. This usually corresponds to a signal level of 1.0 to 2.0 mV at antenna input. The AGC output is designed to control a reverse AGC type of tuner. As the antenna signal level increases, the voltage at pin 13 decreases, causing a gain reduction in the tuner.

Carrier Regeneration

Carrier regeneration is attained by the use of a phase locked loop, thus achieving true synchronous demodulation, with all of its advantages. Following the IF amplifier and preceding the PLL phase detector is a limiting amplifier designed to remove the amplitude modulation that is present on the carrier. The amplifier consists of two cascaded differential stages with direct coupled feedback to set a closed loop gain of 40 dB. This two stage approach with feedback greatly reduces the voltage swing and offsets associated with a single stage limiter. This dramatically improves the differential gain and phase performance without the use of an external tuned circuit. The elimination of the external tuned circuit reduces the system cost and enhances the IF stability. The static phase shift introduced into the phase locked loop by the two stage limiter would cause an error in the required 0° and 90° demodulation angles at the I and Q demodulators. By placing an identical two stage limiter between the PLL VCO and the phase detector, the error offset is canceled and the demodulating angles of 0° and 90° are restored.

DC errors in the phase detector and AFT amplifier can cause phase errors, resulting in quadrature video distortion. Most of the DC offsets are caused by mismatches in the current mirrors of the push-pull output stage, see Figure 2. Switches SW1, SW2, and SW3 are driven by a 1.0 MHz square wave with an accurate 1:1 mark/space ratio. Switches SW1 and SW2 maintain the same sense of error signal, while SW2 ensures errors due to the top PNP current mirrors average to zero on the external loop filter capacitor. In a similar way, SW3 by interchanging Q3 and Q4, cancels errors due to the bottom NPN mirror. With phase errors reduced to a minimum, there is no need for any external phase adjustments. The phase detector output is filtered and it is used to control the VCO in a corrective manner. When the PLL establishes a locked condition, there will be a 90° phase shift between the two phase detector inputs.

The voltage controlled oscillator and frequency doubler circuits are shown in Figure 3. The oscillator operates at one half of the picture carrier frequency and is tuned by a control bias that is applied to the reactance stage input. Reactance tuning allows a higher Q to be maintained in the tank circuit as opposed to a phase shift type of oscillator with the same tuning range. The oscillator frequency is internally doubled to picture carrier frequency by a balanced multiplier. Note that the multiplier input signals are at 90° to each other for frequency doubling.

Since the oscillator operates at one half of the picture carrier frequency, radiation from the external tuned circuit components will not desensitize the system, even if picked up by the amplifier input leads. This significantly reduces the possibility of a PLL push-off condition. Running the oscillator at twice the picture carrier and dividing it down is another way of solving the IF input radiation problem, but there are two significant disadvantages. First and foremost, radiation into the antenna now becomes a problem. In the U.S., twice the picture carrier falls directly into the passband of channel 6, producing a very noticeable beat. Any second order harmonics, four times picture carrier, will fall into the passband of channel 8. Second, it is more difficult to produce a stable oscillator that operates at twice the IF frequency than one that operates at one half of the IF frequency.

Video and Sound Intercarrier Demodulation

To ensure that the above performance improvements were not lost elsewhere, great care was taken with the design of the video demodulator and video amplifiers. One example is in the architectural placement of the phase shift amplifier (Figure 4) that is required for video demodulation. This amplifier was placed in series with the IF signal side of the demodulator, instead of the oscillator side as is common practice. The 90° phase shift is obtained by a capacitively coupling each of the differential amplifier driver emitters to the video demodulator inputs. This results in an output current that is at 90° with respect to the input voltage over a wide range of frequencies. Small phase errors that are caused by the transistor dynamic small-signal emitter resistance are corrected with the use of cross-coupled emitter resistors. This arrangement leads to a simpler design with the ability to tailor the demodulation angle for the lowest possible distortion at the IF/demodulator interface. The dynamic emitter resistances, which can give rise to distortion, are now in quadrature with the capacitive reactance and therefore contribute very little to the resultant output.

After the PLL attains phase lock, video and sound demodulation is obtained by the use of two separate double balanced multipliers. Video demodulation is accomplished by multiplying the non-limited 90° phase shifted carrier signal, with the regenerated vision carrier that is obtained from the frequency doubler output. Both positive and negative video outputs are produced. The phase relationship between the video demodulator inputs is 0° since the carrier signal is phase shifted 90°. This is done in order to cancel out the 90° phase shift that is present at the inputs of the phase detector when it is locked. The sound intercarrier signal is also recovered by a multiplier in a similar manner to that of the video. In this case the carrier signal is not phase shifted, and the phase relationship between the sound demodulator inputs is 90°. A consequence of this phase relationship is that only the higher frequency video components are demodulated while the lower frequency components, those that fall within the vestigial sideband, are suppressed. With negative polarity modulation systems, a significant reduction in the level of white character sound buzz and hum is achieved. This is most noticeable when demodulating video signals that contain a high luma level which can cause the modulation index to exceed 100 percent.

Video Outputs

Each of the video outputs are part of a wide bandwidth operational amplifier with internal DC feedback and frequency compensation. The AGC reference provides the same composite video output level of approximately 2.2 V_{p-p} for both positive and negative polarities of video modulation. The positive video output appears at pin 6 and is intended to drive the luma and chroma channels. This output contains a white spot inverter that is used to

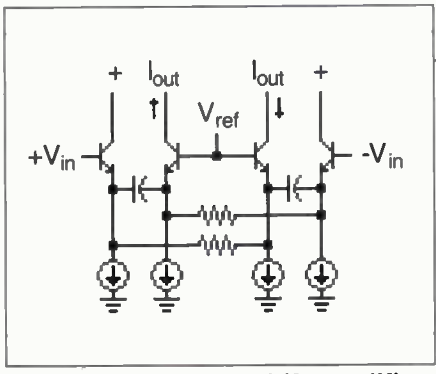


Figure 4. 90° phase shift amplifier.

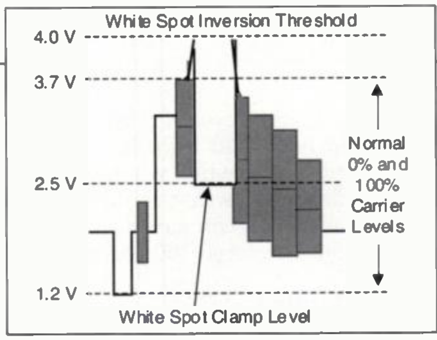


Figure 5. Positive video output with white spot inversion.

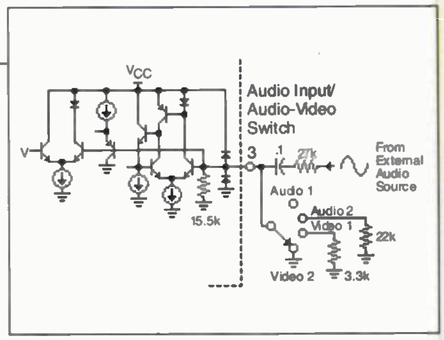


Figure 6. Audio-video switch programming.

invert and clamp any demodulated noise that is significantly above the white level. This effectively removes the whiter than white noise produced by the true synchronous demodulator and prevents the CRT from being overdriven and defocused. The white spot inversion threshold and clamp levels are set to approximately 4.0 V and 2.5 V respectively. The negative video output appears at pin 5 and is intended to be used as a sync separator source. With a simple preseparator low pass noise filter, this output will provide optimum sync performance.

AM and FM Sound IF and Detection

The intercarrier sound that is present at the Q demodulator output, pin 28, normally connects through a ceramic bandpass filter to either the FM IF and detector input at pin 2, or the AM IF and detector input at pin 23. With the FM IF, intercarrier sound is limited by a five stage AC coupled amplifier yielding high sensitivity and a high level of AM rejection. The typical limiting threshold is 80 µV, and the AM rejection ratio is in excess of 50 dB. A self tuning quadrature demodulator accomplishes FM detection. An internal reactance stage with phase compensation is controlled to automatically adjust the tuning of an external tank circuit eliminating the need for manual alignment. The tank is a parallel circuit consisting of a fixed value inductor, capacitor, and resistor. The tuning range is controlled by the ratio of the internal capacitance change to that of the fixed external tank capacitance. The internal capacitance is controlled by the voltage present on the sound AFT filter, pin 7. The capacitance ranges from 0.25 pF to 19 pF. Selection of the external components determines the tuning range and performance. Multi-standard applications that require a wide intercarrier tuning range can be accomplished by using a small external capacitance with a large inductance. With the proper selection of components, the circuit is capable of self tuning from 4.3 MHz to 6.6 MHz.

The sound AFT time constant is set by an external capacitor that is connected from pin 7 to ground. The demodulated sound bandwidth is in excess of 100 kHz making this device well suited for MTS (multi-channel television sound) stereo and SAP (second audio program) TV applications. Sound de-emphasis is controlled by the time constant of an internal 18 kΩ resistor and an external capacitor that is connected from pin 4 to ground. The FM IF is active in PAL 1, PAL 2, and NTSC modes with 2.0 V_{p-p} of audio at the variable and constant outputs.

With the AM IF, intercarrier sound is amplified and detected by a fully balanced exalted carrier demodulator. The detector provides 2.0 V_{p-p} recovered audio output at pin 24. An internal low pass filter is incorporated to suppress any high frequency harmonics that may be present at the demodulator output. The AM IF is active in both the SECAM and NTSC modes.

Audio Input/Audio-Video Switch

The audio input/audio-video switch is a multifunction input that selects the source for the audio that appears at the variable audio output, pin 27, and the polarity of the video outputs at pins 5 and 6. There are four possible modes for this input and they are each selected by applying a specific DC voltage level to pin 3, see Figure 6. Audio 1 is intended for applications where internally demodulated audio is present at the variable and constant outputs. The variable output can be used internal to the TV chassis and the constant output can be connected to a jack for earphone or recorder use. Audio 1 is selected by not having a DC path from pin 3 to

Television Standard		Mode Selections		AGC		Sound			
System	Video Modulation Polarity	Pin 10 Voltage (V)	Pin 16 DC Loading	Reference & Method	Time Constant Pin #	IF and Demodulator: Active	IF and Demodulator: Inhibited	Audio Output Pin #	Muting
PAL 1	Negative	4.0 to 5.0	Open	Black Level Sync Tip Keyed	14	FM	AM	24, FM 27, FM	No
PAL 2	Negative	3.2 to 4.0	Open	Black Level Sync Tip Keyed	14	FM	AM	24, FM 27, FM	Yes
SECAM	Positive	1.9 to 3.0	Open	Black Level Back Porch Keyed White Level Peak Detected Video	14 7	AM	FM	24, AM 27, AM	No
NTSC	Negative	Ground	Open	Black Level Sync Tip Keyed	14	AM & FM	–	24, AM 27, FM	No
AM D2MAC	Negative	Don't Care*	Ground	Black Level Peak Detected Digital Video	7	–	AM & FM	–	No

*This input is overridden when pin 16 is grounded.

Table 1. Television standard modes.

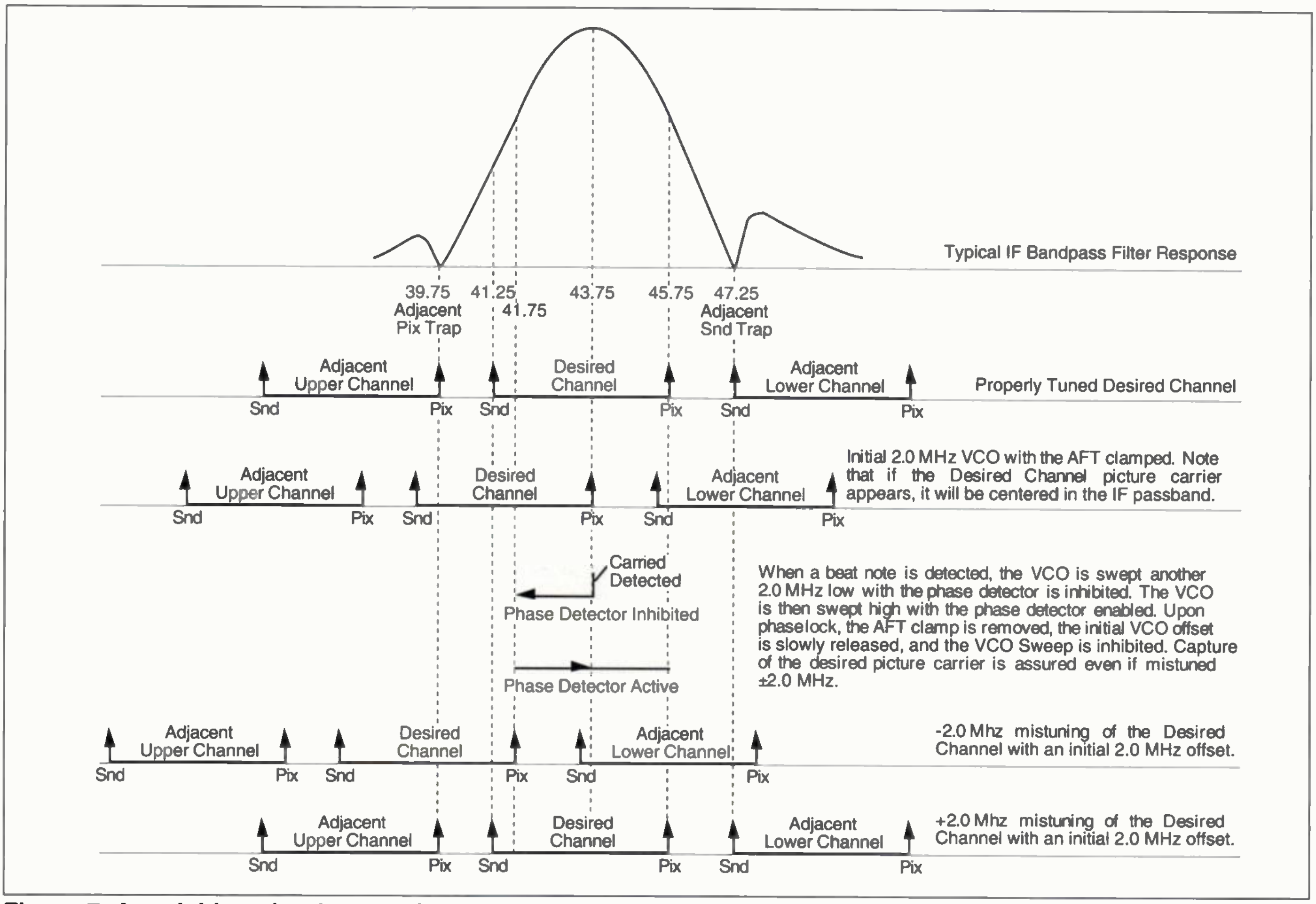


Figure 7. Acquisition circuit operation.

ground. Internally demodulated audio (AM or FM) will appear at pins 24 and 27, negative video at pin 5, and positive video at pin 6. If there is an AC coupled audio source present at pin 3, it will be internally disconnected. Audio 2 is intended for European applications where internal and external audio sources must be routed through the Peritel socket. Internally demodulated audio present at the constant output can be routed out the Peritel socket while external audio can be routed in, AC coupled to pin 3, and level adjusted at pin 1 for use within the TV chassis. Audio 2 is selected by connecting a 22 kΩ resistor from pin 3 to ground. Internally demodulated audio (AM or FM) appears at pin 24, negative video at pin 5, positive video at pin 6, and the AC coupled external audio source at pin 3 appears at pin 27 inverted. Video 1 and 2 modes provide a simple means to recover scrambled video in systems that use some form of alternate line video inversion. Descrambling is accomplished by switching between the two video modes. Video 1 is selected by connecting a 3.3 kΩ resistor from pin 3 to ground. Internally demodulated audio (AM or FM) will appear at pins 24 and 27, negative video at pin 5, and positive video at pin 6. Video 2 is enabled when pin 3 is grounded, usually by an IC or a transistor that is gated on alternate or multiple lines. Internally demodulated audio (AM or FM) appears at pins 24 and 27, positive video with white spot inversion at pin 5, and negative video at pin 6. Note that Video 1 mode is identical to Audio 1. Video 1 is provided so that when descrambling, pin 3 does not have to pass through the voltage range that selects Audio 2. This prevents unwanted switching noise and buzz from appearing at the audio outputs.

DC Volume Control

The DC volume control consists of an electronically controlled audio amplifier that has a range of 12 dB gain, to 60 dB attenuation. The audio output level is set by applying a control voltage to pin 1. This can be derived from an electronic source such as digital to analog converter, or a manual source such as the wiper of a potentiometer that is connected from V_{CC} to ground. Because no audio signal is present on pin 1, any potential for hum and noise pickup can easily be bypassed.

Multi-Standard Operating Modes

The MC44302 is designed to operate properly with PAL (B, G, I,) SECAM (L), NTSC (M), and AM D2MAC television transmission standards. There are two multifunction inputs that are used to select the proper control methods for video demodulation, sound intercarrier demodulation, and AGC. This keeps the sense of the video signal at the outputs the same, whether positive or negative modulation is being received.

The PAL, NTSC, and SECAM standard are each selected by applying a specific DC voltage level to the Video Mode Switch at pin 10. With PAL 1 selected, AGC is keyed on the sync pulse by the horizontal PLL which is locked to the flyback or video sync pulse present at pin 17. The FM sound IF and detector is active with the demodulated audio appearing at pins 24 and 27. The PAL 2 selection is identical to PAL 1 with the addition of sound muting when the acquisition circuit is unlocked or vertical sync is absent. With SECAM selected, the video level is established by both, a long time constant peak white detector, and a back porch keyed AGC that corrects for transmitted black level errors while maintaining fast AGC response. The AM sound detector is active with the demodulated audio appearing at pins 24 and 27. With NTSC selected, AGC and sound muting is the same as for PAL 1 mode. The FM and AM detectors are both active with the FM output at pin 27 and the AM output at pin 24. The AM output can be used to obtain the sync signal in suppressed sync scrambling systems that amplitude modulate it on the sound carrier.

The AM D2MAC standard is selected by grounding the horizontal PLL filter/AM D2MAC select at pin 16. When grounded, this pin overrides the control of pin 10, and AGC is performed by peak video averaging at pin 7. Noise interference on the digital sound channel is eliminated since both the AM and FM sound IF and detectors are inhibited. By placing pin 3 in the Audio 2 mode, the variable audio output at pin 27 is active and can be used to control the level of the externally processed digital sound.

Signal Acquisition and AFT

The automatic fine tuning (AFT) portion of this integrated circuit is unconventional in form. AFT control is derived by amplifying the phase detector error voltage and applying it to the tuner local oscillator (LO) after phase lock is established. This method eliminates the need for a discriminator coil along with the associated alignment, and the potential for IF instability due to coil radiation.

This device is unique in that the VCO loop is used as the frequency reference for the tuner AFT loop. After signal acquisition and phase lock, the VCO and AFT loops will reach a steady state condition. The VCO will have moved only a small amount from its nominal frequency (Δf_{VCO}) with the tuner local oscillator (Δf_{LO}) correcting for the majority of the frequency error (Δf_e). Therefore in steady state condition $\Delta f_e = \Delta f_{VCO} + \Delta f_{LO}$, and $\Delta f_{LO} >> \Delta f_{VCO}$. This is due to the much higher gain in the tuner LO loop when compared to that of the VCO loop. In this way, the VCO can be used as the frequency reference for the AFT system provided that the PLL can be initially locked to the incoming IF signal. This combination of the tuner LO loop and the VCO loop forms a double loop PLL system. Analysis shows that the overall system stability can be assured by treating the VCO loop as a single stand alone PLL. This is valid if the VCO loop has low gain and high bandwidth which guarantees initial capture, while the tuner LO loop has high gain and low bandwidth which minimizes frequency and phase offsets.

The AFT system is designed to acquire the vision carrier, without false locking to the sound or adjacent sound carriers, with an initial tuner LO frequency error of ±2.0 MHz. This error is reduced to less than ±10 kHz upon establishing acquisition and after both the VCO loop and tuner AFT loop have reached their steady state condition. In contrast, the discriminator coil type of AFT has a highly asymmetric lock characteristics with a frequency error in the range of about –2.0 MHz to +1.0 MHz. This large frequency error is due to the effects of lower loop gain combined with the IF filter slope. Higher loop gain can be incorporated into the discriminator coil type of AFT but circuit problems due to large DC offsets, and IF stability due to coil radiation at the picture carrier frequency can be difficult to resolve. In order to achieve a high performance level, without encountering the ill effects associated with high gain discriminator circuits, a novel approach to establishing PLL lock up was developed.

