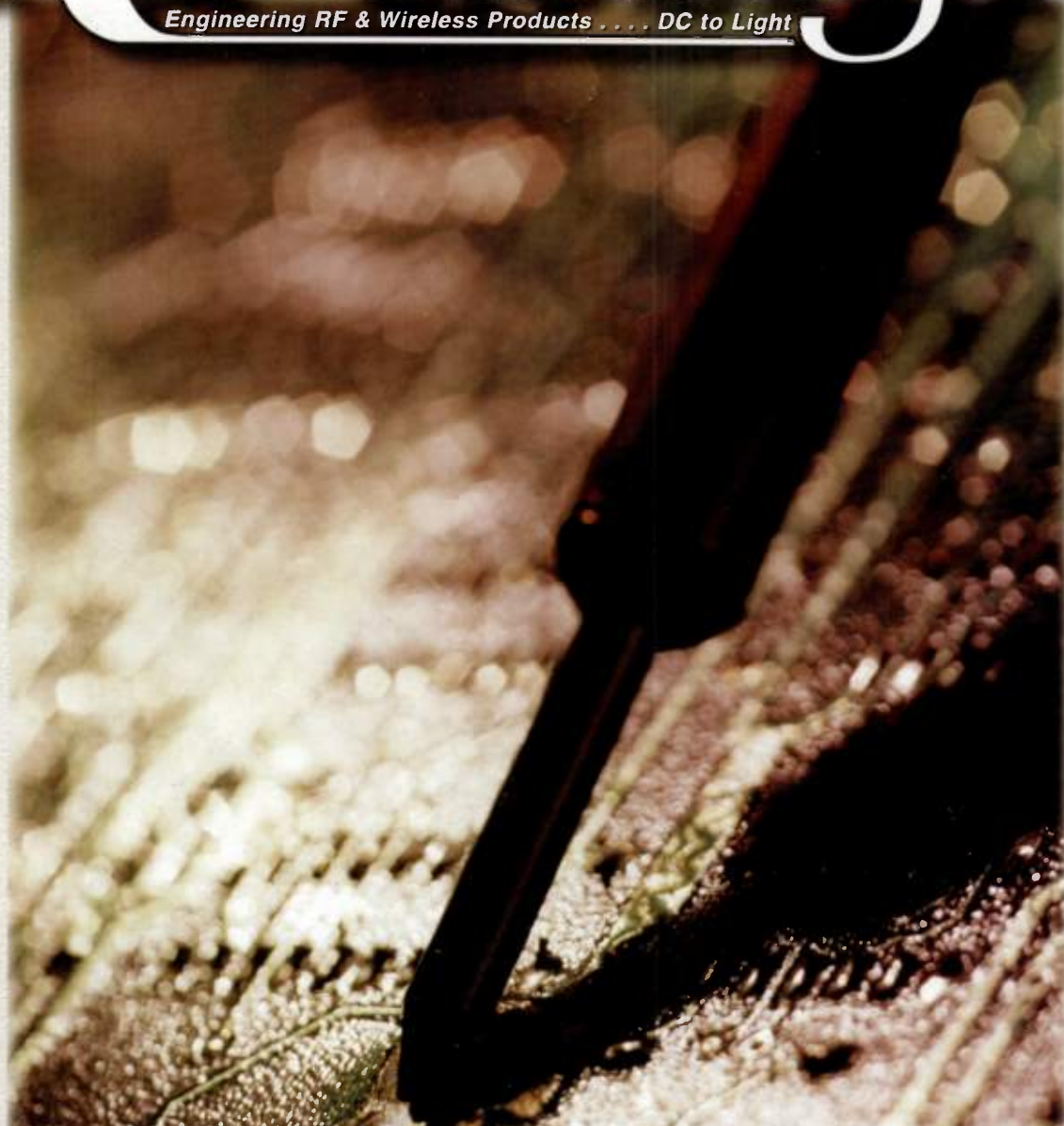


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December 2002



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Design Guide



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Edited by Bill Travis

Frequency comparator has status output

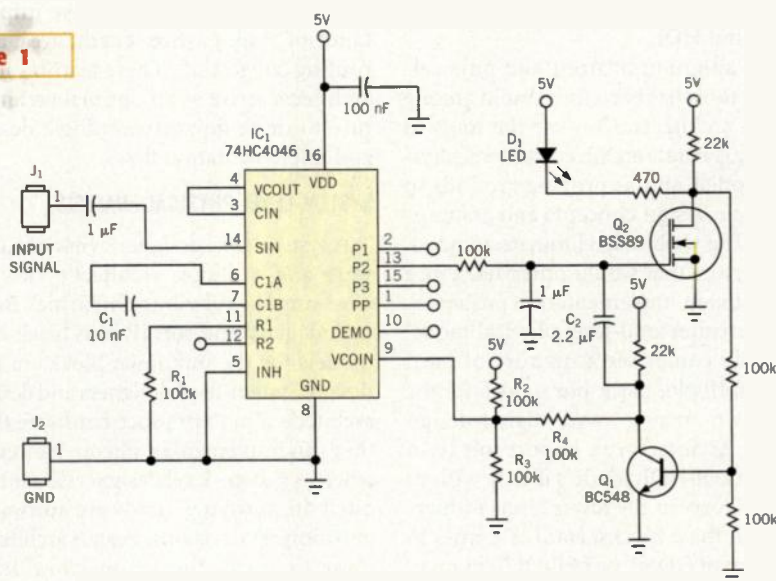
Susanne Nell, Breitenfurt, Austria

THE ORIGINAL APPLICATION for the circuit in Figure 1 was to check the number of revolutions of

an engine with only one LED as an indicator. The measurement of the number of revolutions usually involves sensors with a frequency output proportional to the number of revolutions. The circuit compares the frequency output of such a sensor with a lower and upper limit and gives a visual result, using one LED. If the frequency is below the lower limit, the LED remains unlit. If the frequency is between the limits, the LED blinks at a constant rate, and if the speed is higher than the upper limit, the LED stays permanently lit. Although a microcontroller can do this job, it is sometimes better to use an analog circuit—for example, if the frequency you want to check is too high for a simple controller. The circuit in Figure 1 uses one standard, inexpensive IC, and you need not write any software. It is also less costly than a comparable microcontroller-based circuit.

The main part is IC₁, a 74HC4046 PLL chip. With a 12V supply, you can also use the CD4046 without an additional volt-

Figure 1



This analog frequency comparator uses an LED to indicate upper and lower frequency limits.

age regulator. The chip contains an oscillator, a phase comparator, and one amplifier for the input signal. The input signal connects to the input of the phase comparator with its integrated ac amplifier. The circuit compares this amplified signal with the VCO frequency. This frequency is adjustable, using C₁, R₁, and the voltage on Pin 9. If the frequency of the input signal is lower than that of the VCO, the output of the phase comparator (Pin 13) is low. In this case, Q₂ is off, Q₁ is on, and the LED is off, indicating "low frequency." Resistors R₂, R₃, and R₄ determine the voltage on Pin 9 and the lower frequency limit switching point. If the frequency of the input signal increases and reaches the value of the VCO's frequency, the phase comparator's output switches high.

This high-level output turns Q₂ on and Q₁ off. With Q₁ off, the voltage of the

VCO increases to a second higher value determined by R₂ and R₃, and the VCO generates the frequency for the high-limit switching point. If the frequency of the input signal is between these two limits, the phase comparator generates a rectangular waveform. The feedback capacitor, C₂ determines the frequency of this waveform. With a value of 2.2 μF for C₂, you can achieve a frequency of approximately 1 Hz. This frequency is the blinking rate for the LED. If the frequency of the input signal increases to a point higher than the upper VCO frequency value, the phase comparator output stays high, and the LED turns on permanently. With the values shown in Figure 1, the lower and upper frequency limits are 3.81 and 7.35 kHz, respectively.

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System-level design tools' final description of the hardware partition may comprise a mixture of library blocks, hard macros, and black-box models. **Figure 1** shows that the hardware elements of the design may include a microprocessor and some RAM, or hard IP (intellectual property); some reusable elements from a previous-generation design, or soft IP; RTL from system-level library elements; black-box models for analog blocks; and digital blocks that the designer has yet to describe in detail. The tools can typically output this information in the form of structural HDL.

The adoption of front-end physical-design tools has been most rapid among design architects, who use the tools to quickly generate architectural-level physical models and as proving grounds to test their design concepts and assumptions. The tools help eliminate architectural errors that would otherwise cause downstream implementation problems.

An architectural-level physical model typically comprises a mixture of hard and soft IP, plus black-box models for the unknown analog- and digital-design blocks. Architects can import soft IP in the form of HDL models if they wish to microfloorplan the lower levels of hierarchy in these blocks. Hard IP comes in the form of GDSII, or LEF/DEF (library-exchange format/design-exchange format), so the boundaries of these blocks are well-defined (**Figure 2**).

Black-box models are considerably more fluid. Architects can enter an estimated gate-count usage and aspect ratio for each block. They can add ports to these blocks and create connectivity to the rest of the blocks in the design. They can manipulate the hierarchy of the blocks and experiment with various placement options. The physical model is based on an accurate underlying description of the chosen process technology, so architects can evaluate alternative technologies and quickly assess the physical impact on their designs. Built-in analysis tools give instant feedback on the effects of placement on timing, routing congestion, area, and power. Architects can manually place critical hard macros and fix them in position. They can then use automatic-placement-optimization features to place the remainder of the

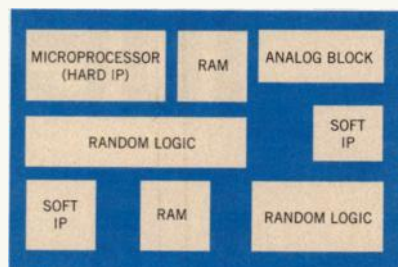


Figure 2 An architectural-level floorplan helps implementers visualize the relationships among physical blocks.

blocks and control the relative importance of timing, wire length, area, and routing congestion. These features help architects arrive at an optimal architecture to drive downstream logic design and implementation flows.

SYSTEM-LEVEL PHYSICAL ANALYSIS

A system-level designer's view of hardware and a design architect's view of hardware have obvious similarities. Both include hard and soft IP, plus black-box models for the unknown blocks in the design. System-level designers and design architects aim to produce hardware that they can implement in silicon. However, whereas system-level designers are interested in verifying hardware/software-partitioning decisions, design architects want to verify the architectural-level physical implementation.

Front-end physical-design tools support HDL input primarily to enable the importation of pre-existing IP. However, the same HDL-input features are ideal for importing structural HDL code that hardware/software codesign tools generate.

Importing structural Verilog or VHDL into front-end physical design tools is typically a fast process, so system-level designers can use these tools at any stage to gain a quick view of the physical implications of their hardware/software-partitioning decisions. This ability bridges the gap between the system level and the implementation level. The high-level physical model allows system-level designers to:

- assess area requirements,
- verify logical partitioning choices,
- establish high-level timing constraints and highlight timing violations,

- identify potential routing-congestion hot spots,
- conduct a quick power analysis, and
- optimize the physical hierarchy and regenerate structural HDL code.

Front-end physical-design tools give system-level designers an accurate evaluation platform to explore the physical implications of hardware/software-partitioning choices. The tools rapidly evaluate a design's performance against its physical constraints. This information allows designers to assess multiple what-if scenarios and adds confidence that partitioning choices will not cause downstream implementation problems.

The shift to higher levels of logical design abstraction that began in the late 1980s has continued unabated. But even the most abstract levels of description must consider the second- and third-order physical effects that dominate current generations of silicon-process technology. Front-end physical-design tools provide this link between system level and silicon.

Front-end physical-design tools give early feedback on the implications of hardware/software-partitioning choices in the physical domain and, hence, enhance predictability throughout the design flow. System-level designers immediately see the physical impact of high-level changes, so they can quickly evaluate many partitioning alternatives. An accurate underlying process-technology model delivers a clear representation of how the design will function in silicon. It allows system-level designers and downstream logic-design and -implementation teams to share a vision of how the design will perform, because the tool's analytical capability locates physical problems early in the design flow, when they are easiest to fix. □

AUTHOR'S BIOGRAPHY

Christopher Clee began his EDA career in 1988 at Praxis Electronic Design, a pioneer in language-based design and logic synthesis. Since then, he has run the gamut of the industry, with technical and product-marketing roles supporting tools in ASIC-, full-custom-, and pc-board-design flows. He is currently director of marketing for SOC architect, the front-end physical-design system from Icinergy Software.

Envelope follower combines fast response, low ripple

Harry Bissell, Royal Oak, MI

ENVELOPE FOLLOWERS EXTRACT amplitude information from complex audio waveforms. The resulting dc voltage often drives nonlinear stages, such as voltage-controlled amplifiers or filters. You must make a careful trade-off between the speed of response to a rapidly changing input signal and the amount of ripple in the dc output that you can tolerate. If the system is too slow, the output has low ripple but badly distorts the envelope shape. If it's too fast, ripple can modulate the nonlinear stages, causing audible distortion products. Audio sources, such as a guitar, pose special problems. The instrument has an attack of a few milliseconds and a long decay time. The musician may "mute" the strings at any time, causing the normal exponential decay to terminate abruptly. The waveform is sometimes unsymmetrical and may have multiple

zero crossings. The fundamental frequency range is typically from approximately 80 Hz to 1.5 kHz. Previous circuits have used a full-wave bridge and a large averaging filter. A filter time constant sufficient to reduce ripple makes the circuit unable to follow rapid changes in amplitude. Peak-detecting circuits can follow the rapid attack and provide low ripple during the exponential decay but cannot

follow the rapid decay of a muted string. The design in Figure 1 features fast attack and low ripple with minimal filtering, and it can follow a rapid decrease in signal (mute).

