A PROJECT REPORT ON THE STUDY OF THE

INTEGRATED ENGINE REGULATOR KRD-99B

(The electronic hydro-mechanical control system of **AL31FP**)

A report submitted towards the fulfillment of requirements during the summer internship.

(16 June 2025 to 15 July 2025)

HINDUSTAN AERONAUTICS LIMITED

(SUKHOI ENGINE DIVISION)

SUNABEDA

KORAPUT, ODISHA – 763003

CERTIFICATE

This is to certify that the project entitled **"STUDY OF THE INTEGRATED ENGINE REGULATOR KRD-99B"** is a bonafide work carried out during summer training from **16.06.2025 to 15.07.2025** and is submitted by **Pranjal Panigrahi** (VT No.: 25-410), student of Electronics & Tele-communication Engineering Department, under the able guidance of **Shri B. Murali Krishna** (Chief Manager – Maintenance), Hindustan Aeronautics Limited, Sukhoi Engine Division, Sunabeda, Koraput, Odisha.

He has taken interest & zeal in the project & has worked with appreciable team work with other team members.

His conducts during the training are satisfactory & we wish him all success in future.

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Yours Sincerely

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CONTENTS

HISTORY OF HAL

(Hindustan Aeronautics Limited)


Seth Walchand Hirachand

The beginning of HAL can be traced to the year 1940 when a far-sighted industrialist, the late Seth Watchband Harahan, set up a company called Hindustan Aircraft Limited at Bangalore with the object of establishing an aviation industry that can manufacture, assemble and overhaul aircraft. Initially aircraft like Curtiss Hawk, Vulture Bomber and Harlow Trainer was taken up for manufacture and overhaul in collaboration with Inter Continental Aircraft Company of the USA.

With the escalation of the Second World War the government of India took over the management of the company in 1942 and handed it over to US Air force for repair and overhaul of various aircraft. The main activity for the next few years after the war was reconditioning and conversion of war surplus aircraft for the use of IAF and Civil Operators.

To fulfil the fresh mandate of the post independent India and to meet the challenges of open market economy of recent times the mission of the company has been redefined as:

To become a globally competitive aerospace industry while working as instrument for achieving self-reliance in design, manufacture and maintenance of aerospace defence equipment and diversifying to related areas, managing the business on commercial lines in a climate of growing professional competence.

In the six decades, HAL has spread its wings to cover various activities in the areas of design, development, manufacture and maintenance. Today HAL has 14 production divisions spread over at Bangalore, Nasik, Koraput, Kanpur, Luck now, Korowai, Hyderabad and Barrack pore. These divisions are fully backed by 9 design centres, which are co-located with the productive divisions. These canters are engaged in the design and development of combat aircraft, helicopter, aero engine, engine test beds, aircraft communication and navigation systems and accessories of mechanical and fuel systems and instruments.

The current program includes production of Dhruv an Advanced Light Helicopter, Jaguar, LCA, Su-30 MKI and upgrades of MIGs, Jaguar and Avro HS-748.

Hindustan Aeronautics Limited, KORAPUT DIVISION:

An agreement was signed in August, 1962 with the Soviet Union for manufacture of MiG-21 E7FL Air craft under license the Aeroengine Factory at Koraput (Odisha), the Air frame Factory at Nasik (Maharashtra), and the Avionics Factory at Hyderabad (Andhra Pradesh) have been set up to meet this requirement on the name of Aeronautics India Limited which was formed on April 1964 and new company under the name of Hindustan Aeronautics Limited was formed. The government sanction for the first phase of construct of the Aero engine factory at Sunabeda (Koraput) was accorded March 1964 and the factory started manufacture of R11F2-Series-III engines for fitment on MIG-21FL Aircraft from 1969 onwards. The first engines

of imported category manufactured in December 1968 and various categories of engines were produced during the subsequent years. The first raw material engine was produced in February 1971.

The production programmed for the factory also includes manufacture of forging and casting required for MiG-Aircraft. To meet the Air force requirement for improved fight interceptor aircraft, an agreement was signed with USSR in August1976 for manufacturing MiG-21BIS Aircraft. The power plant of this aircraft is the R25 turbojet engine. The government approval for setting up capital facilities was accorded in October 1977. The first engine of imported category delivered to HAL Nasik Division in the year 1978-79. The FI raw material engine was delivered during January1983. With signing of the inter-governmental agreement for manufacture of MiG 27M Aircraft on 19th March 1982, this Division would be involved in the manufacture of R-29B series of engine from the year 1984-85.

In order to attain self-sufficiency and to avoid difficulties regarding supply of Raw Material & other layout items from USSR, it was decided to provide indigenous supply of spares manufacturing for Overhaul/maintenance of the fleet. The Government approval for undertaking the tax received during 1977-78 and the indigenisation plan was formed to tackle,

- ARS and first moving spares.
- Metallic material.
- Non-metallic material.
- Ready-made articles.

