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DESIGN AND DEVELOPMENT OF ANTENNA PLATFORM FOR LCA MULTI-MODE RADAR

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Project Perspective

Multi-Mode Radar (MMR) is a vital weapon component of a fighter aircraft such as India's Light Combat Aircraft (LCA) TEJAS. It is a versatile instrument supporting various modes such as target search, track-while-scan, single target track and multiple target track. The Antenna PLatform (APL) is an electromechanical subsystem of the MMR with a two axis gimbal mechanism and position servo with Mil-Std-1553B interface to the Radar Processor (RP). APL positions the flat plate antenna so as to point the RF beam in the desired direction.

Indigenous development of APL for LCA-MMR was taken up by BARC & ECIL in the year 1999, for Aeronautical Development Agency, Bangalore. Control Instrumentation Division, BARC took up the responsibility for the design and development of control electronics hardware and software. The design and development of all mechanical hardware including the pedestal and gimbal box, procurement and project management functions were handled by ECIL.

APL Functions

The primary function of the APL is to support scan mode of operation of the LCA MMR by accurately positioning the flat-plate antenna at the commanded angles. The 650mm diameter antenna is fixed on the elevation arms of two-axis steering mechanism with $\pm 60^\circ$ coverage in inner elevation and $\pm 70^\circ$ coverage in outer azimuth. The antenna, which is a large, compliant, unbalanced load is stabilized against aircraft body rates (pitch, roll and yaw) using knowledge of aircraft's instantaneous attitude as measured by aircraft INS. The high bandwidth position servo holds the antenna rigidly in the presence of torque disturbances due to varying linear acceleration (g) and vibrations of the aircraft.

APL is made up of three sub-assemblies- flat-plate antenna, gimbal box and pedestal. The gimbal box and pedestal are investment-cast, precision-machined Aluminium structures. The gimbal box houses two-axis steering mechanisms along with gears, bearings, motors, resolvers, rotary joint, cable-wrap, wires, cables and connectors. The pedestal houses card-cage, line filter and associated wiring. All the control electronics are packaged into three cassettes and housed in the card-cage with vents for forced-air cooling.

The gimbal position is measured by a pair of precision resolvers. Each axis is driven by a pair of geared brush-less servo motors. The two motors of each axis are arranged in counter-torque mode for eliminating the effect of gear back-lash. Each of the four motors is driven by four-quadrant PWM torque amplifier which employs vector control technique. These motor controllers are realized on ADMC 401 DSPs. The current command to the motor controller originates from the SHARC DSP-based servo controller which communicates with the Radar Processor via Mil-STD-1553B bus and implements position and rate loops for both axes. The DSP software also supports configuration, testing, tuning, diagnostics and trouble-shooting functions. A PC-based tester station is developed by BARC to facilitate factory testing and tuning.

Table 1: Salient system parameters of APL

Antenna Weight	5.125 Kg
Antenna Diameter	650 mm
Antenna Inertia	0.12 KgM^2
Antenna Stiffness	8700 NM/Rad (min)
Power Supply	115/200V, 400 Hz, 3 Ph, (Mil-STD704D)
APL Weight	< 20 Kg
Interface to RP	Mil-STD-1553B
RP Ref. Frame	NED
EMC	MIL-STD-461C
Acceleration (Functional)	Fore : 2.02g Aft: 7.27g Left: 3.62g Right: 3.62g Up: 8.4g Down : 3.9g
Acceleration (Structural)	1.5 X Acceleration (Functional)
Random Vibration – Flight envelope	PSD of 0.02 g2/Hz from 15 Hz to 1000 Hz and falling off at the rate of 6 db/ Octave from 1000-2000 Hz

Table 2: Salient performance specifications

Angle Coverage	±70 °(AZ); ±60°(EL)
Scan rate	5-7 (AZ), 3.5-5 (EL) (Rad/sec)
Acceleration	75-125 (Rad/sec)
Servo turn around time	< 40 msec
Error while scanning (1σ)	< 1 mRad@ 1 Rad/sec
Linear acc. disturbance rejection	<0.1 mRad/m/sec^2 (0-4 Rad/sec) <0.5 mRad/m/sec^2 (> 4 Rad/sec)
Position measurement resolution	0.1 mRad
Position loop bandwidth	> 10 Hz
Body rates	60°/sec (Yaw), 20°& 80°/sec (Pitch), 85°& 120°/sec (Roll)

System context

Fig.1 shows the APL system context. The APL shares mechanical mounting interfaces with the aircraft bulk-head on one side and the antenna on the other. APL interfaces to RP using dual media 1553B bus, over which it receives commands from RP and transmits measured data and other responses. APL can also be interfaced to a test PC in place of RP using the same 1553B interface. APL's command interface with test PC is a superset of RP command set.

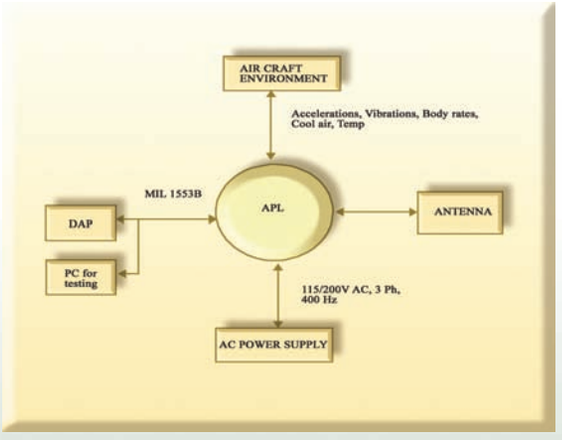


Fig. 1: APL system context

The aircraft environment of body rates, accelerations and vibrations impact the APL design and performance. APL is cooled by forced air supplied by aircraft. The power supply to APL is interlocked with air-flow. APL provides mounting and routing support for the RF cables and wave-guides leading to the antenna.

APL receives Mil-Std-704D compliant 3 phase AC power from the aircraft.

Design Features

Fig. 2 shows an assembled APL with antenna, gimbal box and pedestal. The pedestal houses the card cage with control electronics cassettes.

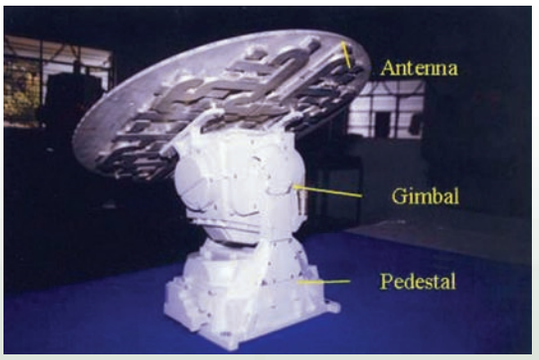


Fig. 2: APL assembly view

The control electronics is made up of three cassettes, (a) DSP-based controller cassette (APLCON) (b) Motor power amplifier cassette (APLAMP) and (c) power supply cassette (APLPS). The cassettes plug in to a mother board fixed to the bottom of the card cage (Fig. 3). All external connections are brought out on two connectors on the card cage which plug in to mating connectors on the pedestal.

All the four geared motors are housed in the gimbal box and are cooled by the cool air supply delivered by the aircraft. Two motors of each axis are coupled to the corresponding sector gears which drive the gimbals. Gimbal box also house two precision resolvers which measure the respective gimbal position to 16 bit resolution. As the gimbals rotate, the wires passing from the gimbal box to card cage (motors and resolver signals) are required to wrap and unwrap. All these signals are carried through a custom-designed, multi-conductor cable harness.

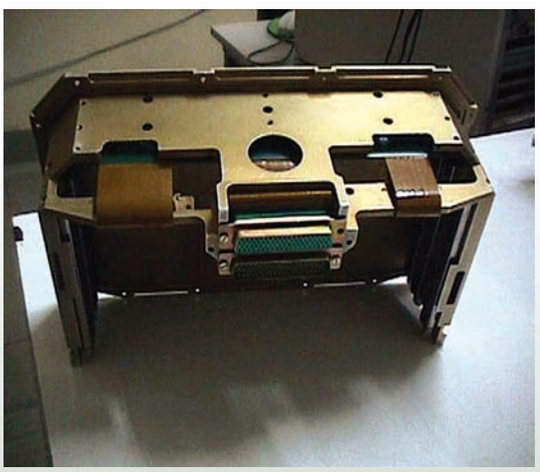


Fig. 3: APL card cage

The transmitter power is coupled to the antenna using two-axis rotary joint.

The 3 phase AC line filter circuit is encapsulated in a machined Al box. It filters common mode and normal mode conducted noise passing between air-craft power lines and APL. The signal interface with the aircraft side include the 4 wire AC power leads and APL_PROTECTED_FAULT – all extended through a 38999 connector (Fig. 4).

APL control electronics is galvanically isolated from the aircraft's AC power source. The motor amplifier is in turn isolated from the APL logic supply.

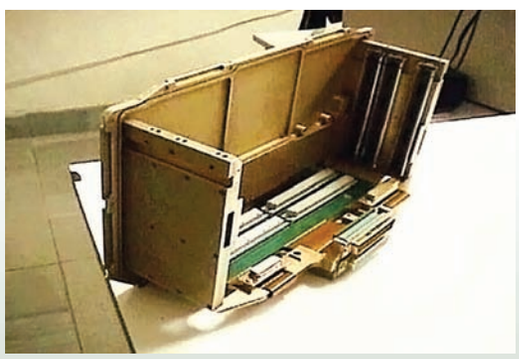


Fig. 4: APL card cage with motherboard

Drive System Design

The drive system (Fig. 5) consisting of motors, gear train and amplifiers are designed to meet the torque, speed, acceleration and power requirements. The average and peak loads have impact on the thermal design. The drive

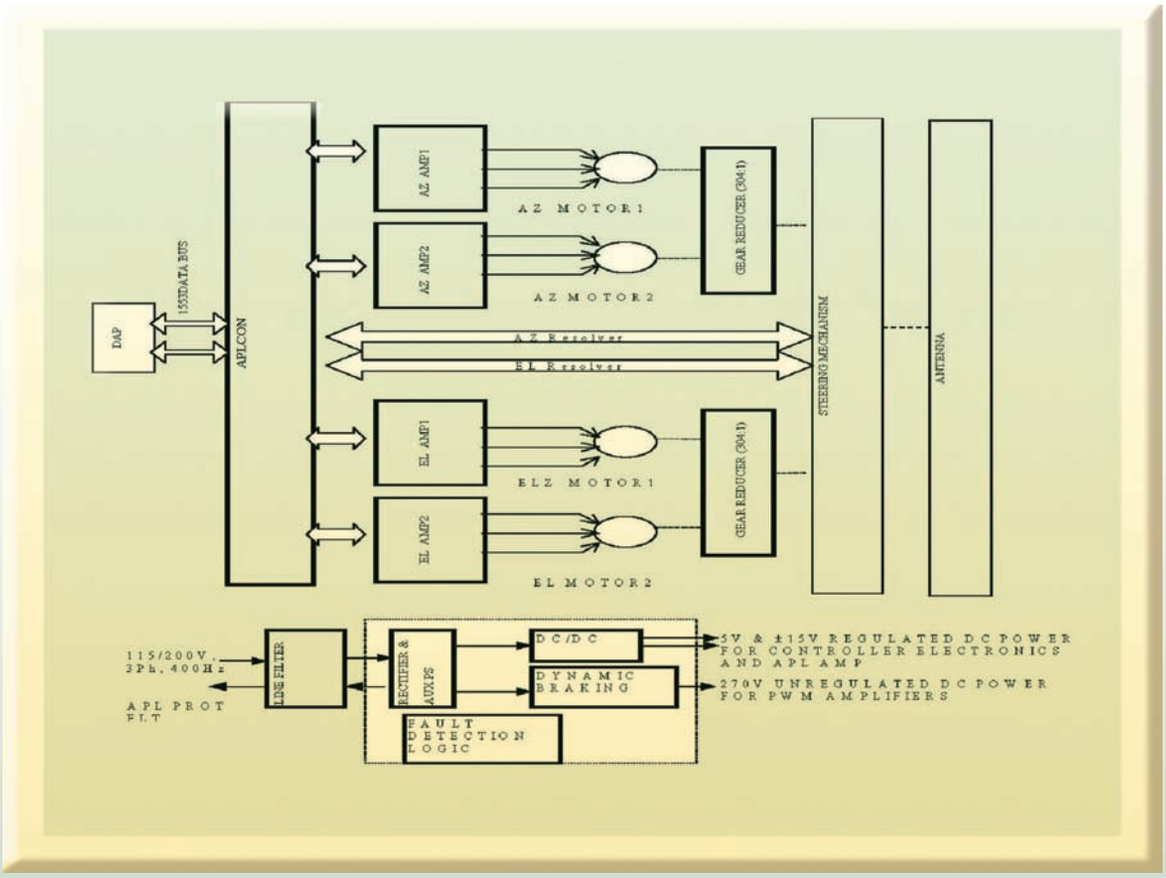


Fig. 5: APL hardware block diagram

system is designed to meet the intermittent high torque demands during aircraft 'g' accelerations and at antenna turn-around where quick accelerations are required.

