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TECHNOLOGY FOCUS

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Special Issue on

Indigenous Electronic Components & Devices

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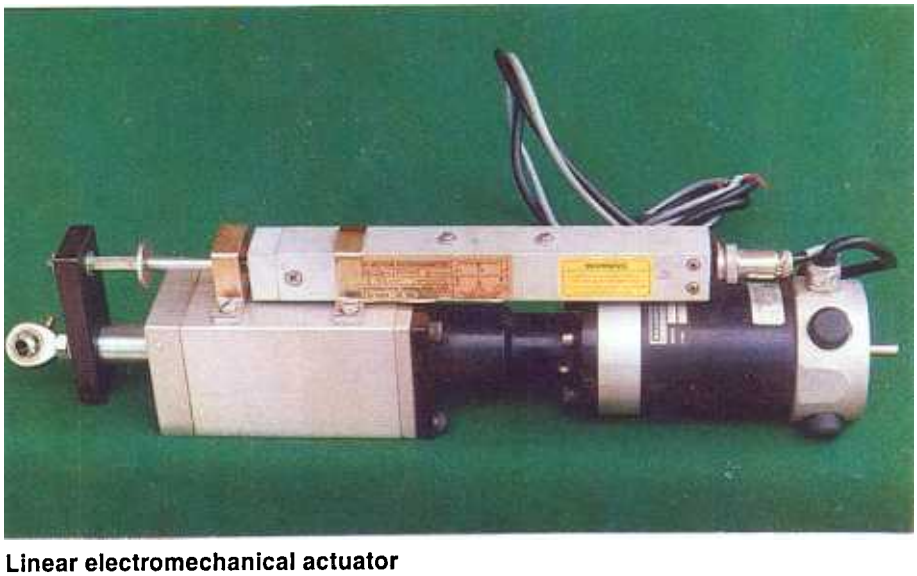

Linear electromechanical actuator

सत्यमेव जयते
डॉ. पी. रामा राव
अध्यक्ष
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I am happy to learn that a special issue of **Technology Focus** on Indigenous Electronic Components is being brought out on the occasion of the DRDO Directors Conference.

Materials and electronic components are among the vital inputs in the making of high technology systems. There has been significant progress in ensuring technological self-reliance in the materials area, especially products based on metallic alloys. The progress in the area of electric materials and electronic devices has generally not kept pace with the requirements. The DRDO recognised that they, as users must take this up on their own if rapid progress is to be made. It is thus that several initiatives have been taken by DRDO for indigenous development of electronic components, which deserve our praise.

This special issue, I hope, will prove to be a source of inspiration for sustained endeavours to make possible wholesome self-reliance in the field of critical electronic components.

P. Rama Rao

(P. Rama Rao)

Guest Editorial

Electronics plays a significant role in present day weapon systems. The development of strategic systems and sub-systems is critically dependent on the availability of electronic components. In DRDO, we have been taking steps towards indigenisation of several components and devices. The action was initiated in 1993 and presently we have a large number of electronic components, VLSIs and other devices which have been indigenised.

This issue of *Technology Focus* highlights some of the components which have been indigenised. Of the large list of components, we have selected a few which we hope will give flavour of the kind of strategic components which are now available through Indian sources. We hope this initiative will receive further encouragement and the activities will be expanded in the coming years. We believe this initiative is a significant contribution to the self-reliance initiative in DRDO.

J.P. Gupta & K. Neelakantan
Guest Editors

Electronic Components

Electronic components and devices are used in Defence systems like missiles, aircraft, tanks, or ships. Till recently, the requirement of most of these components was met from suppliers abroad.

DRDO has evolved a programme called Components and Devices, CODE to boost up DRDO efforts to achieve self-reliance in the development of critical components required in various systems of its ongoing projects. A large number of electronic components and devices have now been developed and productionised under this programme. Some of the important ones are highlighted here.

The CODE Programme has not only made the country self-reliant in electronic components but also has helped in saving precious foreign exchange and reducing components and systems cost.