Figures 7 and 9 graphically illustrate the acquisition circuit operation. In the absence of an IF signal, the acquisition circuit examines the state of the video (I) and sound (Q) demodulators detecting that the VCO is out of lock. On loss of lock, the AFT output at pin 11 (tuner LO drive) is clamped, and the lock detector output at pin 18 is placed in a sink mode, causing its filter capacitor to discharge. As the capacitor voltage falls below 3.7 V, the application of a VCO offset starts and is completed at 3.0 V. The capacitor voltage will continue to fall stopping at 2.7 V until the acquisition circuit detects a signal.

The AFT offset is typically set to –2.0 MHz so that if a nominal IF signal appears, it would be centered in the IF filter passband where there is minimum attenuation. Note that even if the tuner LO drifts high by as much as 2.0 MHz, the signal will still not be significantly attenuated.

On the arrival of a signal, beat notes are detected at the output of the

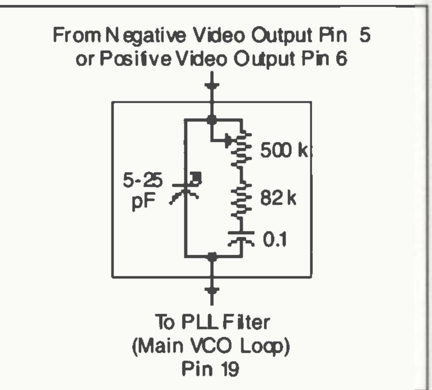
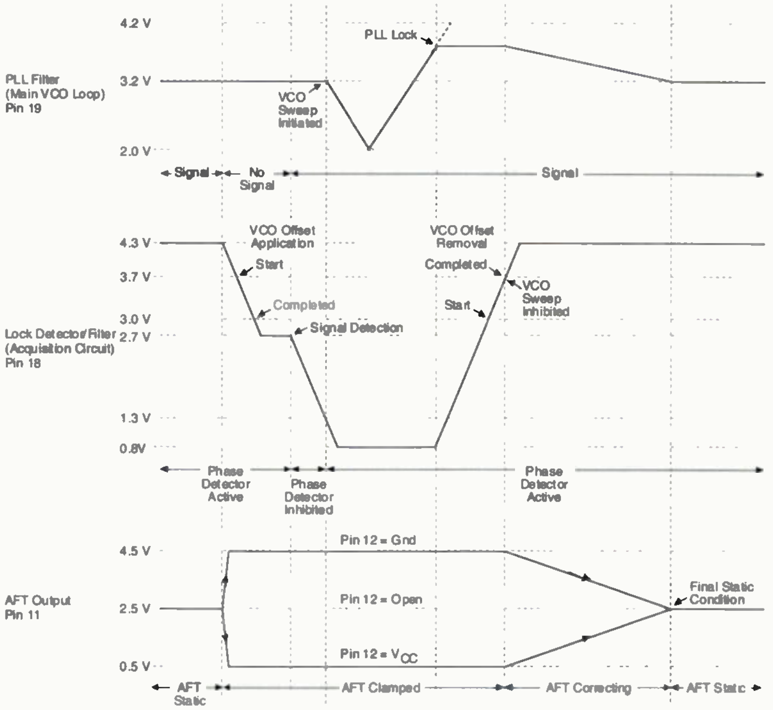


Figure 8. Differential phase correction circuit.

demodulators, and the lock detector output is again placed in a sink mode to further discharge the filter capacitor. When the capacitor voltage falls below 1.3 V, the VCO sweep is enabled. This causes the VCO to be swept an additional –2.0 MHz from its out of lock nominal centered IF frequency. During this negative sweep, the PLL phase detector is inhibited so that a phase lock signal cannot be obtained. When the capacitor voltage falls below 0.8 V, the phase detector is activated, and the VCO is swept in a positive direction from –2.0 MHz to +2.0 MHz of the out of lock centered IF frequency. The PLL will therefore lock to the first carrier it encounters. This in fact has to be a vision carrier since the sound carrier is more than 2.0 MHz below the nominal frequency, and the adjacent lower channel sound carrier is higher than the vision carrier. On achieving lock, the lock detector output is released allowing the voltage across the filter capacitor to rise. When this voltage reaches 3.0 V, removal of the VCO offset starts. At 3.7 V removal is completed, the VCO sweep circuit is inhibited, and the AFT clamp is removed.

The phase detector remains permanently enabled. Upon removal of the AFT clamp, a large error voltage appears at the AFT amplifier output which drives the IF signal back to the correct frequency. Since the tuner LO loop is slow and the VCO loop is fast, the VCO is able to track the IF signal while maintaining phase lock as its frequency is swept until the final static conditions are reached. For large frequency errors during this period, the slew rate of the tuner LO loop is automatically increased but not to the extent where it would cause a VCO tracking problem. This technique allows the acquisition time of the circuit to be reduced considerably while still using a larger than normal time constant in the tuner LO loop. In this



In order to make the above drawing easier to comprehend, the vertical voltage axis was drawn to scale but the horizontal time axis was not. The typical slewing time for each output with the component values shown in the application circuit is as follows:

PLL Filter (Main VCO Loop) Pin 19 - 3.5 ms total sweep time when discharging down from 4.2 V to 2.0 V and charging back up to 4.2 V.

Lock Detector/Filter (Acquisition Circuit) Pin 18 - 4.0 ms when slewing up from 0.8 V to 4.3 V.

AFT Output Pin 11 - 12 ms when slewing from 4.5 V or 0.5 V to the final static condition of 2.5 V.

Figure 9. Acquisition circuit timing.

way, any possibility of phase modulating the LO with video is removed.

The amount of AFT offset is controlled by the output swing of pin 11, the voltage to frequency sensitivity of the tuner's AFT input, voltage gain or attenuation of any interface level shifting circuitry, and the alignment accuracy of the VCO coil. The amount of VCO offset and VCO sweep is controlled by the change in capacitance ratio of the internal tuning capacitor to that of the fixed external tank capacitors.

It must be noted that in the operating description of this device, any reference made to the amount of VCO offset or sweep is the actual effect on the IF passband. The true VCO frequency change is only one half of that stated due to the frequency doubler circuit.

The AFT system is designed to control all types of varactor tuned local oscillators via the AFT mode switch input at pin 12. This input is used to activate the output of the AFT control amplifier that appears at pin 11, and to select the control voltage polarity versus IF frequency. With the AFT mode switch input connected to VCC, pin 11 is placed in a sourcing mode when the IF carrier frequency is below nominal. With the AFT mode switch input grounded, pin 11 is placed in a sinking mode when the IF carrier frequency is below nominal. With the AFT mode switch input disconnected, pin 11 is internally clamped to one half of V_{CC}, see the bottom diagram in Figure 9. Under this condition the TV set can be tuned manually and appear to have a conventional type of AFT with a smooth capture characteristic. Most other PLL AFT systems cannot be manually tuned in this manner as they tend to exhibit an undesirable abrupt capture characteristic. Digital phase locked loop tuning systems can also be controlled with the addition of a varactor diode used to shift the PLL reference oscillator.

Differential Phase and Sound Buzz

Even with all the care taken in this design, some residual differential phase still remains. Although small, it results in an output on the phase detector that modulates the VCO and the sound intercarrier. This in turn has the potential of degrading the stereo sound performance. In addition, there is a quadrature differential phase shift that is produced by the shape of the IF bandpass filter. Both produce currents in the output of the phase detector which in turn phase modulates the VCO. This phase modulation is imposed on the sound intercarrier resulting in a video related sound buzz. These currents can be canceled by injecting the correct amplitude and phase of demodulated video into the PLL filter. This can be accomplished with the addition of the differential phase correction circuit shown in Figure 8. The phase detector current that is due to the in-phase differential gain is canceled by the resistor current, and the quadrature component that is induced by the IF filter is canceled by the capacitor current. With proper adjustment, the differential phase distortion can be reduced to less than 0.5 degrees as well as eliminating any perceptible sound buzz. The source for the demodulated video to be injected into the PLL filter can be obtained from pins 5 or 6. This must be determined experimentally for a given printed circuit board layout in order to obtain the best results. With the use of the correction circuit, this system achieves a similar level of performance to that of a parallel sound IF system.

Conclusion

The article has demonstrated that with new design techniques and a great deal of attention to detail, it is possible to produce a single channel multi-standard video/ sound IF amplifier system that has superior performance, few external components, and a single coil adjustment. This system is economical, requires no shielding and is much easier to implement than existing systems. *RF*

About the Authors

Jade Alberkrack is a principal staff applications engineer and a member of the technical staff at Motorola's Analog IC Division. He is responsible for customer applications and new product definition the area of linear and switching regulators, and motor controllers.

Michael McGinn received his Higher National Certificate in Electrical Engineering at Birkenhead Technical College and Part III I.E.E. at Hatfield Technical College. He is a member of the technical staff for Motorola's Analog IC Division and is responsible for the design of video and television ICs.

The authors can be reached at Motorola, (602) 413–3873.

Synthesizer Reaches 3200 MHz for ATE and Communications

By the Engineering Staff
Programmed Test Sources, inc.

Featured on this month's cover is the PTS 3200, a precision frequency generator which supplies low-noise signals from 1 MHz to 3200 MHz with a resolution of 1 Hz and high agility. Its fast frequency switching (1 to 20 μs) sets it apart from most other synthesized sources targeting the commercial market. Furthermore, price was a specific design goal: key customers were involved early in the development process, providing input on price and performance specifications which would be required for a commercially successful product. The result is a unit which seeks to set a new standard for overall performance-to-price ratio.

The PTS 3200 synthesizer offers low-noise and fast switching times to 3200 MHz.

Synthesizer applications span a wide range of electronic disciplines. Two current projects illustrate how the PTS 3200 is used:

Radar Application

Scientists at Lincoln Laboratory (Lexington, MA) have designed an upgrade to an existing instrumentation radar which uses the PTS 3200. In this application, the synthesizer serves as one of the LO sources in the IF chain and allows for the correction of Doppler-induced errors. The fast switching time of the PTS 3200 provides for independent correction of each radar return pulse. At the same time, the signal purity is sufficient to meet stringent phase noise requirements. Previously, this function had been performed by a custom waveform generator developed specifically for this purpose. With the introduction of the PTS 3200, system performance specifications can be met with commercial hardware, with resultant savings in cost and maintenance.

Automatic Test Equipment (ATE)

Another application for fast-switching low-noise frequency synthesizers is in the area of automatic test equipment. At Teradyne, Inc. (Boston, MA), the A580 mixed-signal test platform was recently enhanced to address the growing market for wireless communications ICs. This versatile tester line currently includes a number of PTS frequency synthesizer products acting as low-jitter clock sources and CW transmitters.

For the wireless and microwave markets, the A580 tester family has been enhanced with full RF/Microwave Functional and Parametric Test capability. The PTS 3200 with its low spurious and phase noise is a key building block for both the Microwave Source and Measurement Instrumentation features that Teradyne has added to its product line. The PTS 3200's fast switching makes it particularly well suited for Teradyne's ATE application enabling the fastest possible test times.

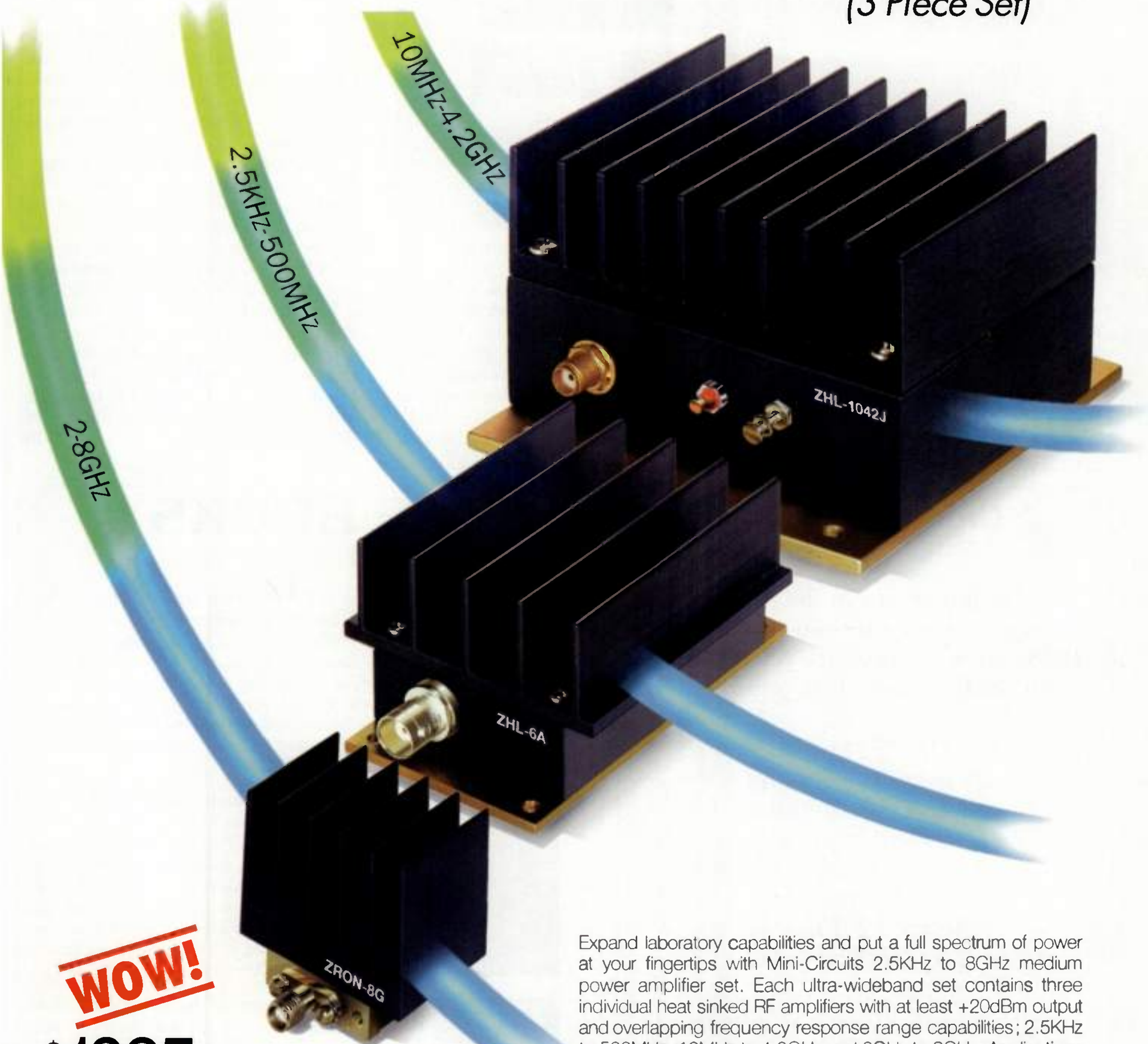
Teradyne's ATE application also required an extremely low-noise fixed-frequency output. Because of the PTS 3200's modular architecture, internally-generated 100 MHz multiples were accessible, and at very little additional cost PTS engineers were able to provide an extremely low noise output (–130 dBc/Hz, 10 kHz offset).

Design Description

The PTS 3200 is a beat frequency generator, in which the output frequency of 1-1600 MHz is the result of down-conversion of a wideband oscillator and a signal covering a 100 MHz band, which contains all fine resolution frequency steps. Together, they are embedded in a drift-cancelling loop. The range of 1600-3200 MHz is obtained by doubling. A high-gain broadband amplifier follows the mixer stage to obtain a leveled output of +13 dBm. From the user's perspective, the unit has a single range output, because the automatic switching of the

2.5KHz-8GHz AMPLIFIERS

(3 Piece Set)



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Model :	Freq. (MHz)	Gain (dB)	Power Output, dBm @ 1dB Compression	DC Power Volt V	DC Power Current mA	Conn. Type	Indiv. Price ($) (1-9 qty.)
ZHL-6A	.0025-500	21	+23	+24	350	BNC	199
ZHL-1042J	10-4200	25	+20	+15	330	SMA	495
ZRON-8G	2000-8000	20	+20	+15	310	SMA	495

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doubler is accomplished in less than 20 µs.

The availability of silicon semiconductors with gain to frequencies of over 5 GHz made a design possible which heretofore would have called for a YIG-tuned oscillator for the high-frequency section, with its attendant price and power penalties. In the lower frequency portions, both DDS and direct analog synthesis are used to best advantage within the constraints of space, dissipation and cost.

The same cost-performance considerations were applied to the choice of manufacturing technology. After careful cost and reliability evaluation, it was decided to limit surface-mount to the performance-critical UHF/microwave sections, and to employ through-hole technology where it is appropriate. Fully modular packaging is also employed, which enhances manufacturability, test and mean-time-to-repair. The modular approach also allows for the easy integration of a variety of standard or customer-specific options.

In summary, the PTS 3200 expands PTS' capability to address customers' needs in commercial signal source and test markets with economically priced highly reliable equipment. The price of the PTS 3200 is $13,500 (depending on options), with delivery in 60 days.

For more information on this synthesizer, circle Info/Card #251 or contact the company directly at: Programmed Test Sources, inc., 9 Beaverbrook Road, P.O. Box 517, Littleton, MA 01460; tel: (508) 486-3008; fax: (508) 486-4495. *RF*

Call for Articles

RF Design is now in the process of developiong our editorial schedule for 1996. Some of the topics we will cover in the first part of the year are:

DECT Design
Transmitter Design
CAD / CAE Methods
RF Switching
PCS Design
Signal Processing
Active RF Filters
2.4 GHz Circuits

Your technical article may help many other RF engineers get their jobs done more effectively! Send a brief abstract of your proposed article to:

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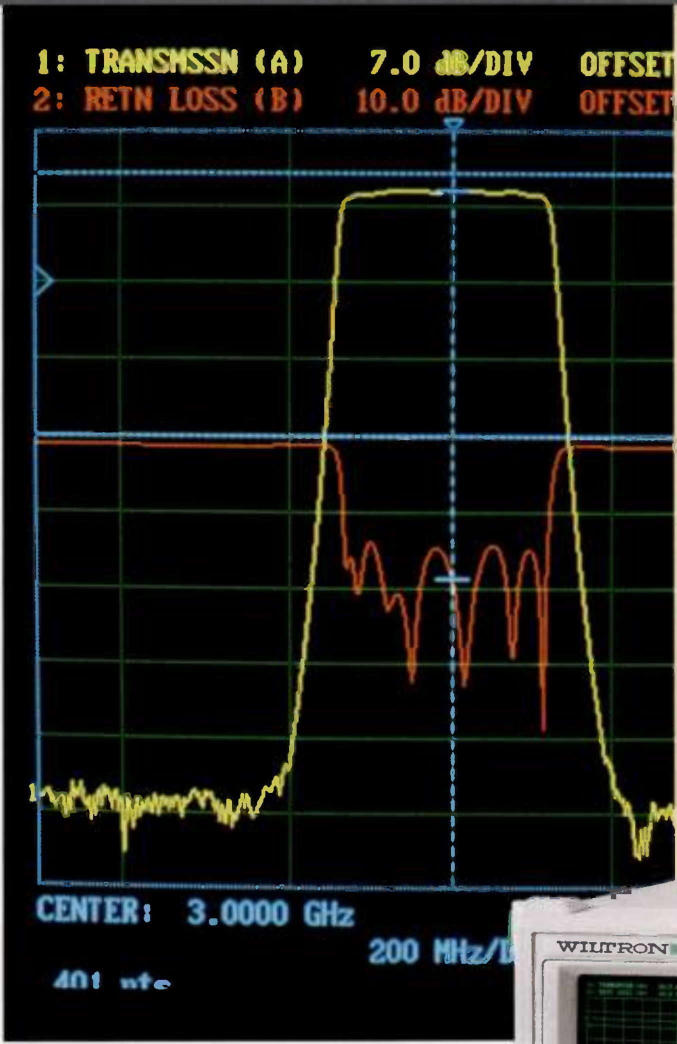
Low Cost Network Analysis For High Throughput Manufacturing.



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INFO/CARD 28

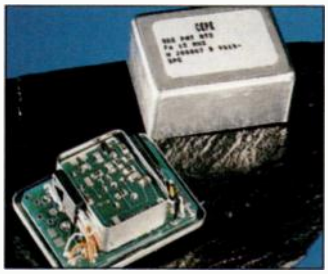
3V, 50 MIPS DSP

AT&T's DSP1627 is able to process 50 million instructions per second (MIPS) from a 2.7 V power supply, and replaces earlier generation DSPs which required two chips to share the processing for the modem and voice coding functions in digital cellular phones. The DSP1627 has current drain of only 0.7 mA/MIPS at 2.7 V. The DSP is also well-suited for cellular base-station applications, providing 70 MIPS from a 5 V power supply. With a complement of 36 kilo-words (KW) of ROM and 6 KW of dual-ported RAM available on chip, the DSP1627 meets the memory requirements for full-rate IS-136, Japanese and the pan-European GSM digital cellular standards. The DSP chip includes an on-chip clock synthesizer, eight-bit parallel host interface to standard microcontroller protocols, and power management. Source code for the DSP1627 is backward-compatible with code for the DSP161X family. The device is built using AT&T's 0.5μ process. The chip is packaged in an ultra-thin, 100-pin TQFP and will be available in small volume quantities in 4Q95. Pricing for the DSP1627 is $49 each.