The circuit uses three identical peak-hold circuits in parallel that reset in a round-robin fashion. The circuit applies the input signal to all three stages simultaneously. As each stage resets in turn, the two remaining stages still hold the last peak voltage. Diodes select the highest held voltage at the output of each peak-hold circuit, so a lower output voltage results. A small RC filter smooths the step response as the peak-hold circuits reset, so a lower output voltage results. To ensure that one of the detectors holds the highest peak value for the entire input period, the reset clock period is slightly longer than one-half the period of the lowest input frequency. Figure 2 illustrates typical circuit operation and

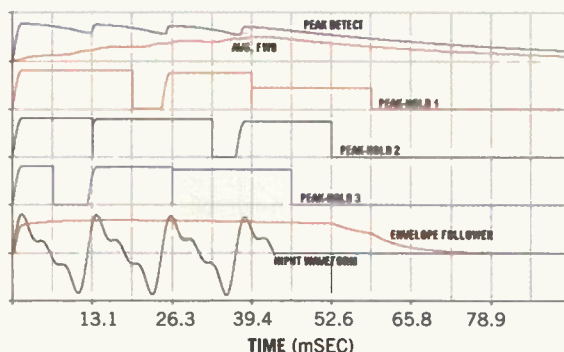
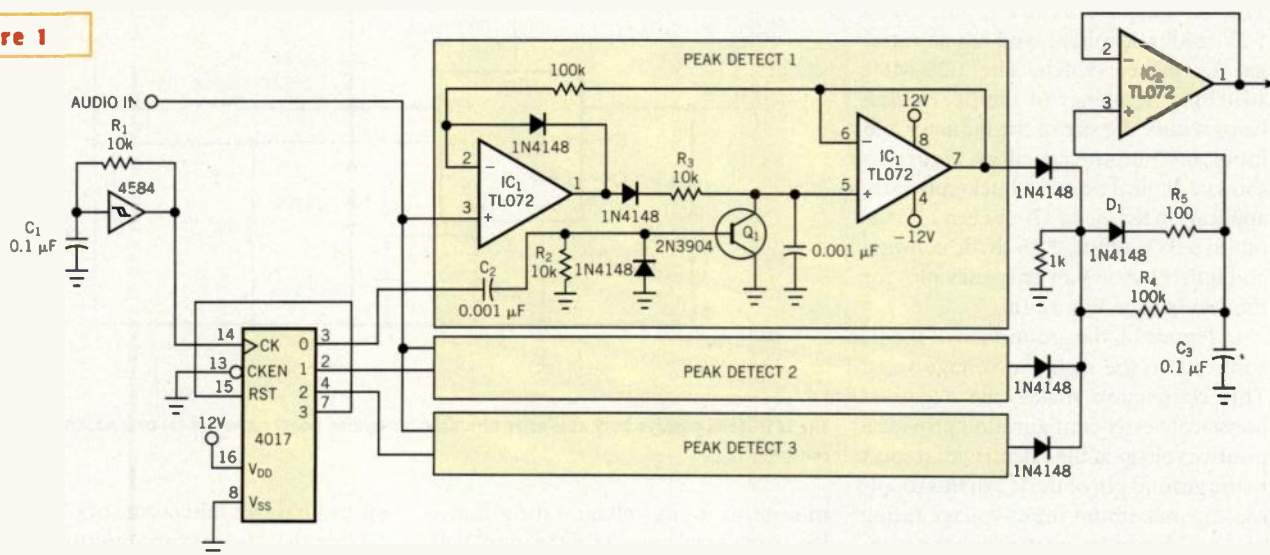


Figure 2

Waveforms of typical circuit operation show the improvement over full-wave average and peak-detecting circuits with similar time constants.

Figure 1



This envelope detector provides the seemingly contradictory features of fast response and low ripple.

shows the improvement over full-wave average and peak-detecting circuits with similar time constants. CMOS Schmitt inverter IC₁ forms the master reset clock, and C₁ and R₁ produce the desired period. CMOS counter IC₂ is a ring counter that provides the sequential reset pulses.

The peak-hold circuit is a classic configuration with the addition of the reset circuit. R₂ and C₂ differentiate the rising edge of the reset pulse; this edge drives the base of Q₁. Series resistor R₃ prevents excessive op-amp current while Q₁ is conducting. The filter network compris-

ing R₄, R₅, C₃, and D₁ provides minimal filtering to reduce the step changes in the output during unusually fast decay times.

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Positive regulator makes negative dc/dc converter

Keith Szolusha, Linear Technology Corp, Milpitas, CA

POWER-SUPPLY designers can choose from a plethora of available positive buck regulators that can also serve as negative boost dc/dc converters. Some buck regulators have a negative-feedback reference voltage expressly for this purpose, but ICs that have positive-reference feedback voltages far outnumber these negative-feedback regulators. You can take advantage of this greater variety of devices by using a positive buck switch-mode regulator to create an excellent negative boost converter. All you need are a few small modifications to the typical buck-converter configuration. **Figure 1a** shows a -5V-output, 1.4A negative boost converter using the LT1765EFE positive-buck-converter, switch-mode regulator. This IC accepts 3 to 25V input, uses a 1.2V feedback voltage, and has an internal 3A power switch. The 1.25-MHz switching frequency of the LT1765EFE helps reduce the size of the inductor and input and output capacitors. **Figure 1b** shows a typical positive-buck-converter application for the LT1765EFE: a 12V-input to 3.3V-output, 2.2A dc/dc converter. **Figure 2** shows an efficiency plot for the regulator in **Figure 1a**.

In **Figure 1a**, the ground pin of the IC connects to the negative voltage V_{OUT}. This connection makes the negative-boost-converter configuration provide a positive voltage at the FB pin with respect to the ground pin of the IC. In this topology, the maximum input voltage rating of the IC has to be greater than the magnitude of output voltage for the negative boost converter. The IC must also have a

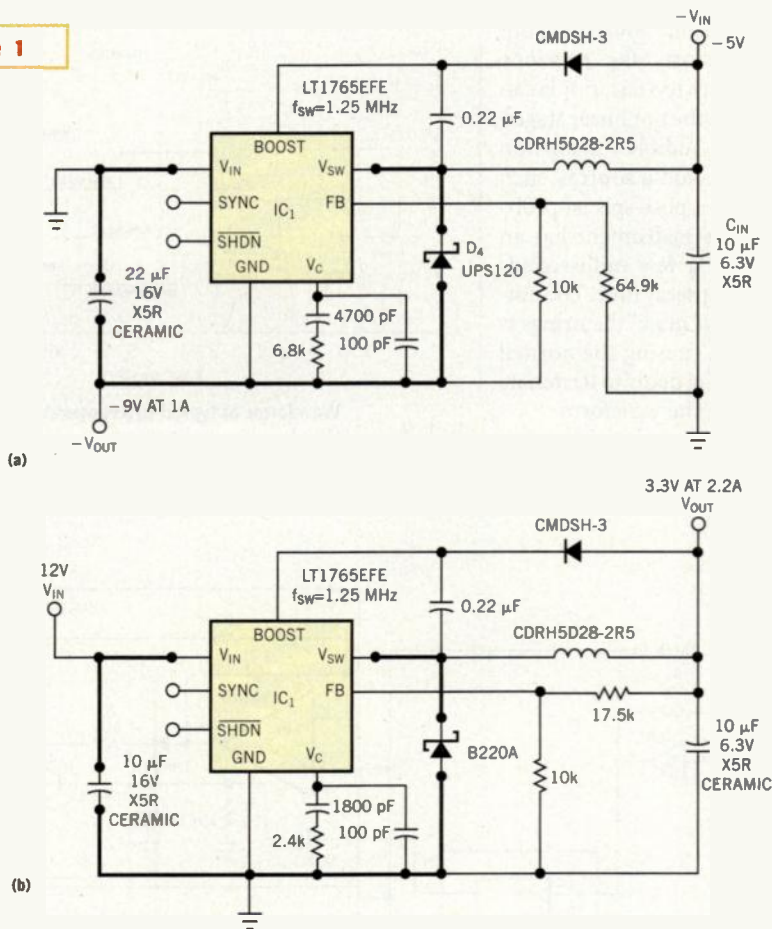
The LT1765EFE positive buck converter can make a negative boost converter (a) or a positive buck converter (b).

minimum input-voltage rating that is less than the magnitude of the input voltage, to ensure that the circuit turns on upon power-up, because the output volt-

age can have an initial state of 0V.

Note that the maximum output current for the negative boost converter in **Figure 1a** is much lower than the maxi-

Figure 1

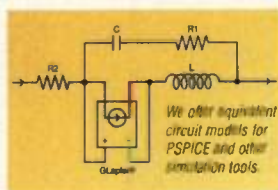




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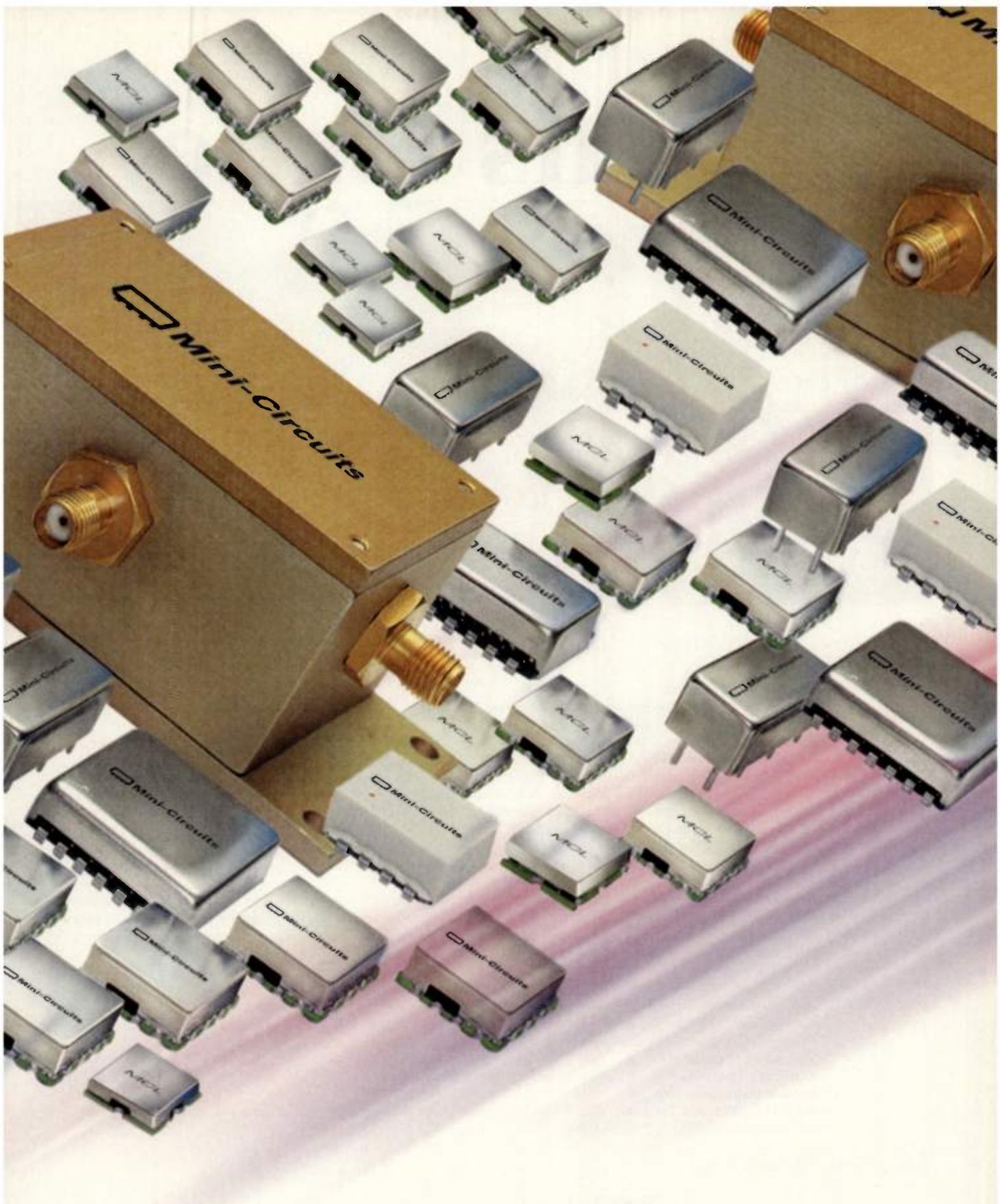
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13.	Other Not Distributed (Sum of 12a, 12b, and 12c)	765	1,030
14.	Total (Sum of 12a, 12b, and 12c)	42,602	41,533
15.	Percent Paid and/or Requested Circulation (Sum of 3a, 3b, 3c, and 3d)	97.7%	98.3%

16. Publication of Statement of Ownership: ☒ Publication required and is printed in the Dec 2002 issue of this publication. ☐ Publication not required.