Microwave Components

Microwave components have assumed great importance due to continuing stringent technical requirements to be met by present day and futuristic communication, radar and electronic warfare systems. Their development is an involved and lengthy process comprising CAD design, MIC fabrication, precision machining, assembly and bonding, testing and evaluation, and documentation. Some of these products developed and productionised under CODE programme are given here.

Frequency & Phase Correlators

Frequency and phase correlators (0.5 to 2.0 GHz & 2.0 to 8.0 GHz) are critical microwave components used in instantaneous frequency measuring receivers for electronic warfare systems. They are widely used and required in large quantities. DRDO has designed and developed these components and transferred the technology to CEL, Ghaziabad for production and use in military equipment.

Power Dividers

Power dividers are passive components that split input signal into two or more identical output signals. The device is reciprocal and can be used to coherently add/combine in phase multiple signals into one output signal. Symmetrical design and internal terminations provide high isolation with excellent amplitude and phase tracking of all outputs. These power dividers are built in octave as well as extreme wide bandwidths (even decades and greater). These power dividers find specific applications in airborne and shipborne electronic warfare systems, antenna feed networks (phased arrays), local oscillator distribution networks, multichannel receivers for coherent signal processing, matrix amplifiers, balance and image rejection mixers, external levelling, reference etc.

Frequency & Phase Correlators—Important Characteristics

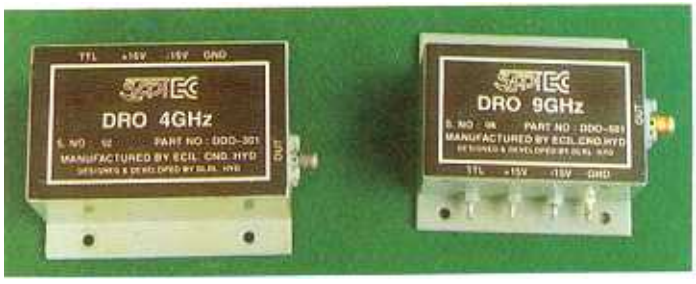
Parameters	*FC0520*	*FC2080*
Frequency coverage(GHz)	0.5 to 2.0	2.0 to 8.0
Deviation from best fit straight line (typ)	$\pm 15^{o}$	$\pm 15^{o}$
Input power range (dbm)	+8 to +12	+8 to +12

Power Dividers—Important Characteristics

	Power Divider	
Parameter	*Two Way*	*Four Way*
Model No	P2M-0618	P4M-1-0206
Frequency (GHz)	6.0 to 18.0	2.0 to 6.0
VSWR (max)	1.6:1	1.6:1
Isolation (min) (dB)	17	17
Insertion loss (max) (dB)	2	1
Amplitude IMBA. (dB)	± 0.4	± 0.5
Phase (deg)	± 5	± 4
Max input power (W)	4	4
Size (mm^3)	29x24x13	70x61x14

Two way and four way power dividers have been developed and productionised in the frequency ranges 2 to 6 GHz and 6 to 8 GHz under CODE Programme by FLIC Microwaves, Hyderabad.

Dielectric Resonator Oscillator



Dielectric Resonator Oscillator popularly known as DROs are highly stable, fixed frequency microwave signal sources which find extensive applications, such as local oscillators and BITE sources in many electronic warfare systems, and satellite, TV and digital communications. They offer inherent advantages like low phase noise, relatively high efficiency, compactness, low cost, size and compatibility with modern microwave integrated circuits.

Dielectric Resonator Oscillator— Important Characteristics

Frequency (fixed) (GHz)	4,9,14,16
Power output	+ 10 dB m into 50 ohms
Temp stability	10 PPM/^{o}C
DC power	± 12V,5V,100mA
Phase noise	- 95 dbc at 100 KHz
Output connnector	SMA (J)
Size	62x59x28 mm
Operating temp	- 20 to + 70 ^{o}C

The DROs clearly fill the gap between a free running oscillator and a synthesised source. These are being manufactured by ECIL, Kushaiguda, Hyderabad.