The various departments present in this division are:

Forge, Foundry, Tool room, Small parts and fuel, Heat metal and welding, Blades, Electroplating, Heat treatment, Compressor, Turbine, CNC, Assembly, Overhaul, Gear, Test house, Maintenance.

There are seven divisions of HAL in India. The divisions are:

1. Bangalore Division (Karnataka), Barrackpore Division (West Bengal) (It is a branch of Bangalore Division)
2. Nasik Division (Maharashtra)
3. Koraput Division (Odisha)
4. Hyderabad Division (Andhra Pradesh)
5. Lucknow Division (Uttar Pradesh)
6. Kanpur Division (Uttar Pradesh)
7. Korwa Division (Uttar Pradesh)

Products of HAL, Koraput Division:

The final product manufactures in HAL, Koraput Division are MiG engine and Sukhoi. Some components of MiG Engines are being originally manufactured where some other parts are usually imported from other countries. Besides new production, old and damaged Mig engines are repaired in this division HAL, Koraput Division itself is a sophisticated aero engine industry. The state of art-technology of required for an aeronautical industry is existing in HAL, Koraput Division. While the division started manufacturing and overall MiG 4 Aero engine over the years. It has come in a long way in a long way in manufacturing and overhauling of engine. The indigenous names of HAL, Koraput Division product are given in the table laid below:

INDIGENOUS NAMES OF HAL PRODUCTS:

SL. No.	AIRCRAFT	ENGINE	INDIGENOUS NAME
1	MIG-21FL	R11-F20	BADAL
2	MIG-21M/MF	R11-F2S/F2SK	TRISHUL
3	MIG-21BIS	R-25	VIKRAM
4	MIG-23MF	R-29	RAKSHAK
5	MIG-23BN	R-29B	VIJAY
6	MIG-25	R-29B	GARUD
7	MIG-27M	R-29B	BAHADUR
8	MIG-29	RD-33	VAJ
9	GNAT	ORPHEUS-701	AJEET
10	HF-24	ORPHEUS-703	MARUT
11	HJT-16	VIPER-11	KIRAN
12	JAGUAR	ADOUR MK-803	SHAMSHOR
13	MIRAGE-2000	M-53	VAJRA
14	HS-748 (AVRO)	DART-531	CHITRA
15	ALLOUTEE	ARTOUSTE-IIIB	CHE (HELICOPTER) CHEETAH
16	AN-32	----------	SUTLUJ
17	MI-8	----------	PRATAP
18	MI	----------	AKBAR
19	HPT-32	PISTON ENGINE	----------
20	SU-30	AL31FP	SUKHOI

For the last 2 years the Division has started overhauling RD-33 engines required for Mig-29 under the license with USSR. The division at present is geared up to go in producing of MKI SUKHOI-30 Hypersonic fighter plane engines. The project work has convinced now.

The following are the products developed and designed by HAL:

SL. NO.	NAME OF THE CRAFT	PURPOSE
1	HT	TRAINER
2	PUSHPAK	TRAINER
3	KRISHAK	AIR OBSERVATION
4	MARUT (HF-24)	GROUND ATTACK
5	MARUT (TRAINER)	ADVANCED JET TRAINER
6	KIRAN MAKE-II&IA	AGRICULTURAL
7	BASANT	GROUND ATTACK
8	AJEET	AB TRAINER
9	HPT-32	TRANSONIC JET
10	AJEET	TRAINER

HAL has five main complexes in India:

1. Bangalore complex.
2. MiG complex.
3. Accessories complex
4. Design complex.
5. Helicopter complex.

Bangalore complex:

- Aircraft Division - Manufacturing Jaguar Aircrafts
- Engine Division - Manufacturing Jaguar Engines
- Indl& Marine Gas Turbine (IMGT)
- Forge and Foundry Division - Manufacturing high Precision castings and forgings
- Overhaul Division - Overhaul of Jaguar and other Engines
- Airport Service Center - Manufacturing launching of pads and common satellites
- Aerospace Division
- Central Material & process Laboratory

MiG complex:

- Aircraft Division Nasik - Manufacturing and Overhaul of airframes.
- Aircraft Overhaul Division, Nasik

- Engine Division, Koraput - Manufacturing and Overhaul of MiG engine
- Sukhoi Engine Division, Koraput
- Aircraft Upgrade R&D Centre, Nasik
- Gas Turbine R&D Center, Koraput

Accessories complex:

- Avionics Division Hyderabad - Manufacturing of navigational equipment
- Transport Aircraft R&D Center, Kanpur - Manufacturing of passenger Aircraft and gliders.
- Accessories Division, Lucknow - Manufacturing of hydraulic pumps, fuel pumps and stator generator.
- Avionics Division, Korwa – Manufacturing of advanced navigational equipment.
- Strategic Electronics R&D Center – Hyderabad
- Aircraft System & Eqpt R&D Center - Lucknow, Korwa
- Transport Aircraft R&D Center - Kanpur

Design Complex:

- Aircraft R&D Center
- Mission & Combat System R&D Center
- Engine Test System R&D Center

Helicopter Complex:

- Rotary Wing R&D Center
- Helicopter Division
- Helicopter MRO Division
- Barrackpore Division
- Composite Manufacturing Division

Head Office:

The head office of HAL is located at Bangalore another at New Delhi under the minister of defense.