The drive motors are low-inertia, high-speed, high-torque geared motors with sinusoidal back EMF and resolver position sensors. The speed reduction is obtained in two stages: the gear box integral to the motor provides a reduction ratio of 1:50 and sector gear provides a further speed reduction of 6 to provide an overall ratio of 300.

APL CON

APL CON (Fig. 6) is a single board computer, based on SHARC 21062 DSP and houses all the circuitry for interfacing with resolvers, Mil-std-1553B bus, power supply and motor amplifiers. The code and non-volatile parameters reside on onboard FLASH memory. The circuits comprise of CPLD logic, two 16 bit RDC, 2500 Hz oscillator for resolver excitation, quad DAC and dual media 1553 remote terminal interface. APLCON hosts the main ACS software which implements 1553 command processing, stabilization and servo loop control functions.

APL AMP

APL AMP is a two PCB cassette and force-air cooled. The main board (APLAMP-DSP) (Fig. 7) contains the motor control DSPs and low voltage circuitry. The power board (APLAMP-PM) (Fig. 8) contains the 3 phase PWM inverters for the four drives. The DSP performs torque

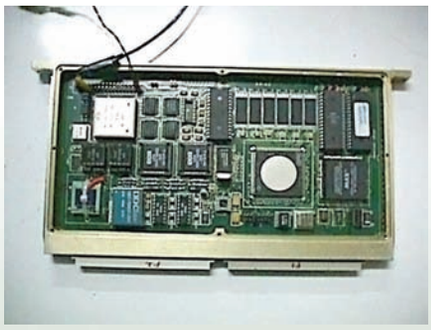


Fig. 6: APL CON

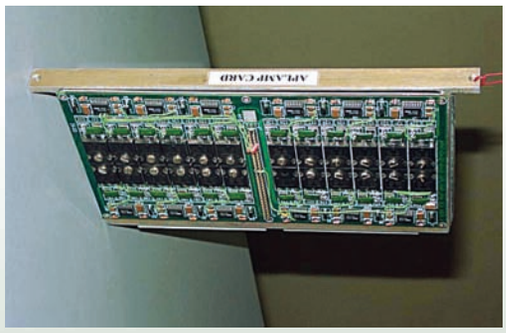


Fig. 8: APLAMP - POWER

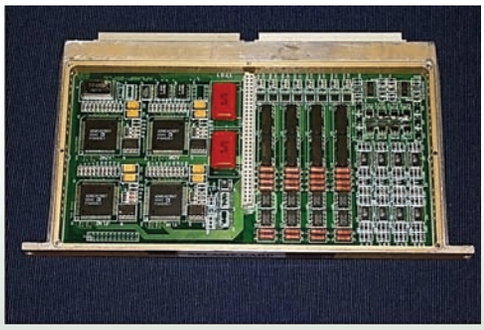


Fig. 7: APL AMP - DSP

loop control, vector control and PWM control of the 3 phase MOSFET inverter powering the motors. APLAMP delivers > 1200 W of peak power. The APLCON-APLAMP interface consists of isolated high-speed serial link through which it receives current demand and transmits amplifier status. 270V unregulated DC power for the inverters and isolated 5V and ±15V logic supply are extended from APLPS module (Fig. 9).

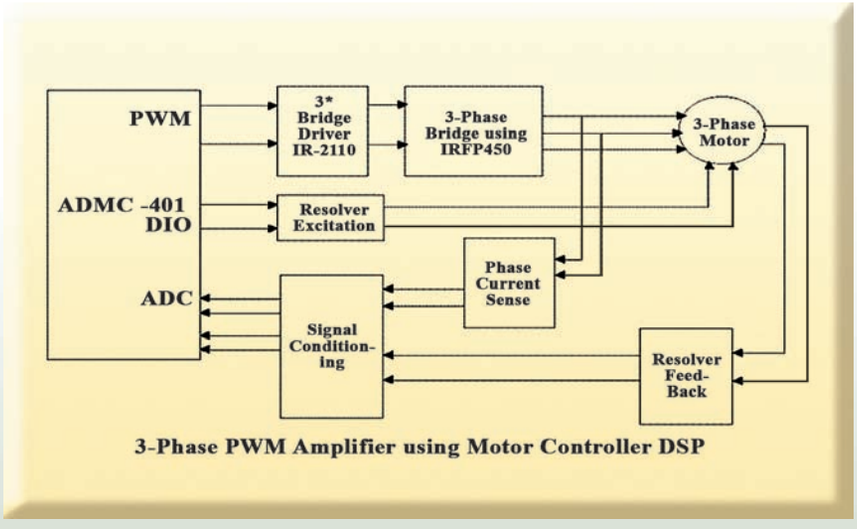


Fig. 9: Motor amplifier – one channel

Features

- Includes all hardware resources required for torque control, vector control and PWM inverter control for four of 3-phase, 4-pole PMAC motors (300W, 270V, 22000 RPM) with resolver rotor position sensors.
- Four quadrant operation.
- Based on four Analog Devices Motor controller DSP ADMC-401.
- Generates 10KHz / 6V(peak) resolver excitation for motor mounted resolvers. Signal conditioning and A/D interface for measuring rotor position using Sin and Cos outputs.
- Measurement of current in 2 phases of each motor, after pre-amplification and isolation.
- DC link voltage measurement for DC link compensation.
- Measurement of DC link current.
- Protection from over-current by forcing PWM trip and bridge shutdown.
- Temperature monitoring for safe shutdown.
- Interface to APL CON through isolated high-speed serial link.
- Receive Current/Torque demand from APL CON and return the measured current and motor speed with amplifier status.
- Generation of ±15V isolated floating power supply for motor phase current measurement and ±5V analog supply for signal conditioning.

APL Power Supply (APLPS)

The primary function of the APLPS (Fig. 10) is to rectify the incoming AC power and provide DC power to the APL CON and APL AMP units. The input power to the APLPS is MIL-STD-704D compliant, 115V, 3 phase power at 400Hz.

APLPS is a two PCB cassette and is force-air cooled. It houses all the circuitry for generating LV and HV DC power supply for APL CON and APL AMP cassettes. 270V of unregulated DC voltage is produced by full-wave rectification of the 115V, 3 ph, 400 Hz input. Onboard DC/DC converters (Fig. 11) generate two sets of isolated 5V and ±15V DC voltages : one set for APLCON and the other for APL AMP. Other circuits include soft start control, dynamic braking resistors and control logic, power supply fault monitoring logic, remote shutdown and reset logic.

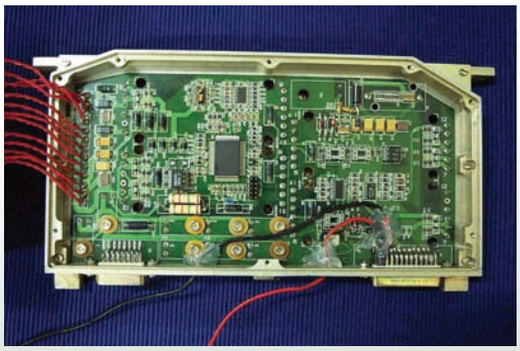


Fig. 10: Power supply control module

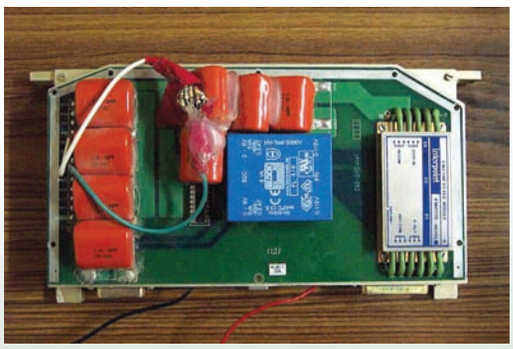


Fig. 11: DC/DC Converters

A separate 12VDC auxiliary supply, powers monitoring and fault detection circuits. APLPS extends an open collector output as APL_PROTECTED_FAULT signal to the aircraft via the line filter.

Control functions

Control Objectives

The accuracy and speed with which APL positions the antenna as commanded by RP, impinges on the MMR performance. The position servo is designed to meet the following control objectives :

The above objectives are quantified by various performance specifications. The achievable performance is constrained by the inertia, compliance of the mechanical elements, physical limits of the devices (current, torque, voltage, thermal) and drive friction.

Control Objective	Why	Related Servo Parameters
Fast and accurate command response	To minimize scanning errors, maximize usable scan volume	Turn-around time, rise-time, overshoot, settling time, bandwidth, Type 2 servo, Ka
High disturbance rejection	To hold antenna rigidly under aircraft 'g' forces and vibrations. Reject body rates (pitch, roll, yaw)	High bandwidth High loop gain
Stable and robust	To accommodate measurement lags, ageing, component replacement	Stability margins
Good noise rejection	Sensor noise, quantization noise	Bandwidth

Controller design

The controller (Fig. 12) for each axis is designed as linear cascade compensators with inner torque loops, intermediate rate loop and outer position loop.

Fig. 12 shows the main functional block diagram of APL, emphasizing its role as a feedback control system.

The input demand angles to the position loop is set by RP via radar bus. The commanded AZ/EL angles are transformed from the navigation frame (NED) frame to scanner frame (s-frame) using instantaneous body attitudes (yaw, pitch, roll angles of the aircraft) and offset between body frame and scanner frame. The position loop attempts to nullify the position error i.e. the difference between the command angle and measured gimbal (resolver) angle. The position controller is tuned to optimize the servo performance such as rise time, settling time, turn-around time, bandwidth etc.

The output of position loop is input to the inner rate loop which in turn encloses the two motor torque loops. The two motor currents are offset by 5-10% of rated current, so as to work in counter torque mode and cancel servo oscillations due to backlash. The current loop, sets (Fig. 13) the output voltage of the PWM inverters, which drive the 3 phase PMAC motor.

Periodically (200 Hz) APL measures the antenna positions, corrects these for radome aberrations, transforms these gimbal angles in to NED frame and then transmits them to RP on demand.

Current loop

Two current controllers for each motor regulate the direct (Id) and quadrature (Iq) currents through the motor.