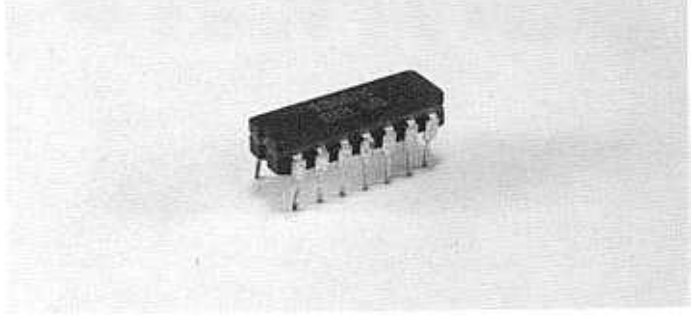
Diplexers

A Diplexer is a passive filter network capable of separating or combining two signals of different frequencies at a common port. A 2 to 18 GHz broad band diplexer has been designed and developed by FLIC Microwave, Hyderabad. It splits the input signal into two bands of 2 to 6 GHz and 6 to 18 GHz. These diplexers have been formed by connecting a high pass and a low pass filter in parallel. The structure used for realization of this diplexer is suspended substrate stripline which offers advantages of low insertion loss, sharp rejection characteristics and multioctave bandwidths.

Diplexers—Important Characteristics

Frequency range	2 to 18 GHz
Crossover frequency	6 GHz
Crossover frequency tolerance	± 0.5 %
Passband insertion loss	< 2.0 dB
Crossover region	± 4 %
VSWR	2 : 1 (max)
Temperature range	- 20 to + 70 ^{o}C

Mixer Pre-amplifier



Mixer Pre-Amplifier—Important Characteristics

Frequency	2.0 to 8.0 GHz
VSWR	2.5 : 1
LO-RF isolation	18 dB (min)
IF	160 MHz
IF bandwidth	± 30 MHz
Operating temperature	- 40 to +70 ^{o}C

Mixer pre-amplifiers are critical components used in the tuner chains of superhetrodyne receivers. Its function is to receive RF input in the frequency range of 2 to 8 GHz, local oscillator input in the frequency range of 2.16 to 8.16 GHz and generate amplified output centered around 160 MHz with a bandwidth of 60 MHz. Developed under CODE Programme by HAL, Hyderabad.

SP2T RF Switch 2 - 18 GHz

Switches are the most widely used microwave components and in many electronic warfare radar systems. They are primarily used to route signals between ports. Switches using PIN diodes as the control devices are most common because of fast switching, low loss and high isolation. In addition, they offer high reliability and high drive requirement.

These PIN switches work in multioctave bands and are available in different configurations. Manufactured by ECIL, Hyderabad.

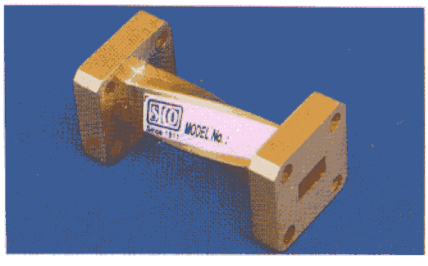
SP2T RF Switch 2 - 18 GHz— Important Characteristics

Frequency	2.0 to 18.0 GHz
Isolation	50 dB (min)
Insertion loss	3 dB (max)
VSWR (Port on)	2 : 1 (max)
Power handling	+ 13 dBm CW (max)
Driver	Integral TTL
Switching speed	200 ns
Operating temp	-20 to +70 °C

Millimeterwave Components

Millimeterwaves have many advantages over microwaves, such as broad bandwidths, higher spatial resolutions, probability of interception/interference, small antenna and equipment size. Their ability to penetrate clouds, smoke, dust and fog make them logical choice over IR and optical wavelengths for adverse weather conditions. Their uses span military, industrial, medical and scientific requirements. Most of these components have been developed by Scientific Instruments Company Ltd, Ghaziabad under CODE Programme. Some important ones are highlighted here.

Ka-Band & W-Band Waveguide 90° Twists



Waveguide twists are designed for any application which requires changes in waveguide orientation with minimum energy loss and reflections. Used as integral parts of many ferrite devices, these twists efficiently adapt polarization-rotated RF field to the orientation of the remaining transmission line components.