17. Signature and Title of Editor, Publisher, Business Manager, or Owner: _____ Date: 9/28/02

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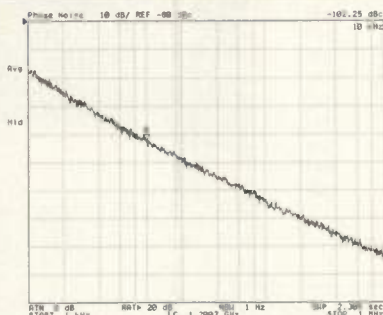
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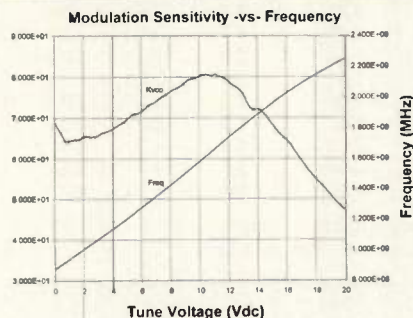
Part Number	Frequency Range(MHz)	Tuning Voltage	Typical 10 kHz Phase Noise	Supply Voltage	Output Power	Package Size
VC0790-600T	400-800	0.0 - 20.0	-102 dBc/Hz	+5 V	+3 dBm	0.5 x 0.5 x 0.18 in.
VC0790-1500T	1000-2000	0.0 - 20.0	-98 dBc/Hz	+5 V	+2 dBm	0.5 x 0.5 x 0.18 in.
VC0790-2300T	2100-2500	1.0 - 4.0	-89 dBc/Hz	+5 V	+3 dBm	0.5 x 0.5 x 0.18 in.
VC0793-600T	400-800	0.0 - 20.0	-104 dBc/Hz	+12 V	+7 dBm	0.5 x 0.5 x 0.18 in.
VC0793-1500T	1000-2000	0.0 - 20.0	-99 dBc/Hz	+12 V	+7 dBm	0.5 x 0.5 x 0.18 in.

Actual data for VC0793-1500T

Phase noise from HP3852 for 1000-2000 MHz VCO



Tuning Sensitivity from HP3852 for 1000-2000 MHz VCO



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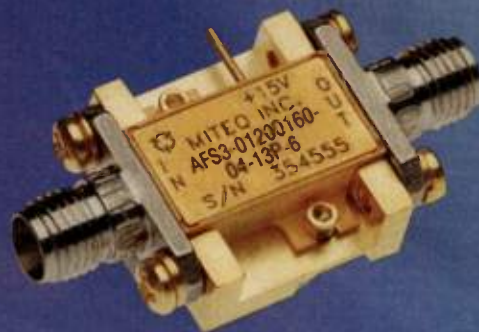


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AMPLIFIERS

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness ($\pm$ dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
TEMPERATURE COMPENSATED AMPLIFIERS								
AFS3-01000200-15-TC-6	1-2	36-40	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-02000400-15-TC-6	2-4	22-26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS3-02000400-15-TC-6	2-4	22-26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-04000800-20-TC-2	4-8	18-22	1.00	2.0	2.0:1	2.0:1	+5	100
AFS3-04000800-18-TC-4	4-8	26-30	1.00	1.8	2.0:1	2.0:1	+8	150
AFS2-02000800-40-TC-2	2-8	14-19	1.50	4.0	2.0:1	2.0:1	+5	100
AFS3-02000800-30-TC-4	2-8	22-27	1.50	3.0	2.0:1	2.2:1	+8	150
AFS2-08001200-30-TC-2	8-12	12-16	1.00	3.0	2.0:1	2.0:1	+5	100
AFS3-08001200-22-TC-4	8-12	24-28	1.00	2.2	2.0:1	2.0:1	+8	150
AFS4-12001800-30-TC-8	12-18	22-26	1.00	3.0	2.0:1	2.0:1	+8	250
AFS4-06001800-35-TC-6	6-18	22-26	1.00	3.5	2.0:1	2.0:1	+8	250
AFS6-06001800-35-TC-8	6-18	30-34	1.00	3.5	2.0:1	2.0:1	+8	400
AFS4-02001800-45-TC-5	2-18	18-24	1.50	4.5	2.2:1	2.2:1	+8	175

Note: All specifications guaranteed -54 to +85°C.
Many other frequencies, noise figures and gain windows are available.

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Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness ($\pm$ dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
HIGHER POWER AMPLIFIERS								
AFS4-00050100-25-25P-6	0.5-2	36	1.50	2.5*	2.0:1	2.5:1	+25	325
AFS3-00100100-23-25P-6	.1-1	38	2.00	2.3	2.5:1	2.5:1	+25	280
AFS3-00100200-25-27P-6	.1-2	33	1.50	2.5	2.0:1	2.5:1	+27	300
AFS3-00100300-25-23P-6	.1-3	25	1.50	2.5	2.0:1	2.5:1	+23	300
AFS3-00100400-26-20P-4	.1-4	26	1.50	2.6	2.0:1	2.0:1	+20	250
AFS4-00100600-25-20P-4	.1-6	32	1.50	2.5	2.0:1	2.0:1	+20	300
AFS4-00100800-28-20P-4	.1-8	30	1.50	2.8	2.0:1	2.0:1	+20	300
AFS4-00101200-40-20P-4	.1-12	20	1.50	4.0	2.0:1	2.0:1	+20	300
AFS4-00501800-60-20P-6	.5-18	25	2.75	6.0	2.5:1	2.5:1	+20	350
AFS5-00102000-60-18P-6	.1-20	25	3.00	6.0	2.5:1	2.5:1	+18	360
AFS3-01000200-20-27P-6	1-2	33	1.50	2.0	2.0:1	2.0:1	+27	350
AFS3-02000400-30-25P-6	2-4	28	1.50	3.0	2.0:1	2.0:1	+25	250
AFS3-04000800-40-20P-4	4-8	20	1.00	4.0	2.0:1	2.0:1	+20	200
AFS4-08001200-50-20P-4	8-12	22	1.25	5.0	2.0:1	2.0:1	+20	200
AFS6-12001800-40-20P-6	12-18	28	2.00	4.0	2.0:1	2.0:1	+20	375
AFS6-06001800-50-20P-6	6-18	23	2.00	5.0	2.0:1	2.0:1	+20	365
AFS4-02001800-60-20P-6	2-18	23	2.50	6.0	2.5:1	2.0:1	+20	350

*Noise figure degrades below 100 MHz. Please consult factory for details.
Note: Noise figures increase below 500 MHz in bands wider than .1-10 GHz.

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Model Number	Frequency Range (GHz)	Gain (Min.) (dB)	Gain Flatness (±dB)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
MODERATE BAND AMPLIFIERS								
AFS2-00700080-05-10P-4	.7-8	30	0.50	0.45	1.5:1	1.5:1	+10	90
AFS2-00800100-05-10P-4	.8-1	30	0.50	0.45	1.5:1	1.5:1	+10	90
AFS3-01200160-05-13P-6	1.2-1.6	40	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-01400170-05-13P-6	1.4-1.7	40	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-01500180-04-13P-6	1.5-1.8	40	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-01500250-06-13P-6	1.5-2.5	36	0.50	0.60	2.0:1	2.0:1	+13	150
AFS3-01700190-04-13P-6	1.7-1.9	36	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-01800220-05-13P-6	1.8-2.2	36	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-02200230-04-13P-6	2.2-2.3	36	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-02300270-05-13P-6	2.3-2.7	34	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-02700290-05-13P-6	2.7-2.9	32	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-02900310-05-13P-6	2.9-3.1	32	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-03100350-06-10P-4	3.1-3.5	29	0.50	0.6	1.5:1	1.5:1	+10	150
AFS4-03400420-06-13P-6	3.4-4.2	40	0.50	0.60	1.5:1	1.5:1	+13	225
AFS3-04400510-07-5P-4	4.4-5.1	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-04500480-07-5P-4	4.5-4.8	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05200600-07-5P-4	5.2-6	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05400590-07-5P-4	5.4-5.9	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05800670-07-5P-4	5.8-6.7	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-07250775-06-5P-4	7.25-7.75	30	0.50	0.60	1.5:1	1.5:1	+5	100
AFS3-07900840-07-5P-4	7.9-8.4	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS4-08500960-08-5P-4	8.5-9.6	32	0.75	0.80	1.5:1	1.5:1	+5	125
AFS3-09001100-09-5P-4	9-11	26	0.50	0.90	1.5:1	1.5:1	+5	100
AFS4-09001100-09-5P-4	9-11	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS4-10951175-09-5P-4	10.95-11.75	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS4-11701220-09-5P-4	11.7-12.2	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS2-12201280-10-8P-4	12.2-12.8	14	0.75	1.00	1.5:1	1.5:1	+8	80
AFS4-12201280-10-12P-4	12.2-12.8	27	0.75	1.00	1.5:1	1.5:1	+12	200
AFS4-12701330-13-10P-4	12.7-13.3	27	0.75	1.30	1.5:1	1.5:1	+10	175
AFS4-13201400-14-10P-4	13.2-14	24	0.75	1.40	1.5:1	1.5:1	+10	175
AFS4-14001450-14-10P-4	14-14.5	24	0.75	1.40	1.5:1	1.5:1	+10	175
AFS4-20202120-20-8P-4	20.2-21.2	20	1.00	2.00	1.5:1	1.5:1	+8	175
AFS4-21202400-22-10P-4	21.2-24	18	1.00	2.2	2.0:1	2.0:1	+10	100
OCTAVE BAND AMPLIFIERS								
AFS3-00120025-09-10P-4	.12-.25	38	0.50	0.9	2.0:1	2.0:1	+10	175
AFS3-00250050-08-10P-4	.25-.5	38	0.50	0.8	2.0:1	2.0:1	+10	125
AFS3-00500100-05-10P-6	.5-1	38	0.75	0.5	2.0:1	2.0:1	+10	150
AFS3-01000200-05-10P-6	1-2	38	1.00	0.5	2.0:1	2.0:1	+10	150
AFS3-01200240-05-10P-6	1.2-2.4	34	1.00	0.5	2.0:1	2.0:1	+10	175
AFS3-02000400-06-10P-4	2-4	30	1.00	0.6	2.0:1	2.0:1	+10	125
AFS3-02600520-10-10P-4	2.6-5.2	28	1.00	1.0	2.0:1	2.0:1	+10	150
AFS3-04000800-07-10P-4	4-8	30	1.00	0.7	2.0:1	2.0:1	+10	125
AFS3-08001200-09-10P-4	8-12	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-08001600-15-8P-4	8-16	26	1.00	1.5	2.0:1	2.0:1	+8	80
AFS4-12002400-25-10P-4	12-24	20	2.00	2.5	2.0:1	2.0:1	+10	85
AFS4-12001800-18-10P-4	12-18	26	1.00	1.8	2.0:1	2.0:1	+10	125
AFS4-18002650-28-8P-4	18-26.5	18	1.75	2.8	2.5:1	2.2:1	+8	150
MULTIOCTAVE BAND AMPLIFIERS								
AFS1-00040200-12-10P-4	.04-2	15	1.50	1.2	2.5:1	2.0:1	+10	75
AFS3-00300140-08-10P-4	.3-1.4	33	1.00	0.8	2.0:1	2.0:1	+10	150
AFS2-00400350-12-10P-4	.4-3.5	22	1.50	1.2	2.0:1	2.0:1	+10	80
AFS3-00500200-08-15P-4	.5-2	38	1.00	0.8	2.0:1	2.0:1	+15	125
AFS3-01000400-09-10P-4	1-4	30	1.50	0.9	2.0:1	2.0:1	+10	125
AFS3-02000800-09-10P-4	2-8	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS4-02001800-23-10P-4	2-18	25	2.00	2.3	2.0:1	2.0:1	+10	175
AFS4-06001800-22-10P-4	6-18	24	2.00	2.2	2.0:1	2.0:1	+10	150
AFS4-08001800-22-10P-4	8-18	26	2.00	2.2	2.0:1	2.0:1	+10	150
ULTRA WIDEBAND AMPLIFIERS								
AFS3-00100100-09-10P-4	.1-1	38	1.00	0.9	2.0:1	2.0:1	+10	150
AFS3-00100200-10-15P-4	.1-2	38	1.00	1.0	2.0:1	2.0:1	+15	150
AFS3-00100300-11-10P-4	.1-3	32	1.00	1.1	2.0:1	2.0:1	+10	150
AFS3-00100400-13-10P-4	.1-4	28	1.00	1.3	2.0:1	2.0:1	+10	150
AFS3-00100600-13-10P-4	.1-6	28	1.25	1.3	2.0:1	2.0:1	+10	125
AFS3-00100800-14-10P-4	.1-8	25	1.50	1.4	2.0:1	2.0:1	+10	125
AFS4-00101200-22-10P-4	.1-12	28	1.50	2.2	2.0:1	2.0:1	+10	175
AFS4-00101400-23-10P-4	.1-14	24	2.00	2.3	2.5:1	2.5:1	+10	200
AFS4-00101800-25-10P-4	.1-18	25	2.00	2.5	2.5:1	2.5:1	+10	175
AFS4-00102000-30-10P-4	.1-20	20	2.50	3.0	2.5:1	2.5:1	+10	175
AFS4-00102650-40-8P-4	.1-26.5	18	2.50	4.0	2.5:1	2.5:1	+8	175

Note: Noise figure increases below 500 MHz in bands greater than 0.1-10 GHz.