AT&T Microelectronics
INFO/CARD #250

OCVCXO for GSM

CEPE, a Thomson-CSF subsidiary has introduced a high stability oven controlled crystal oscillator for GSM bas stations, with fast warm-up time and a small package using an SC-cut resonator. Center frequency is 13 MHz, with overall frequency stability from –10 to +70 °C plus one year aging of $5{\times}10^{-8}$. The output signal is 5V HCMOS, with a duty factor of 40/60. An external control voltage, ranging from 0 to 7 V, is designed to compensate for

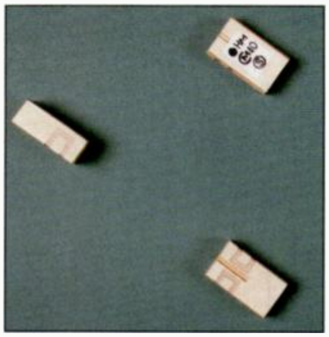


aging over a 15 year period. Warm-up time to within $\pm5{\times}10^{-8}$ of final frequency at –10 °C is 5 minutes. Power requirements are +12 V (±10 percent) at 400 mA during warmup and at 120 mA under steady state at 25 °C. An oven alarm signal is at 4.5 V when the oven is operating and is at 0.5 V when the oven has malfunctioned. Dimensions for the OCVCXO are 40 × 30 × 19 mm.

Thomson Components & Tubes Corp. Special Products Div.
INFO/CARD #249

Compact Filter

Murata Electronics has announced the development of a microwave filter which is 40 percent smaller than previous surface-mount device filters. The largest filter in the family measures 10.2 × 5.2 mm. M-Block filters are assembled

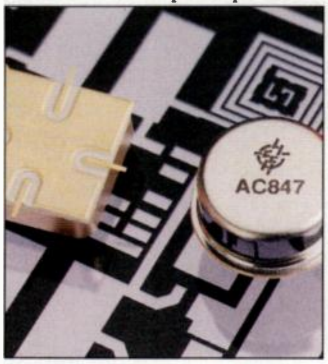


using a process which reduces the number of components and allows the filter to be assembled from a single block of ceramic. The filters in the M-Block series are available for the 915 MHz ISM band; for CT1, 40-channel analog cordless applications; and for CT1, 80-channel analog cordless applications. A filter for CT2 applications is forthcoming. The CT1 filters have center bandwidths at 914.5, 959.5, 886.0 and 931.0 MHz. All these filters have two-pole responses. Maximum power handling is 1 W average.

Murata Electronics North America
INFO/CARD #248

Thin-Film Amplifiers

The model AC847 thin-film cascadable amplifier operates over the frequency range of 10 to 800 MHz. Typical gain is 13.5 dB. Typical noise figure is 2.5 dB. Output power at the 1 dB compression point is typically 16.7 dBm. Maximum continuous RF power is +13 dBm and maximum peak power is

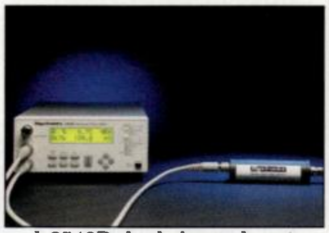


0.5 W. Operating current is 44.0 mA at 15 volts. Typical maximum VSWR is 1.5:1. Typical third-order intercept point is 32 dBm. Second harmonic intercept point is +48.0 dBm at +15 V and +50.0 dBm at +12 V. Second order two-tone intercept point is +43 dBm at +15 V and +43 dBm at +12 V. The AC847 is packaged in a standard four-pin TO-8 housing and is also available in SMA, flatpack and surface mount housings.

Cougar Components
INFO/CARD #247

Power Meter

Giga-tronics' 8540B Series Universal Power Meter and the 80400A Series Modulation Power Sensors give users the ability to perform high speed power measurements over a wide dynamic range. The 8541B single-channel



and 8542B dual-channel meters share the following capabilities: measurement speeds over GPIB up to 200 readings per second; extremely accurate average power measurements of AM, two-tone, pulse and digitally modulated signals such as BPSK, OQPSK, π/4 DQPSK and 0.3 GMSK using the 80400A Series Modulation Power Sensors; using the same sensors, burst average power measurements can be made, even for pulse signals which are amplitude modulated during the burst; dynamic range is –60 or –70 dBm to +20 dBm over a frequency range of 10 MHz to 18 GHz. Current users of the 8540 meters can upgrade to the 'B' series without having to replace their present meter. U.S. list pricing for the 8541B and 8542B are $3,095 and $4,595, respectively.

Giga-tronics Inc.
INFO/CARD #246

AMPLIFIERS

Broadband Amp

Amplifier Research has introduced a solid-state RF power amplifier that delivers a minimum 40 W CW power from DC to 1 MHz. The Model 40AD1 is direct coupled throughout, permitting use of very low frequency source signals. The amplifier is 100-percent immune to load mismatches and can be operated into any load-VSWR condition without damage, oscillation, foldback, or shutdown. Price is $4,300.
Amplifier Research
INFO/CARD #245

5 W Satcom Amplifier

Celeritek introduces a 5 W (at 1 dB compression), solid-state power amplifier designed for C-band satcom transmit applications. Two operating frequency bands are available: the Intelsat 5.850 to 6.425 GHz band, and the IndiaSat 6.725 to 7.025 GHz band. Minimum gain is 50 dB, and power is +12.0 to +15.5 VDC. The amplifier measures less than 5 × 3 × 3/4 inches.
Celeritek, Inc.
INFO/CARD #244

SIGNAL PROCESSING COMPONENTS

High-Power Bandpass Filter

A CDPD or AMPS cellular bandpass filter designed for high-power transmit applications is now available from Delta Microwave. Features include 869 to 894 MHz passband, 0.40 dB insertion loss, 150 W RMS average power, and 1.5 kW peak power. The filter rejects 824-849 MHz (60 dB) and 920-2700 MHz (35 dB). Size is 13 × 2.5 × 2.5 inches.
Delta Microwave
INFO/CARD #243

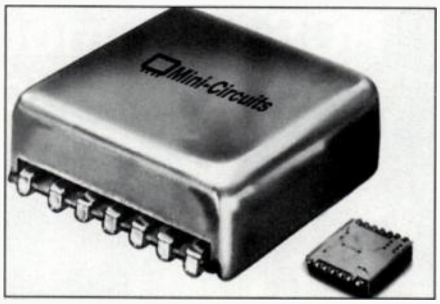
BNC Attenuators

Two BNC model coaxial fixed attenuators, one in the DC to 2000 MHz range, the other in the DC to 4 GHz range are now available from Inmet Corp. Model 9073 features attenuation values of 1 through 20 dB in 1 dB increments, while model 9033 has attenuation values of 1 through 30 dB in 1/2 dB increments.
Inmet Corporation
INFO/CARD #242

Preselector for Satcom

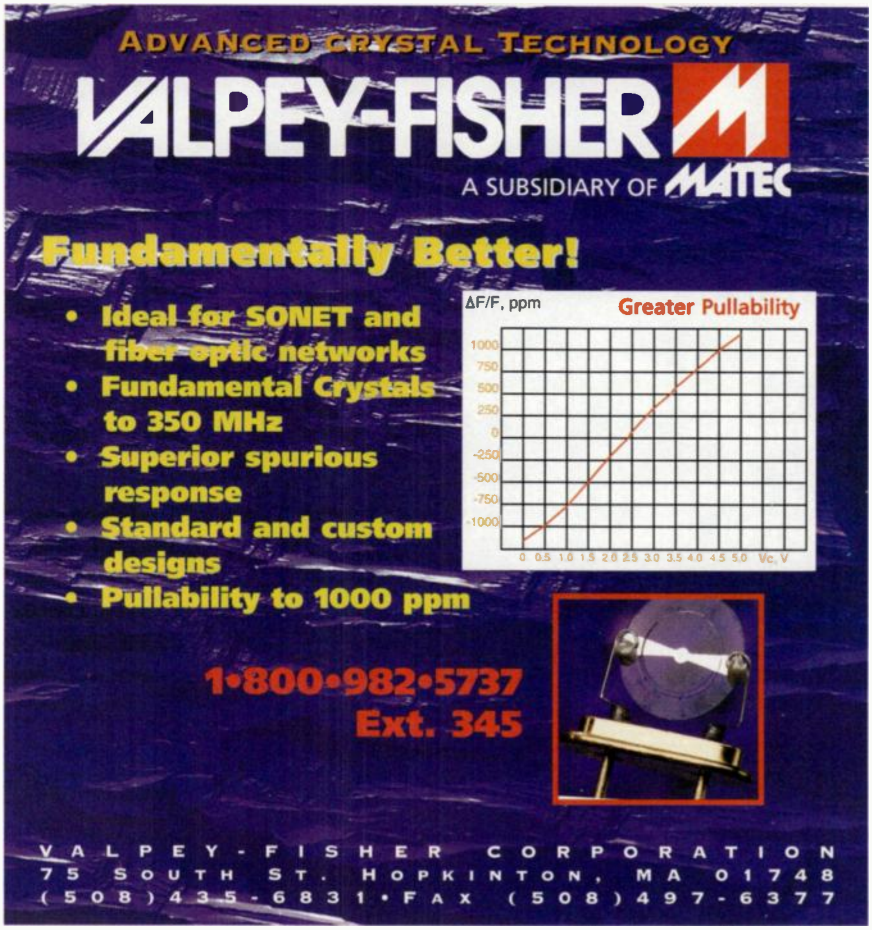
Pole/Zero has announced their digitally tuned, 225 to 400 MHz high dynamic range co-site preselector with optimized SATCOM performance. With a tuning time of less than 20 μs to 251 center frequencies, the preselector features gain of up to 40 dB and noise figure less than 5 dB. Power handling is 1 W inband and 5 W in the stopband. An optional fiber optic control module is available.
Pole/Zero Corp.
INFO/CARD #241

8-Way Power Splitter

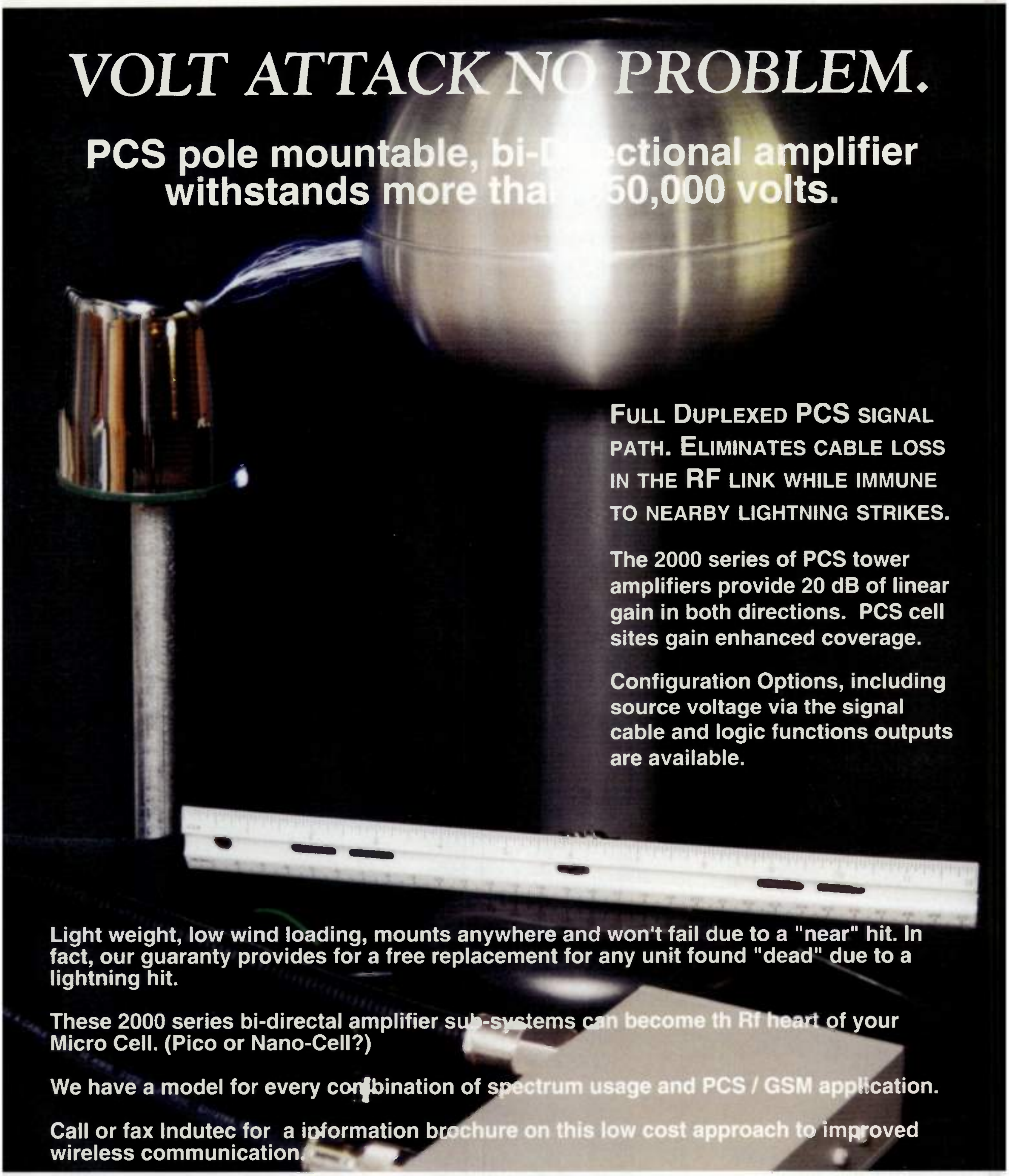


Mini-Circuits has introduced a very broadband, eight-way, 0°, surface mount power splitter covering 10 to 850 MHz. Model JCPS-8-850-75 is a 75 ohm unit and typically has 25 dB isolation, low insertion loss of 0.7

INFO/CARD 29



INFO/CARD 30



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The insert section of this RF Design magazine has a short description of our product line. We make superb directional couplers, delay lines, filter products, splitters, combiners and amplifiers for PCS / GSM and cellular applications.

INFO/CARD 31

dB and maximum amplitude unbalance of 0.7 dB at midband. This 1 W power splitter also exhibits low VSWR – 1.35:1 input/1.25:1 output. The splitter's shielded metal case features solder plated J-leads. Price in quantities of 1 to 9 is $69.95 each.
Mini-Circuits
INFO/CARD #240

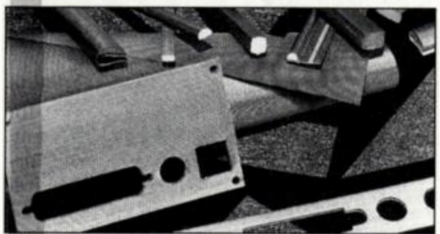
Leadless Filters

Lark has enhanced its filter line with the addition of "universal surface mount configuration". The configuration allows in-line, right angle, or even 180° layout of input and output transmission lines with relation to each other. Center frequencies range from 836.5 MHz to 2442.5 MHz. All filters are contained in packages with footprints measuring 0.438 × 0.438 inches and measuring 0.17 inches high.
Lark Engineering Co.
INFO/CARD #239

EMI SHIELDING

Shielding Gaskets

AMP® now offers a shielding product to provide a unique EMI/RFI solution to control radiated noise. QUIETSHIELD™ gaskets, available in input/output and profile versions, are more flexible that other EMI/RFI alternative. The gaskets provide a



shielding effectiveness of 70 to 100 dB between 1 MHz and 18 GHz and have a low compression-set foam rating of less than 10 percent memory loss at 70 °C. The QUIETSHIELD gaskets are manufactured of Flectron® metallized fabric by Monsanto.
AMP Incorporated
INFO/CARD #238

Foil Tapes

Tesa tape has introduced a series of foil pressure-sensitive tapes for shielding, laminating and component mounting in EMI/RFI applications. The new series includes four metal foil tapes – two with copper foil, a tin-clad copper foil, and an aluminum foil. These tapes have conductive acrylic adhesives which provide high, constant conductivity and solvent resistance.
tesa tape inc.
INFO/CARD #237

Stick-on Shielding

Gore's improved PEEL N' SHIELD EMI gasket assemblies offer simplified shield design and reduce assembly time. The GORE-SHEILD EMI gasket material is held in place with an integral conductive pressure sensitive adhesive. Semi-automated tooling installs small, complex gaskets at the rate of 3 to 4 pieces per minute while maintaining ±0.003 inch positioning accuracy.
W.L. Gore & Assoc., Inc.
INFO/CARD #236

RFI/EMI Shielding Vents

Tech-Etch has introduced new Quiet Vents with honeycomb media which provide maximum air flow through openings requiring RFI/EMI shielding to 90 dB attenuation levels. The honeycomb design yields 97 percent open vent area, resulting in reduced turbulence and lower noise levels.
Tech-Etch, Inc.
INFO/CARD #235

EMC Shielding

Designed for numerous applications ranging from flange and lid gaskets to enclosure door seals, British-made ZEMREX shielding products from Warth are supplied in standard or custom shapes. The spring-like wiping action of the highly durable beryllium copper finger strips provides a constant low resistant contact with low closure force for door seals. Warth's increasing range of wire mesh and loaded elastomer provides economic attenuation and excellent environmental sealing.
Warth Intl. Ltd.
INFO/CARD #234

DISCRETE COMPONENTS

Porcelain & Trim Caps

North American Capacitor Co. (NACC) introduces Mallory/Microelectronics line of mutilayer ceramic and porcelain capacitors in chip and leaded styles, and variable or trimming capacitors operable at frequencies up to 300 GHz. Q-factors exceed 10,000 at 1 MHz for the fixed porcelain capacitors. Variable ceramic capacitors have minimum Q-factors of 1,200 to 10,000 at 100 MHz, while sapphire dielectric trimmers have minimum Q-factors of 1,500 to 5,000 at 250 MHz.
North American Capacitor Co.
INFO/CARD #233

Quartz Crystals

KVG produces quartz crystals for pager, GPS and GSM application in HC-52 as well as HC-52-SMD enclosure with 6 mm height. The pager crystals are in the 40 to 100 MHz frequency range and have ±3 ppm frequency stability from –10 to +60 °C and high shock stability (up to 5000 g). Crystals for GPS and GSM applications are in the 10 to 20 MHz frequency range and can be produced with tightly specified electrical parameters, low aging rates (< 1 ppm/yr)

and minimum temperature hysteresis.
KVG North America Inc.
INFO/CARD #232

Chip Inductors

Coiltronics announces the availability of two product families of 1210 series chip inductors for SMT applications. The CTX32 family is suited for low level signal designs, while the CTX32C family is engineered for moderate power applications.
Coiltronics, Inc.
INFO/CARD #231

SIGNAL SOURCES

Clock Oscillators

Micro Networks has released three precision clock oscillator families. The M100 series provides output in a frequency range from 300 to 650 MHz. Each device includes an on-board crystal reference and provides complementary ECL/PECL clock outputs with less than 5 ps (rms) output jitter. The M200/210 series operates in the same frequency range and is capable of multiplying a low frequency input source by a factor of 5 to 255. The M300 is a family of voltage controlled crystal oscillators with output frequency centered at 622.0800 MHz.
Micro Networks
INFO/CARD #230

10.0 MHz OCXO

PTI has introduced another OCXO at 10.0 MHz. Model XO5019 series offers frequency stability of $\pm 1 \times 10^{-8}$ over −20 to +60 °C, less than $\pm 5 \times 10^{-10}$ per day aging, sinewave output and −165 dBc/Hz phase noise performance at 10 kHz offset. The unit employs PTI's 10.0 MHz SC-cut resonator. The unit measures 2.00 × 2.00 × 0.75 inches. Price per unit for 1 to 9 units is less than $500.
Piezo Technology, Inc.
INFO/CARD #229

TEST EQUIPMENT

Updated Testset

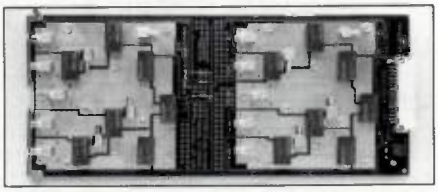
The new microprocessor and firmware in IFR's COM-120B are designed to provide maximum speed for update of operational screens and keyboard inputs. The COM-120B also offers new features such as full scan spectrum analyzer with split screen mode and PCMCIA Type II memory card. Options for EDACS® trunking and new application software are also new.
IFR Systems, Inc.
INFO/CARD #228