Ka-Band Directional Couplers

This is a four-pole waveguide junction used to provide an efficient, convenient means for sampling a finite quantity of power flowing in a transmission line or for injecting desired signals into the line. Because of high directivity characteristics, the power extracted by these devices is dependent only upon the coupling and the energy flow in one direction through the line. Conversely, the energy introduced through the coupling arm flows in the desired direction through the main waveguide. With this characteristic, directional couplers are excellent waveguide components for use in the measurement of signal source power and frequency. They also find applications in the diversion of control energy to drive microwave AFC loops, for insertion of local oscillator or marker signals and in any other test applications requiring a coupling function.

Millimeterwave Components—Important Characteristics

Component/device		*Parameters*				
	Frequency	*Frequency bandwidth (GHz)*	*VSWR*	*Coupling/ Attenuation (dB)*	*Insertion loss (dB)*	*Isolation (dB)*
Ka-Band Directional Coupler	Ka-band	26-40	1.15:1	3,10 & 20	1	> 20
Ka & W-Band E/H Plane Tuners	Ka-band	26-40	10:1 (max)	—	—	—
	W-band	75-110	10:1 (max)	—	—	—
Ka & W-Band Fixed Attenuators	Ka-band	26-40	1.15:1	3,6,10 & 20	—	—
	W-band	75-110	1.15:1	3,6,10 & 20	—	—
Ka-Band Orthomode Transducers	Ka-band	35 ± 3	1.25:1	—	< 0.5	30
Ka & W-Band Waveguide 90° Twists	Ka-band	26-40	1.05:1	—	< 0.2	—
	W-band	75-110	1.15:1	—	< 0.2	—

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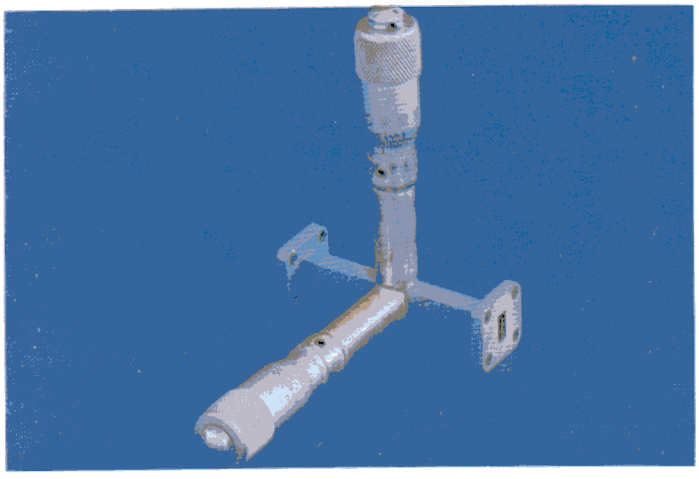
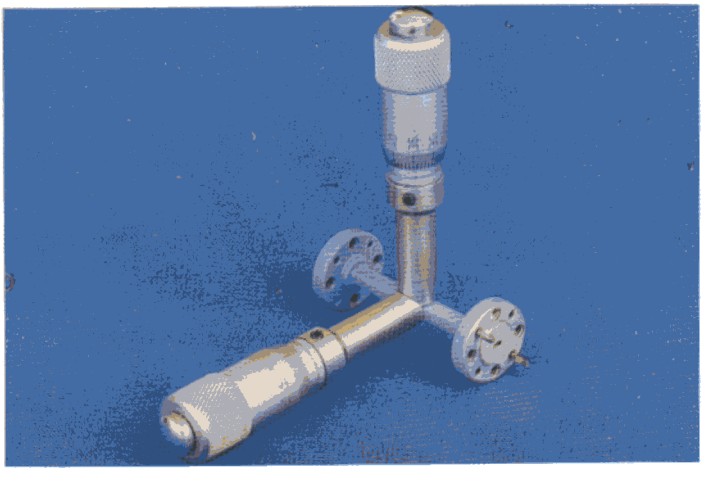
attenuators are used millimeterwav ontrolling the signal ower. These attenuators absorb
appli requiring the insertion curately know g waves with egligible reflection and are not
fixed uation in waveguide tr ssion lines fc icy sensitive in specified band