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Johanson Technology provides leading edge RF Ceramic Component Solutions including capacitors, inductors, low pass filters, band pass filters, baluns, couplers, & diplexers operating from 900 MHz to 5.5 GHz. Visit our web site today for our latest product information including our NEW 5.5 GHz component designer kits!

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Commercial, Military, and Industrial Use

Mini-Circuits proudly introduces MCA1, the world's first commercially available line of low temperature cofired ceramic (LTCC) frequency mixers! Highly reliable, extremely broad band, and very low in cost, these patent pending double balanced mixers have excellent electrical performance and are available in level 7, 10, and 13 (LO) models for your 300MHz to 6GHz designs. As for ruggedness and reliability, MCA1 mixers have all circuitry hermetically embedded inside the ceramic making them impervious to most environmental conditions. The process also gives you superior stability under temperature, high repeatability, and compact 0.065" profile. They're ideal for the COTS program, as well as your commercial and industrial applications. So contact Mini-Circuits now. Our team is ready to handle your needs worldwide with quick shipments, custom designs, high volume production capability, and fast turn-around.

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

\$5.95 **IN STOCK**
from ea. (Qty. 10)



Typical Specifications

Model	LO Level (dBm)	Freq. (MHz)	Conv. Loss (dB)	LO-RF Isol. (dB)	Price \$ ea. (Qty. 10)
MCA1-24	7	300-2400	6.1	40	5.95
MCA1-42	7	1000-4200	6.1	35	6.95
MCA1-60	7	1600-6000	6.2	30	7.95
MCA1-24LH	10	300-2400	6.5	40	6.45
MCA1-42LH	10	1000-4200	6.0	38	7.45
MCA1-60LH	10	1700-6000	6.3	30	8.45
MCA1-24MH	13	300-2400	6.1	40	6.95
MCA1-42MH	13	1000-4200	6.2	35	7.95
MCA1-60MH	13	1600-6000	6.4	27	8.95

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Microwave Technology is a leading supplier of GaAs-based products, offering high-linearity, low phase noise dynamic range and wide bandwidth. MwT offers hybrid modules/connectorized amplifiers for military/defense and wireless communications. MwT's proprietary GaAs process provides the best IP3 ACPR performance. The devices are ideally suited for frequency sources above 10 GHz.

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ETS - Lindgren
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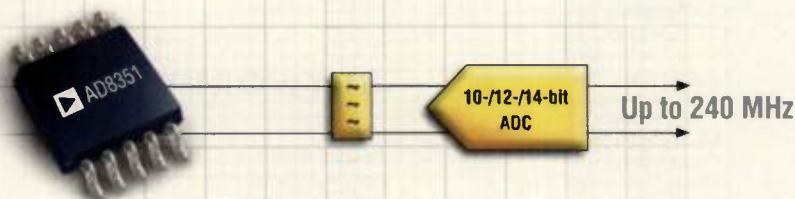
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Features

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Shielding

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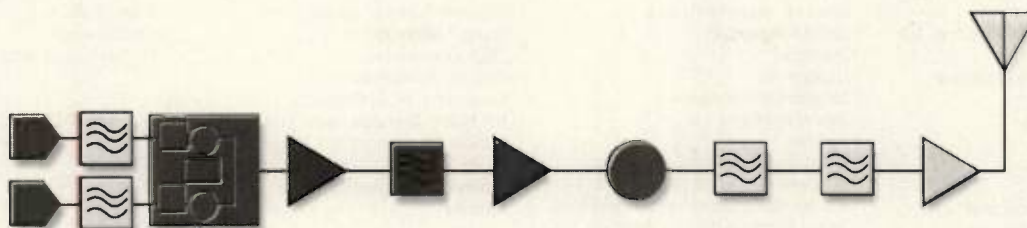
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Baseband-to-RF in a few chips.



Baseband-to-RF in two chips.



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- Output frequency range 800 MHz to 2.7 GHz
- Baseband I/Q bandwidth dc to 200 MHz
- Output level P1dB +5 dBm
- Sideband suppression -42 dBm
- Noise floor -156 dBm/Hz

AD9777 TxDAC+, AD8349 Quadrature Modulator

Whether you're designing a base station to meet today's standards or planning a network to meet the challenges of tomorrow's wide-band standards, only ADI has the complete transmit solution in two chips. The AD9777 is the 16-bit member of the AD977x TxDAC+ family of pin-compatible, high performance, programmable 2x/4x/8x interpolating D/A converters. The AD8349 is the next-generation quadrature modulator with the lowest noise floor and improved output power to provide the necessary dynamic range for direct conversion, thus eliminating an intermediate mixing stage and the many associated components. *For more information on these and the rest of our high performance RF IC portfolio, call 1-800-ANALOGD or visit our website.*

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Components/Hybrid Packages

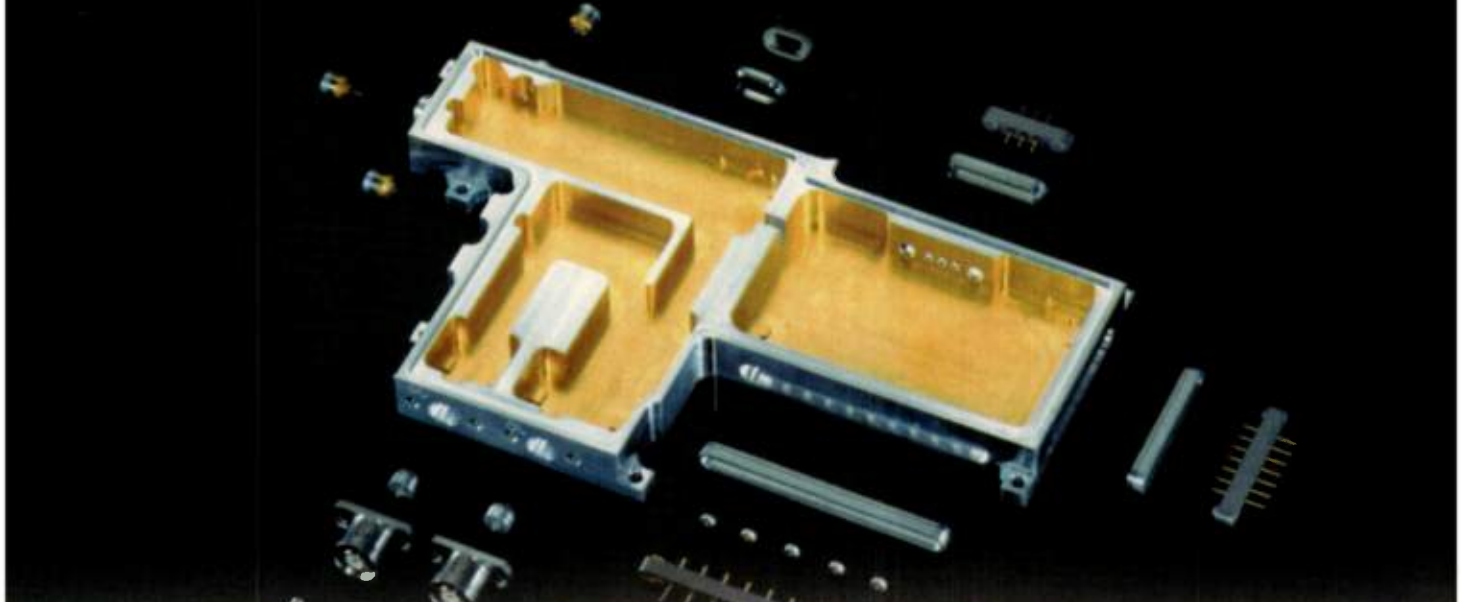
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From Design to Delivery!

Solder Free!

Pacific Aerospace & Electronics-Interconnect Divisions' laser weldable connectors provide a means to produce hermetic aluminum packaging without traditional solder interfaces. These connectors are designed to laser weld directly into the aluminum package thus eliminating hermetic failure due to solder joint fatigue.

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Kryoflex® is a family of polycrystalline ceramics developed for the purpose of hermetically sealing materials with high expansion rates. Kryoflex® takes up where glass leaves off, at about 10ppm/C. Pacific Aerospace & Electronics - Interconnect Divisions' EWS™ (Explosively Welded Stack) is a process used to permanently fuse, at the molecular level, otherwise incompatible metals. These multilayered "stacks" are then machined into the laser weldable connector bodies that have the right material in the right place. Using Kryoflex® in conjunction with the EWS™ process allows Pacific Aerospace & Electronics - Interconnect Division to produce aluminum connectors that are easily interfaced into an aluminum package via a laser weld.

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State-of-the-art Computer Aided

Design, CNC machining, complete plating facilities, and total laser weld capability. It's all right here!

Pacific Aerospace & Electronics - Interconnect Division has the highly trained personnel and equipment needed to produce hermetic aluminum packaging. Having the entire manufacturing process in-house allows us to maintain our exacting process and quality control standards through every step of production. To our customers, this means cost savings and shorter delivery times.

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An existing inventory of proven laser weldable connector designs allows for faster turnaround. Choose from many different DC feed-throughs including MIL-83513 Micro Ds, MIL-C-28748 Rack and Panel, and a host of RF connectors, including LWPT™, SMA, SSMA, BMAs, etc....In addition, we have a large inventory of EWS™ material that can be used to quickly fill orders with special requirements.

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- 2 configurations and 6 mounting styles suitable for all RF structures
- Operating temp: -55° to +125°C
- Cap ranges: 0.3-1.2 pF to 0.8-8.0 pF

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- Q: > 5000 at 100 MHz
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Microwave Tuning Elements

Metallic tuning elements

- 2 to 33 GHz

Dielectric tuning elements

- Alumina, quartz, sapphire
- 6 to 100 GHz

Dielectric resonator tuners

- 2 to 18 GHz

LC tuning elements

- 5 to 11 GHz

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Advanced Control Components
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Microwave Technology is a leading supplier of GaAs-based products, offering high-linearity, low phase noise dynamic range and wide bandwidth. MwT offers hybrid modules/connectorized amplifiers for military/defense and wireless communications. MwT's proprietary GaAs process provides the best IP3 ACPR performance. The devices are ideally suited for frequency sources above 10 GHz.

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SPECIFICATIONS

Model	Freq (MHz)	Gain Midband (dB)	Gain Flat (typ) (±dB)	Max. P _{out} 1 (dBm)	Dynamic Range (Typ @2GHz ²) NF(dB) IP3(dBm)	Price \$ea. (1-9)
ZJL-5G	20-5000	9.0	±0.55	15.0	8.5 32.0	80 129.95
ZJL-7G	20-7000	10.0	±1.0	8.0	5.0 24.0	50 99.95
ZJL-4G	20-4000	12.4	±0.25	13.5	5.5 30.5	75 129.95
ZJL-6G	20-6000	13.0	±1.6	9.0	4.5 24.0	50 114.95
ZJL-4HG	20-4000	17.0	±1.5	15.0	4.5 30.5	75 129.95
ZJL-3G	20-3000	19.0	±2.2	8.0	3.8 22.0	45 114.95
ZKL-2R7	10-2700	24.0	±0.7	13.0	5.0 30.0	120 149.95
ZKL-2R5	10-2500	30.0	±1.5	15.0	5.0 31.0	120 149.95
ZKL-2	10-2000	33.5	±1.0	15.0	4.0 31.0	120 149.95
ZKL-1R5	10-1500	40.0	±1.2	15.0	3.0 31.0	115 149.95

NOTES:

1. Typical at 1dB compression.
2. ZKL dynamic range specified at 1GHz.
3. All units at 12V DC.



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Celeritek
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CTT, Inc.
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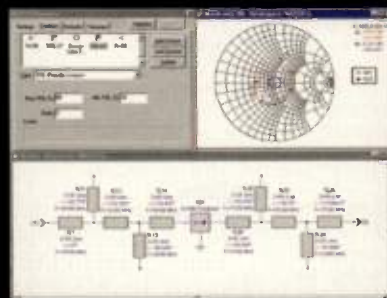
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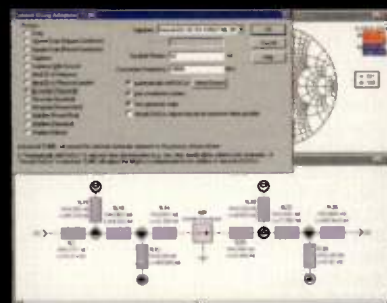
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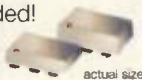
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Microwave Technology is a leading supplier of GaAs-based products, offering high-linearity, low phase noise dynamic range and wide bandwidth. MwT offers hybrid modules/connectorized amplifiers for military/defense and wireless communications. MwT's proprietary GaAs process provides the best IP3 ACPR performance. The devices are ideally suited for frequency sources above 10 GHz.