GPIB Available for Synthesizers

The PTS D310 and PTS D620 are broadband dual-channel instruments, each containing two fully independent low-phase noise, low spurious output, fast switching frequency synthesizers, housed in one rack or bench-top cabinet. Each independent channel can now be controlled either through the standard 50-pin parallel interface (TTL-level logic), or through an optional GPIB interface. The cost of the GPIB interface for either the PTS 310 or PTS 620 is $800.00.
Programmed Test Sources, Inc.
INFO/CARD #227

1.3 GHz Multiplexer Card

Keithley Instruments has introduced the Model 7016 high performance multiplexer switching card, which offers a characteristic



impedance of 50 Ω and a bandwidth of DC to 1.3 GHz. The 7016 card has two 1 × 4 multiplexers, for a total of eight switching channels. SMA connectors are used to connect external signals and source and measure hardware to channel inputs and outputs.
Keithley Instruments, Inc.
INFO/CARD #226

RF Signal Generator

The HM8133 is Hameg Instrument's synthesized RF signal generator. Both AM and FM modulation signals are accepted. FM modulation for carrier frequencies as high as 990 MHz is possible for both internal and external modulation. The overall operating range covers 1 Hz up to 1 GHz. Frequency accuracy is better than $\pm 0.5 \times 10^{-7}$. List price is $4120.00.
Hameg Instruments, Inc.
INFO/CARD #225

Rubidium Standards

Frequency Electronics now offers two sizes of commercial rubidium frequency standards. One fits existing sockets (model FE-5660A) and one for smaller-size applications (model FE-5650A). Model FE-5650A measures only 3 × 3 × 1.4 inches. Both units have warm-up times of less than four minutes, resolution of 2×10^{-12}, low harmonics and low spurious. In quantities of 1,000, prices are $1,595 for the FE-5660A and $1,795 for the FE-5650A.
Frequency Electronics, Inc.
INFO/CARD #224

VXI Digital Signal Analyzer

Stanford Telecom has introduced the STEL 1010, a high speed, high resolution VXI digital signal analyzer. The STEL 1010 is intended for use with the HP E1430 high resolution analog/digital module. This combination provides the capability of both high speed A/D (up to 256 mega sample per second, 8 bits/second) and high resolution A/D (10.24 MSPS, 18 effective bits/sample).
Stanford Telecommunications, Inc.
INFO/CARD #223

SUBSYSTEMS

Antenna Monitor

Noise Com has introduced an antenna and RSSI monitor for AMPS cellular base stations. The Antenna VSWR and Interference Level Monitor (ANVIL™) performs two main functions, it measures the VSWR of diversity receive antennas at base stations and it also measures the received signal strength of a specified channel. The latter function can be used to perform C/I monitoring and propaga-

tion analysis. An alarm threshold can be set, and LEDs and dry contact switches are provided as alarm indicators.
Noise Com
INFO/CARD #222

PCS Aerodynamic Antenna

COMSAT RSI, Mark Antennas offers a sleek, low profile PCS base station aerodynamic antenna. The antenna employs a linear array of radiating strip line elements fed from a corporate feed network. A sealed laminated RF assembly and UV-stabilized radome provide all-weather protection. This antenna has been wind tunnel tested to guarantee performance under adverse weather conditions.
COMSAT RSI, Mark Antennas
INFO/CARD #221

Log Periodic With 40 dB F/B

The Decibel Products Division of Allen Telecom has introduced the dB DIRECTOR™ – a log periodic for use in the 806 to 960 MHz band with up to 40 dB front-to-back ratio. The directional log periodics are manufactured with 80° or 90° horizontal 3 dB beamwidth. The gains of the dB DIRECTOR antennas range from 9 to 13 dB.
Allen Telecom
Decibel Products Div.
INFO/CARD #220

Cordless Phone Antennas

The HEA series flexible helical antenna from Toko America receive 46 to 49 MHz and have 50 Ω input impedance with a maximum VSWR of 2. They operate without degradation over a wide temperature range from −20 to +60 °C. They sell for

RF design

engineering principles and practices

July 1995

Featuring These RF Companies:

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LCF Enterprises

Lark Engineering

Milcom International

Oscillatek

Richardson Electronics

Stanford Microdevices

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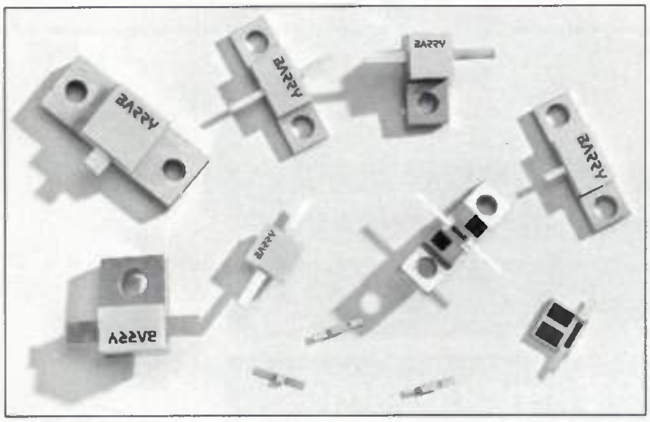
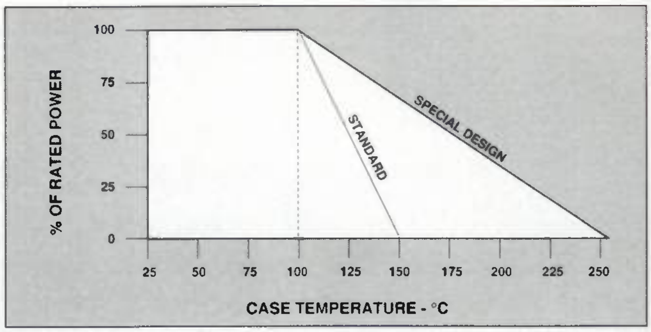
Product Data Sheets

Special Advertising Section

Hi Power Resistors, Terminations and Attenuators

To address the rigorous demands of today's R.F. and microwave systems, Barry Industries offers complete families of resistors, terminations and attenuators to meet the specific hi power demands many current designs require. Barry Industries use of the latest materials and technology in manufacturing thick film passive devices, together with high temperature processing, produces hi-rel, cost effective devices that exhibit maximum heat dissipation and thermal stability. Contact Barry Industries for component data sheets.





- **Applications**
  - Power Dividers
  - Power Amplifiers
  - Quadrature Hybrid Couplers
  - Circulators
  - Cellular Circuits
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  Custom Configurations Available
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  10 Watts to 1000 Watts CW
- **Low Thermal Resistance**
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General Specifications*

Resistive Elements:	Proprietary Thick Films
Substrate:	Beryllium Oxide
Cover:	Alumina Ceramic or BeO.
Mounting Flange:	Copper, Nickel plated per QQ-N-290
Leads:	.003"/.005" Copper or Beryllium Copper.

* Other materials and plating specifications available when stringent mechanical and/or thermal requirements are specified.

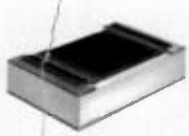
- **Attenuation Range**
  1 to 32 dB in 1 dB steps standard.
  .5 & .25 steps are available.
- **Frequency Range**
  DC to 6.0 GHz. Dependant on Circuit Parasitics and Mounting Configurations.

Chip Resistors

RK - Quarter Wrap

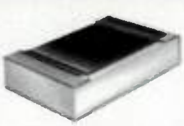
RP-Wrap Around

RS-Flip Chip



RM-Flip Chip with Backpad

Microwave Terminations

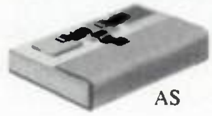


TV-Termination

TW-Cube Termination

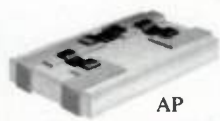
Microwave Attenuators

Pi Pad

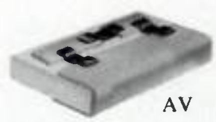


AS

AK

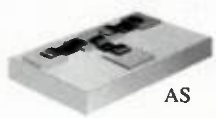


AP



AV

T Pad



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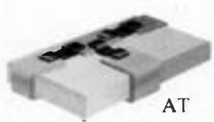

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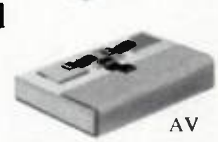


AV

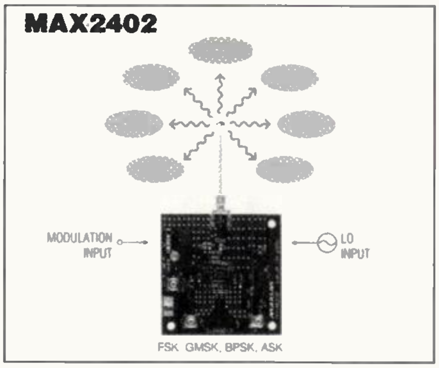
Barry Industries, Inc., 67 Mechanic Street, Attleboro, MA 02703, Tel: (508) 226-3350 Fax: (508) 226-3317

$1.83 in 1000 piece lots.
Toko America, Inc.
INFO/CARD #219

SEMICONDUCTORS

800 - 1000 MHz Transmitter

Maxim Integrated Products introduces the MAX2402, a transmitter that integrates a double-balanced mixer, buffered local oscillator port, variable gain stage, and power amplifier in a single, 20-pin SSOP device. It is compatible with both



direct-sequence and frequency-hopping spread-spectrum designs in the 902 to 928 MHz ISM band. The power amplifier provides more than 20 dBm output. Prices start at $3.59 each in qty. of 1000 or more.
Maxim Integrated Products
INFO/CARD #218

MPEG Decoder

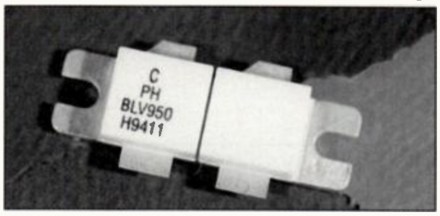
SGS-THOMSON has introduced single-chip MPEG decoder ICs which decodes MPEG1 video, MPEG2 video and MPEG/Musicam audio. The STI3430 combines the functions of MPEG system decoding and CD-ROM decoding on a single chip. It operates on a 3.3 V supply and consumes less than 0.5 W. The STI3520A contains an MPEG2 video decoder, an MPEG audio decoder and a clock generator. It is packaged in a PQFP160 and dissipates less than 1W from a 3.3 V supply.
SGS-THOMSON Microelectronics, Inc.
INFO/CARD #217

C-Band GaAs FET

Toshiba has introduced a high efficiency low intermodulation distortion C-band GaAs FET family. The TIM3742 family covers 3.7 to 4.2 GHz with typical 1 dB compression point power outputs (P1dB) ranging from 36.5 to 45. 0 dBm. The TIM 5964 covers 5.9 to 6.4 GHz with typical P1dB ranging from 36.5 5 to 45.5 dBm. The TIM6472 family covers 6.4 to 7.2 GHz with typical P1dB ranging from 36.5 to 42.5 dBm. Pricing in 100 piece quantities range from $280 for 4 W devices to 1350 for 30 W devices.
Toshiba America Electronic Components, Inc.
INFO/CARD #216

150 W, 800-960 MHz Transistor

Philips' new 150 W UHF push-pull power transistor for linear common emitter class AB operation in the 800 to 960 MHz range



is now available from Richardson Electronics. The BLV950 has a minimum gain of 8 dB and 45 percent efficiency at 150 W. Other features include emitter ballasting resistors for optimum temperature profile, gold metallization to ensure reliability and internal input/output matching.
Richardson Electronics, Ltd.
INFO/CARD #215

100W MOSFET

Designed for high power 900 MHz basestation applications, the NEC NEM0995F01-30 class AB, silicon MOSFET typically delivers 95 W at VDD = 30 V. Linear gain is > 12 dB, and drain efficiency is 43 percent. Third order intermodulation distortion is –37 dBc at 42 dBm average Pout. The NEM0995F01-30 MOSFET is available in industry-compatible hermetic packages.
California Eastern Laboratories
INFO/CARD #214

12-Bit A/D

Burr-Brown's ADS7819 is a 12-bit monolithic, 800 kHz sampling, analog-to-digital converter complete with an inherent sample/hold, internal clock, and internal 2.5 V reference. It operates from ±5 V supplies. Key specs include –77 dB THD (max), 77 dB SFDR (min) and 69 dB SINAD (min) with a 250 kHz input signal. The device is available in 28-pin plastic DIP and 28-lead SOIC packages. The ADS7819 is priced at $22.15 in quantities of 100.
Burr-Brown Corp.
INFO/CARD #213

Monolithic Amps

Synergy Microwave announces new monolithic amplifiers spanning DC to 2000 MHz. The SBA-1 has a 1 dB compression point at 1000 MHz of +9.5 dBm and +6.5 dBm at 2000 MHz. The SBA-2 offers maximum power of +8.5 dBm at 1000 MHz and +8.0 dBm at 2000 MHz. The SBA-3 has +11.8 dBm output power at 1000 MHz and +10.5 dBm at 2000 MHz. At 2 GHz, typical gains are 6.8, 7.8, and 10 dB for the SBA-1, -2, and -3, respectively. These devices are supplied in SOT-143 packages. Unit prices in 25 to 99 quantities are $1.37 for the SBA-1 and -2, and $1.68 for the SBA-3.
Synergy Microwave Corp.
INFO/CARD #212

A Review of Classic Filter Responses

By Gary A. Breed
Editor

In keeping with our philosophy of presenting concepts that assume a BSEE and no experience, this month's tutorial is a very basic, but essential topic for RF designers. The classic filter responses are outlined, with notes on the characterstics of each type that are useful in certain RF applications.

Filters are as common in RF systems as any other circuit element. In general, they are used to reject information on unwanted frequencies and select desired frequencies, but that job is not as simple as is appears. Filter designers have a long list of options when it comes to filters; options that include frequency-domain performance, time-domain performance, component selection and physical construction. This tutorial introduces the classic Bessel, Butterworth, Chebyshev and Elliptic filter frequency domain behaviors. Because this is such a wide-ranging topic, this brief article should only be considered as a first introduction to filters. A bibliography of filter reterences is included at the end to provide the "next step" in your filter education.

Readers should be aware that all of these filters can be implemented in inductor-capacitor lumped elements, microstrip or stripline transmission line sections, active filters using high frequency operational or discrete amplifiers, or as digital filters using various digital techniques, including dedicated digital signal processing (DSP) devices.

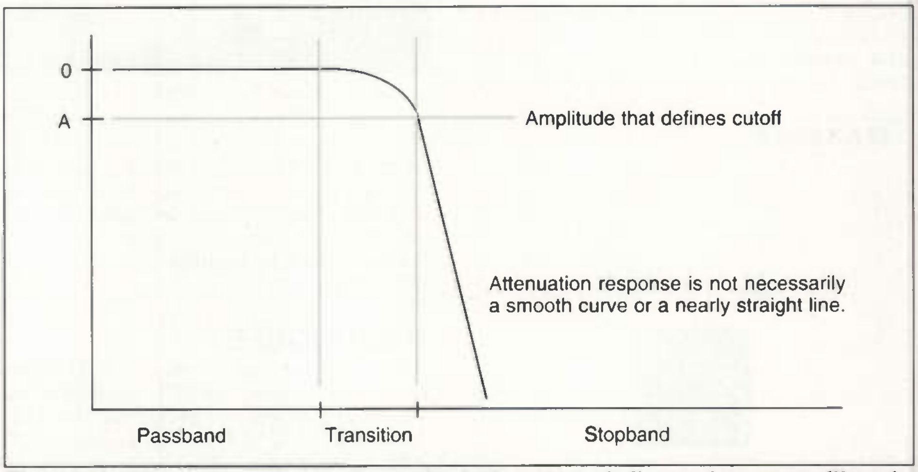


Figure 1. The generalized characteristics that define a lowpass filter in the frequency domain. The shape chosen for this illustration approximates the Butterworth response.

Filter Terminology

Filters are described by both their frequency domain and time domain responses. For RF applications, the frequency domain (attenuation versus frequency) is most commonly used, but time domain (group delay or ringing) is also very important, as it causees distortion in modulated signals.

The frequency domain characteristics of a low pass filter are typically divided into three parts of the response curve, as shown in lowpass filter example of Figure 1: the passband region, the transition region and the stopband region. In the passband, different filters may have a flat frequency response or some degree of ripple (amplitude variation). In the stopband, the attenuation may fall off in a straight line, start with a steep slope and then change to a lesser slope, or it may reach a maximum value and have a ripple about that value. The transition region may be small, for a filter which quickly begins attenuating above the desired cutoff frequency, or it may be large in a filter where the attenuation change is more gradual.

The transition region is the range where maximum time variation occurs. In simple filters, the time variation a greater for filters with rapid cutoff, less for filters with more gradual changes in attenuation. The time delay associated with filter passband-to-stopband transition is called group delay. The phemonenon associated with this time variation is called ringing, so called because it actually generates a signal in the frequency domain when "struck" with a step or impulse voltage.

These characterstics are valid for a highpass filter, a left-to-right mirror image of Figure 1, and for the upper and lower edges of a bandpass filter, which can be thought of as a highpass filter and a lowpass filter separated by the passband.

The passband of a filter may be defined in one of two principal ways. Some filters use the convention of the 3 dB attenuation frequency as the cutoff. This is mainly used in filters with no passband ripple. For filters with passband ripple, the cutoff is usually defined as the maximum attenuation due to ripple. Figures 2 and 3 show these defining conventions.

With this admittedly simple set of descriptive parameters, we can look at the classic filter types and their responses. They are described in the order of increasing slope of the attenuation from passband to stopband.

The Bessel Filter

This filter type is based on equations that assure the minimum time delay variation, usually referred to as maximally flat delay. As noted earlier, the relationship of time response to rate of attenuation in the frequency domain is an inverse one. Therefore, the Bessel filter has the least selectivity, or rejection of signals, due to its very slow

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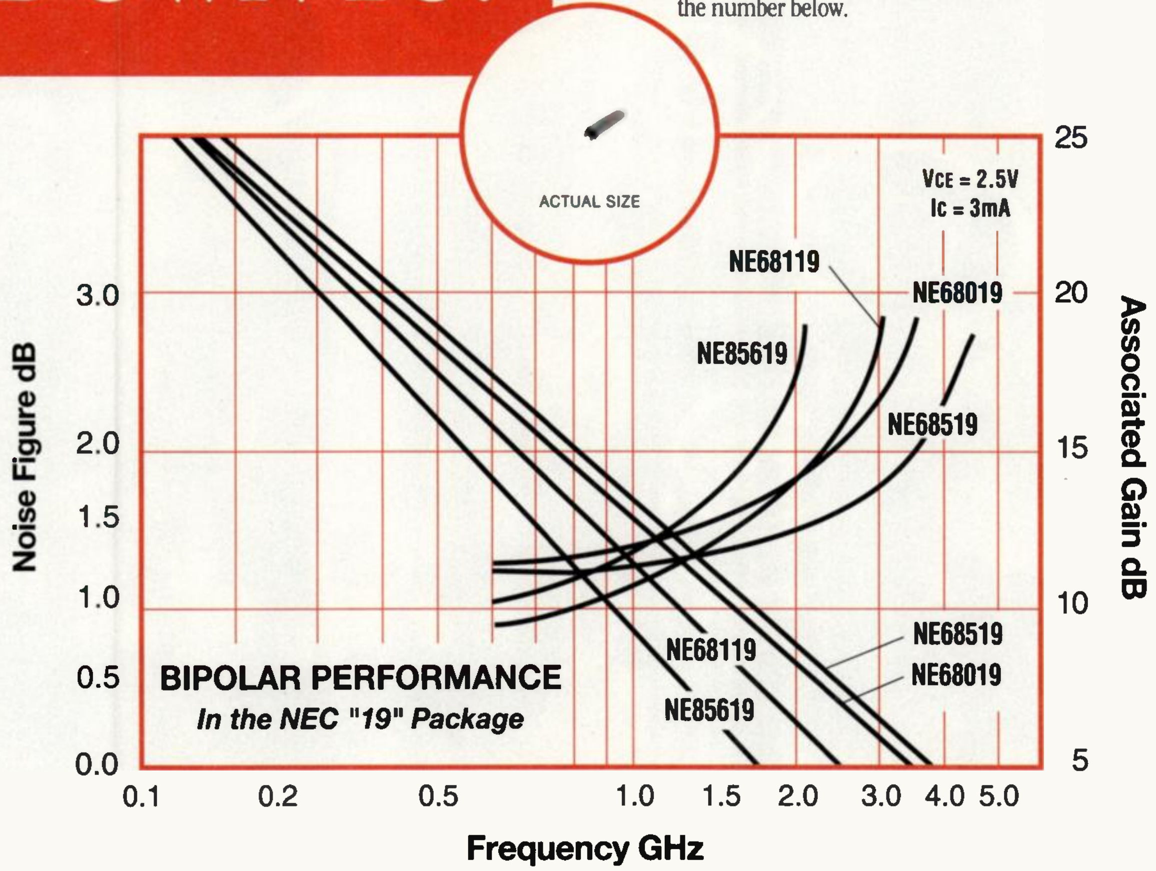
12 GHz f_T Bipolars: one third the size of a SOT-23!