K W-Band lane ends

e and H-plane ons of waveg lide waveguide transm ies for te and developmental
ch are accurately b ed angle. T ese applications.
ds provide accurate s and d tional chang

K & W d Plane Tuner





These tuners are excellent millimeterwave impedance atching networks, designed to provide the reliable ismatch control required in most experimental and te applications. They introduce waveguide transmission line for simultaneous control of both phase and amplitude of the RF reflection coefficient. They can be used as peaking devices to optimise the output power of low level signal sources and as impedance matching devices to cancel reflections in transmission lines or to match the line to crystal mounts, Bolometer mounts, terminations and similar components. These tuners are hybrid wave guide Tee sections with precision micrometer-driven tunable shorts in both E-plane and H-plane arms.

Ka-Band Orthomode Transducers

Orthomode transducers act as duplexers in the communication systems. Transmitted signal goes through circular waveguide section to the transmitting antenna and nothing is coupled to the receiver. Received signal from the antenna is coupled to the receiver connected with rectangular section and no power is coupled to the transmitter.

Integration Components

Low ESR Aluminium Electrolytic Capacitors

These capacitors consist of two foils interleaved with a high quality absorbent paper and wound tightly into a cylinder. Contacts are made by riveted tabs of aluminium and attached to the foils. This winding is then impregnated with a specialised electrolyte and housed in high purity aluminium containers. These capacitors are used in power supply filters and other high energy applications where high capacitance, high ripple current capability and excellent load life are required. Solid screw terminals and all welded construction are employed to ensure reliable contact, better thermal characteristics and enhanced service life. Developed under CODE Programme by ELNET, Hosur (Tamilnadu).

Low ESR Aluminium Electrolytic Capacitors—Important Characteristics

Capacitance value	470 µF	1000 µF
Capacitance tolerance (%)	- 10 ± 30	- 10 ± 30
Voltage rating (VDC)	400	400
ESR (milli ohms)	87	42
Ripple current at 85 °C at 100 Hz	3	5.3
Stability after life test of 2000 h at 85 °C (%)	± 15	± 15
Operating temp (°C)	- 40 to 85	- 40 to 85

RF Co-axial Cables

PTFE dielectric flexible RF co-axial cables are ideal for use in RF and microwave communication, electronic warfare and radar systems, mainly because of their features combining high performance with reliability and light weight. The indigenously-developed PTFE dielectric RF cables RG-303 and RG-142 meet the technical requirements of MIL–data sheet Mil-C-17/11C.

RF Co-axial Cables—Important Characteristics

Parameter	*RG-303*	*RG-142*
Characteristic impedance (ohms)	50 ± 2	50 ± 2
Operating frequency (GHz)	3	8
Operating temp range (°C)	- 55 to 200	- 55 to 200
Continuous working voltage (V)	1400	1400
Attenuation (db/100 ft)	50 MHz:2.7 3 GHz:28.0	50 MHz:4.0 8 GHz:66.0
Capacitance (pF/ft)	32	29.3

RF Co-axial Cable RG-400

Flexible cables, developed under CODE Programme by the FLU-TEF Industries, Ahmedabad, are the simplest, most versatile and popular means for transmission of RF and microwave energy. The latest MIL version M17/128-RG-400 has continuous swept, maximum VSWR and attenuation requirement from 50 MHz to 12.4 GHz. The use of fluoropolymer (Teflon) insulation materials for dielectric core and jacket construction has resulted in optimisation of size, improved electrical performance and wider operating temperature range.