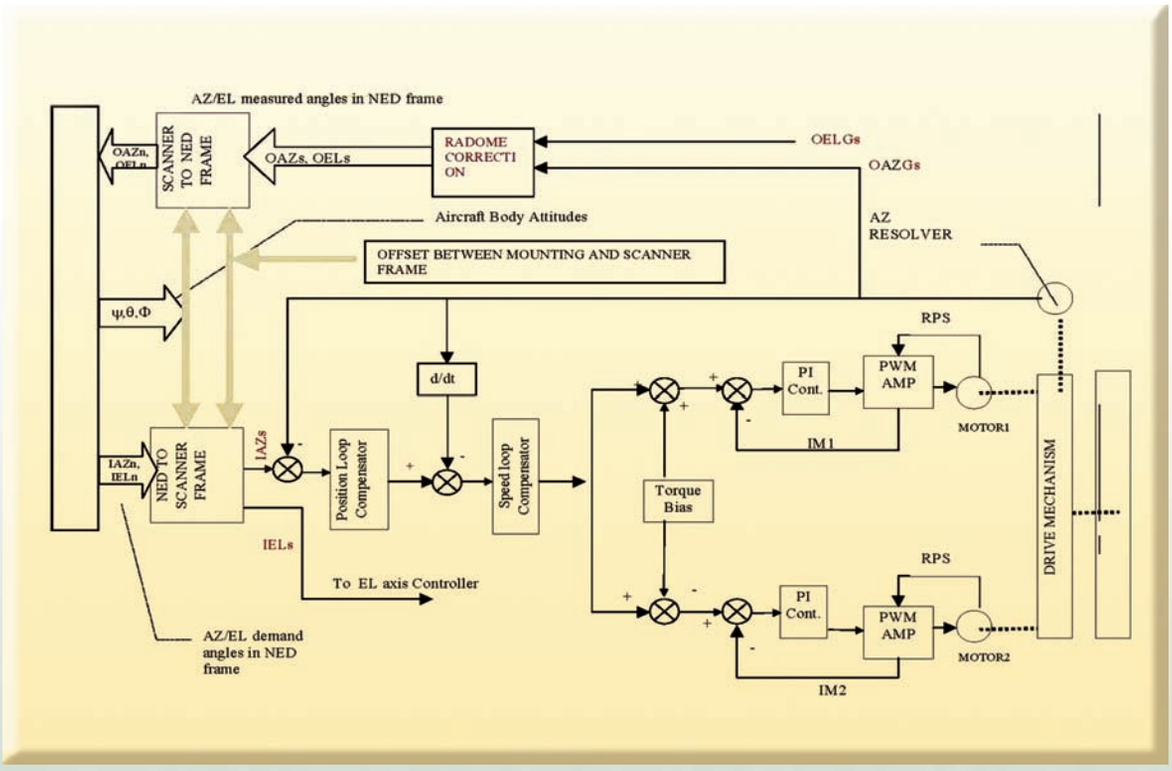


Fig. 12: Control loops

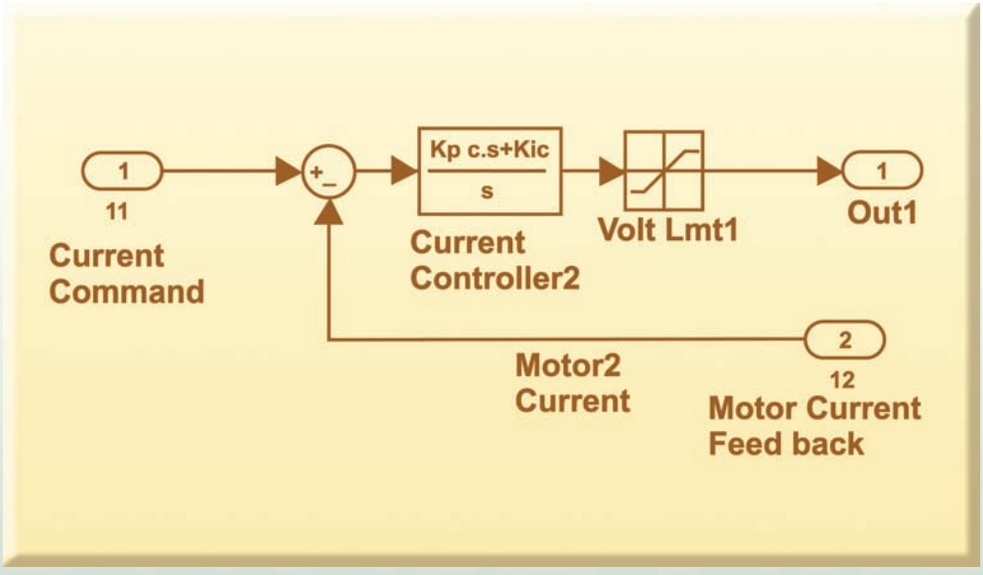


Fig. 13: Current loop

Each is a high bandwidth PI controller. The Iq current demand is set by the outer rate loop where as Id current demand is set to zero. These controllers are realized in ADMC 401 DSP firmware with 20 KHz update rate.

Vector Control of AC Servo Motors

Fig. 14 shows the vector control scheme for computing the instantaneous 3-phase winding voltages for the permanent magnet synchronous motors. The motors selected for APL are 3-phase, 4 pole permanent magnet synchronous motors with near sinusoidal back-EMF profile and resolver as rotor position sensor. These are low inertia, high torque, high speed motors and specified for operation with winding temperatures up to 225°C.

Two of the motor phase currents (I_{as}, I_{bs}) are sampled using a simultaneous sampling ADC. The third phase current can then be computed for a balanced 3-phase system.

$$I_{as} + I_{bs} + I_{cs} = 0 .$$

Then using forward CLARKE transformation, 3-phase currents are transformed into 2-phase currents.

$$\begin{bmatrix} i_{s\alpha}(t) \\ i_{s\beta}(t) \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & \cos(\gamma) & \cos(2\gamma) \\ 0 & \cos(\gamma) & \cos(2\gamma) \end{bmatrix}\begin{bmatrix} i_{sA}(t) \\ i_{sB}(t) \\ i_{sC}(t) \end{bmatrix},$$

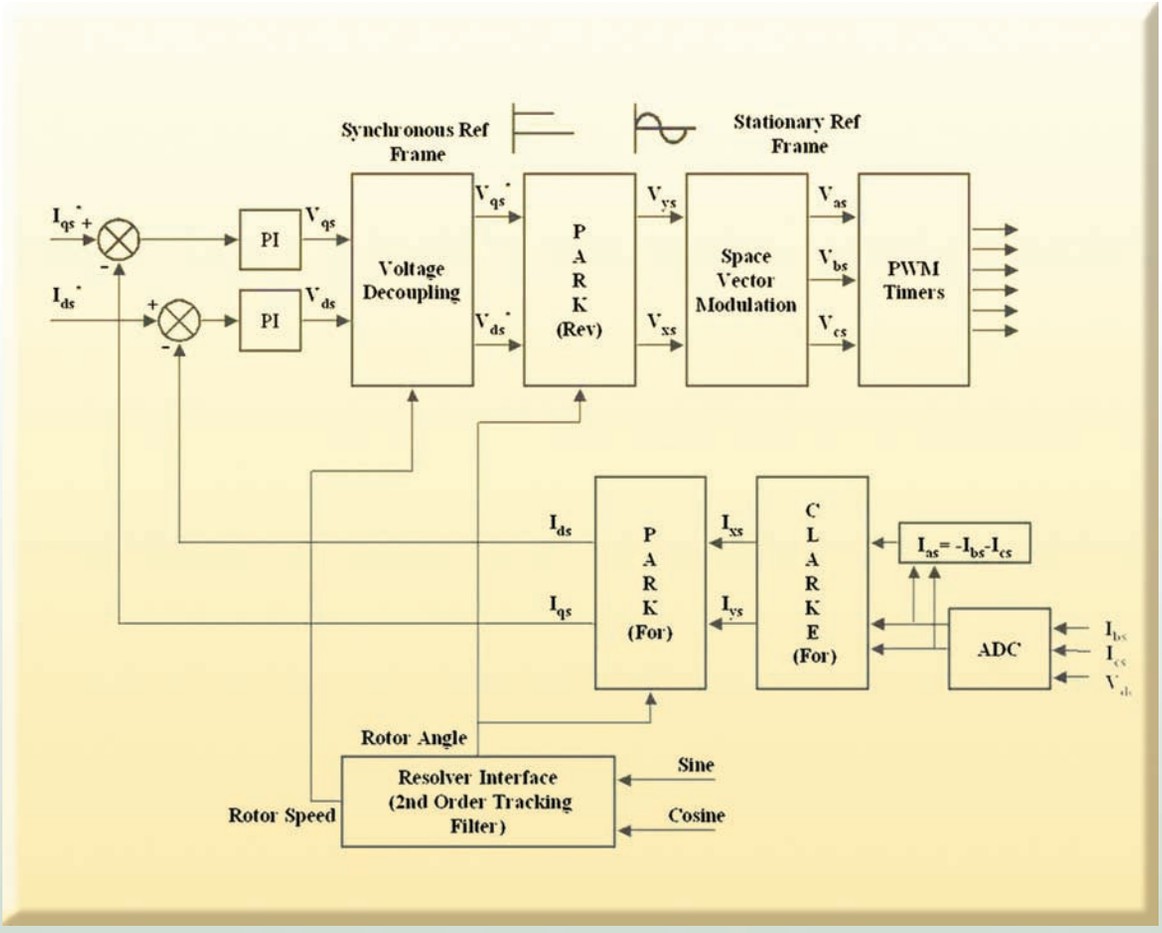


Fig. 14: Vector control scheme

where $\gamma = e^{j2/3\pi}$

Next, forward Park transformation yields the 2- phase current in the d-q frame (rotor frame) as given below, where q is the instantaneous rotor position.

$$\begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} = \begin{bmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} i_{s\alpha} \\ i_{s\beta} \end{bmatrix}$$

The external speed loop controller sets the demand torque. i_{sq} is the measured torque equivalent current. The control objective is to regulate i_{sq} ie motor torque. The direct axis current demand (i.e. field flux) is set to 0.

Two PI controllers are used: one for controlling i_{sq} and other for $i_{sd.}$

The PI controller outputs are used to manipulate the motor winding voltage. V_{qs} is the quadrature axis voltage and V_{ds} is the direct axis voltage. First these are transformed back in to the stator frame by Reverse Park transformation:

Reverse Clarke transformation yields instantaneous 3-phase voltage demands from the 2-phase quantities. These are then converted in to equivalent PWM pulse widths for the inverter.

$$\begin{bmatrix} V_{xs} \\ V_{ys} \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} V_{ds} \\ V_{qs} \end{bmatrix}$$

Speed loop and torque bias

Two speed loop controllers (Fig. 15) – one per axis, regulate the gimbal speeds. Each is a tunable PI controller realised in SHARC DSP software with 200 Hz update rate. The speed demand typically arrives from the outer position loop. Gimbal velocity is measured by differentiating gimbal position. Velocity demands are limited to 8 Rad/sec. The speed loop has bandwidth > 30 Hz.