Need performance, but short on real estate? Our new bipolars from NEC deliver up to 9 dB Gain and 1.5 dB Noise Figure at 1.9 GHz — in an ultra-super mini mold "19" package that's just 1.6 X 0.8 mm!

These bipolars operate below 3V and at low current to reduce battery size and increase battery life for your wireless applications.

Want the performance, but not quite ready for the miniature package? They're also available in traditional SOT-23, 323, and 143 style packages — and a new high performance 4 pin "18" package that delivers MAG of 13.0 dB at 1 V, 1 mA, 900 MHz.

They're available now, on tape and reel, and priced to meet your needs. For Data Sheets and a copy of *Automated Assembly of Miniature Parts*, call your nearest CEL Sales Office or circle the number below.



NEC Bipolars are available in these packages (shown approx. 2X size)

NEC "19" Pkg	NEC "18" Pkg	NEC "30" Pkg	NEC "33" Pkg	NEC "39" Pkg
Ultra Super Mini Mold	4 Pin Super Mini Mold	SOT-323 Style	SOT-23 Style	SOT-143 Style

CEL California Eastern Laboratories

NEC

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INFO/CARD 50

FILTERS

low pass, high pass, bandpass

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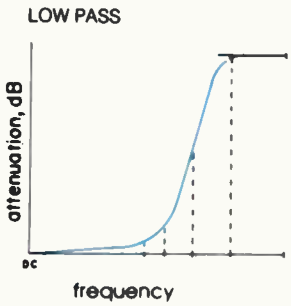
dc to 3GHz from $11.45



low pass, Plug-in, dc to 155MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
●★LP-1.9	DC-1.9	3.4-4.7	4.7-200
●★LP-2.5	DC-2.5	3.8-5.0	5.0-200
★LP-5	DC-5	8-10	10-200
★LP-10.7	DC-11	19-24	24-200
★LP-21.4	DC-22	32-41	41-200
★LP-30	DC-32	47-61	61-200
★LP-50	DC-48	70-90	90-200
★LP-70	DC-60	90-117	117-300
★LP-90	DC-81	121-157	157-400
★LP-100	DC-98	146-189	189-400
★LP-150	DC-140	210-300	300-600

dc to 1200MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
★LP-200	DC-190	290-390	390-800
★LP-250	DC-225	320-400	400-1200
★LP-300	DC-270	410-550	550-1200
★LP-450	DC-400	580-750	750-1800
★LP-550	DC-520	750-920	920-2000
★LP-600	DC-680	840-1120	1120-2000
★LP-750	DC-700	1000-1300	1300-2000
★LP-800	DC-720	1080-1400	1400-2000
★LP-850	DC-780	1100-1400	1400-2000
★LP-1000	DC-900	1340-1750	1750-2000
★LP-1200	DC-1000	1620-2100	2100-2500

All models priced qty. 1-9 ($ea.), Conn. Type P = 11.45, B = 32.95, S = 34.95, N = 35.95
● Exceptions: ★LP-1.9 P = 13.95, B = 34.95, ★LP-2.5 P = 14.95, B = 35.95
On both models, add following to B price: $3.00 for N, $2.00 for S
75 ohm versions available

Surface-mount

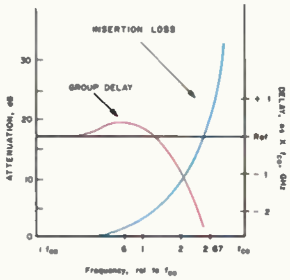
dc to 108MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
SCLF-5	DC-5.0	8-10	10-200
SCLF-8	DC-8.0	12.5-16.5	16.5-200
SCLF-10.7	DC-11	19-24	24-200
SCLF-21.4	DC-22	32-41	41-200
SCLF-25	DC-25	36-47	47-200
SCLF-30	DC-30	47-61	61-200
SCLF-45	DC-45	70-90	90-200
SCLF-95	DC-95	146-189	189-400

dc to 1200MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
SCLF-135	DC-135	210-300	300-600
SCLF-190	DC-190	290-390	390-800
SCLF-225	DC-225	340-440	440-1200
SCLF-380	DC-380	580-750	750-1800
SCLF-420	DC-420	750-920	920-2000
SCLF-550	DC-550	800-1050	1050-2000
SCLF-700	DC-700	1000-1300	1300-2000
SCLF-1000	DC-1000	1620-2100	2100-2500

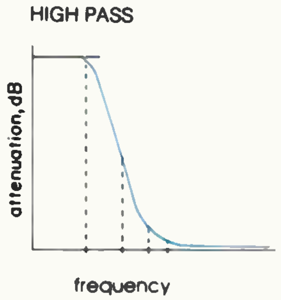
Price: SCLF 21.4–SCLF 420 $11.45 ea. SCLF-8, 10.7, 550, 700, 1000 $12.95 ea. SCLF-5 $14.95 Qty. (1-9)



Flat Time Delay, dc to 1870MHz

Model No.	Passband MHz loss < 1.2dB	Stopband MHz loss >10dB	Stopband MHz loss >20dB	VSWR Freq. Range, DC thru 0.2fco X	VSWR Freq. Range, DC thru 0.6fco X	Group Delay Variations, ns Freq. Range, DC thru fco X	Group Delay Variations, ns Freq. Range, DC thru 2fco X	Group Delay Variations, ns Freq. Range, DC thru 2.67fco X
★BLP-39	DC-23	78-117	117	1.3:1	2.3:1	0.70	4.0	5.00
★BLP-117	DC-65	234-312	312	1.3:1	2.4:1	0.35	1.4	1.90
★BLP-156	DC-94	312-416	416	1.3:1	1.1:1	0.30	1.1	1.50
★BLP-200	DC-120	400-534	534	1.6:1	1.9:1	0.40	1.3	1.60
★BLP-300	DC-180	600-801	801	1.25:1	2.2:1	0.20	0.6	0.80
★BLP-467	DC-280	934-1246	1246	1.25:1	2.2:1	0.15	0.4	0.55
▲BLP-933	DC-560	1866-2490	2490	1.3:1	2.2:1	0.09	0.2	0.28
▲BLP-1870	DC-850	3740-5000	5000	1.45:1	2.9:1	0.05	0.1	0.15

Price, (1-9 qty), all models: plug-in $19.95, BNC $36.95, SMA $38.95, Type N $39.95
NOTE: ▲ -933 and -1870 only with N and SMA connectors.



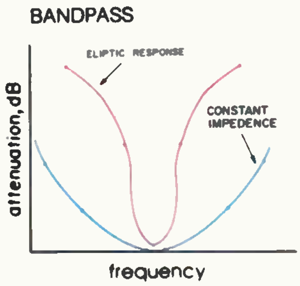
high pass, Plug-in, 13 to 1200MHz

Model No.	Stopband MHz loss > 40dB	Stopband MHz loss > 20dB	Passband, MHz loss < 1dB	VSWR Pass-band Typ.
★HP-25	DC-13	13-19	27.5-200	1.7:1
★HP-50	DC-20	20-26	41-200	1.5:1
★HP-100	DC-40	40-55	90-400	1.5:1
★HP-150	DC-70	70-95	133-600	1.8:1
★HP-175	DC-70	70-105	160-800	1.5:1
★HP-200	DC-90	90-116	185-800	1.6:1
★HP-250	DC-100	100-150	225-1200	1.3:1
★HP-300	DC-145	145-190	†290-1200	1.7:1

210 to 2200MHz

Model No.	Stopband MHz loss >40dB	Stopband MHz loss > 20dB	Passband, MHz loss < 1dB	VSWR Pass-band Typ.
★HP-400	DC-210	210-290	395-1600	1.7:1
★HP-500	DC-280	280-365	500-1600	1.9:1
★HP-600	DC-350	350-440	600-1600	2.0:1
★HP-700	DC-400	400-520	700-1800	1.6:1
★HP-800	DC-445	445-570	780-2000	2.1:1
★HP-900	DC-520	520-660	910-2100	1.8:1
★HP-1000	DC-550	550-720	1000-2200	1.9:1

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95. For ★HP-25, Add $2 ea. †Loss 1.5 dB max.



bandpass, Elliptic Response, 10.7 to 70MHz

Model No.	Center Freq. (MHz)	Passband I.L. 1.5 dB Max. (MHz)	3 dB Bandwidth Typ. (MHz)	Stopbands I.L. > 20dB at MHz	Stopbands I.L. > 35dB at MHz
★BP-10.7	10.7	9.5-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000
★BP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000
★BP-30	30.0	27.0-33.0	25-35	22 & 40	3.2 & 99-1000
★BP-60	60.0	55.0-67.0	49.8-70.5	44 & 79	4.6 & 190-1000
★BP-70	70.0	63.0-77.0	58.0-82.0	51 & 94	6.0 & 193-1000

Price, (1-9 qty), all models: plug-in $18.95, BNC $40.95, SMA $42.95, Type N $43.95

Constant Impedance, 21.4 to 70MHz

Model No.	Center Freq. MHz	Passband MHz loss < 1dB	Stopband loss > 20dB at MHz	VSWR 1:3:1 Total Band MHz
★IF-21.4	21.4	18-25	1.3 & 150	DC-220
★IF-30	30.0	25-35	1.9 & 210	DC-330
★IF-40	42.0	35-49	2.6 & 300	DC-400
★IF-50	50.0	41-58	3.1 & 350	DC-440
★IF-60	60.0	50-70	3.8 & 400	DC-500
★IF-70	70.0	58-82	4.4 & 490	DC-550

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95

NOTE: **★Add Prefix P, B, N, or S for Pin, BNC, N, or SMA connector requirement.**

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change in attenuation with frequency. The approximate Bessel frequency response curve shape is shown in Figure 2. Bessel filters are used when group delay must be kept to an absolute minimum, and frequency response characteristics are not stringent. Should a filter be needed with critical response specifications in both time and frequency domains, a more complex design is needed, which is beyond the scope of this tutorial.

The Butterworth Filter

Using component values selected according to approximations developed by Butterworth, a filter can be made with an improved attenuation slope over the Bessel, while keeping a maximally flat frequency response. In a simple filter, this type has the flattest response in the passband, a modest group delay, and an attenuation rate of 6n dB per octave, where n is the filter order. Because of the Bessel filter's poor selectivity, the Butterworth type is usually considered to have the smallest group delay in a practical RF filter. The Butterworth filter response curve is very close to the shape used in Figure 1.

The Chebyshev Filter

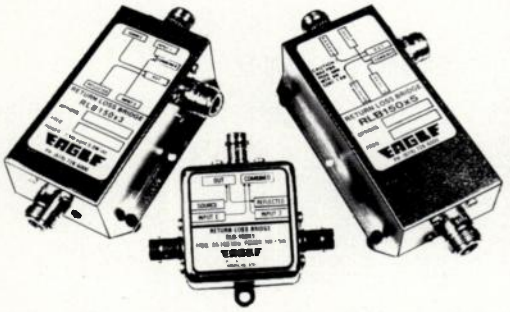
The next filter type, based on Chebyshev approximations, trades a degree of ripple in the passband and greater group delay for a steeper attenuation slope. The mathematical basis for this filter allows the design of many types of filters, using passband ripple as the variable parameter, allowing the designer to choose from a nearly Butterworth response to several dB of ripple. Most Chebyshev filters are designed for ripple in the 0.1 to 3 dB range. Increased ripple brings both increased group delay and more rapid initial slope in attenuation versus frequency. Chebyshev filter response is illustrated in Figure 3.

These first three filters all have the same topology, and can be implemented quite simply in a ladder network of inductors and capacitors. The component values are selected according to the mathematics of each type, and determine the final response. The final filter type we'll look at has a greater complexity that offers new response options.

Elliptic-Function Filters

This family of filters offers control over passband ripple simultaneously with a steep attenuation characteristic above the passband. To obtain these advantages, two tradeoffs are made: greater complexity and a finite stopband attenuation. The complexity arises from the transmission zeros that occur in the stopband (see Figure 4), which are created by "tuned circuits" that are part of the filter design. The parallel or series L-C combinations that make up the tuned circuits replace some of the individual components in the previous filter types.

Elliptic filters have achieved considerable popularity with designers who have taken the extra time required to understand their mathematical foundations. The flexibility to control passband ripple while maintaining excellent selectivity is the key attraction.



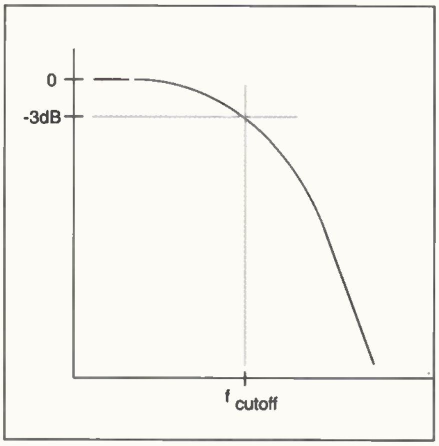


Figure 2. The Bessel response has minimal time domain effects, but it has a frequency response that is very far from that of an ideal filter.

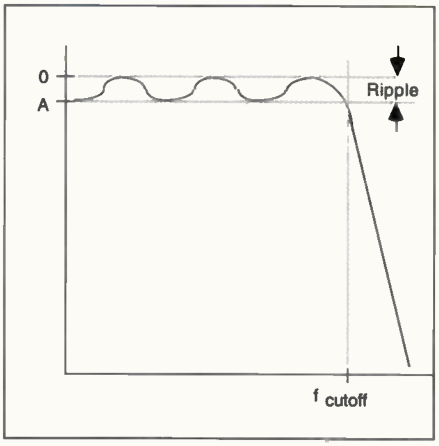


Figure 3. Chebyshev response is characterized by a steeper attenuation slope, but at the cost of introducing amplitude ripple within the passband.

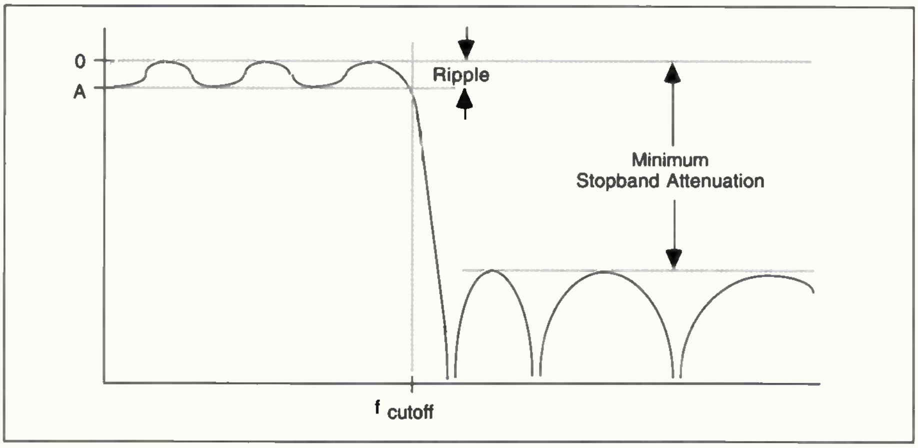


Figure 4. The elliptic, or Cauer filter response also has passband ripple, but achieves an even greater steeper attenuation slope near the cutoff frequency. However, the stopband attenuation does not continue to increase with frequency, rather it returns in a regular manner to the design minimum attenuation level.

Summary

This tutorial has probably been the simplest of those we have presented so far, because the topic is so broad. We hope that it at least sets the stage for further readings. *RF*

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Program Calculates Cascaded RF System Specifications

By Brad S. Avants
E-Systems, Greenville Div.

RFSys is used to calculate the effects of cascading RF and microwave components together in a system. The user inputs the specifications for the individual system components, and the program supplies the user with cascaded specifications such as the gain, compression point, noise figure, and intercept points. it also supplies the user with noise floor information as well as signal to noise ratios.

This program allows quick system analysis. A familiar user interface combined with powerful, yet easy to use functions allows for quick results. The cable function allows users to insert lengths of popular cable types allowing the program to calculate loss automatically. Also, the user can insert whole RF chains as a single component for higher level systems integration.

Customization of the program is easily accomplished by use of the initialization file. This file can be modified by using the program itself or by using any text editor. New cable types can also be easily included by adding entries to the CABLE.DAT file.The main RFSys screen is shown in Figure 1.

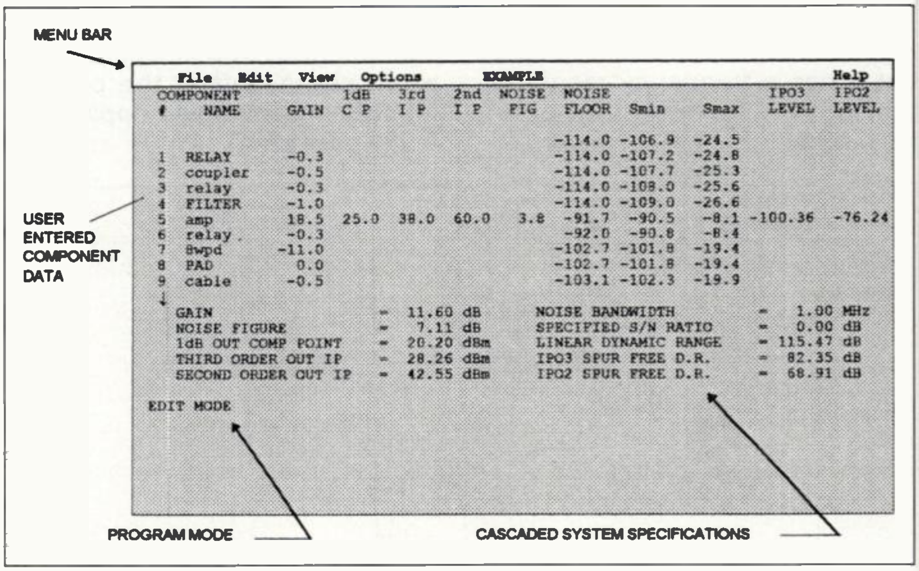


Figure 1. The main RFSys screen.

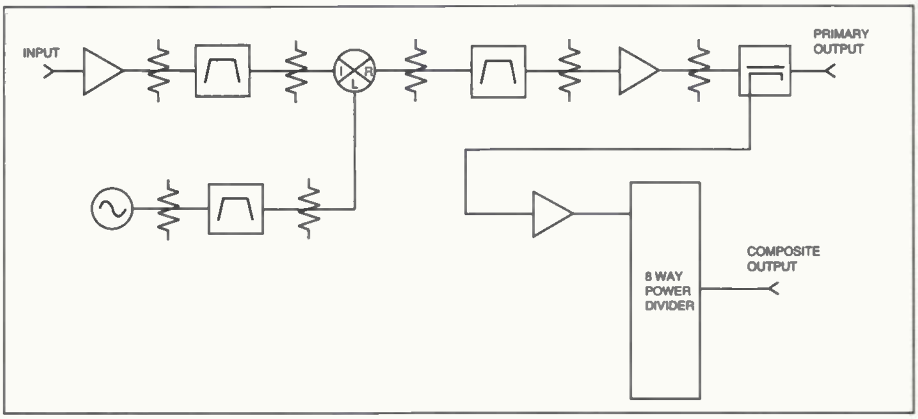


Figure 2. Frequency converter used as an analysis example.

RFSys Example

The block diagram in Figure 2 shows a basic frequency converter. The program can be used to help optimize the circuit by relaying data to the engineer in real time. Changes made to the components will immediately affect the overall performance of the circuit.

To analyze the circuit, start with the first amplifier after the input.

Gain = 13 dB
1 dB CP = 22dBm
3rd Order Output IP = 38 dBm
2nd Order Output IP = 63 dBm
Noise Figure = 6 dB

To enter the component, first position the edit cursor on the name column of the first component. You can do this by either clicking on the component name with the mouse or by using the cursor keys. Enter the component name (amp) and press enter. Next, use the cursor key to move to the right and enter the output compression point. Instead of pressing enter after typing in the value, you can press the right arrow key to finalize the entry and move the cursor to the right. Continue until all of the values have been entered.