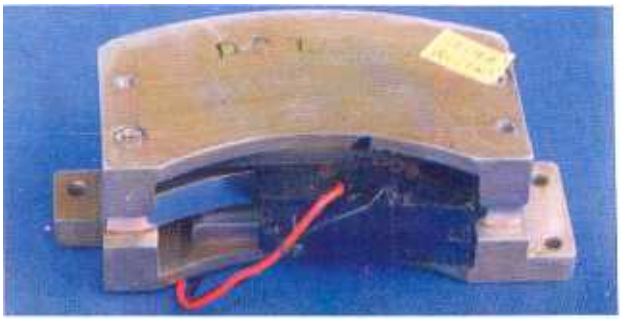
RF Co-axial Cable RG-400—Important Characteristics

Characteristic impedance	50 ± 2 ohms
Operating frequency	12.4 GHz (max)
Operating temp range (°C)	- 55 to + 200
Continuous working voltage	1400 mV rms (max)
Attenuation (dB/ft)	3.2 dB 15.0 MHz 90 dB 12.4 GHz
Capacitance	32 pf/ft

Special Components

A large number of special components have been productionised for the Integrated Guided Missile Development Programme of DRDO, particularly for the guided weapons and gun control systems of the ongoing DRDO projects.

Segmented DC Torque Motor



This is a limited angle torquer with a specified limit of 10^{o}. It is a single moving coil over an iron yoke suspended between two similar poles (samarium cobalt magnets). These motors are used for gun sight calibration, night vision devices, trigger mechanism and small compact electromechanical devices. Developed by Delta Motor Company, Secunderabad.

Segmented DC Torque Motor— Important Characteristics	
Resistance	5.0 ± 12.5 %
Voltage	20 V
Current	2.25 A
Torque sensitivity	30 ± 10 % oz-in/amp
Back emf constant	0.346 ± 10 % V/rad/s
Inductance	5.25 ± 30 % mh
Peak torque	110 oz-in
Continuous stall torque	90 oz-in
Actuator constant	21.5 oz-in/watt
Ele. time constant	0.15 ms
Stroke	± 10^{o}

Integrated Power Unit for Actuators

This is a critical aerospace hydraulic unit developed by Pantex Gee Bee Fluid Power Ltd, Hyderabad, for driving the electrohydraulic actuators. It consists of a 'Bootstrap Reservoir' made of aluminium and a manifold on the reservoir. This manifold consists of cartridge type pressure relief valves (both high and low pressure), non-return valve and filters (both high and low pressure). This unit has provisions for indication of oil level inside the reservoir and removal of trapped air inside through a bleed valve. It is packaged in an integrated fashion, reducing the space requirement, pressure losses and also the chances of leakage as compared to the distributed power unit being used earlier. It is a light weight unit capable of withstanding environmental conditions like vibration, shock, temperature, altitude etc., that are required for aerospace applications.

Integrated Power Unit for Actuators—Important Characteristics	
Medium	Hydraulic oil MIL-H-5606E
Oil capacity	2.0 lit
System pressure	210 bar
Reservoir pressure	3.5 bar
Filtration	3 micron abs (pressure)
Rating	10 micron abs (return)

Servo Valve

Servo Valve—Important Characteristics	
Rated current	10 mA
Flow gain	1.2 ± 10 %
Flow rate	12 ± 10 % lpm
Null bias	< 0.3 mA
Hysterisis	< 0.3 mA
Pressure gain	> 4000 psi/mA
Nonlinearity	< 10 %

Servo valve (flow control valve) plays a major role in electrohydraulic actuation system. It consists of a torque motor stage and a hydraulic amplifier stage. Output flow rate is proportional to the input current. Servo valves are used in accurate position machine tool element, accurate position gun turrets and steering the aerospace vehicle systems. These are developed under CODE Programme by Jadavpur University, Calcutta.

AC-AC LVDT Coil

This is a sensitive AC device used for measuring minute mechanical displacements. It consists of low voltage displacement transducer (LVDT) coil comprising one primary and two secondaries, wound on an acrylic bobbin. A ferromagnetic core moves inside the coil which is housed in an aluminium cover. The output is proportional to the displacement. These LVDTs require very low force and have high resolution and sensitivity over very small displacements. Developed under CODE Programme by Spanktronics, Bangalore.