Output of speed loop forms current demand to the two motors which drive the respective axes. The two motor

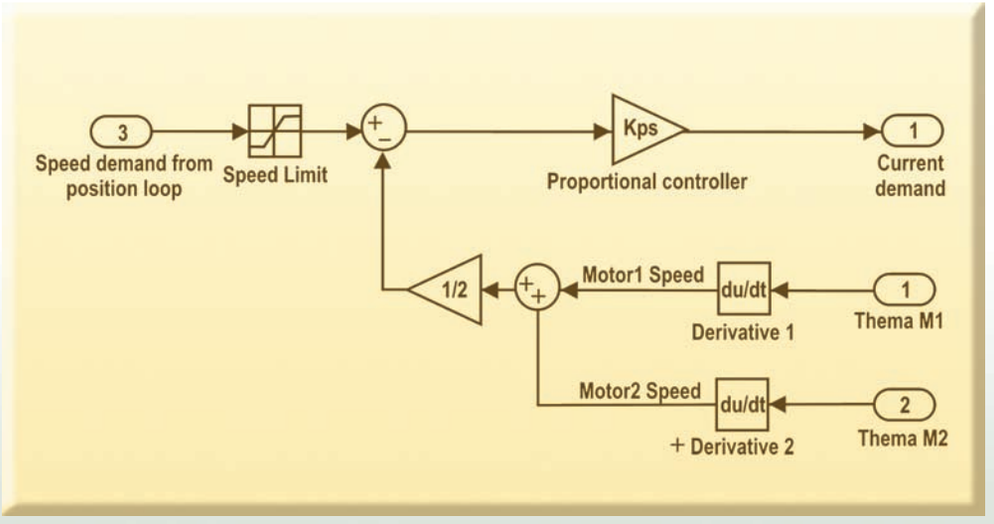


Fig. 15: Speed loop controller

current demands are biased with a programmable offset (~ ±0.1 A) which eliminates the limit cycle oscillations due to gear backlash.

Position Loop

The position controller (Fig.16) dictates the servo performance of the APL. APL is required to reach and settle at the demand position quickly with minimum overshoots. Fast acceleration and deceleration are required to achieve quick turn-around while scanning. High gain, wide band position loop is also required to provide disturbance rejection. Type II servo is required to provide zero position error while scanning. These objectives are achieved with adequate gain and phase margins to guarantee robustness against variations in the plant parameters. Achievable bandwidth is limited by the structural resonance.

The position controller is designed as tunable, type II servo. The servo parameters are tuned to meet required command response and disturbance rejection performance. The achieved bandwidth is > 10 Hz. Other features include integral wind-up inhibit, position demand limiting and position error limiting.

Position controllers are also realized in SHARC DSP software with 200 Hz update rate. Resolver sensed gimbal position is measured to a resolution of 0.005 deg. resolution.

Slew Mode

The controller switches to SLEW mode (Fig. 17) for large position errors (> 11 °). This reduces overshoot and settling time. SLEW mode is disengaged and position mode is reentered automatically when position error falls below 0.5°. In the slew mode, speed demand is proportional to the square root of the remaining angle; this ensures that the antenna coasts to the final position with a constant deceleration.

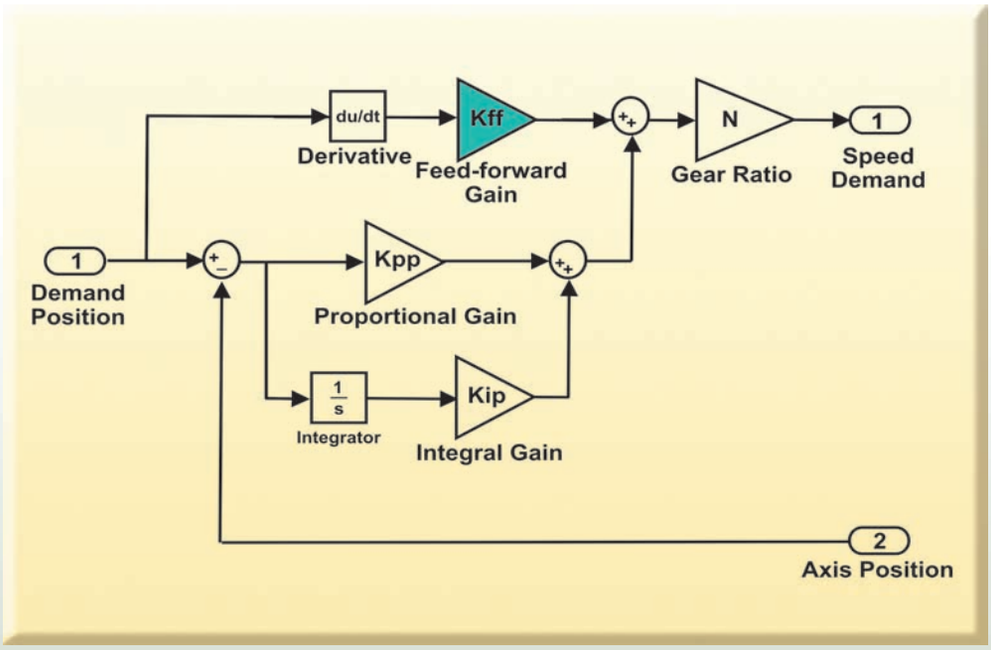


Fig.16: Position loop with rate feed forward

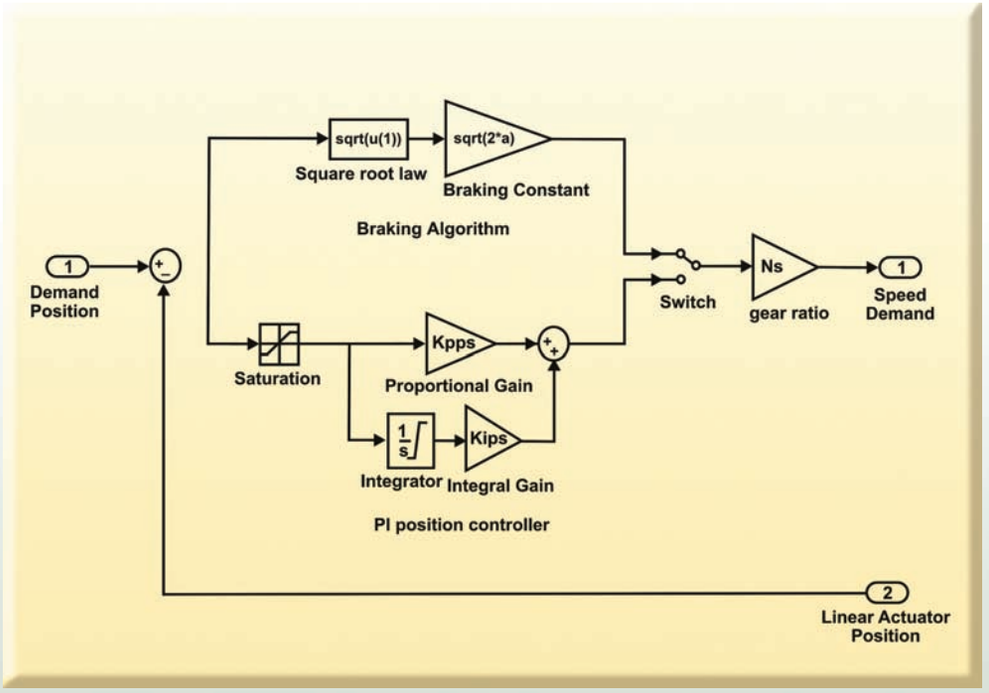


Fig. 17: Position loop with SLEW switch

Rate Feed forward Control

Further improvement in the command performance is obtained, by adding a signal proportional to the command rate to the speed demand. This improves turn-around time and command bandwidth. Command rate feed forward improves command response without affecting disturbance response.

End-stop control

As the antenna approaches pre-programmed end stops, speed limit is reduced as a function of square root of angle-to-end stop. Thus the possibility of the antenna, hitting end-stops at high velocity, is avoided (Fig. 18).

Fig. 18: End stop control

Dynamic braking

When APL is powered down and DC link voltage is higher than a predefined value, a resistance is connected across

DC link voltage. This provides a braking torque to the motors, thus braking the antenna during transport.

In case of protection faults, the antenna is stopped immediately using regenerative braking.

Stabilization

APL stabilizes the antenna against aircraft body rates. As the air craft yaws, pitches and rolls, the antenna is repositioned, so as to maintain the required orientation in space. The stabilization used is of feed forward type : the demand NED frame angles are transformed into scanner frame before feeding to the position servo. Similarly, measured AZ/EL gimbal angles are transformed back into NED frame angles and forwarded to RP. The instantaneous aircraft attitude is obtained from aircraft's INS via RP 200 Hz rate.

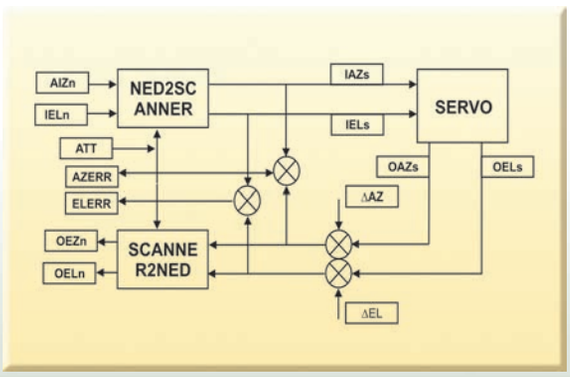


Fig. 19: Stabilization

Built-in tests

Built-in tests are provided to promote fault detection, isolation and maintenance at various levels. While continous tests monitor health of major components, there are other tests which can be called-up on demand via the radar bus. Thus it can be verified that each of the motors can deliver the required torque. Any misalignment of the resolver can be detected by position test. A maximum of 16 software variables can be selected from a pool of variables, for continuous monitoring via radar bus. Other tests include built-in scan patterns, torque disturbance tests and radar bus loop back tests.

Servo tests

When controlled by the test computer, the system provides built-in support for measuring the servo performance by offering signal injection and monitoring capabilities at various nodes of the cascade controller. The logged data can be viewed graphically using standard software utilities on PC. From these graphs, servo performance measures such as rise-time, settling time, overshoot, turn-around time, pointing error, scan error and bandwidths can be measured. Required injection signals are generated in the TC and include Step, Sine, Triangular and chirp inputs with selectable amplitude, frequency and phase. Alternately, commands can be played back from a file.

Other features

Other features include Reversionary mode enable/ disable via radar bus, Radome aberration correction via down-loadable look up tables, software version identification and checksum read-back, remote shutdown via radar bus, code download to FLASH via serial port and modifiable Servo and System parameters and their persistent storage in FLASH memory.

Software architecture, development and engineering

Software Deployment View

Fig. 20 shows the APL software entities and their deployment view.

APL TC is the PC hosted Tester software used for testing and tuning of APL. It is a non-flying component and executes under WIN/NT.

ACS is the APL control software hosted on SHARC 21062 DSP. The code is booted from onboard FLASH memory to on-chip program RAM during powering on of APL. ACS communicates with APL TC / RP over Radas bus and AMCS over the SPORT channel.