To insert a new component, move

COMPONENT #	NAME	GAIN	1dB CP	3rd IP	2nd IP	NOISE FIG	NOISE FLOOR	Smin	Smax	IPO3 LEVEL	IPO2 LEVEL
							–114.0	–92.3	–16.7		
							–114.0	–95.2	–19.0		
1	Preamp	13.0	22.0	38.0	63.0	6.0	–95.0	–82.2	–6.0	–93.92	–74.95
2	atten	–2.0					–96.9	–84.2	–8.0		
3	filter	–1.0					–97.9	–85.2	–9.0		
4	atten	–3.0					–100.8	–88.2	–12.0		
5	mixer	–8.0	7.0	22.0	66.0	9.0	–107.6	–96.2	–20.0	–101.3	–87.80
6	atten	–3.0					–109.7	–99.2	–23.0		
7	filter	–7.0					–112.7	–106.2	–30.0		
8	atten	–3.0					–113.3	–109.2	–33.0		
9	amp2	23.0	21.0	33.0	200.0	4.5	–86.2	–86.2	–10.0	–86.22	–77.80
10	var att	–0.3					–86.5	–86.5	–10.3		
11	coupler	–1.3					–87.8	–87.8	–11.6		
..											

GAIN	= 7.40 dB	NOISE BANDWIDTH	= 1.00 MHz
NOISE FIGURE	= 18.76 dB	SPECIFIED S/N RATIO	= 0.00 dB
1dB OUT COMP POINT	= 15.40 dBm	LINEAR DYNAMIC RANGE	= 103.22 dB
THIRD ORDER OUT IP	+ 26.55 dBm	IPO3 SPUR FREE D.R.	= 76.25 dB
SECOND ORDER OUT IP	= 56.25 dBm	IPO2 SPUR FREE D.R.	= 72.04 dB

Figure 3. Initial components and analysis.

COMPONENT #	NAME	GAIN	1dB CP	3rd IP	2nd IP	NOISE FIG	NOISE FLOOR	Smin	Smax	IPO3 LEVEL	IPO2 LEVEL
							–114.0	–92.3	–16.7		
1	Preamp	13.0	22.0	38.0	63.0	6.0	–95.0	-79.3	–3.7	–87.03	–70.36
2	atten	–2.0					–96.9	–81.3	–5.7		
3	filter	–1.0					–97.9	–82.3	–6.7		
4	atten	–6.0					–103.6	–88.3	–12.7		
5	mixer	–8.0	7.0	22.0	66.0	9.0	–109.5	–96.3	–20.7	–101.42	–86.53
6	atten	–3.0					–111.2	–99.3	–23.7		
7	filter	–7.0					–113.2	–106.3	–30.7		
8	atten	–3.0					–113.3	–109.3	–33.7		
9	amp2	23.0	21.0	33.0	200.0	4.5	–86.2	–86.3	–10.7	–86.34	–76.53
10	var att	–0.3					–86.6	–86.6	–11.0		
11	coupler	–1.3					–87.9	–87.9	–12.3		
..											

GAIN	= 4.40 dB	NOISE BANDWIDTH	= 1.00 MHz
NOISE FIGURE	= 21.64 dB	SPECIFIED S/N RATIO	= 0.00 dB
1dB OUT COMP POINT	= 13.40 dBm	LINEAR DYNAMIC RANGE	= 101.34 dB
THIRD ORDER OUT IP	= 25.55 dBm	IPO3 SPUR FREE D.R.	= 75.66 dB
SECOND ORDER OUT IP	= 53.57 dBm	IPO2 SPUR FREE D.R.	= 70.76 dB

Figure 4. Analysis after substitution of 6 dB attenuator.

COMPONENT #	NAME	GAIN	1dB CP	3rd IP	2nd IP	NOISE FIG	NOISE FLOOR	Smin	Smax	IPO3 LEVEL	IPO2 LEVEL
							–114.0	–95.2	–18.3		
1	Preamp	13.0	22.0	38.0	63.0	6.0	–95.0	–82.2	–5.3	–91.90	–73.60
2	atten	–2.0					–96.9	–84.2	–7.3		
3	filter	–1.0					–97.9	–85.2	–8.3		
4	atten	–6.0					–103.6	–91.2	–14.3		
5	mixer	–8.0	7.0	22.0	66.0	9.0	–109.5	–99.2	–22.3	–107.45	–89.77
6	atten	–3.0					–111.2	–102.2	–25.3		
7	filter	–4.0					–112.6	–106.2	–29.3		
8	atten	–3.0					–113.2	–109.2	–32.3		
9	amp2	23.0	21.0	33.0	200.0	4.5	–86.2	–86.2	–9.3	–86.20	–76.77
10	var att	–0.3					–86.5	–86.5	–9.6		
11	coupler	–1.3					–87.8	–87.8	–10.9		
..											

		START	LAST	CURRENT	
	GAIN	4.40 dB	6.40	7.40	
	NOISE FIGURE	21.64 dB	19.72	18.78	
	1dB C.P.	13.40 dBm	15.40	16.40	
TWEAK MODE	3rd ORDER OUT I.P.	25.55 dBm	26.94	27.55	
	2nd ORDER OUT I.P.	53.57 dBm	55.57	56.57	Inc = 1.00
	IPO3 S.F.D.R.	75.66	76.53	76.90	

Figure 5. Tweak mode, showing results of going towards a less sharp filter.

COMPONENT #	NAME	GAIN	1dB CP	3rd IP	2nd IP	NOISE FIG	NOISE FLOOR	Smin	Smax	IPO3 LEVEL	IPO2 LEVEL
							–114.0	–95.2	–20.1		
1	Preamp	13.0	22.0	38.0	63.0	6.0	–95.0	-82.2	–7.1	–97.44	–77.30
2	atten	–2.0					–96.9	–84.2	–9.1		
3	filter	–1.0					–97.9	–85.2	–10.1		
4	atten	–6.0					–103.6	–91.2	–16.1		
5	mixer	–8.0	7.0	22.0	66.0	9.0	–109.5	–99.2	–24.1	–114.80	–110.39
6	atten	–3.0					–111.2	–102.2	–27.1		
7	filter	–4.0					–112.6	–106.2	–31.1		
8	atten	–3.0					–113.3	–109.2	–34.1		
9	amp2	23.0	21.0	33.0	200.0	4.5	–86.2	–86.2	–11.1	–96.23	–217.88
10	var att	–0.3					–86.5	–86.5	–11.4		
11	coupler	–1.3					–87.8	–87.8	–12.7		
12	amp	10.0	30.0	38.0	63.0	6.0	–77.8	–77.8	–2.7	–77.76	–64.08
13	8-way pd	–10.2					–88.0	–88.0	–12.9		
..											

GAIN	= 7.20 dB	NOISE BANDWIDTH	= 1.00 MHz
NOISE FIGURE	= 18.82 dB	SPECIFIED S/N RATIO	= 0.00 dB
1dB OUT COMP POINT	= 16.20 dBm	LINEAR DYNAMIC RANGE	= 104.16 dB
THIRD ORDER OUT IP	= 24.56 dBm	IPO3 SPUR FREE D.R.	= 75.02 dB
SECOND ORDER OUT IP	= 48.38 dBm	IPO2 SPUR FREE D.R.	= 68.17 dB

Figure 6. Analysis of frequency converter through the composite output.

the cursor below the first component and press the INSERT key. A new component will be inserted above the current cursor position. By default, the new component will be passive. Just move the cursor onto the appropriate field, enter the component specification, and press enter. After all values have been entered for the component, press the insert key to start on another component. If you make a mistake or need to change a value, click on the value with the mouse and re-enter it

If you need to change a component from passive to active, just select Change Type under the Edit menu. You will then be prompted for the component type you desire (active or passive). Continue entering the components until all have been entered for the primary output as shown in Figure 3.

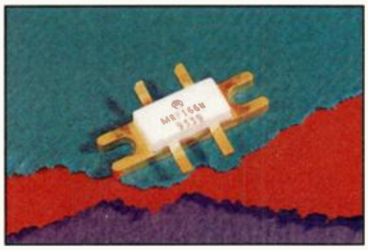
After the circuit is entered, use the Save option under the File menu to save the circuit to disk so that it can be recalled at a later time.

Changes can be made easily to the circuit parameters. For example, the attenuator before the mixer is only 3 dB. Suppose a better match is needed for the mixer, the attenuator can be increased to 6 dB by clicking on the insertion loss of the attenuator and entering the new value. (See Figure 4.) All circuit parameters are updated instantly.

Now we must try to restore the noise figure back to its original value without adversely affecting any other properties of the circuit. By placing the circuit in tweak mode, the affects of the changes we make will be more visible. In tweak mode, the initial results are displayed along with the current results and the results before the last change.

One way to improve the performance

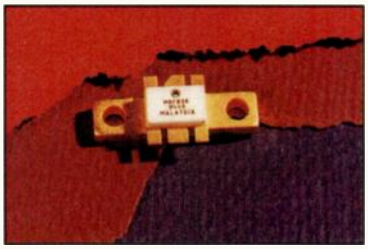
MRF166W - Class A, 40 W, 500 MHz, Broadband Power MOSFET



Motorola's rugged 40 watt RF Power MOSFET is designed primarily for wideband large-signal output and driver stages to 500 MHz. The MRF166W's excellent thermal stability makes it ideal for Class A operation. Its push-pull configuration reduces even numbered harmonics. Other features include a 13 dB minimum gain and 50% efficiency at 40 watts.
Richardson Electronics, Ltd.
40W267 Keslinger Road, LaFox, IL 60147.
1-800-348-5580.

INFO/CARD 73

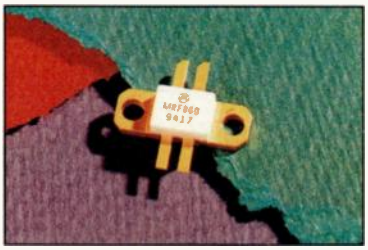
MRF858 - Class A, 800-960 MHz, 3.6 W (CW) RF Power Transistor



Motorola's 3.6 watt (CW) RF power transistor is designed for 24-volt UHF large-signal common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the 800-960 MHz range. Features include an 11 dB minimum gain, an output capacitance of 6.5 pF (typ) at 24 Vdc, a minimum ITO of +44.5 dBm and typical noise figure of 6 dB. The MRF858 will withstand RF input overdrive of 0.85 W CW. It is in an SOE flange package (case 319).
Richardson Electronics, Ltd. 40W267 Keslinger Road, LaFox, IL 60147
1-800-348-5580.

INFO/CARD 72

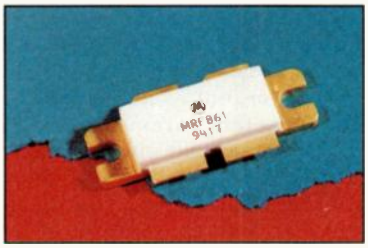
MRF860 - Class A, 800-960 MHz, 13.7 W (CW) RF Power Transistor



Motorola's 13.7 watt (CW) RF power transistor is designed for 24-volt UHF large-signal common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the 800-960 MHz range. Features include an 11 dB minimum gain, an output capacitance of 21 pF (typ) at 24 Vdc, a minimum ITO of +51.5 dBm and typical noise figure of 6.5 dB. The MRF860 will withstand RF input overdrive of 3.25 W CW. It is in a push-pull flange package (case 395B).
Richardson Electronics, Ltd.
40W267 Keslinger Road, LaFox, IL 60147
1-800-348-5580.

INFO/CARD 71

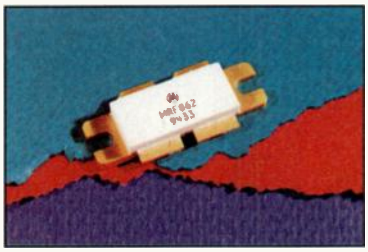
MRF861 - Class A, 800-960 MHz, 27 W (CW) RF Power Transistor



Motorola's 27 watt (CW) RF power transistor is designed for 24-volt UHF large-signal common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the 800-960 MHz range. Features include a 9.5 dB minimum gain, an output capacitance of 45 pF at 24 Vdc, a minimum ITO of +53.5 dBm and typical noise figure of 6.5 dB. The MRF861 will withstand RF input overdrive of 8 W CW. It is in a push-pull flange package (case 375A).
Richardson Electronics, Ltd.
40W267 Keslinger Road, LaFox, IL 60147
1-800-348-5580.

INFO/CARD 74

MRF862 - Class A, 800-960 MHz, 36 W (CW) RF Power Transistor



Motorola's 36 watt (CW) RF power transistor is designed for 24-volt UHF large-signal common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the 800-960 MHz range. Features include a 9 dB minimum gain, an output capacitance of 75 pF at 24 Vdc, a minimum ITO of +55 dBm and typical noise figure of 6.5 dB. The MRF862 will withstand RF input overdrive of 13.6 W CW. It is in a push-pull flange package (case 375A).
Richardson Electronics, Ltd.
40W267 Keslinger Road, LaFox, IL 60147
1-800-348-5580.

INFO/CARD 75

INFO/CARD 56

would be to use a less sharp filter after the mixer. If the frequency plan for the circuit allows for this option, we could improve the system as shown in Figure 5.

If this is too drastic a change for the filter, we could possibly have changed the filter and the attenuators before and after it by 1 dB to produce the same overall affects. Also, if different amplifiers were available, they could be substituted in place of the others. Although this is a simple example, the point is that the affects of these changes would be shown instantly. Therefore, we could quickly substitute many different amplifiers into the circuit in a matter of minutes to determine the optimum configuration. Also, popular components can be created and saved as components so that they can be quickly recalled and inserted into various circuits.

If we want to examine the path to the composite output, we can change the loss of the coupler to represent the coupling loss (20 dB), then add in the additional amplifier and power divider. (See Figure 6.)

If the circuit is composed of connectorized components or of multiple modules, it can be even more accurately modeled by inserting lengths of coax cables using the inert cable command from the Edit Menu. All that is required is the length, frequency, and type of cable (either .086 or .141 semi-rigid). Other cable types can be defined and stored as well.

Conclusion

The RFSys program is best suited for quick analysis of RF circuits and systems. It is not intended as an in-depth simulator, but as a quick glance at cascaded system parameters. While high priced simulators give extremely accurate results after hours of effort, this is often not required. Often what is required is a quick snapshot of the system. This program can provide that in only minutes.

Changes and modifications are also easily accommodated by the user friendly, mouse based data entry system. There have been thousands of RF cascade programs written, but this one was intended to be more user friendly so that circuits could be quickly entered and modified, and results could be seen instantly.

RFSYS is available through Argus Direct Marketing. To order, see the ad on page 104. *RF*

About the Author

Brad Avants is an electronics design engineer with E-Systems in Greenville, Texas. He received his B.S. in Electrical Engineering from Louisiana Tech University in May 1991. He is currently designing RF and microwave communications equipment as well as firmware and digital controller cards. He can be reached at: E-Systems, CBN 024, P.O. Box 6056, Greenville, TX 75043, or by phone at (903) 457-6027.

An Inexpensive and Easy to Fabricate Wideband EMI Sniffer Probe

By Frank Moriarty, General Datacomm, Inc. and
Steve Petix, Global Certification Laboratories, Ltd.

While needing an alternative method for locating electromagnetic interference (EMI) sources at the chip/pin level during the development of telecomm products at General Datacomm Corporation, the authors found that a female BNC to male phono plug adaptor can be modified into a very useful tool for this purpose. It is simple, wideband and capable of locating EMI sources down to the pin level. It can be fabricated as described below or it can be purchased from the authors.

Because of its small size, the EMI sniffer probe can detect EMI at the pin level, while ignoring other sources which may be present on the same card. Larger probes which are commonly available have their uses, but they cannot isolate EMI to the pin level without being influenced by nearby sources. This probe can also be used for detecting cabinet, housing or even cable shielding leaks.

Fabrication

Cover the male phono tip portion of the BNC-to-phono adaptor with an adequate length of 0.125″ shrink tubing and heat shrink it tight. While the tubing is still hot, pinch the end of the tubing that's past the phono tip flat. Trim this portion close to the tip for a neat appearance. Be sure that no part of the phono tip is exposed.

Cover the outer barrel of the adaptor with 0.375″ shrink tubing up to the BNC portion where the probe cable or attenuator will be connected. Figure 1 shows a photo of a completed probe. Figure 2 shows a typical frequency response signature for the EMI probe. This data was obtained by using one of these probes as a transmitter and another as the receiver. This measurement covered the frequency range of 30 to 1000 MHz.

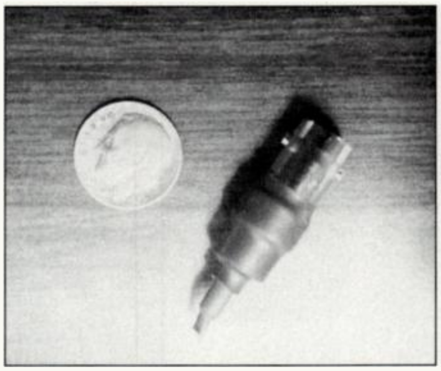


Figure 1. Completed sniffer probe.

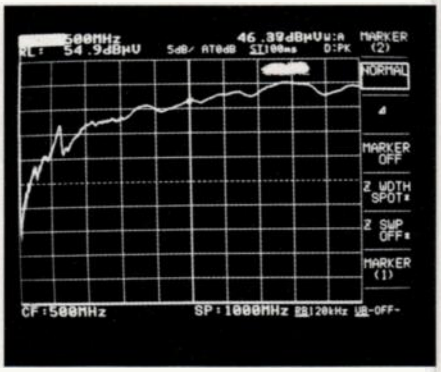


Figure 2. Response signature, 1000 MHz sweep.

Testing Your Probe

Though usually not necessary, you may wish to test your probe before using. If so, proceed as below: The test setup shown in Figure 3 should produce a frequency response signature similar to that seen in Figure 2. Keep the transmit and receive probes very close together, within 0.25″. You are looking for a signature without abrupt resonances in the 30 to 1000 MHz range, as in Figure 2.

Using The Probe For Chip/Pin Troubleshooting

With your probe completed, conduct a schematic/harmonic analysis of the card(s) to be investigated in order to determine which circuit points could generate the offending frequency. By looking for harmonics of the offending frequency and how they are expected to propagate throughout the circuit can be very insightful.

With the above analysis completed, tune your receiver or spectrum analyzer to the offending frequency originally found by your normal test setup. Use one of the larger, conventional electric or magnetic probes to determine if the signal is present on the whole card, sections of it, or a daughter mounted card. This can be done very quickly and can help to confirm your earlier schematic/harmonic analysis.

Connect the sniffer probe, through a coax cable of the impedance required by your analyzer/receiver. Probe the circuit points in the regions pointed out by the earlier analysis. Hold the probe at right angles to the chip pin/lead when a reading is desired from it. If the probe exhibits too high a sensitivity, add a 10 or 20 dB attenuator to the probe's BNC connector, then connect the cable back. In any case, some padding is recommended.

Record all circuit points in which probing agrees with your analysis, or any points which seem to have distinctly high levels of the offending frequency. Points that appear at least 5

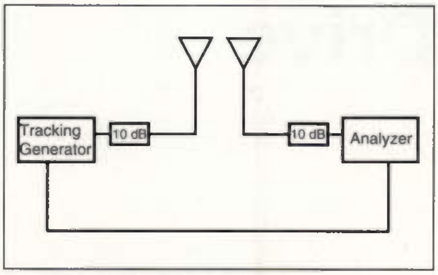


Figure 3. Testing setup.

dB higher than other "sources" of the frequency under study are good candidates to try suppression components such as bypass capacitors, series inductances, bandpass networks, etc.

Repeat this process for any other EMI frequencies needing study. Keep good, clear notes in order to avoid becoming hopelessly confused. In multiple source cases, more than one circuit point fix may be required. Due to space allocations, the authors cannot go into all of the procedures, and techniques for successful EMI suppression.

NOTE: Do not probe circuits containing voltages which could harm you, or your measurement equipment!

Good luck in your board suppression endeavors. Chip level EMI suppression is not the ogre so many make of it. With affordable shielding and a tight budget, it may be the only practical way to comply many devices and systems to a given EMC specification. *RF*

About the Authors

Frank Moriarty, is an EMC engineer at General Datacomm in Middlebury, CT. He has 16 years experience in EMC testing, suppression diagnostics and the redesign of computer peripherals. He may be reached at General Datacomm, Inc. 1579 Straits Turnpike, P.O. Box 1299, Middlebury CT. 06762-1299. Phone: (203) 574-1118.

Steve Petix is working as an EMC engineer/consultant at the Global Certification Laboratories, Ltd. in East Haddam CT. He has over ten years experience in EMC test and measurement, problem mitigation, and materials/enclosure shielding studies. He may be reached at Global Certification Laboratories, Ltd. 4 Matthews Road, East Haddam CT., 06423. Phone: (203) 873-1451, or Fax: (203) 873-1947.

INFO/CARD 59

Developing Applications Drive Capacitor Market

This month's Product Forum looks at the market changes affecting RF capacitors. Several manufacturers offer their opinions regarding today's marketplace and trends in the industry.

Sprague-Goodman Electronics

Sprague-Goodman Electronics, Inc. has specialized in trimmer capacitors since its founding in 1972. Trimmer capacitors occupy a special niche among RF capacitors, since RF circuits require exact capacitance to "tweak" resonant circuits in oscillators, filters, receivers, etc.