AC-AC LVDT Coil—Important Characteristics

Mechanical stroke length	45, 50 & 60 mm
Linearity	± 0.25 % of FSD
Sensitivity	> 10 mV/mm/V
Input voltage	1 V rms at 4 KSC
Vibration tolerance	20 g up to 2 KHz
Operating temp	0 °C to 80 °C

Linear Electromechanical Actuator

Electromechanical actuation system is the state-of-the-art technology. An electrical motor with samarium cobalt magnets (brushed) drive the ball screw mechanism, which converts the rotory motion to the linear motion. The ball screw mechanism is connected to the controlled elements through a set of linkage mechanisms. These actuators are used in flight control system of aerospace vehicles. Developed under CODE Programme by HMP Engineers Ltd., Aurangabad.

Linear Electromechanical Actuator—Important Characteristics

Peak thrust:	150 kgf (1472 N)/ 450 kgf (4415 N)
Stroke	± 25 (total 50 mm)
Back lash	10 µm
Supply voltage	± 26.33 VDC (or 60 V across)
Short-term rated operation point	0.64 Nm 4700 rpm
Maximum current	20 A
Bandwidth (max)	35 Hz to 3 dB at rated load
Ball screw lead	4 mm
Ball screw diameter	12 mm

PLUG INTO FOCUS

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http://www.nic.in/mmapd/doc/welcome.html

Applications Specific Integrated Circuits

The current trend in electronics systems is towards systems that are more complex, faster and smaller than those available in earlier generations. This has become feasible due to the availability of custom components or Applications Specific Integrated Circuits (ASICs). DRDO has been gearing up to meet the challenges posed by this shift in the design philosophy with the creation of a CORE Group for VLSI Design in 1993. Several ASICs as well as generic chips have been developed to meet the requirements of various DRDO projects and programmes. Some of the devices developed are described here. Though many of these devices have been developed for specific projects, they are generic enough to be used in other applications.

Pythagora's Processor

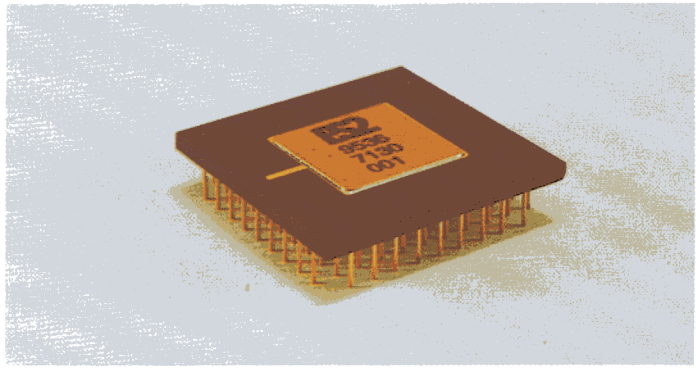
This ASIC converts cartesian coordinates to polar coordinates. The chip accepts 16-bit real (x) and 16-bit imaginary (y) inputs. The inputs can be given in 2's complement or sign magnitude formats. The polar coordinates are computed using the CORDIC algorithm, with 24 stages of pipelining. The CORDIC algorithm is implemented using adders/subtractors and a multiplier. The magnitude output can be scaled in amplitude by factors of 2, 4 or 8.

Features

- 16-bit real and imaginary inputs
- 16-bit magnitude output and 12-bit phase output
- 20 MHz operation

The Pythagora's Processor can compute the magnitude and phase of the vector. This operation finds a variety of applications in digital signal processing. One such application is in digital moving target indicator (MTI).

Frequency Synthesizer



This chip was designed to meet the requirements of SONAR systems. The device works on the principle of direct digital synthesis. It takes the user set values of frequency and phase as inputs. These inputs are given as digital code words and the output is obtained as digital values for sine/cosine waveforms. The user must connect a digital-to-analog converter (DAC) externally to obtain an analog output.

Specifications	
Frequency resolution	0.024 Hz
Operating frequency	25 MHz
Max output frequency	48.8 KHz (8 samples @ 25 MHz)
No. of channels	Programmable from 3 to 64
External interface	8 bits

ANUCO

ANUCO is a floating point arithmetic coprocessor. It supports floating point addition, subtraction, multiplication, division and format conversions. It is a memory-mapped peripheral and can be used with any general purpose microprocessor to obtain enhanced floating point performance. The device supports only the basic arithmetic operations. Other functions such as transcendental functions, trignometric functions etc. are supported through a run-time library. ANUCO has been designed to implement all the arithmetic functions in hardware. The chip has an instruction repertoire of 46 instructions. These include data movement, format conversions, arithmetic operations etc. The design uses a pipelined architecture to provide floating point addition and floating point multiplication.