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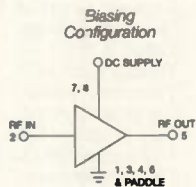


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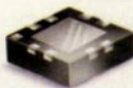
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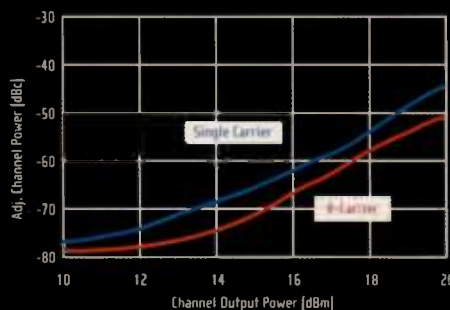
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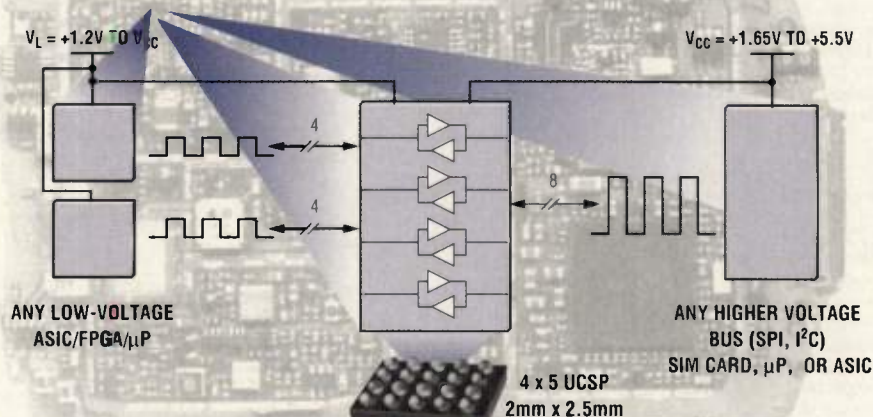
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 Lambda Electronics
 Leader Instruments
 Mouser Electronics, Inc.
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 National Instruments
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 PC Instruments
 Precision Test Systems LTD
 Ramsey Electronics
 Repcal Test Equipment
 Rohde & Schwarz
 Roos Instrument
 Tektronix
 Test Equipment Connection
 TestMart
 Yokogawa Corp. of America

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 Agilent Technologies
Amplifier Research
 Anritsu Corporate Offices
 Antenna Research Associates
 Atlantic Coast Instruments
 Berkeley Varitronics Systems
 Bird Electronic Corp.
 Boonton Electronics
 Contact East
Dorado International Corp.
DoveBid Test & Measurement Group
 ETS - Lindgren
 Giga-tronics
 Herley Industries
 IFR, an Aeroflex Co.
 Instrument Repair & Rental Labs
 Keithley Instruments, Inc.
 Krytar, Inc.
 Lambda Electronics
 LP Technologies
 Micronetics, Inc.
 Millitech
 mm Wave Technologies
 Naptech Test Equipment
 NAVICPmart—Military and Government Only
 PC Instruments

Phase Matrix
 Praxsym
 Precision Test Systems LTD
 Radio Research Instrument
 Repcal Test Equipment
 Rohde & Schwarz
 Roos Instrument
 Talley Communications Corp.
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 Tony Chapman Electronics
 Yokogawa Corp. of America
 Z Technology

Probes

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Amplifier Research
 Antenna Research Associates
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 Braxton Mfg.
 Cascade Microtech
 Castle Microwave
 Digi-Key
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 NAVICPmart—Military and Government Only
 PC Instruments
 Precision Test Systems LTD
 Ramsey Electronics
 Repcal Test Equipment
 Rohde & Schwarz
 Schaffner EMC
 Solar Electronics
 Tegam
 Tektronix
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 Test Equipment Connection
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 Agilent Technologies
 Atlantic Coast Instruments
 Avtech Electrosystems
 Celerity Systems, Inc.
 Directed Energy
DoveBid Test & Measurement Group
 EMCC Dr Rasek
 Instrument Repair & Rental Labs
 Keithley Instruments
 Lambda Electronics
 Leader Instruments
 Millitech
 Mouser Electronics, Inc.

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 NAVICPmart—Military and Government Only
Noise Com, Wireless Telecom Group Inc.
 PC Instruments
 Precision Test Systems LTD
 Quatech
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 Radio Research Instrument
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 Rohde & Schwarz
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 Solar Electronics
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 Symmertricom, Inc.
 T&C Power Conversion
 Tektronix
 Test Equipment Connection
 TestMart
 TrueTime

RLC/Impedance Bridges

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 Atlantic Coast Instruments
 Avcom of Virginia
DoveBid Test & Measurement Group
 Eagle
 Instrument Repair & Rental Labs
 Keithley Instruments
 Lambda Electronics
 Naptech Test Equipment
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 Precision Test Systems LTD
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 Stanford Research Systems
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 Wide Band Engineering

Signal/Sweep Generators

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 Antenna Research Associates
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 Atlantic Coast Instruments
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 Schaffner EMC
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 Test Equipment Connection
 TestMart
 TrueTime
 V. Tech Instruments, Inc.
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Spectrum Analyzers

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Instrument Repair & Rental Labs

Test Eq. Repair & Cal

Spectrum Analyzers

RF Power Sensor Calibration

Network Analyzers

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front



back



Above-average human thumb Average human thumb Our customer's thumb

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Historical Figures With Small Hands



1.) Napoleon
The Conqueror

2.) Tom
Thumb

3.) Three
Blind Mice

4.) Napoleon
The Conqueror's
second cousin

5.) Goliath
(Surprisingly)

6.) Tyrannosaurus Rex

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Innovator in Electronics

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Celerity Systems, Inc.

DoveBld Test & Measurement Group

Instrument Repair & Rental Labs
Lambda Electronics
Naptech Test Equipment
NAVICPmart—Military and Government Only

Noise Com, Wireless Telecom Group Inc.

RDL
Repcal Test Equipment
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Roos Instrument
SynapticAD
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TestMart

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Cushcraft
Dage
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Digi-Key
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Nittany Scientific
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Tality
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+0
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-20
-30
-40
-50
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-100
-110

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Avitronics
AVX Corp.
Bird Electronic Corp.
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Castle Microwave
Channel Microwave

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Communications & Energy
Connecticut Microwave
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Coupling	Model	Freq. (MHz)	Ins. Loss (dB) Midband Typ	Directivity (dB) Midband Typ
9dB	DBTC-9-4	5-1000	1.2	18
10dB	DBTC-10-4-75	5-1000	1.4	20
12dB	DBTC-12-4	5-1000	0.7	21
13dB	DBTC-13-4	5-1000	0.7	18
13dB	DBTC-13-5-75	5-1000	1.0	19
		1000-1500	1.4	17
16dB	DBTC-16-5-75	5-1000	1.0	21
		1000-1500	1.3	19
17dB	DBTC-17-5	50-1000	0.9	20
		1000-1500	1.0	20
		1500-2000	1.1	14
18dB	DBTC-18-4-75	5-1000	0.8	21
20dB	DBTC-20-4	20-1000	0.4	21

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mm Wave Technologies
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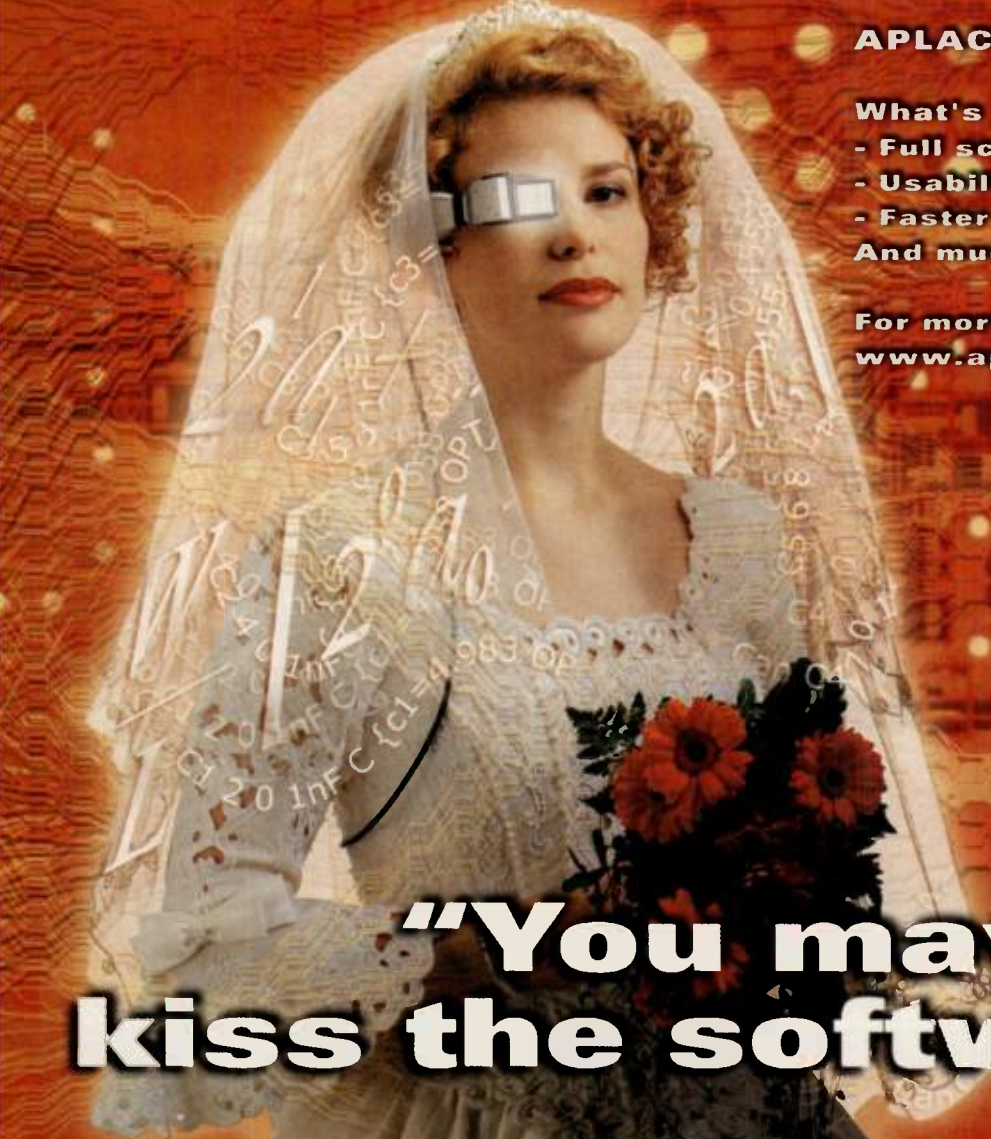
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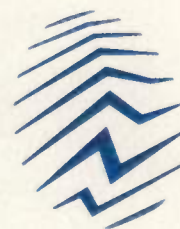
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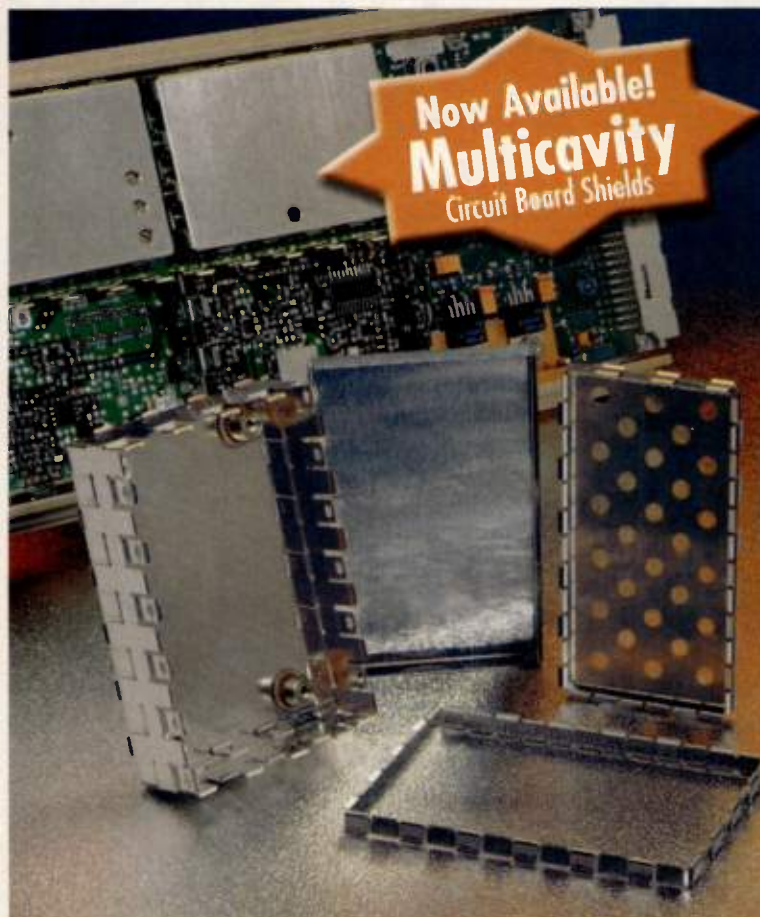
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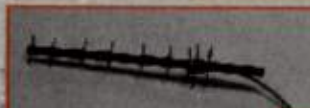
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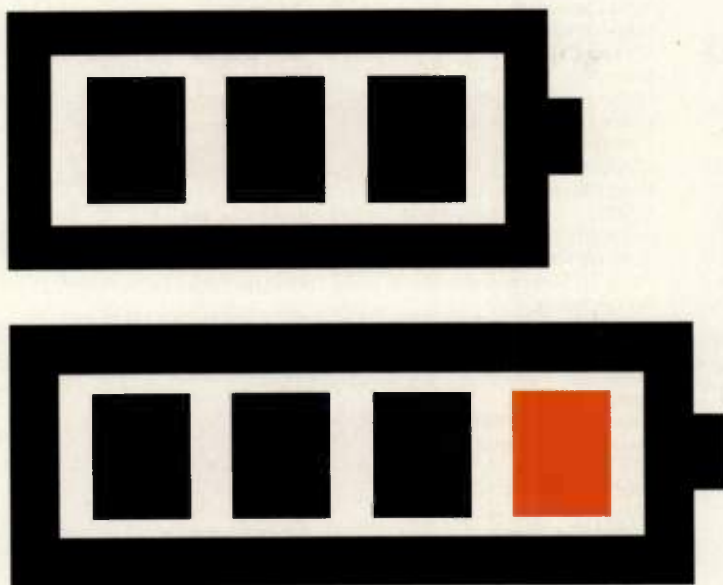
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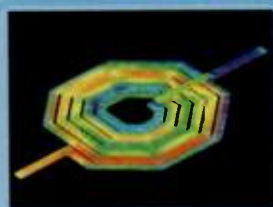
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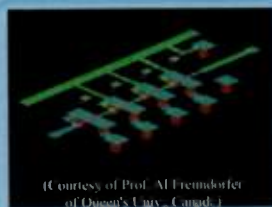
IE3D