The shift in the trimmer capacitor market has been from multiturn types (which require several turns from minimum to maximum capacitance) with excellent temperature stability from –55 to +125° C, to single turn trimmers (which go from minimum to maximum in only 1/2 turn) with moderate stability from –25 to +85° C. Multi-turns are used in volume in military radios. Single turns are used in volume for a wide variety of wireless uses (eg. cellular phones, pagers, remote actuators, radio tracking devices, GPS receivers, wireless LANs). Demand for precision devices has leveled off below the peaks reached during the cold war, while demand for commercial products is growing as new wireless products are developed.

Voltronics Corporation

The market for variable capacitors is expanding as large commercial communication applications replace military usage. Key applications are in cellular radio and other PCS and many high frequency oscillators. Surface mount requires small sealed precise parts with high reliability. There is a growing need for good trimmers operating over 2 GHz. There is also a demand for high voltage, multi-turn trimmers. We service these markets with a very broad line of many dielectrics in sealed versions from 2.5 to 300 pF max. We find today's imaginative engineers need special non standard parts which Voltronics is particularly able to design for them.

COMET North America, Inc.

The tremendous growth in the semiconductor processing marketplace in recent years has also fueled an increased need for RF capacitors. Vacuum capacitors are a critical component in many types of semiconductor processing equipment including, plasma sputtering, plasma etching, steppers, strippers, and chemical vapor deposition (CVD) technologies, and the Flat Panel Display (FPD) industry also utilizes many of the same processing techniques.

This high voltage, vacuum capacitor is used in RF matching networks for semiconductor processing equipment.

The demand for faster throughput and longer MTBF from these industries has forced variable capacitor manufacturers to commit to an unprecedented level of quality and capability. COMET now produces certain capacitor types which are capable of cycling their complete capacitance range in less than one second, and with a projected life of over five-million cycles.

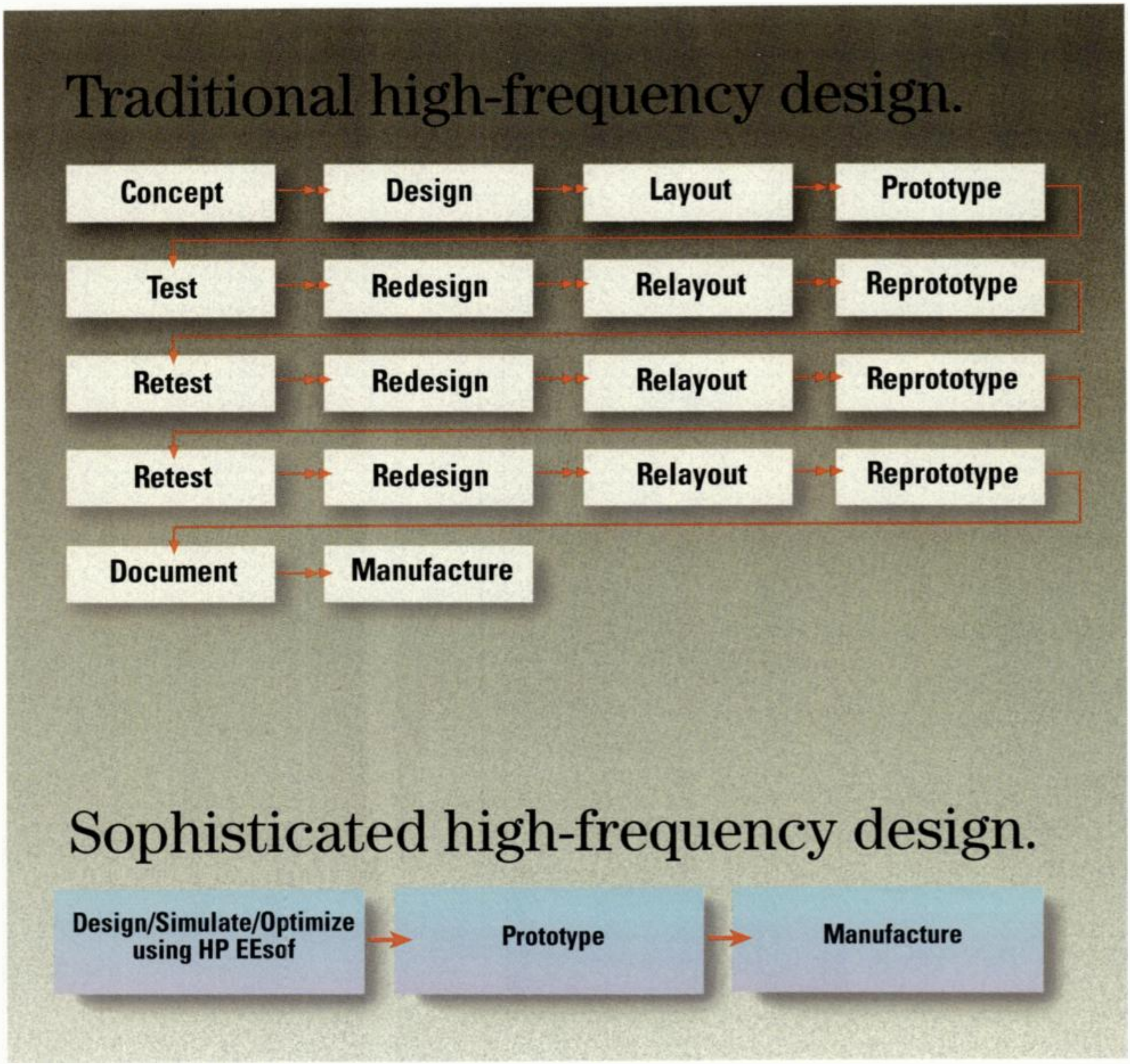
The historically cyclical nature of the semiconductor market is not expected to continue, and most market analysts are projecting steady growth for several years. The worldwide market for the flat panel industry alone is presently estimated to be about $5 billion, and is expected to grow to nearly $40 billion by the year 2000.

MMC Electronics America Inc.

One of the fastest growing markets for RF products is data transmission systems and cellular products. A salesperson's mobile office can communicate with the main office by using a cellular phone to transmit and receive faxes and/or data. Due to these conveniences, more products are being manufactured with RF control/communication.

Cable TV and satellite systems have a large potential for RF capacitors. Cable TV is becoming more complicated by offering more channels at higher frequencies. Consumer satellite systems are also becoming smaller and less expensive, which should increase demand.

Due to the sales potential for smaller and more sophisticated consumer electronics, RF capacitor consumption



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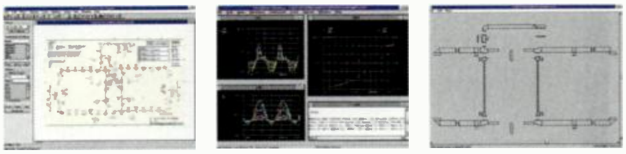

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INFO/CARD 61

Capacitors: U.S. Factory Sales ($ millions); 1984-1993[1]

Year	Paper and Film	Ceramic	Other	Variable	Total
1984	314	670	16	17	1,619
1985	257	465	16	15	1,200
1986	263	493	15	19	1,223
1987	281	546	14	22	1,411
1988	285	607	114	[2]	1,534
1989	281	631	127	[2]	1,536
1990	246	626	54	[2]	1,412
1991	229	629	62	[2]	1,393
1992	233	720	32	na	1,491
1993	299	818	32	na	1,731

[1] Includes factory sales and imports by U.S. manufacturers.
[2] Combined with Other.
na-Not Available
Source: *Electronic Market Data Book*, EIA Marketing Services Department, p.114, 1994.

should continue to rise for the next 2 years.

MMC Electronics is developing capacitors that feature higher values in EIA size footprints as well as an 0805 package containing 2 capacitors to ease handling and reduce insertion time.

Metelics

The requirement for low loss, small size and higher frequency applications of RF capacitors has grown significantly over the last few years. The need for reliable and temperature stable amplifiers and filters is on the rise, more High Q capacitors are in demand. New reduced sizes, higher volume and new techniques will be an important requirement in the next few years. Continued development is on going in the RF capacitor marketplace. Utilizing thin film circuit designs for amplifiers, switches, filters etc. requires a need for a standard bonding technique. This makes the silicon gold metalized capacitor ideal for temperature stabilizing, low loss and reliable bonding pads.

Metelics' new catalog offers a freedom of selecting values and chip sizes to accommodate this growing need for RF capacitors in bypass circuits, DC blocks and many other tuning elements. We look for continued growth over the next 2 years.

Dielectric Laboratories Inc.

The capacitor market for RF and microwave applications is strong and we expect it to last for the next 5 years.

The worldwide expansion of wireless communication spurs the demand for hardware on the ground and in space. High Q capacitors are needed in RF amplifiers, high speed clock circuits, antennas, drivers for optical modulators, etc.

Our customers need to reduce cost, size and improve performance which is typically achieved by higher level of integration. Dielectric Labs' technology focus is on integration of passive devices and recently introduced miniature impedance transformers for 900 MHz amplifiers, miniature RF blocking networks and a patented miniature passive complex impedance device (PCID) for extreme broadband bypassing. Surface mounted devices are preferred.

Dielectric Labs' new software CAP-CAD supports robust RF hybrid designs without multiple prototyping of single or multilayer ceramic capacitors. *RF*

For more information on RF capacitor companies circle the INFO/CARD numbers below:

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Ceramic Devices, Inc.	182
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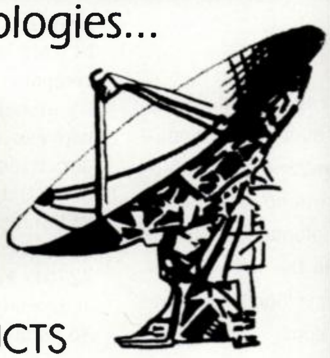

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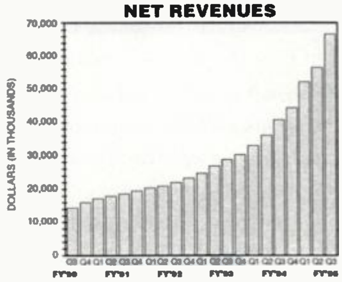

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• CIRCUIT DEVELOPMENT

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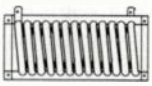

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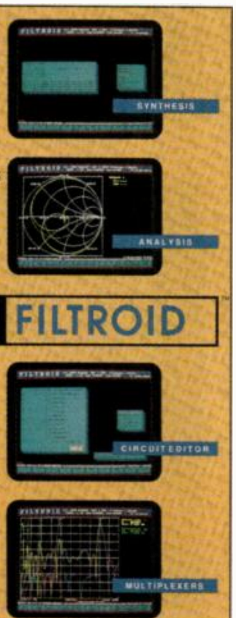

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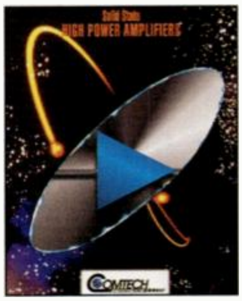

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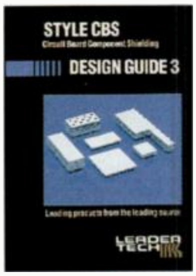

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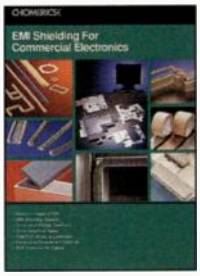

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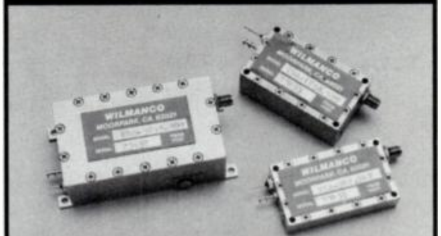

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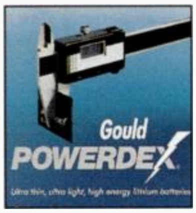

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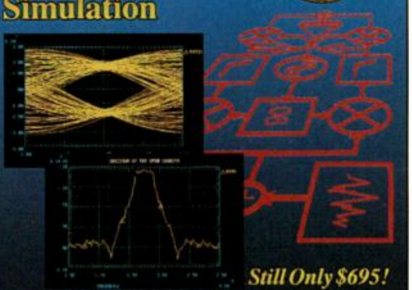

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Southwest Microwave, Inc., 2922 S. Roosevelt St., Tempe, AZ 85282....(800) 587-5995

MULTICOUPLERS
Trontech, Inc., 381 Industrial Way East, Eatontown, NJ 07724....(908) 542-1133 Fax (908) 542-1118

PHASE SHIFTERS
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41 Fairfield Pl., W. Caldwell, NJ 07006....(201) 575-1300 Fax (201) 575-0531

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ITT Cannon RF Products, 585 E.Main ST., New Britain, CT 06051....(800) 532-3750
Merrimac Industries, Inc.,
41 Fairfield Pl., W. Caldwell, NJ 07006....(201) 575-1300 Fax(201) 575-0531
Molex, Inc., 2222 Wellington Ct., Lisle, IL 60532....800-MOLEX78
Richardson Electronics, Ltd., 40W267 Keslinger Rd., LaFox, IL 60147....(800) 348-5580
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Matrix Systems corp., 5177 N. Douglas Fir Rd., Calabasas, CA 91302....(818) 222-2301
MBF Microwave, Inc., Rt. 2, Box 252A, Hardy, AR 72542....(501) 856-2685

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MATERIALS AND HARDWARE

COMPONENTS/HYBRID PACKAGES
Reeves-Hoffman, 400 W. North St., Carlisle, PA 17013.................................(717) 243-5929

CRYSTAL BLANKS
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PC BOARDS
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Racal Instruments, 4 Goodyear St., Irvine, CA 92718...(800) 722-3262

SPECTRUM ANALYZERS
DC TO LIGHT, P.O. Box 7140, Bozeman, MT 59771.................. (406) 586-5399 Fax (406) 586-6556

SERVICES

ANTENNA MEASUREMENT SYSTEMS
Jef Consultants, Inc., 8501 Beck Rd., Bldg. 2227, Belleville, MI 48111-1254 ......(313) 482-5505

ANTENNA DESIGN & MEASUREMENT
Kintronic Labs, 144 Pleasant Grove Rd., Bluff City, TN 37618..(615) 878-3141 Fax (615) 878-4224

CONSULTANTS
Management Recruiters of Boulder ....Fax (303) 447-9536 Tel (303) 447-9900
Windy Bradfield CSAM, Bob Sund ....
Goldman Research, 12705 Monfort, Dallas, TX 75230 ....(214) 788-1122
RF Design & Modeling – Spice, EEsof, Wireless ....WNJU80A@PRODIGY.COM

EMC/EMI TESTING
Liberty BEL EMC SVCS., P.O. Box 5431, MS20, Compton, CA 90224 ....(310) 537-4235
Above MS20 represents RF Design
TUV Rheinland of North America, Inc.,
12 Commerce Road, Newtown, CT 06470 ....(203) 426-0888 Fax (203) 270-8883

EQUIPMENT CALIBRATION
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INSTRUMENT RENTAL/LEASING
Naptech, 12312 Hwy 175, Cobb, CA 95423..............................(800) 336-7723 Fax (707) 928-1963

OEM PRODUCTS
Locus, Inc., 1842 Hoffman St., Madison WI 53704 ....(608) 244-0500

TELEMETRY SYSTEMS & ENGINEERING
Telemetry Technologies, Inc., 3307 West St., Rosenberg, TX 77471 ....(713) 344-9000

SOFTWARE & SYSTEMS, CAD/CAE

SOFTWARE
Design Automation, Inc., 4 Tyler Rd., Lexington, MA 02173........(617) 862-8998 Fax (617) 862-3769
Circuit Simulation
ingSoft Ltd. – the providers of the RF Designer® Solution...(416) 730-9611
312 Dunview Ave., North York, ON M2N-4H9, Canada; bbs: 226-9820 .... Fax: 733-3884

SYSTEM SIMULATION
Tesoft, Inc., 205 Crossing Creek Ct., Roswell, GA 30076 ....(800) 631-1113
Makers of TESLA Com Simulator ....Fax (404) 664-5817 Intl (404) 751-9785

EMC TEST & DESIGN

Products & Services Directory

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EMI/RFI Filters
POTTER PRODUCTION CORPORATION, 3004 Hwy. 51 N., Wesson, MS 39191 ....(601) 643-2215
Santek, 9765 Marconi Dr., #205, San Diego, CA 92173 ....(619) 661-8119
Ferrite Beads, Rods, Forms
Fair-Rite Products Corp., P.O. Box J, Wallkil, NY 12589...(800) 836-0427
Steward, Inc., 1200 E. 36th Street, Chattonooga, TN 37401........(615) 867-4100 Fax (615) 867-4102
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Filtered Connectors
Spectrum Control, Inc., 6000 West Ridge Rd., Erie, PA 16506...(814) 835-4000
Filters, Power Line
Qualtek Electronics Corp., 7675 Jenther Dr., Mentor, OH. 44060 ....(216) 951-3300
RtroN Corp., P.O. Box 743 Skokie, IL 60076.. (708) 679-7180
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CABLE AND CONNECTORS
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ADC Telecommunications, 4900 W. 78th St., Minneapolis, MN 55435 ....(800) 366-3891 X3000

Optical Fibers And Connectors
ADC Telecommunications, 4900 W. 78th St., Minneapolis, MN 55435 ....(800) 366-3891 X3000

EMC TEST EQUIPMENT - EMISSIONS
Absorbers
Advanced Electromagnetics, Inc., P.O. Box 711719, Santee, CA. 92072- 1719............(619) 449-9492

IBEX Group, Inc., 23 Markham Dr., Long Valley , NJ 07853 ....(800) 403-3930
Rantec, 24003 Ventura Blvd., Calabasas, CA. 9130 ....(818) 591-8189
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Advanced Electromagnetics, Inc., P.O. Box 711719, Santee, CA. 92072- 1719............(619) 449-9492
IBEX Group, Inc., 23 Markham Dr., Long Valley , NJ 07853 ....(800) 403-3930
Rantec, 24003 Ventura Blvd., Calabasas, CA. 9130 ....(818) 591-8189
Antennas
Antenna Research Associates, Inc., 11317 Fredrick Ave., Beltsville, MD 20705....(310) 937-8888
Antennas Above 30 MHz
A.H. Systems Inc., 9710 Cozy Croft Ave, Chatsworth, CA 91311..(818) 998-0223 Fax (818) 998-6892
EMCO, P.O. Box 1546, Austin, TX. 78767 ....(512) 835-4684
IBEX Group, Inc., 23 Markham Dr., Long Valley , NJ 07853 ....(800) 403-3930
Antennas Masts
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EMCO, P.O. Box 1546, Austin, TX. 78767 ....(512) 835-4684
IBEX Group, Inc., 23 Markham Dr., Long Valley , NJ 07853 ....(800) 403-3930
Current Probes
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IBEX Group, Inc., 23 Markham Dr., Long Valley , NJ 07853 ....(800) 403-3930
Ion Physics Corp., 11 Industrial Way, Atkinson NH 03811 .... (603) 893-6687

ELECTRONIC COMPONENTS AND EQUIPMENT

Ferrite Absorber Tiles
IBEX Group, Inc. 23 Markham Dr. Long Valley NJ 07853 .... (800) 403-3930
GTEM Cells
Antenna Research Associates, Inc., 11317 Fredrick Ave., Beltsville, MD 20705....(310) 937-8888

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Rantec, 24003 Ventura Blvd., Calabasas, CA. 9130 .... (818) 591-8189
Near Field Probes
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EMCO, P.O. Box 1546, Austin, TX. 78767 .... (512) 835-4684
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IBEX Group, Inc., 23 Markham Dr., Long Valley, NJ 07853 .... (800) 403-3930
Preselectors
IBEX Group, Inc., 23 Markham Dr., Long Valley, NJ 07853 .... (800) 403-3930
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EMC TEST EQUIPMENT - SUSCEPTIBILITY

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EMCO, P.O. Box 1546, Austin, TX. 78767 .... (512) 835-4684
Power Amplifiers
Applied Systems Engineering, Inc., 8623 Hwy. 377 S., Fort Worth, TX 76126 .... (819) 249-4180
Varian Microwave Equip. Prods., 3200 Patrick Henry Dr, Santa Clara, CA 95054....(408) 496-6273
Sheilded Fiber Optic Links
Antenna Research Associates, Inc., 11317 Fredrick Ave., Beltsville, MD 20705....(310) 937-8888
Surge Generators
Velonex Corp., 560 Robert Avenue, Santa Clara, CA 95050 .... (408) 727-7370
Pulse, Surge, Transient, ESD, Hybrid Generators