ANUCO has been successfully interfaced with MC68030, i80386 and i80286 based systems. The device is three to ten times faster than the standard floating point processors available commercially for these processors.

Applications Specific Integrated Circuits—Chip Details

ASIC Chip	*Parameters*			
	Die size (sq mm)	*Complexity (gates)*	*Package (pin CPGA)*	*Technology*
Pythagora's Processor	72	18000	84	1 micron std cell
Frquency Synthesizer	32	10000	68	1 micron std cell
ANUCO	196	43000	208	0.8 micron Gate Array
MMAC	92	20000	144	1 micron std cell
FMAC	36	12000	120	1 micron std cell
Inverse Pythagora's Processor	78	28000	84	1 micron std cell
CMUL	68	18000	140	1 micron std cell
ANUSIG	140	45000	120	1 micron std cell

Specifications

Formats	32 and 64 bit
No of registers	32 registers of 32 bits
Standard	Conforms to IEEE 754
Clock frequency	33 MHz
Linpack performance	0.75 MFLOPS

Features

- General purpose bus interface
- Provides 32 general purpose single precision registers or 16 double precision registers
- 31-bit control and status registers
- 64-bit internal architecture

MMAC

MMAC is a multichannel multiplier accumulator designed for signal processing applications. It can be programmed for functions like (i) multichannel multiply accumulation/subtraction up to 48 bits, (ii) first order and second order infinite impulse response filters, and higher order filters by cascading through internal feedback path.

Features

- Operating frequency 20 MHz
- Supports up to 132 channels (user programmable)
- Selectable 16-bit 2's complement or unsigned magnitude inputs
- Standard TTL (transistor-transistor logic) compatible inputs and outputs
- User-selectable mode of operation
- Optional saturation, scaling and rounding facility for output

Regd with RNI, No. 55787/93

Since the MMAC ASIC supports multichannel operations, it can be used in array signal processing applications, either in front-end filter circuit or in back-end signal processor circuit.

FMAC

FMAC (Fast Multiplier & Accumulator Circuit) is a generic chip useful for many digital signal processing applications. It is basically a multiplier and an accumulator.

Features

- It accepts unsigned/2's complement inputs
- Operates in three modes, namely, multiply and accumulate, multiply, multiply and subtract
- Internally synchronous reset
- 5-stage pipelined architecture

Specifications	
Inputs	16-bit
Accumulated output	36-bit
Clock rate	50 MHz
Independent enables for outputs	
Separate clocks for inputs	

Inverse Pythagora's Processor

This ASIC converts polar coordinates to cartesian coordinates. The chip accepts 16-bit magnitude and 16-bit phase inputs. The inputs can be given in 2's complement or sign magnitude formats. The coordina conversion is done using the CORDIC algorithm. The algorithm is implemented with 26 stages of pipelining.

Specifications
Sine/cosine look up mode
16-bit real and imaginary outputs
20 MHz operating frequency

CMUL

CMUL (Complex Multiplier) basically multiplies two complex numbers and gives the complex product as output. It operates in two modes. In complex multiplier mode, it multiplies two complex words (16-bit each) every 50 nanoseconds. In the filter mode, it adds 16 most significant bits of the multiplier result with input complex word.

Specifications
2's complement fractional arithmetic
Trap logic for -1 into -1
Complex conjuction of either inputs
20 MHz clock rate
Four cycle fall through

ANUSIG

ANUSIG (ANURAG's Digital Signal Processor) is a general purpose digital signal processor.

- Modified Harvard architecture
- 16-bit integer and fixed point data format representation
- 16K address space (program, data)
- 40-bit accumulator width
- Multifunction instructions
- Four external interrupts
- 12 MHz operating frequency

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