PRODUCTS

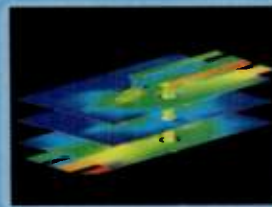
Planar and 3D Electromagnetic Simulation and Optimization Package



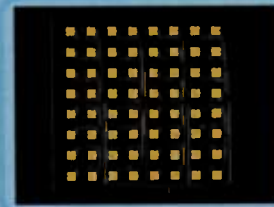
A Spiral Inductor with Thickness on a Semiconductor Substrate



IE3D Simulation of an Entire Low-Noise Amplifier



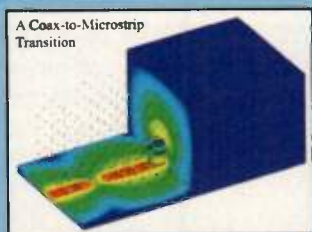
A Multilayer PCB with Vias in High-Speed Circuits



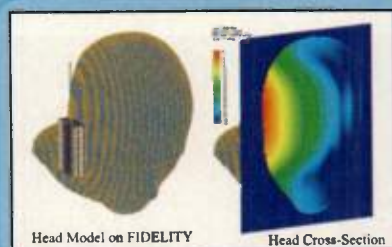
An 8-by-8 Patch Antenna

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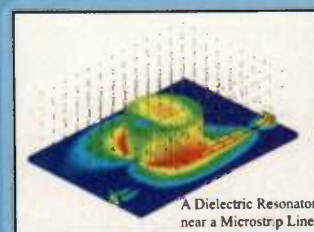


A Coax-to-Microstrip Transition



Head Model on FIDELITY

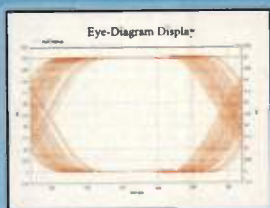
Head Cross-Section



A Dielectric Resonator near a Microstrip Line

MDSPICE

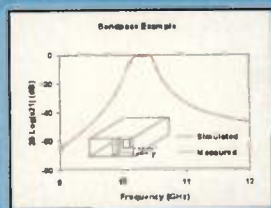
Mixed Frequency- and Time-Domain SPICE Simulator



Eye-Diagram Display

COCAFIL

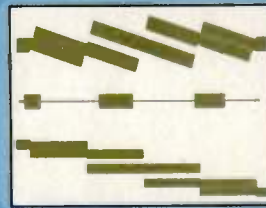
Waveguide Coupled Cavity Filter Design Suite



Bandpass Example

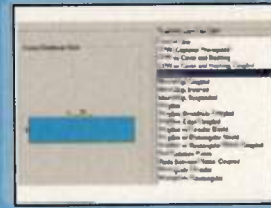
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Planar Filter Synthesis Package



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499.25	1.0	9.0x7.0mm	855104
549.25	1.0	9.0x7.0mm	854707
1086.0	10.0	3.0x3.0mm	855964
1090.0	10.0	3.0x3.0mm	855989
1090.0	10.0	3.8x3.8mm	856096
1220.0	10.0	3.0x3.0mm	856176
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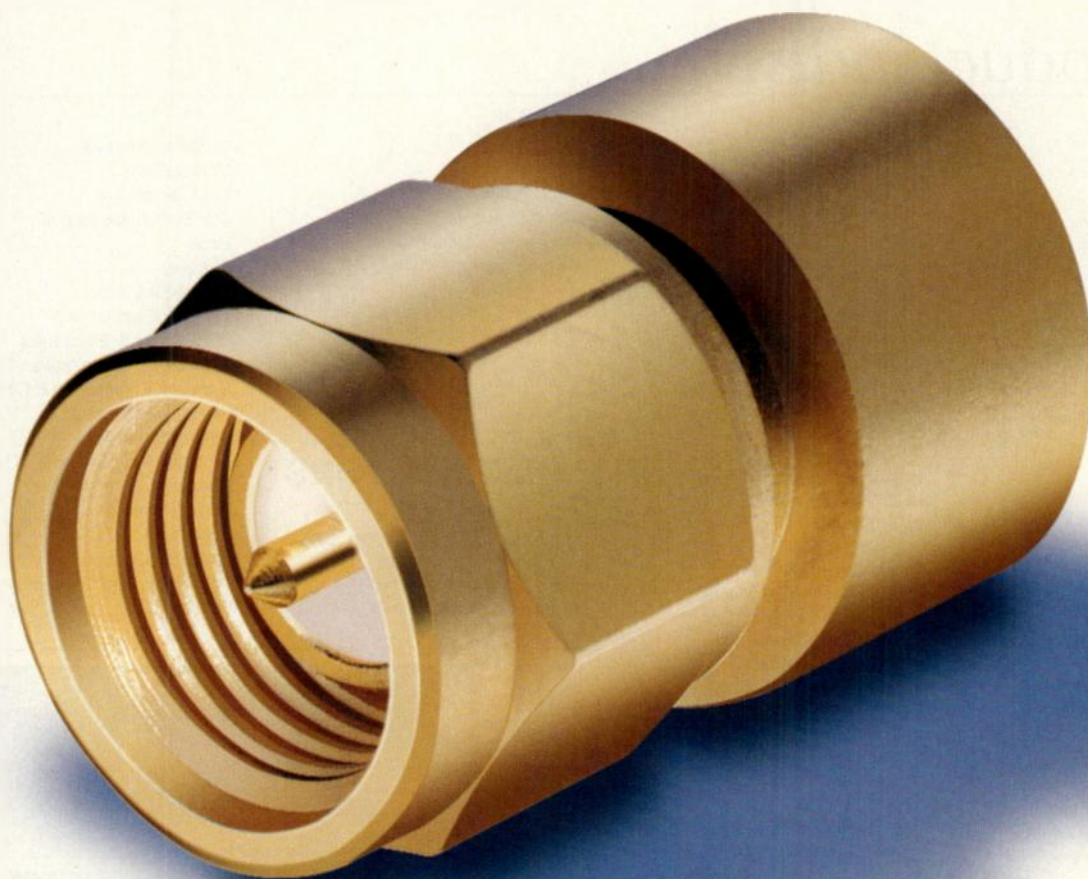
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Actual Size