ESD TEST EQUIPMENT

ESD Event Detectors
EMCO, P.O. Box 1546, Austin, TX. 78767 .... (512) 835-4684
Monroe Electronics, Inc., 100 Housel Avenue, Lyndonville, NY 14098 .... (800) 821-6001
TREK INC., 3932 Salt Works Rd., P.O. Box 728, Medina, NY. 14103 .... (800) FOR-TREK
Surface & Volume Resistivity Meters
Monroe Electronics, Inc., 100 Housel Avenue, Lyndonville, NY 14098 .... (800) 821-6001
TREK INC., 3932 Salt Works Rd., P.O. Box 728, Medina, NY. 14103 .... (800)FOR-TREK

EMC TEST EQUIPMENT - ADDITIONAL

Field Strength Meters
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MATERIALS, HARDWARE AND PACKAGING

SHIELDING MATERIALS

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Conductive Adhesives
Venture Tape Corp., 30 Commerce Rd., Rockland, MA 02370 .... (617) 331-5900
Conductive Fiber/Fabric
Venture Tape Corp., 30 Commerce Rd., Rockland, MA 02370 .... (617) 331-5900
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Fair-Rite Products Corp., P.O. Box J, Wallkil, NY 12589 .... (800) 836-0427
Gasketing Materials
Venture Tape Corp., 30 Commerce Rd., Rockland, MA 02370 .... (617) 331-5900
Laminates
Venture Tape Corp., 30 Commerce Rd., Rockland, MA 02370 .... (617) 331-5900
Magnetic Shielding
Ad-Vance Magnetics, Inc., 625 Monroe St., Rochester, IN 46975 .... (219) 223-3158
Sheilding Foils and Tapes
Venture Tape Corp., 30 Commerce Rd., Rockland, MA 02370 .... (617) 331-5900

SHIELDING EMI/RFI SERVICES

Vacuum Platers, Inc., 115 S. Union Street, Mauston, WI 53948 .... (608) 847-5644

SHIELDED ENCLOSURES - EQUIPMENT

Component/Module Cases
Marmin-Hil Plastics, Inc., 101 Roselle St., Linden, NJ 07036 .... **(908) 925-2940 (800) 886-2940**

SHIELD ROOMS AND CHAMBERS

Shielded Rooms EMI/RFI/Magnetic
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ESD PACKAGING

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Conductive Polyurethane
Pad-Tastics, Inc., P.O. Box 50479, Cicero, IL 60650 .... (708) 780-8402 FAX (708) 780-1636
Custom Packaging
Pad-Tastics, Inc., P.O. Box 50479, Cicero, IL 60650 .... (708) 780-8402 FAX (708) 780-1636

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Freudenberg Building Systems, Inc./Nora Rubber Flooring
94 Glenn St., Lawrence MA 01843 .... (508) 689-0530

TEST LABORATORIES AND CONSULTANTS

TEST LABORATORIES

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TUV Product Service, Inc., 1775 Old Hwy. 8, New Brighton, MN 55112 .... (800) 472-7999
Open Area Test Sites
Compatible Electronics - 8 open field test sites in So. Calif .... (714) 579-0500

EMI/EMC TESTING

LambdaMetrics, P.O. Box 1029, Cedar Park, TX 78630-1029 .... (512) 219-8218
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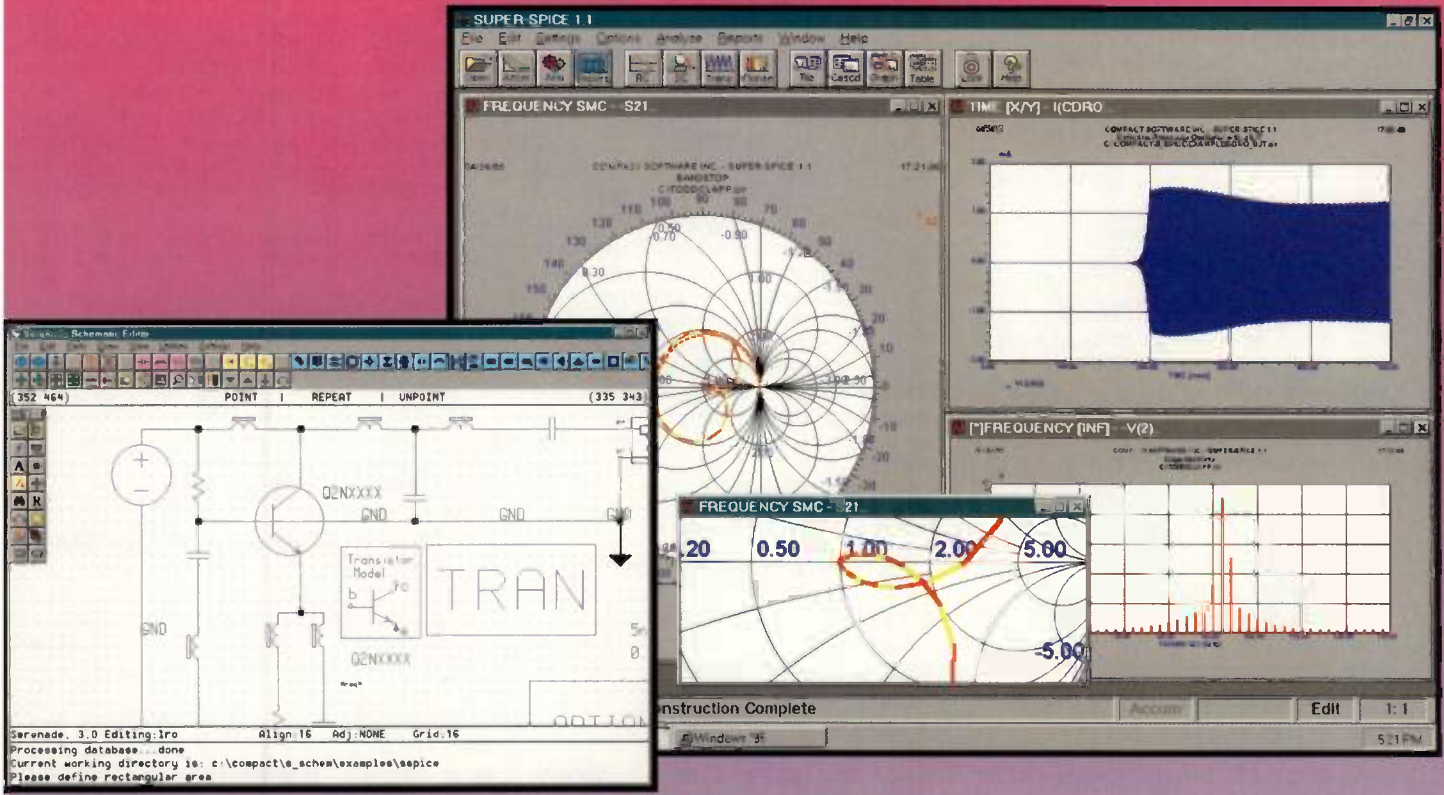

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WRH

Magnetic Component Catalog

J.W. Miller has published a new catalog covering its extensive line of standard magnetic components with comprehensive specifications and dimensional drawings. Products include fixed chokes, adjustable coils, common mode chokes, current sense transformers, differential mode chokes, ferrite beads, surface mount inductors and surface mount transformers.
J.W Miller
INFO/CARD #210

Schottky Diode Mixers

Miteq has released an 86-page catalog with detailed mechanical and electrical specifications for their lines of Schottky diode mixers. Single, double, and triple balanced mixers are included. Also included is a question-and-answer section.
Miteq
INFO/CARD #209

1995 Catalog

Synergy Microwave has released its "1995 New Product Release" catalog to compliment their "1992-1993 Product Catalog". Filled with complete design information, technical articles and mechanical information, this catalog features all the new products released since the previous 1992-1993 Synergy Microwave catalog. A number of new surface mount devices are listed, as well as new VCO products, subharmonic mixers and modulators.
Synergy Microwave Corp.
INFO/CARD #208

Network Analyzer Brochure

Wiltron features economical network analysis systems in a new color product brochure. Applications and system configurations are detailed for three separate families of scalar network analyzers: the new 54100A series, the 54000A series and the 562/68X00B series. Analysis of measurement accuracy is also featured with helpful tips on improving measurement uncertainty.
Wiltron Company
INFO/CARD #207

Through-Hole Products

Five new items are among the crystals and hybrid oscillators featured in the latest through-hole products catalog from M-tron Industries. The 32-page catalog, devoted exclusively to through-hole products contains complete descriptions and specifications for: microprocessor crystals, AT strip crystals, high-frequency fundamentals, processor-specific crystals, and crystal products for extreme environments. Microprocessor clock oscillators, surface-mount clock oscillators utilizing strip crystal capabilities, and industrial, automotive, and military oscillators designed to withstand harsh environments.
M-tron Industries, Inc.
INFO/CARD #206

RF Connector Catalog

Connex Connector has entered the RF connector marketplace, and has prepared a 114-page catalog offering over 10,000 stock parts ranging from BNC to SMA to SMB microminiature styles.
Connex Connector Corp.
INFO/CARD #205

Mobile Radio Analyzer Data

A two-page color data sheet on new software for the MA-10 mobile radio analyzer has been released by Wandel & Golterman. All features of the software, which allows

the MA-10 to service and optimize radio cells, are described in the data sheet.
Wandel & Golterman, Inc.
INFO/CARD #204

RF and Microwave Capabilities Brochure

A 50-page capabilities and products brochure, now available from REMEC, covers typical custom models of the complete line of filters, channelizers, switched filters, switches, limiters, detectors, integrated switch products, multipliers and comb generators, frequency generation integrated products, amplifiers, power amplifiers, amplifier integrated products, converters, and high-reliability space products.
REMEC, Inc.
INFO/CARD #203

CATV Downconverter Literature

Anadigics has announced the availability of a technical brief on the company's new ACD series of downconverter MMICs for CATV applications. The brief provides an introduction to Anadigic's ACD series of downconverter MMICs, which is designed to be used as the second downconverter in double conversion cable television tuners.
Anadigics, Inc.
INFO/CARD #202

Low Noise Amplifiers

LNY Sales has released a four-page catalog featuring a new line of low noise amplifiers manufactured by Plessey Tellumat. As the exclusive U.S. and Canadian agent for Plessey Tellumat, LNY Sales will distribute the catalog which features over 75 models of the low noise amplifiers. The PTSA series devices range in frequency from 2.4-2.7 GHz to 14-14.5 GHz and offer noise figures from 0.7 to 1.9 dB.
LNY Sales, Inc.
INFO/CARD #201

PTFE PCB Fabrication

Southwest Circuits has released a 16-page guide to fabricating PTFE prototypes, titled "What Does it Take to Get a Good Teflon® Circuit Board Prototype Around Here?". The guide details Southwest Circuits' new PTFE prototyping service for microwave/wireless-applied printed circuit boards.
Southwest Circuits
INFO/CARD #200

CAE/CAD Catalog

Compact Software has released a Corporate Product Catalog that overviews Compact's CAE/CAD product line. Compact's products for schematic capture, linear simulation, nonlinear simulation, electro-optical simulation, physical layout, system simulation, time-domain simulation and full-wave EM simulation tools.
Compact Software
INFO/CARD #199

Semiconductor Catalog

Toshiba America Electronic Components has announced the availability of its 1995 semiconductor catalog. The 36-page catalog provides information and specifications on Toshiba's ASICs, RISC processors, microcomputer products, logic and memory products, discrete devices, bipolar ICs, and high power semiconductors.
Toshiba Electronic Components, Inc.
INFO/CARD #198

3-D Simulation

Bay Technology announces IE3D version 2.1. IE3D, which employs the efficient full wave method of moments algorithm. Easy importation of, and editing of, GDS-II, DXF, CIF and Gerber file formats minimizes modeling time. The user can optimize circuits for desired results simply by entering the electrical values wanted and the geometry modifications allowed. A variable grid is used to automatically mesh the geometries, while edge coupled areas can be manually forced into a finer grid. IE3D operates on any 486 or Pentium PC that operates MS-Windows or Windows NY and has at least 8M of RAM. Pricing is $10,000 for Windows 3.1 and $17,000 for Windows NT.

Bay Technology
INFO/CARD #195

3-D EM Structure Simulator

HP EEsof has released version 4.0 of the HP High-Frequency Structure Simulator (HFSS). HFSS is a 3-D electromagnetic simulator for designers of RF and microwave components, transitions, and antennas. The new release adds the ability to analyze antenna parameters such as antenna gain and directivity, use new voltage and current gap sources that allow easier excitation of structures, specify a range of plane wave excitations that can be used with radar cross section plots, and characterize anisotropic dielectric materials such as sapphire and GaAs. HFSS release 4.0 is available at a price of $41,800.

HP EEsof
INFO/CARD #194

RF Instrument Drivers

National Instruments has announced LabVIEW and LabWindows instrument drivers for 78 RF/microwave GPIB and VXI instruments from vendors including Anritsu Wiltron, Hewlett-Packard, Wandel & Goltermann, Rohde & Schwarz, and Tektronix. Drivers are available from either National Instruments or the instrument vendor. Those supplied through National Instruments are available in LabVIEW or LabWindows sources code, at no charge, from National Instruments FTP or BBS sites.

National Instruments
INFO/CARD #193

NEC-2 on PCs

EZNEC is an antenna modeling program which combines the NEC-2 calculating engine with the easy-to-learn ELNEC user interface. EZNEC takes full advantage of system resources, including extended memory, and automatically uses the hard disk as additional virtual RAM if needed. EZNEC uses spreadsheet-like entry of all description parameters – wires, sources, loads, transmission lines, and ground media. The program is several times faster than MININEC-based programs and permits up to 500 segments. Price is $89.00 per license.

Roy Lewallen
INFO/CARD #192

EE Utilities

EE Ref v1.5 is a Windows based desktop reference that provides more than 135 screens of engineering conversions, formulas, and references. Filters, transforms, integral tables, coax specs, serial port pinouts and other reference materials are some of the items included. EE Ref v1.5 is priced at $24.95 /copy + S&H.

Waypoint Software
INFO/CARD #191

System Simulation

Version 1.8 of Elanix' SystemView includes a new analysis window for analytic examination of spectra and waveforms. The new sink calculator performs user-specified block processing operations on sink data generated by the user's system simulation; examples include auto- and cross-correlation, windowed spectral analysis, eye patterns, and other displays. In the this latest release, block operations may be cascaded to produce sophisticated processing sequences. Also, a new automated macro feature allows the user to automatically reproduce a sequence of block operations on new simulation data. SystemView v1.8 is available for $2450.

ELANIX, Inc.
INFO/CARD #190

Extended EDA

Micr Sim has extended the capabilities of its Design Center Desktop EDA system with the inclusion of the BSIM3 model in version 6.1. The Design Center with PSpice uses the latest MOS device model, BSIM3, from the University of California, Berkeley, as does the Technology Modeling associates (TMA) AURORA parameter extractor. All BSIM3 model parameters extracted using TMA's AURORA are certified to be completely compatible for use with MicroSim's PSpice.

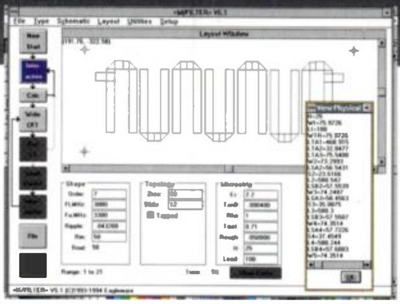
MicroSim Corp.
INFO/CARD #189

Model Fitting

SCIENTIST version 2.0 fro Windows fits model equations to experimental data. SCIENTIST fits equations to data - anything from simple linear algebraic equations to systems of differential equations. Price is $395.

MicroMath Scientific Software
INFO/CARD #188

TURBO-CHARGE TOUCHSTONE



EXAMPLE GENESYS SCREEN

SUPER-CHARGE SPICE

with GENESYS, a suite of programs for synthesizing microwave filters amplifiers, oscillators, active filters, matching networks and L-C filters for your Touchstone, Spice and =SuperStar= simulator.

MICROWAVE FILTERS
End coupled
Edge coupled
Hairpin
Stepped-Z
Combline
Interdigital
Elliptic lowpass
Elliptic bandpass
Sub lowpass
Stub bandpass
Stub bandstop
Edge bandstop

OSCILLATORS
L-C series mode
L-C Colpitts
L-C Clapp
T-line and L-C VCO
VCO with xformer
Cavity bipolar and hybrid
Dielectric resonator
Terminal SAW bipolar
Port SAW hybrid
Port SAW MOSFET
Pierce and Colpitts crystal
Driscoll crystal
Butler overtone
Overtone with multiplier

MATCHING NETWORKS
L-C pi and L
L-C tee
T-line quarter wave
T-line single/double stub
General order bandpass
L-C pseudo lowpass
T-line pseudo lowpass
T-line stepped-Z
Custom with R' s and xformers

LUMPED FILTERS
Conventional all-pole
Conventional elliptic
Top-C coupled
Top-L coupled
Shunt-C coupled
Tubular
Blinchikoff flat delay
Zig-zag
Eagleware symmetric

ACTIVE FILTERS
GIC transform
Single feedback
Multiple feedback
Low sensitivity
State variable (biquad)
VCVS
Dual amplifier

GENESYS FOR SIMULATION ENGINES.. TOUCHSTONE SPICE SUPERSTAR

Touchstone is a product of HP/EEsof GENESYS and =SuperStar= are products of Eagleware

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INFO/CARD 69

New 3 Volt Downconverters: From RF to IF for 99¢

NEC miniature downconverters are the latest addition to CEL's growing family of 3 Volt RF ICs.

Need low distortion? Our new *UPC2758T* delivers +5 dBm output IP3. Low current application? Choose the *UPC2757T*. It provides 13 dB of conversion gain from only 5.6 mA. Both feature a mixer, LO and IF buffer amplifier, and a *Power Down* function to prolong battery life.

Another low current device, the *UPC2756T*, helps simplify your designs by combining mixer, IF amplifier and oscillator — all on a single chip.

All three feature 3 dB RF bandwidth to 2.0 GHz, with 3 dB IF bandwidth of 10 to 300 MHz.

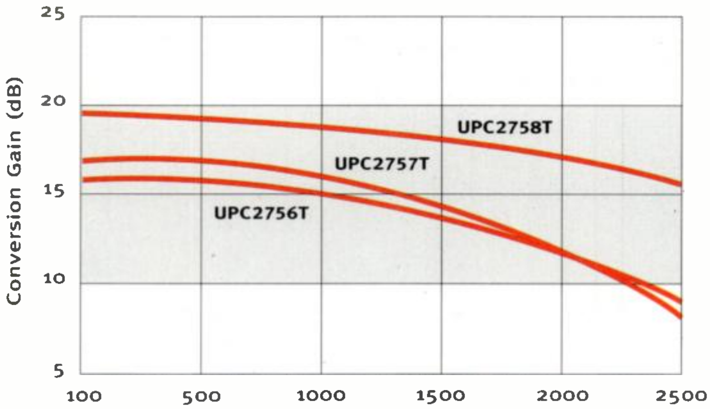
Housed in miniature packages no bigger than a SOT-143, these devices are available now on tape and reel and priced in quantity from only 99¢.

Best of all, they can be combined with CEL's other MMICs and discretes to provide complete GPS, PCN or 2.4 GHz wireless LAN solutions.

Need a higher level of integration? The 3 Volt *UPC2753GR* IF downconverter combines an RF input amplifier, Gilbert cell mixer, LO input buffer, IF amplifier with AGC, external filter port, and IF output limiting amplifier — all in a miniature 20 pin SSOP package. This device features DC to 400 MHz RF response, DC to 20 MHz IF response, and typical overall conversion gain of 79 dB.

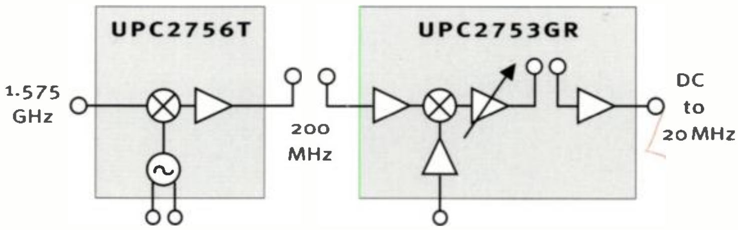
For data sheets and a Silicon MMIC Product Selection Guide, call your nearest CEL Sales Office, or circle the number below.

CONVERSION GAIN



Vcc = 3V LO Power = -5 dBm IF = 200 MHz

RECEIVER LINEUP



TYPICAL SPECIFICATIONS

PART	OPERATING VOLTAGE	Icc	CONVERSION GAIN	OUTPUT IP3
UPC2758T[1]	3V	11 mA	17 dB	+5 dBm
UPC2757T[1]	3V	5.6 mA	13 dB	0 dBm
UPC2756T[2]	3V	5.9 mA	14 dB	0 dBm

1. Measured at 2.0 GHz 2. Measured at 1.6 GHz

CEL California Eastern Laboratories

INFO/CARD 70

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