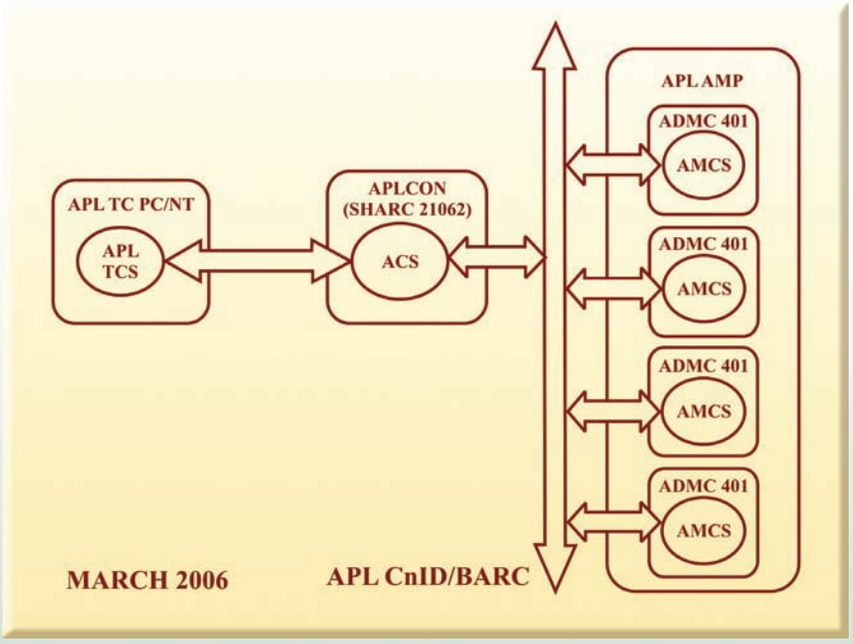


Fig. 20: Software deployment view

AMCS is the APL motor control software hosted on the ADSP 401 motor control DSPs in the APLAMP cassette. There are 4 instances of AMCS executing concurrently. The code is booted from on-board EEPROM to on-chip program RAM during powering on of APL.

Each AMCS instance communicates with ACS over the SPORT channel using multi-channel protocol.

APL software engineering was carried out as per IEEE 12207, tailored to the project requirements. Independent reviews, verification and validation were conducted by the Aeronautical Development Agency, Bangalore.

Safety Features

Following safety features are incorporated in APL control electronics:

a. *End-stops*: Spring loaded end stops are located at either extremity for restricting the antenna movement.

b. *Dynamic braking* : Even when APL is powered-down, antenna rotation due to aircraft movement is restricted by dynamic braking circuit in APLPS.

c. *Regenerative braking*: Under specified crippling faults such as sustained full torque demand, excessive velocity feed-back, resolver fault and amplifier serial link loop-back error, regenerative braking is applied by APLAMP. APLAMP applies regenerative braking closing internal speed loop with speed demand set to zero.

d. *Reversionary mode on Radar bus failure*: On sustained loss of communication with RP, APL reverts to (0,0) position.

e. *End-stop control*: APL limits demand speeds at end-stops.

f. *Demand limiting:* Demand positions are limited to end-stops. Demand speeds and currents are limited to set values.

g. *APLAMP fault detection*: APLAMP shuts-off the MOSFET switches on detection of abnormal conditions such as over current, high temperature etc.

h. *APLPS fault detection*: APL PS detects power supply faults and shuts-off the DC-DC converters on sustained fault.

i. *Software version number and checksum*: Power-on tests verify that APL is loaded with correct software version. Checksums for code and configurable constants are also verified.

Test Computer

APL can be comprehensively tested and evaluated from a PC configured as 1553 Bus Controller and hosting APLTC software (Fig. 21). The commands supported by the tester are a superset of the RP command set. These additional capabilities promote development testing, software qualification testing, control loop tuning, servo performance measurement and acceptance testing of APL. Selected parameters are logged at 200 Hz rate. Logged data is then analysed and viewed using commercial software.

Performance measurement & Safety-Of-Flight Tests

A comprehensive functional test plan was drawn up covering the specified functionality, performance and external interfaces of APL. A subset of these tests are performed during the climatic and environmental tests as part of the safety-of-flight test suite.

Safety-of-flight tests cover the following :

1. Continuous Operation tests
2. EMC tests
3. Acceleration tests
4. Sinusoidal vibration tests
5. Random vibration tests
6. Low temperature tests
7. High temperature storage and operating
8. *CATH*

The graphs (Figs. 22-27) depict the system performance during some of the above tests.

Conclusions

Development of air-worthy APL was a challenging endeavor drawing upon expertise in the areas of controls, electronics, software, drives, structural analysis, fabrication technology, thermal engineering, quality assurance and software verification and validation. After

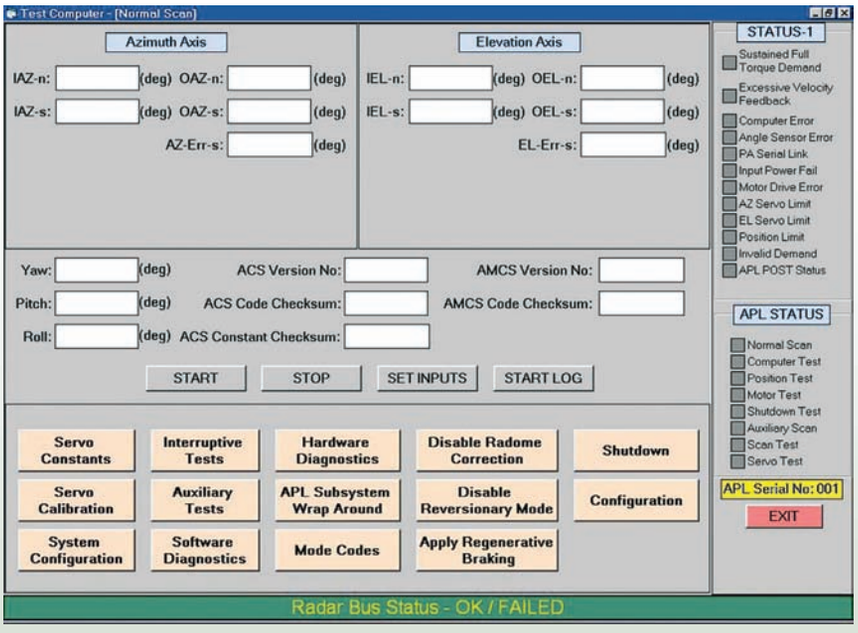


Fig. 21: Test Computer- Main screen

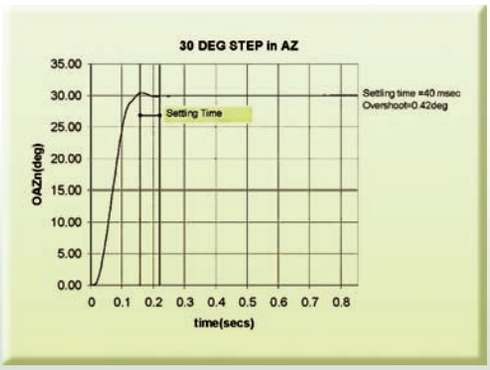


Fig. 22: 30 deg. step response

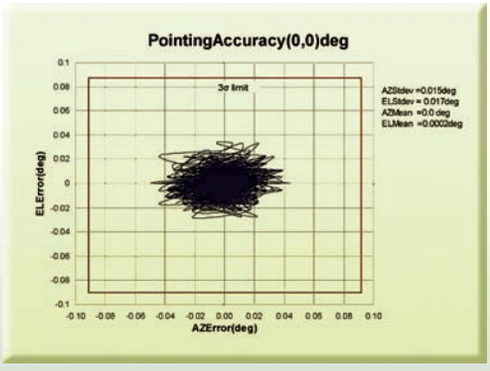


Fig. 23: Pointing accuracy

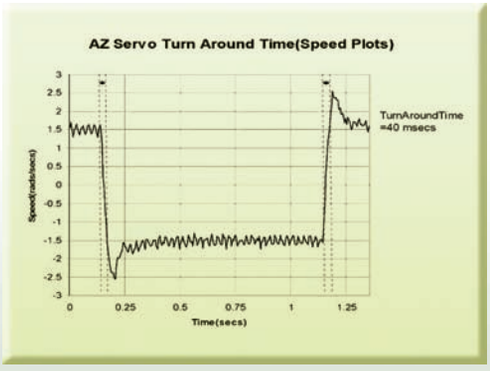


Fig. 24: Turn-around time measurement

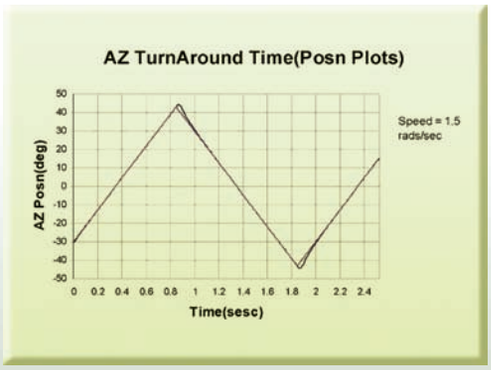


Fig. 25: Scanning test

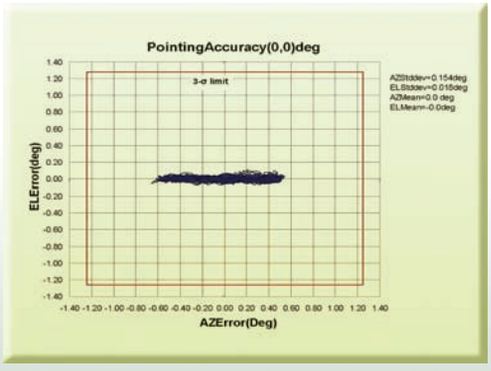


Fig. 26: Pointing error during sinusoidal vibration in Y direction

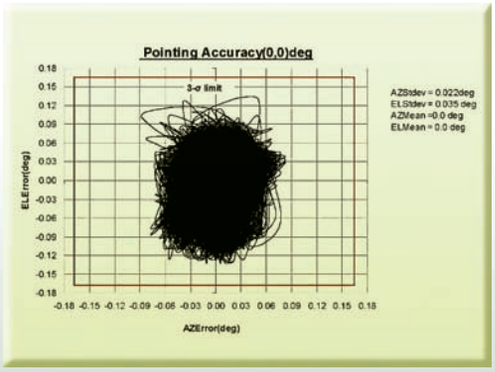


Fig. 27: Pointing error during 4g acceleration

years of trials and tribulations, first APL was successfully integrated with the MMR and flown in hack aircraft during May 2006. This was preceded by a 2-month long campaign of safety-of-flight tests during which the unit was tested for compliance under specified climatic, environmental and EMI envelope. User has now placed series production order with ECIL. With the total requirements of APLs and its variants expected to be a few hundreds, over the next few years, this is a precursor to a new product line and technology base at ECIL. As per the recent MoU, BARC will be assisting ECIL in the series production of these units.

बीएआरसी न्यूज़लैटर
BARC NEWSLETTER

NEONATAL SCREENING FOR CONGENITAL HYPOTHYROIDISM – ADAPTING THE HTSH-IRMA KIT FOR THE PURPOSE

J Kumarasamy, Yogita Raut and MGR Rajan
Laboratory Nuclear Medicine Section
Radiochemistry & Isotope Group

Introduction

Congenital Hypothyroidism (CH) is one of the common causes of mental retardation[1] in children, which can be easily prevented if diagnosed within a few days after birth. Congenital hypothyroidism is a clinical condition when a baby is born with decreased thyroid hormone production at birth. Hypothyroidism in the newborn, may result from absence or abnormal development of the thyroid gland, destruction of thyroid gland *in utero,* failure of pituitary gland to stimulate thyroid gland, defective or abnormal formation of thyroid hormones. Of these, incomplete development of the thyroid gland is the most common defect. Most of the affected children would suffer from growth failure, irreversible mental retardation, and a variety of neuropsychological deficits[1,2,6]. Detection of CH, solely by clinical signs and symptoms alone is apparent at about three months, but by this time, irreversible damage to brain development would have already occurred. In North America and Europe, the prevalence of permanent CH is reported to be about 1:4000[3]*. Girls are affected twice as often compared to boys. Realizing these facts, western countries have implemented National Level Screening Programs (NLSP) in the last two decades, to detect CH and institute early treatment. Similar efforts were instituted elsewhere in some countries in Eastern Europe, South America, Asia and Africa[2]. The World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) have provided technical assistance[4] and guidance to developing countries, to carryout pilot studies (see Fig.1A-C). The efficacy of timely detection, treatment and its consequent benefits to the child is evident in Fig. 2 A-D. The Indian Pediatric Association (IPA)[5] enumerates three main factors for the non-existence of NLSP in a developing country like India. They are: inconvenient methods, lack of reliable laboratories and cost.