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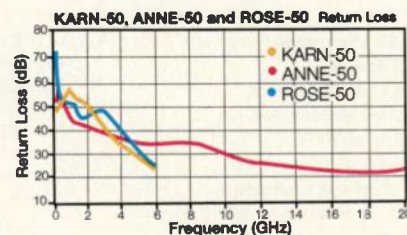
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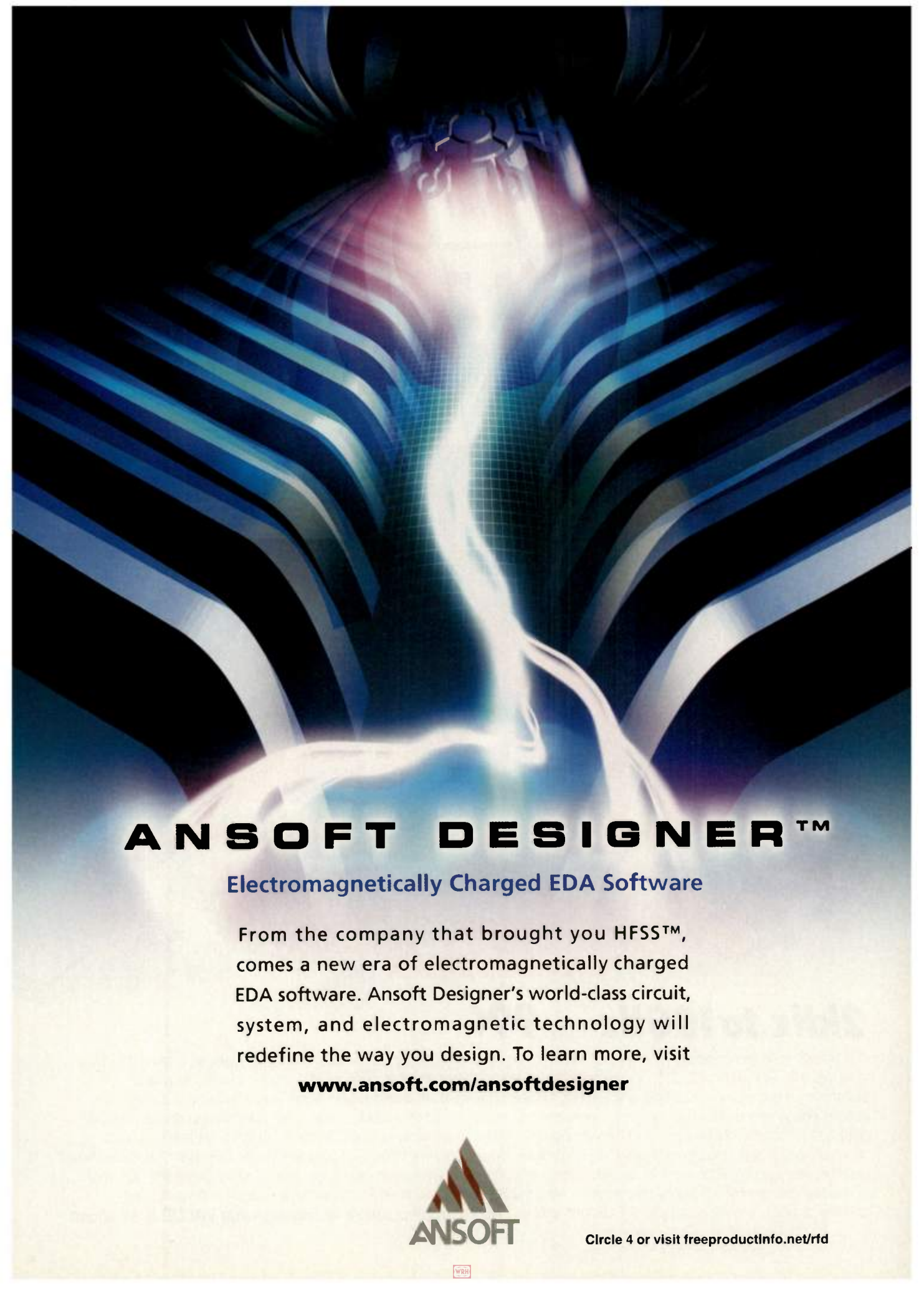
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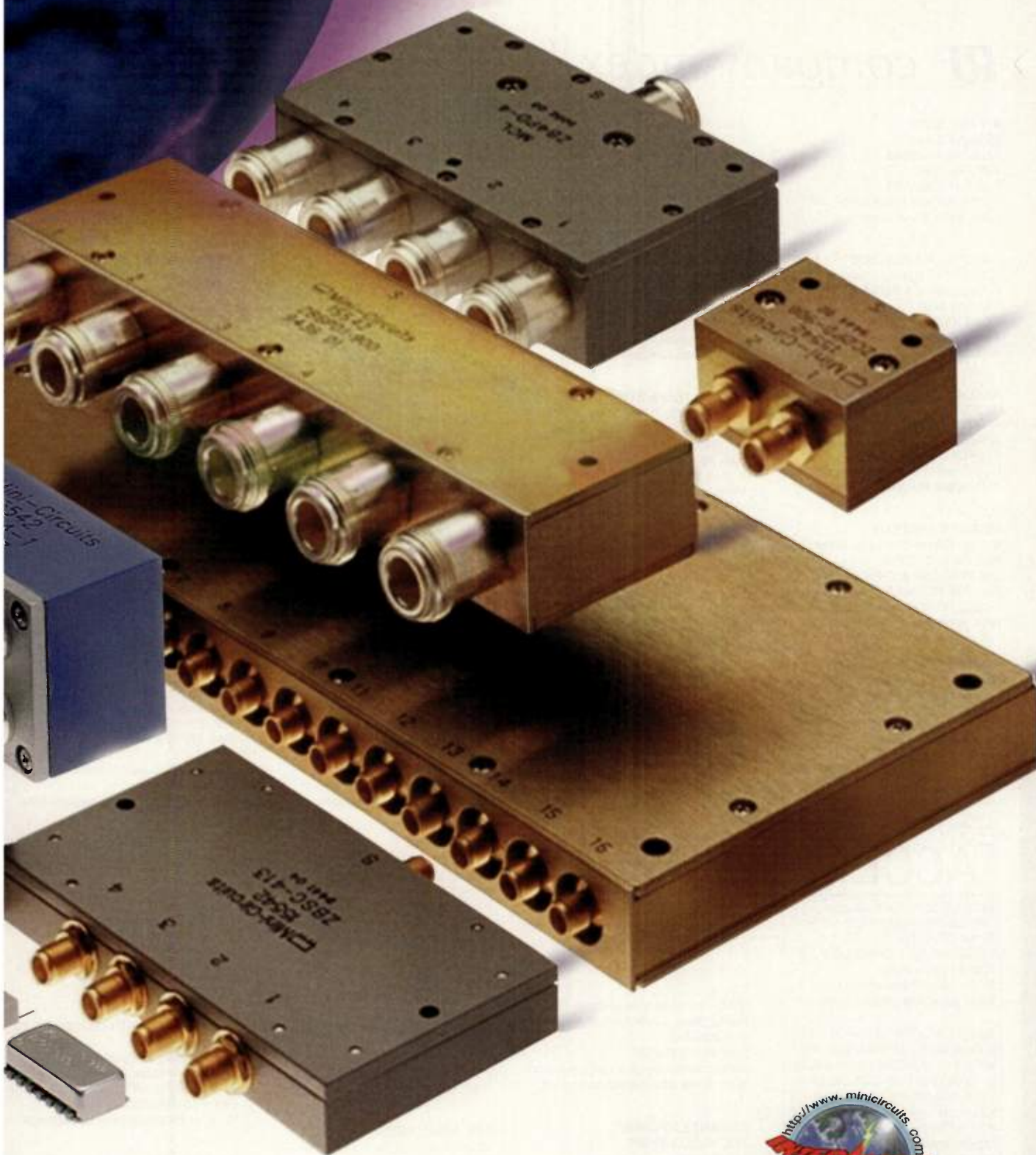
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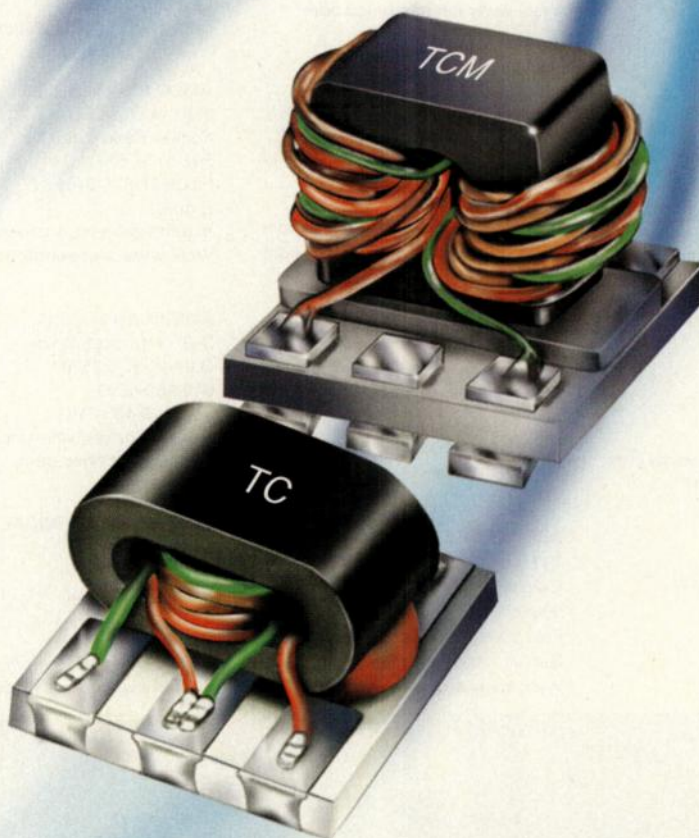
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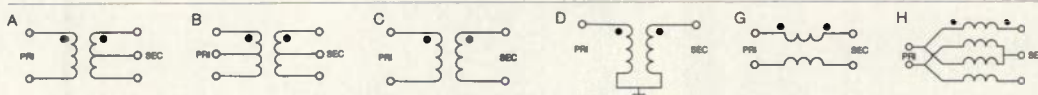
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TC4-1W	4A	3-800	10-100	1.19
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TC8-1	8A	2-500	10-100	1.19
TC9-1	9A	2-200	5-40	1.29
TC16-1T	16A	20-300	50-150	1.59
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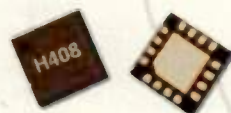
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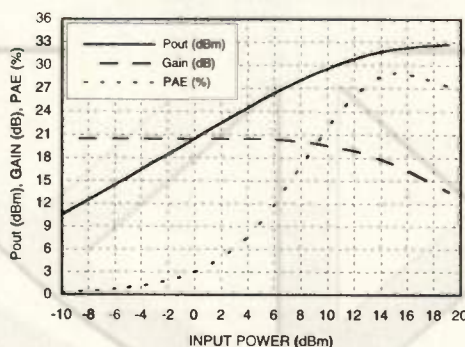
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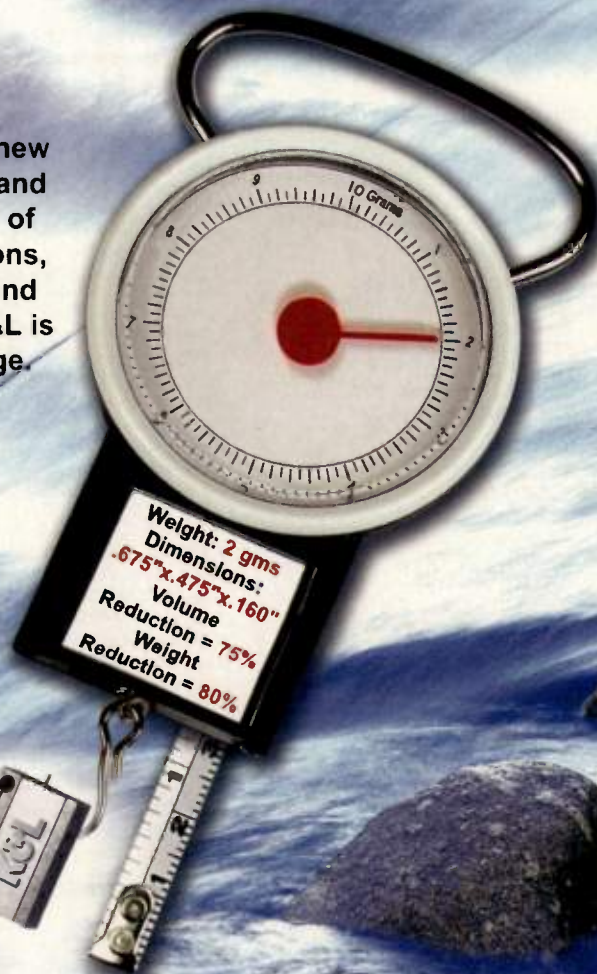
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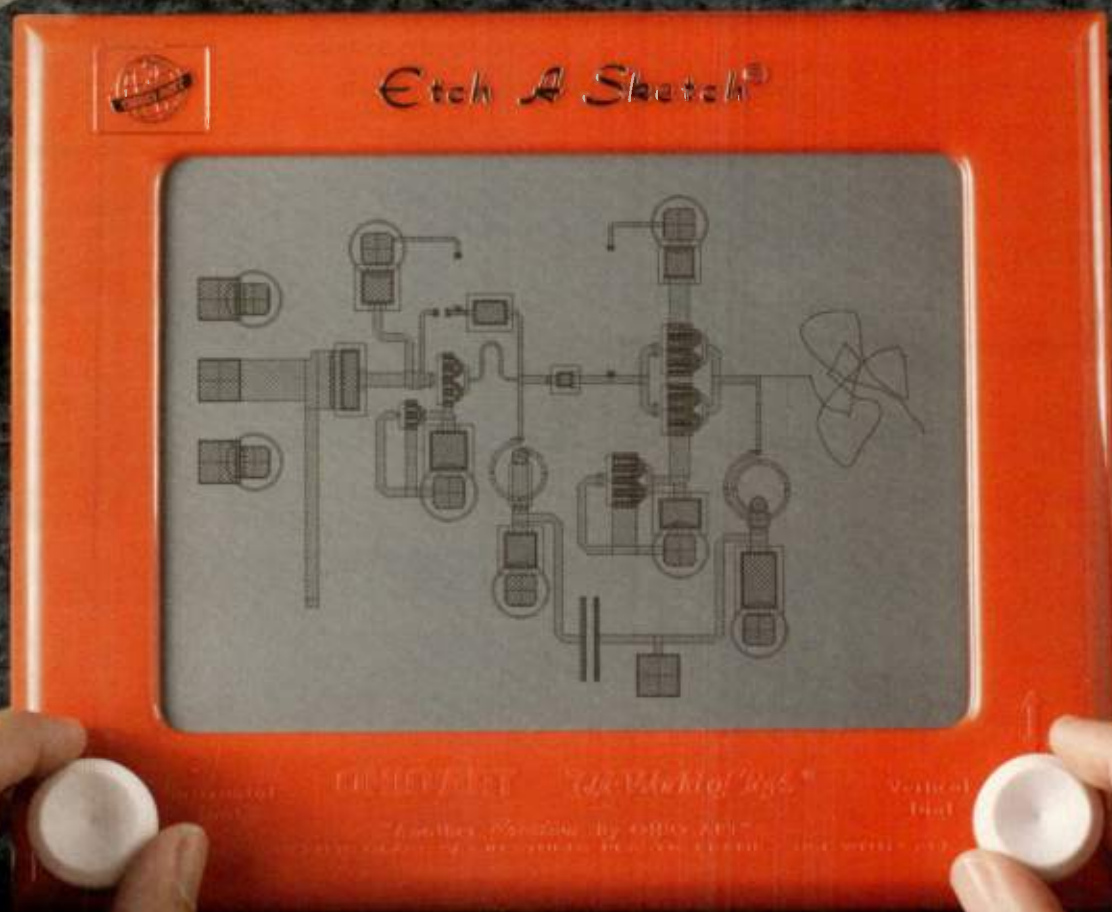
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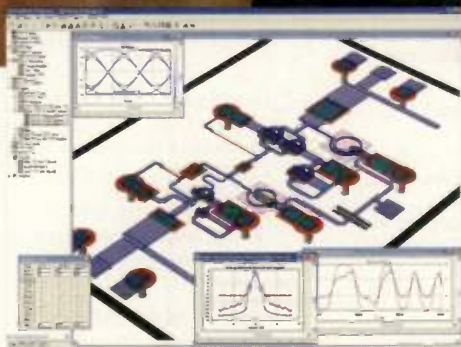
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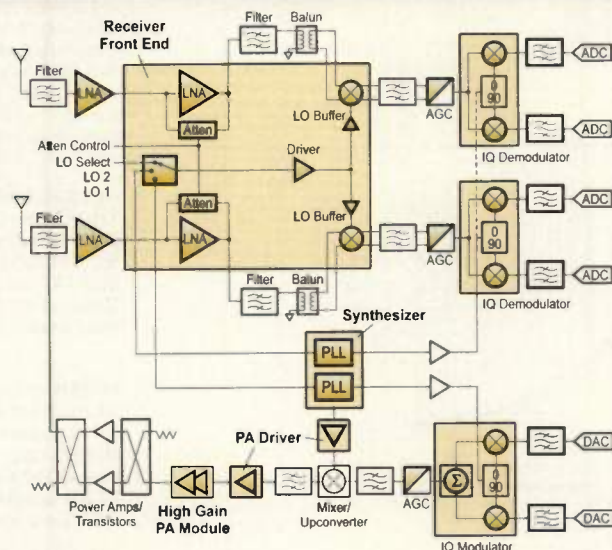
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Ultra-Linear PA Drivers and High Gain 50 Ohm Modules (GaAs HBT)						
Part Number	RF Frequency (MHz)	P _{1dB} (dBm)	Gain (dB)	Output IP3 (dBm)	Supply Voltage	Package Type
CX65001-12	160-700	24	22	45	5.0	SOIC 8-Lead
CX65002-12	700-1400	24	18	47	5.0	SOIC 8-Lead
CX65003-12	1400-2500	24.5	11.5	48	5.0	SOIC 8-Lead
CX65100-11	700-1300	29.5	29.5	39	3.4	8x8 mm 8L LCC
CX65101-11	1700-2200	28.5	21.5	40	3.4	8x8 mm 8L LCC
CX65102-11	1700-2200	28	22	39	3.4	6x6 mm 6L LCC
CX65104-11	700-1300	31	28	40	5.0	8x8 mm 8L LCC
CX65105-11	1700-2200	27	24	40	5.0	8x8 mm 8L LCC
Diversity Receiver Front Ends / Downconverters (+/- 5 V _{DC} , GaAs MESFET)						
Part Number	RF Frequency (MHz)	Frequency (MHz)	Gain (dB)	Input IP3 (dBm) Full / Mixer	NF (dB) Full / LNA	Package Type
CX42053-11	700-1300	10-250	15	13 / 27	3.0 / 1.8	24 Pin PQFP
CX42054-11	1700-2200	10-250	11	10 / 24	4.6 / 2.6	24 Pin PQFP
Dual Fractional-N Synthesizers / PLLs (+3 V _{DC} , SiGe BiCMOS)						
Part Number	Main / RF Frequency (MHz)	Aux / IF Frequency (MHz)	Current @ 3 V (mA)	Main / RF Step Size (Hz)	Phase Noise @ 10 kHz Offset (dBc/Hz)	Package Type
CX72300-11	100-2100	500	13	< 100	-89 @ 2 GHz	28 Pin TSSOP
CX72301-11	100-1000	500	11	< 100	-95 @ 850 MHz	28 Pin TSSOP
CX72302-11	100-6100	1000	17	< 400	-80 @ 6 GHz	28 Pin TSSOP
CX74038-12*	100-2600	800	7	< 10	-85 @ 2.4 GHz	20 Pin TSSOP
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*CX74038 series are Fractional-N / Integer-N synthesizers.