A technically sound assay, suited for neonatal screening for CH that can be used by small and large laboratories throughout the country is an urgent requirement. Generally, TSH is assayed by ImmunoRadioMetric Assay (IRMA) or an equivalent non-isotopic assay in serum, for which about 1ml of blood is required. It is difficult to draw blood from 3-4 day old neonates and more so in pre-term babies and hence, serum-based TSH assays, as conducted on children and adults, would be difficult. Filter paper blood-spot assays are in use in many laboratories, world wide, but this technique has its own limitations[7,8] i.e. collection and storage of samples on filter paper, effect of the type of filter paper used, uniformity in the spread of blood on the paper, variations in quantitatively eluting the TSH from the dried blood on the paper into the assay tubes, removing paper residue from the assay tubes during the washing step etc. All

** Reasonably large screening studies from Hong Kong and Shandong province of China have shown an incidence of 1:2404 and 1:2831 respectively[9].*

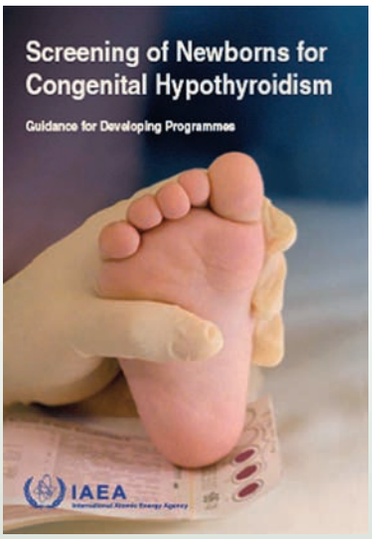


Fig. 1A: IAEA and WHO disseminate technical know-how and conduct awareness programmes on Congenital Hypothyroidism

Fig. 1B

Fig. 1C

Photographs from IAEA Documentation as seen in Figs. 1B&1C

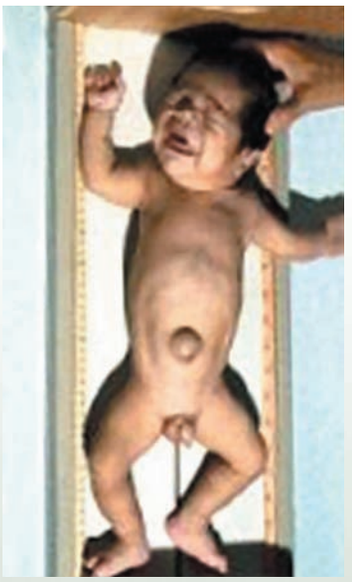


Fig. 2A: Congenital hypothyroidism. An infant with cretinism. Note the hypotonic posture, coarse facial features and umbilical hernia

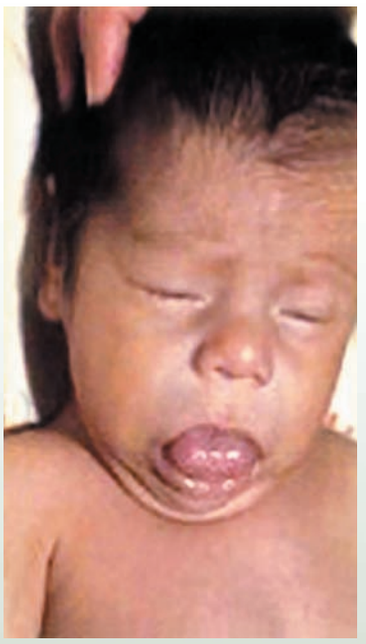


Fig. 2B: Congenital hypothyroidism. Close-up of the face of the infant shown in Fig. 2A. Note the macroglossia

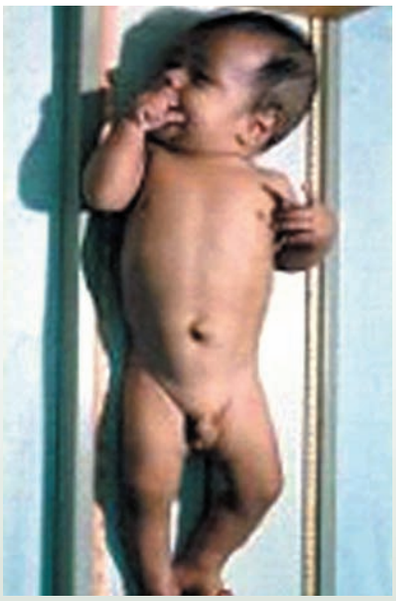


Fig. 2C: Congenital hypothyroidism after treatment. The infant shown in Fig. 2A-B a few months after starting thyroid hormone replacement

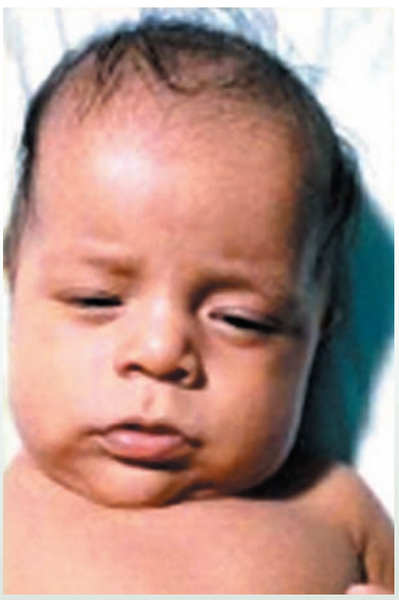


Fig. 2D: Congenital hypothyroidism after treatment. Close-up of the infant in Fig. 2A-B a few months after starting thyroid hormone replacement

these would contribute to making the analytical imprecision, quiet large. To reduce the imprecision we have used two approaches: 1) by extracting the blood from five blood-spot punches and using it for duplicate estimations and 2) carrying out the assay directly from a very small volume of whole blood i.e., 25 or 50µl. This volume of blood is much lesser than what is required for making blood spots on filter paper (Fig.3A, 3B). With some practice, a semi-automatic pipette can be used to collect this small volume of blood directly from the heel-prick of an infant. We have compared the whole blood TSH assay with blood-spot TSH assays for assay performance and compared various assay parameters. Blood samples from adult thyroid patients, who visited our center for thyroid investigations, were used in the study and compared with serum TSH estimations carried out as per standard procedures.

Fig. 3A: Guthrie Cards are commercially available for blood collection

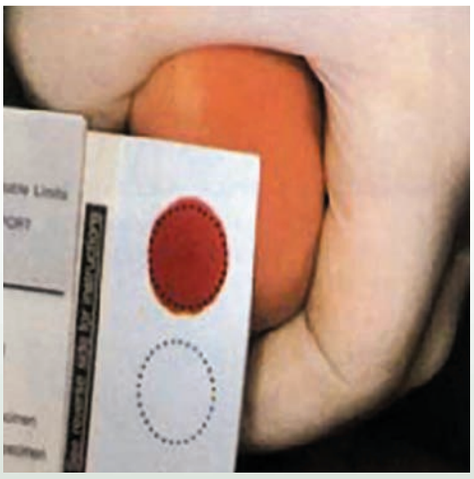


Fig. 3B: Application of blood on card

Materials

Plain polystyrene test tubes (standard size 12 x 75 mm) were obtained from M/s. Tarsons, Kolkata. Tris buffer salt, EDTA, boric acid, sodium hydroxide were of Analytical Reagent grade and procured locally. Bovine serum albumin (BSA) was from Himedia, Mumbai. Whatman™ 3MM filter paper sheets (57 x 46 cm) procured locally were cut into strips of 7 x 23 cms. The strips were dried at 40°C for 2-3 h to remove adsorbed moisture if any, and wrapped in aluminum foil and were stored with desiccant sachets in self-sealing polyethylene pouches until required. A paper-punch to punch out 5mm spots from filter paper was procured locally. It is important that the punch is sharp and gives paper spots with clearly cut edges. hTSH IRMA kits used in the study were procured from BRIT, Vashi.

Methods

Preparation of Whole Blood Standards / QC for hTSH

Since the assay measures hTSH in whole blood, standards had to be prepared in whole blood. This is achieved practically by adding an equal volume of serum with known TSH-concentration to an equal volume of washed packed RBC, isolated from healthy donors so that 50% hematocrit is obtained as recommended by WHO. The procedure adopted is as follows: 7 ml blood from healthy volunteers without any thyroid dysfunction was drawn into EDTA Vaccutainer™ tubes. RBC were separated by centrifuging at 3000 RPM for 10 min. and the plasma discarded. The RBC were washed 3 times by resuspending in 7 ml of sterile normal saline containing 0.2% sodium azide as preservative. Blood sample from different donors were treated separately to collect RBC. Packed RBCs from different volunteers were pooled and washed once with sterile normal saline. To 1ml of packed RBC placed in individual vials, 1ml each of hTSH serum standards 0, 5, 15, 50, 100 μIU/mL was added. Thorough mixing was ensured by swirling gently for several minutes. Similarly QC samples supplied with the kit were also adjusted to 50% hematocrit by adding RBCs. Whole blood standards were stored at 4°C and used within a month. Addition of RBCs to serum standards/QCs causes doubling of volume however, the TSH concentration remains the same as it is now expressed per ml of whole blood. Therefore, the results are directly reported in serum equivalent i.e. TSH μIU/mL serum.

Experiment-1: Blood Spot hTSH – IRMA

Preparation of blood spots for standards/QC/ samples on filter paper

Whole blood hTSH standard/QC (200 μL each) was drawn using semi-automatic pipette and spread on to Whatman filter paper strips as circles of about 2 cm diameter. Necessary precautions were taken to achieve uniformity in the spread of blood. A few such spots were made on each strip ensuring that there was sufficient space between spots to avoid overlap (Figs. 3A & B). Blood from adult patients was collected in plain glass tubes and 200 μL spotted immediately as described, before clotting took

place. The strips were made wide enough (7 cm) so that details of the patient, like Name, Case number etc. could be written on the strip itself. The strips were air-dried for an hour at RT then dried at 37°C for 2 h, wrapped in a clean aluminum foil and stored with a desiccant sachet in self-sealing polythene pouches at 4°C. Prior to setting up assays, the strips were brought to room temperature and 5 mm diameter spots were punched out from the blood spot choosing areas where spread of blood was uniform. These Filter Paper Blood Spots (FPBS) were used for assays as described below.

1) hTSH - IRMA using Two FPBS

In this experiment, two FPBS from each standard/QC/ patient sample were placed in individual assay tubes appropriately labeled. 100µl of TSH tracer was added along with 100µl of Tris-BSA buffer (0.1 M with 0.02%BSA) to all the tubes. The tubes were incubated for 2 h in an orbital shaker at 150 RPM and then overnight (15 –18 h) at RT without shaking. After incubation, contents of the tubes were aspirated, the filter paper spots removed carefully and the tubes washed twice with 2ml of wash buffer provided in the kit. The tubes were counted in a gamma counter for bound radioactivity. A calibration curve of TSH concentration vs bound counts was drawn. The sample values were read by interpolation from the calibration curve.

2) hTSH - IRMA using extract from Five FPBS

In this experiment, five FPBS from each standard/QC/ patient sample were placed in individual plain polystyrene tubes labeled appropriately, 500µl of 0.05M phosphate buffered saline pH 7.4 (PBS) was added to each tube covered tightly and kept for elution overnight at RT on an orbital shaker (150 RPM). On the following day, the eluate was assayed for TSH as follows. 200 µl of the eluate and 100µl of TSH tracer were added to the TSH assay tubes. The tubes were incubated for 2h at room temperature on an orbital shaker (150 RPM), after which, the tubes were aspirated, washed with wash buffer, counted for radioactivity and sample concentration obtained as stated earlier.

Experiment 2: Whole Blood hTSH – IRMA

Two sets of TSH antibody coated tubes were arranged and numbered from A – E along with tubes for samples and controls. 200µl of Tris-EDTA buffer with 0.02%BSA was added into all tubes. In one set, 25 µl and in the other set, 50 µl of whole blood TSH standard/QC samples/patient samples were added. The tubes were incubated on an orbital shaker for 2h at RT. After incubation, the contents were aspirated out and tubes washed with 1ml of PBS. 100µl of TSH tracer and 200µl of PBS were then added to all tubes in both the sets. The tubes were further incubated for 1 h at RT on an orbital shaker (150 RPM). After incubation, the contents were aspirated and the tubes washed twice with wash buffer (0.1M borate buffer pH 8 containing Tween 20). The tubes were counted in a gamma counter for bound radioactivity and data processed as stated earlier.

Assay Validation

A) Recovery

Recovery samples were prepared by mixing100µL of each whole blood standard A to E with 100µL aliquots of patient blood sample. These samples were assayed along with neat patients blood sample for calculating percentage recovery.

B) Correlation with serum TSH values

Patients samples (n=69) were assayed for TSH by both, blood spot IRMA and whole blood IRMA and the values were compared with serum TSH. Statistical analysis performed and results tabulated.

Results

The results of all the experiments are summarized in Fig. 4 and Tables 1-3. Fig. 4 shows typical standard curves obtained with 2FPBS, 5FPBS, 25µl WB and 50µl WB. The assay with 50µl WB sample gives the standard curve with highest B_{max} and a better overall precision and this is expected as the sample volume is comparatively larger. A clear standard curve could be obtained with

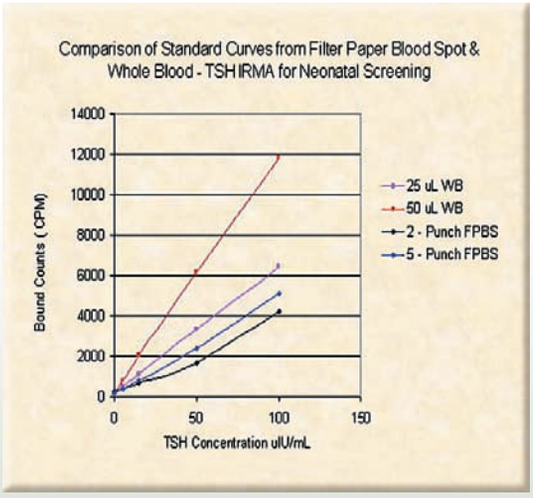


Fig. 4: Comparison of standard curves from FBPS & WB TSH IRMA for neonatal screening

Table 1: Bound Counts (CPM) obtained in different hTSH assays

TSH Concentration µlu/mL	Filter Paper Blood Spot hTSH - IRMA		Whole Blood hTSH - IRMA	
	2 – Punch FPBS	5 – Punch FPBS	25µl Whole blood	50µl Whole blood
0	246	183	163	149
5	365	382	474	827
15	635	789	1125	2054
50	1701	2404	3329	6165
100	4241	5148	6426	11822
Total CPM	1,26,000	1,40,620	1,08,924	1,08,924
Assay Date	28/02/06	17/05/06	02-11-06	02-11-06
Kit Exp. Date	20/03/06	23/06/06	20-11-2006	20-11-2006

the difference in bound counts between the various standard points in all the assay methods, though this is better with increasing sample volumes (Table 1). Among the assays compared, FPBS assays had higher imprecision compared to WB assays (Fig. 5). Recovery of TSH added to sample show

Table 2: Recovery (50ml-Whole Blood hTSH IRMA)

Dilutions	Observed(O) (TSHµlu/mL)	Corrected O (O – ½ Pt value)	Expected (E)	%Recovery %O/E
Patients sample undiluted	4.4	-	-	-
Sample + (Standard 5µlu/mL) (1:1)	4.8	2.6	2.5	104%
Sample + (Standard 15µlu/mL) (1:1)	9.7	7.5	7.5	100%
Sample + (Standard 50µlu/mL) (1:1)	26.3	24.1	25	96.4%
Sample + (Standard 100µlu/mL) (1:1)	53.3	51.1	50	102%

Table 3: Correlation of Serum TSH with FPBS - TSH and WB - TSH

	Serum TSH	2 Punch FPBS	5 Punch FPBS	25 µL WB	50 µL WB
Serum TSH	1	r = 0.998+ y = 0.992x +1.112	r = 0.997+ y = 1.00x + 0.710	r = 0.997+ y = 0.9863x + 0.02	r = 0.999+ y = 0.992x + 0.26
2 Punch FPBS		1	r = 0.998+ y = 1.01x – 0.416	r = 0.997+ y = 0.991x – 1.04	r = 0.998+ y = 0.997x – 0.810
5 Punch FPBS			1	r = 0.994+ y = 0.975x – 0.54	r = 0.996+ y = 0.982x – 0.334
25 µL WB				1	r = 0.998+ y = 1.004x + 0.273
50 µL WB					1

+ p< 0.01 * n = 69

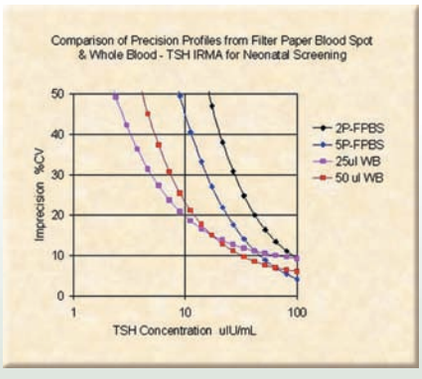


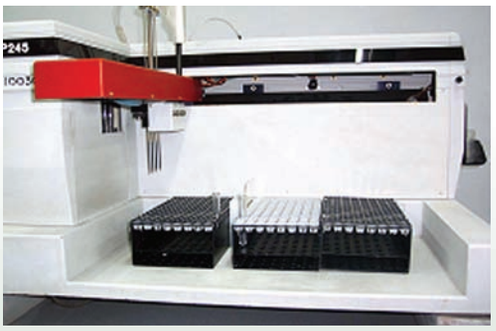
Fig. 5: Comparison of precision profiles from FBPS & WB TSH IRMA for neonatal screening

that it is within acceptable limits of ±15% over the entire range (Table 2). Table 3 gives the correlation coefficients observed between the TSH estimates (using serum samples in the standard lab procedure) and estimates using FPBS and WB samples.

Discussion

The assays were designed with standard points of 0, 5, 15, 50 and 100 μIU/ml since it is to be used for screening CH, where a moderate sensitivity is adequate, as the babies with TSH values >15 μIU/ml would be called back for follow up studies. The results show that it is possible to develop a TSH assay using either blood spots or small volumes of whole blood with existing TSH-IRMA kits*. Blood spot assays are reported to have a higher imprecision as compared to serum assays and were also observed in our study. The assay using 25μl and 50μl whole blood has better discrimination between various standards as compared to that of FPBS and also a lower %CV. The whole blood hTSH assay is simple, has minimum steps and short (3-4 h) assay time. All infants with TSH >40 μlu/mL are considered to have primary hypothyroidism until proved otherwise[2]. Therefore, concentration region between 15 to 50 μlu/mL is of clinical importance and the count rate (CPM) obtained in this concentration region with WB format, is better as compared to that of FPBS. Automation of WB hTSH – IRMA would be easy whereas automating blood spot assay is difficult because the paper spots may block the aspiration probe of the machine.

A majority of European and Japanese programs favor screening by means of primary TSH measurements, supplemented by T4 determination on those infants with elevated TSH values, while CH screening programs practiced in North America use a two-tiered laboratory approach, in which, initial T4 measurement is followed by measurement of TSH in specimens with low T4 values. Diagnosis based on either one may miss out a variety of pathological situations[2]. Screening for both T4 and TSH may not be feasible because of cost constraints. However, no treatment would be cheaper than prevention itself. The 5 FPBS assay protocol was considered seeing the replicate errors in the 2 FPBS assay. It requires an extra step of elution prior to assay but the reduction in imprecision and increase in confidence of the assay, makes up for the inconvenience. The concept of a WB assay was thought of, while spotting the blood from a heel prick onto a filter paper. If the heel is held up during the heel prick procedure, the blood wells up and forms a nice convex drop. It is quite easy to draw blood into a pipette directly from the heel prick into the assay tube. 25 μl or 50 μl samples for two or three replicates can be done quite quickly. Since the precision of the assay is quite satisfactory, repeat assays are seldom required. Nonetheless a third WB sample can be kept for repeat assay if required.



Zenyx SP-245, Stratec –SR 300

RIA – Automation facilities available at LNMS Parel

Conclusion

The major hurdle in screening for CH at national level in India appears to be the non-availability of a suitable TSH kit for neonatal screening. We have shown that it is

** For the purpose of standardization and validation, we have used blood spots and whole blood samples from adults, but since adult blood is not significantly different from neonatal blood vis–a-vis TSH measurements in the methods described would be suitable for neonatal blood also.*

possible to use the existing hTSH-IRMA kit (supplied by BRIT) for neonatal screening for CH with minimum modifications. Depending on the convenience and availability of trained manpower, one can adapt either FPBS-TSH or WB-TSH from the heel prick of a three-day infant.

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KNOWLEDGE MANAGEMENT FOR RADIATION PROTECTION PROFESSIONALS (KMRPP-07): REPORT OF THE WORKSHOP

A discussion meet was organised by the Health Physics Divn., BARC, on 3-4 May, 2007, at the Radiation Protection Training & Information Centre. Several topics related to radiological safety in nuclear power plants were addressed during the course of the workshop.

Mr R.K. Sinha, Director, RDDG, BARC, discussed about the developments in the field of nuclear power reactor designs and the safety features. Mr K.A. Pendarkar, Head, IDD, BARC, highlighted the recent trends in ICRP recommendations. Dr B.S. Tomar, Radiochemistry Division, BARC shared his operational expertise and experiences in the field of gamma spectrometry systems. Mr B. Krishna Mohan, RRDD, BARC covered Reactor Physics aspects of various reactors.

Mr S.F. Vhora, NPCIL, discussed the safety features incorporated in the design of operating PHWRs and also the Indian 700 MWe PHWR. Dr V.K. Manchanda, Head, Radiochemistry Divn., spoke about developments in liquid scintillation counters and their applications. Mr R.A. Agrawal, RPDD, BARC discussed the problems associated with shielding of pipelines and equipment in the work areas, in achieving ALARA radiation dose limits. Mr S.K. Munshi, FRD, BARC, discussed the various stages involved in fuel reprocessing. Mr Raj Kanwar, Head, WMD, BARC, elaborated on the safety aspects of handling radioactive wastes and achievements in the vitrification process in handling HLWs. Mr H.S. Kushwaha, Director, H S & E G, BARC, discussed the design features of the Indian PHWRs, in meeting safety requirements during earthquakes.