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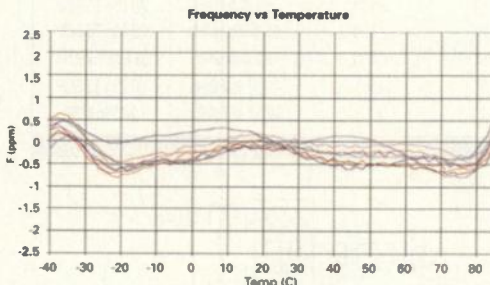
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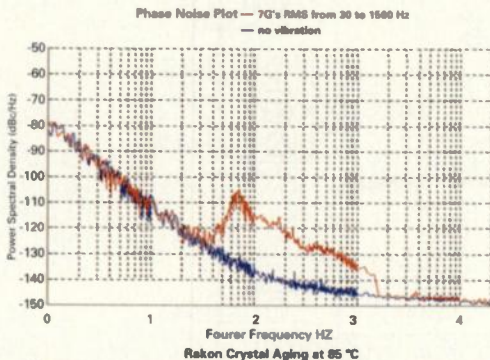
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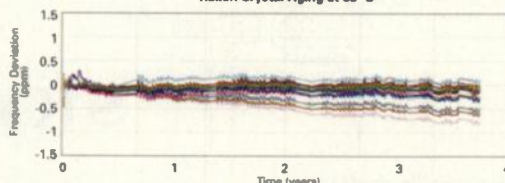
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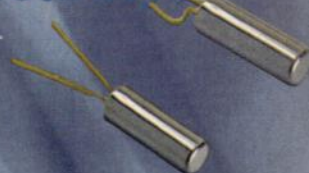
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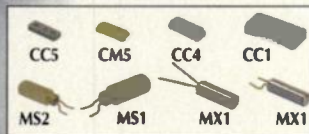
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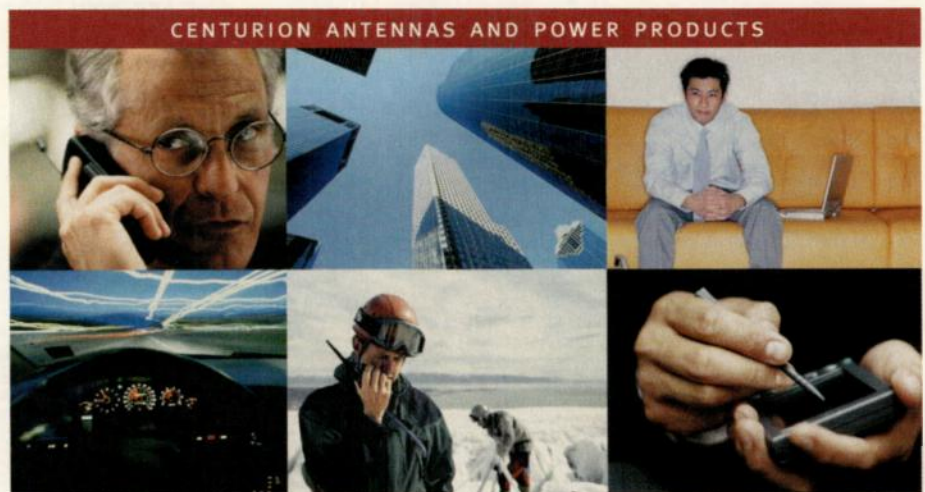
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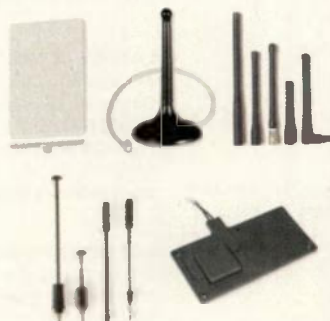


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DAC4101	0.01-4.0	-30 to 5	0.60	0.25	120	-10	1.5	5	2
DAQ6101	0.1-6.0	-30 to 5	0.50	0.25	120	-10	1.5	5	2
DAQ10501	0.05-10.0	-30 to 5	0.75	0.25	120	-10	1.5	5	2

THRESHOLD DETECTORS

Model	Frequency Range GHz	Input Power Range dBm	Power Flatness $\pm$ dB	Power Temperature Stability $\pm$ dB	Hysteresis dB	Pulse Response μ sec	VSWR Input	Volt. V	Cur. mA
DTC4003	0.01-4.0	-10 to 20	0.30	0.20	0.2	15	1.2	5	3
DTQ6001	0.1-6.0	-30 to -5	0.50	0.25	0.2	15	1.5	5	2.5
DTS6015	0.1-6.0	-30 to -5	0.50	0.25	0.2	15	1.5	5	2.5

Specifications are typical.

VCOS

Model	Freq. Range (MHz)	Tuning Voltage Range (Volts)	Output Power/ Variation (dBm/ $\pm$ dB)	Typical Phase Noise Offset at 10kHz/100kHz (dBc/Hz)	Nominal Modulation Sensitivity (MHz/V)	Typical Harmonic Suppression (dBc)	D.C. Bias Voltage (Volts)	D.C. Bias Current (mA)
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OAS5100	4600-5100	0-15	10/2.0	-70/-100	30	-25	5.0	100
OAS7700	5700-7700	0-15	10/2.0	-68/-98	150	-25	5.0	100
Straight Oscillator available in SMT0-8 or CougarPak™.								
OS6100	4700-6100	0-15	0/3.0	-70/-100	100	-5	5.0	30
OS8600	7000-8600	0-15	0/3.0	-65/-95	200	-5	5.0	30

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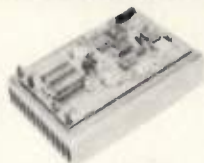
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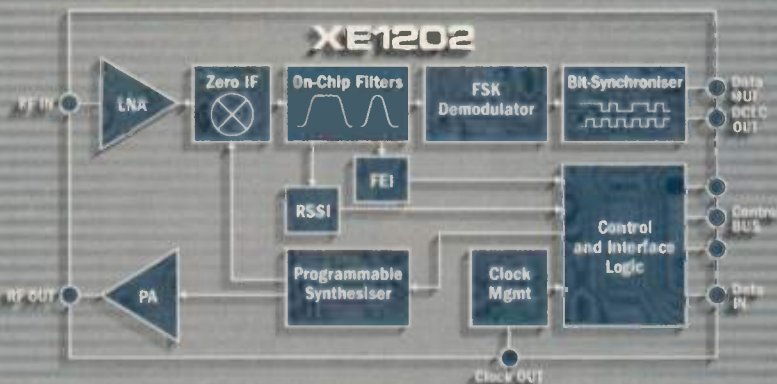
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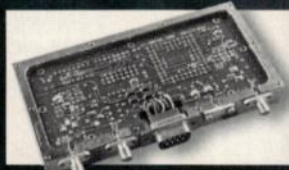
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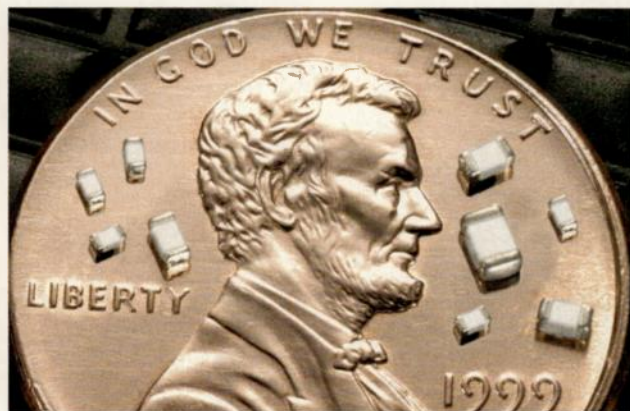
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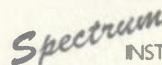
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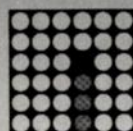
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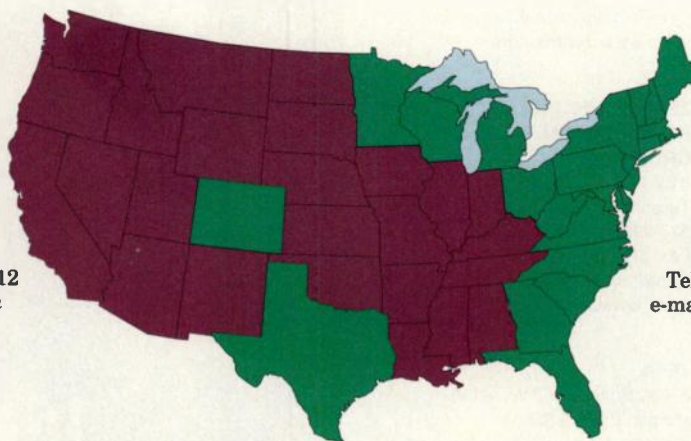
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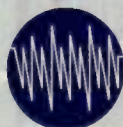
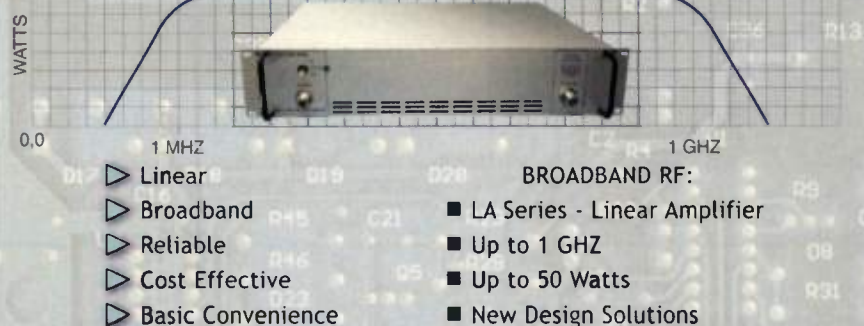
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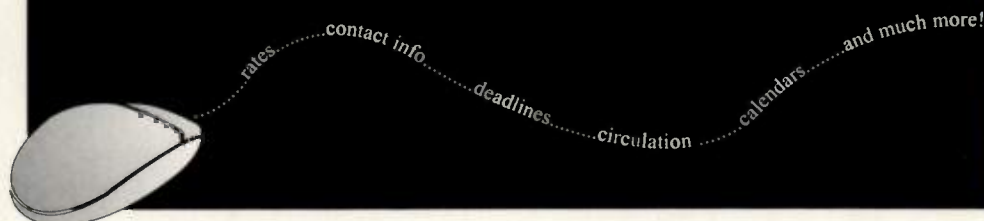
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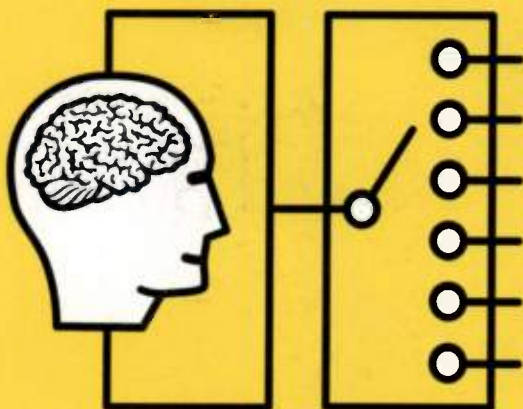
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