Mr M.L. Joshi, Head, HPD, BARC, concluded the discussion meet with the hope, that a similar exercise would be undertaken in the near feature, for the benefit of the second level of radiation protection professionals in nuclear power plants.

12TH NATIONAL SEMINAR ON PHYSICS AND TECHNOLOGY OF SENSORS (NSPTS-12) HELD AT TRAINING SCHOOL HOSTEL, ANUSHAKTINAGAR : A REPORT

National Seminar on Physics and Technology of Sensors (NSPTS) was held at multi-purpose hall, BARC Training School Hostel, Anushaktinagar, Mumbai during March 7-9, 2007. This seminar is an annual event organized at different universities and national laboratories. The present seminar organized by the Technical Physics and Prototype Engineering Division was 12th in the series and was held at BARC for the first time. The seminar was jointly sponsored by the Board of Research in Nuclear Sciences, Department of Science and Technology, Department of Space and Council of Scientific and Industrial Research. The main objective of this seminar was to provide a platform to scientists and engineers working in the field of sensors to discuss new developments in the field and interact with other scientists, engineers and industry. About 150 scientists and engineers both from India and abroad participated in the conference.

Dr V.C. Sahni, Director , RRCAT and Director Physics Group, BARC welcomed the participants. He pointed out that sensor development was an important activity in DAE. Prof. S.A. Gangal, University of Pune gave an introduction to NSPTS series and mentioned about increase in the interest of researchers in the field of sensors. While inaugurating the seminar Dr S. Banerjee, Director, BARC remarked on the need for sensor development and their applications in various fields. He also enumerated the large number of discoveries in the field of sensors and their applications in industrial and medical areas. Dr Baldev Raj, Director IGCAR delivered the keynote address. He presented work done by IGCAR and other units of DAE on sensors, useful for nuclear reactor applications and SQUID devices developed at IGCAR. The inauguration function concluded with a formal vote of thanks by Dr S.K. Gupta, Convener of the seminar.

Dr S. Banerjee, Director, BARC delivering the Inaugural address

The seminar programme included invited talks and contributed papers in the form of oral and poster presentations. A total of 22 invited talks by speakers from India as well as abroad and 93 contributory papers were presented in the seminar. The seminar covered the key areas of sensors viz. (a) micro-fabricated sensors, (b) electrochemical and bio-sensors, (c) sensor for nuclear reactors, (d) polymer sensors, (e) gas sensors, (f) sensors for multiple analytes, (g) nano & MEMS sensors. An exhibition of the industry products was arranged as part of the seminar. An important feature of the seminar was the large number of presentations on sensors, developed for use in nuclear power plants. Many awards were announced during the seminar. Dr B. Sasi from IGCAR, Kalpakkam; Dr Sudha J. Kulkarni and Dr M. Zahid from University of Pune were selected for the R. Chandrashekhar memorial prize in the category of best continued industry oriented research work. Dr N.G. Patel prize was awarded to Dr C. Roychaudhuri, Bengal Engineering and Science University for the best oral presentation. In addition to this six contributory papers were given awards for poster presentations.

In the concluding session, the summary of the seminar was presented by Prof. R.N. Karekar, University of Pune.

A view of the participants at NSPTS-12

Dr Baldev Raj, Director, IGCAR delivering the Keynote address

This was followed by a panel discussion by Mr B. B. Biswas and Dr S K Gupta from BARC, Dr Amita Gupta from SSPL, Dr S. Basu from Jadavpur University, Prof. S. A. Gangal and Prof. R. N. Karekar, University of Pune. Participants emphasized that interaction between industry and research centers should be increased and efforts should be made to convert developed technologies into production. In this regard, it was pointed out that the requirement of industry should be determined and projects should be based on such requirement for more effective utilization of the developments.

भा.प.अ.केंद्र के वैज्ञानिकों को सम्मान
BARC SCIENTISTS HONOURED


C.P. Kaushik

श्री सी.पी. कौशिक, अपशिष्ट प्रबंधन सुविधाएं को दिनांक 4-8 दिसम्बर, 2006 के दौरान मल्टीपरपज हॉल, भापअ केन्द्र प्रशिक्षण विद्यालय छात्रावास, अणुशक्तिनगर, मुंबई में आयोजित पदार्थ रसायनिकी पर अंतरराष्ट्रीय संगोष्ठी में उनके पेपर "स्टडीज ऑफ मटीरियल इशूज, सांइस एण्ड टेक्नोलॉजी फॉर इम्मोबिलाइज़ेशन ऑफ सल्फेट बियरिंग हाई लेबल रेडियोएक्टिव वेस्ट" के लिए उन्हे सर्वोत्कृष्ट शोध-पत्र का पुरस्कार प्रदान किया गया ।

Mr C.P. Kaushik, Waste Management Facilities received the best paper award for the paper entitled "Studies of Material Issues, Science and Technology for immobilization of Sulphate Bearing High Level Radioactive Liquid Waste" at the International Symposium on Materials Chemistry (ISMC-2006) held at Multipurpose hall, BARC Training School Hostel, Anushaktinagar, Mumbai during Dec. 4-8, 2006.


K.G. Bhushan

डॉ के.जी.भूषण, तकनीकी भौतिकी एवं प्रोटोटाइप इंजीनियरी प्रभाग (TP&PED) ने मार्च 26-30, 2007 के दौरान इंटरनैशनल सैंटर एन्ड सिडेड डे गोवा, गोवा में आयोजित, आइएसएमएएस सिम्पोज़ियम ऑन मॉस स्पेक्ट्रोमेट्री के बारहवें सम्मेलन में "ए फूरिये ट्रांसफोर्म इलेक्ट्रोस्टेटिक आयन ट्रेप फॉर हाई रेज़ोल्यूशन मास स्पेक्ट्रोमेट्री," का शोध-पत्र की प्रस्तुति पर "बेस्ट इन्नोवेटिव रिसर्च प्रेज़न्टेशन" नामक पुरस्कार प्राप्त किया। भाभा परमाणु अनुसंधान केंद्र के भौतिकी वर्ग से डॉ. एस.सी.गडकरी, डॉ जे.वी .यखमी, एवं डॉ. वी.सी. साहनी , भी इस शोध-पत्र के सह-लेखक थे ।

Dr K. G. Bhushan of Technical Physics & Prototype Engg. Division (TP&PED) received the "Best Innovative Research Presentation" award for the paper entitled "A Fourier Transform Electrostatic Ion Trap for High Resolution Mass Spectrometry", presented at the '12th ISMAS Symposium on Mass Spectrometry' during March 26 – 30, 2007, held at the International Center & Cidade de Goa, Goa. Co-authors of the paper were : Dr S. C. Gadkari, Dr J. V. Yakhmi and Dr V. C. Sahni, Physics Group, BARC.


Shailesh Sonar


Dr S.E. D'Souza


Dr K.P. Mishra

श्री शैलेश सोनार, (भा.प.अ. केंद्र - मुंबई विश्वविद्यालय सहयोगात्मक योजना के तहत पीएचडी के विद्यार्थी) विकिरण जैविकी एवं स्वास्थ्य विज्ञान प्रभाग, भा.प.अ. केंद्र को उनके शोध-पत्र "ए नोबल डोक्सोरुबिसिन एनकैप्सुलेटेड $_{p}H$ सेंसिटिव लिपोसम फॉर टारगेटेड कैंसर थैरेपी" हेतु "के.एस. कोरगाँवकर पुरस्कार" प्राप्त हुआ। इस शोध-पत्र के सहलेखक डॉ. सांद्रा ई.डिसूज़ा एवं डॉ. कौशला प्रसाद मिश्रा हैं। शोध-पत्र भारतीय जैव भौतिकी सोसाइटी के जैवभौतिकी पर राष्ट्रीय संगोष्ठी में प्रस्तुत किया गया, जिसका आयोजन 13-15 फरवरी 2007 के दौरान इंडियन नेशनल साइंस अकादमी, नई दिल्ली में हुआ । इस पुरस्कार में प्रशंसापत्र और रु. 1,500/- का नकद पुरस्कार दिया जाता हैं।

Mr Shailesh Sonar (a Ph.D. student under the BARC-University of Mumbai Collaboration Scheme) from Radiation Biology and Health Sciences Division, BARC

has received the "K.S. Korgaonkar Award" for his paper "A Novel Doxorubicin encapsulated pH-sensitive Liposome for Targeted Cancer Therapy". This paper co-authored by Dr Sandra E. D'Souza and Dr Kaushala Prasad Mishra was presented at the Indian Biophysical Society's (IBS-2007) National Symposium on Biophysics : Trends in Biomedical Research, held at the Indian National Science Academy (INSA), New Delhi, during February 13-15, 2007. The award consists of a citation and a prize of Rs. 1,500/-.

Dr V.C. Sahni

डॉ.वी.सी.साहनी को लेज़र-विज्ञान एवं नवीन प्रौद्योगिकी के विकास तथा इसके अनुप्रयोग में विशिष्ट योगदान हेतु इन्डियन फिज़िक्स एसोसियेशन के द्वारा वर्ष 2004 का " एम एम चुगानी " पुरस्कार से सम्मानित किया गया।

डॉ.साहनी की वर्तमान अनुसंधान रुचि में गतिवर्धक, सिंक्रोट्रॉन विकिरण स्रोत एवं इनका उपयोग, संघनित भौतिक पदार्थ, इलेक्ट्रान गतिवर्धक एवं लेज़र सहित भौतिक अनुसंधान हेतु विभिन्न प्रकार के विकसित उपस्कर तथा इनका अनुप्रयोग भी शामिल हैं।

ये वर्ष 2005 में भौतिकी प्रयोगात्मक अनुसंधान हेतु (SRS) भारतीय सिंक्रोट्रॉन विकिरण स्रोत (एस आर एस) इंडस-2 के कार्यक्रम का माध्यम रहे। भारत के इस सबसे बडे स्वदेश विकसित कण गतिवर्धक में विभिन्न प्रकार की प्रौद्योगिकी अपनाए जाने की विशिष्टता है।

डीएई /सीईआरएन सहयोग से डॉ.साहनी की जिनेवा/सीईआरएन में बन रहे विशाल कण गतिवर्धक लार्ज हेड्रोन कोलाइडर (LHC), हेतु उच्च गुणात्मक घटकों के विकास तथा वितरण हेतु रूपरेखा का प्ररूप बनाने में पहल है।

ये नैशनल अकादमी आफ साइन्सिस, भारत के सदस्य भी हैं। इस समय डॉ साहनी भौतिक वर्ग, भाभा परमाणु अनुसंधान केंद्र, मुंबई एवं आर आर सी ए टी, इन्दौर दोनों के अध्यक्ष हैं।

Dr V.C. Sahni was conferred the 'M.M. Chugani Award" for the year 2004, by the Indian Physics Association, for his outstanding contributions to basic sciences as well as to the development of new technologies and their applications.

Dr Sahni's current research interests include accelerators, synchrotron radiation sources and their utilization, condensed matter physics, building and using various kinds of advanced equipment for physics research and applications including electron accelerators and lasers. He has been instrumental in the commissioning of the INDUS-2, the Indian Synchrotron Radiation Source (SRS) for research in experimental physics in 2005. This particle accelerator, the biggest in the country, has the distinction of utilizing several technologies, developed indigenously. As part of DAE/CERN collaboration, Dr Sahni has spear-headed the design, development and delivery of prototypes of many high quality components and subsystems, for the Large Hadron Collider(LHC), the world's biggest particle accelerator, coming up at CERN, Geneva. Dr Sahni is also a fellow of the National Academy of Sciences, India. At present he is both Director, Physics Group, BARC and Director, RRCAT, Indore.

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