- New Delhi
- Mumbai
- Chennai
- Visakhapatnam

Locations:

INTRODUCTION

The engine electronic control unit KRD is a part of the electronic hydro-mechanic system for engine adjustment and control. The KRD-99B adjust the engine parameters and gives the signals for the engine in conjunction with hydro-mechanic units NR-31VT1 (fuel control unit), RSF-31VT1 (nozzle and reheat control unit) and 4033A flow metering device.

Complex engine regulator is to regulate the engine and signals are supposed to be received by the engine and aircraft system. KRD-99B is an electronics-controlled device which works in a closed loop system with the engine AL31FP.

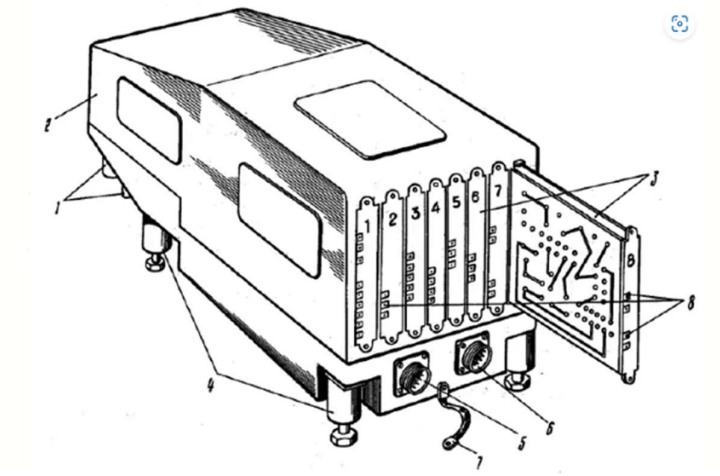
PURPOSE

Controls the engine parameters in association with hydro-mechanical regulation system. It sends the signal to the engine control devices and to air-borne recorders.

SPECIFICATION

Nominal operational voltage is 27±0.3v. but can work up to 18v with increase in tolerance of parameters by 50%. Max current by 10amps.

LOCATION: On Aircraft



(*Fig: KRD-99B With its PCB CARDs and the labelling's)*

1. Connector
2. Casing
3. PCBs (two sided)
4. Shock Absorbers
5. Connector X1K
6. Connector X1K
7. Strip of Earthing
8. Adjustment screws for changing control laws

INTEGRATED REGULATOR KRD-99B (REGULATION & OPERATION)

The regulator is a part of electronic-hydraulic system of adjusting and controlling of engine and is intended for adjusting of parameters of engine and distribution of signals in the electro circuit of controlling of engine, and also distribution of the information about the operation of engine and regulator in data recording devices. Together with hydro mechanical units HP and PCP, the regulator ensures the following:

- Adjustment (restriction) of the maximum frequency of rotation n1 (Low Pressure Rotor) depending on temperature of stopped flow of air 101
- Adjustment (restriction) of the maximum frequency of rotation n2 (High Pressure Rotor) depending on temperature of stopped flow of air 101
- Adjustment (restriction) of the maximum temperature of gas T04 behind the low-pressure turbine depending on temperature of stopped flow of air T01
- Adjustment of angle of turning (X1 depending on frequency of rotation) and temperature of stopped flow of air T01
- Anti-hunting protection and increase of stocks of stability of operation of the engine during action of command
- Automatic start-up during run-down
- Control with ignition of after burning and signal system about its ignition
- Control of switching on of cooling of turbine (unit T)
- Restriction of temperature of gases for THD on start of engine
- Formation and distribution of discrete signals about operating modes of engine in systems of automatics of engine and aircraft
- Inspection and signal system of limiting modes of the engine
- Formation and distribution of signals about limiting modes of operations turbo starter
- Continuous automatic control of channels of regulator in flight with distribution of signals at their failure on signal system
- Pre-fight inspection of regulator
- Distribution of signals about operating mode of engine on voice informer
- Distribution of signals in systems
- Blocking of emergency discharge of fuel and switching on of fuel by-pass

Into structure of regulator enter:

- Regulator KRD-99B - 1 piece
- Moving sensor DP-110 - 2 piece

Units of regulator are placed on the aircraft as follows:

- KRD-99B in fuselage of aircraft
- DP-110 on engine

- The KRD-99B system consists of KRD and two DP_110 position pick-up sensors. The KRD operates with the help of different hydro-mechanical aggregates of engine. The KRD operates with 27v dc.

The hydro-mechanical aggregates are listed below:

- **HP-31BT (main fuel pump):** The pump functions for fuel supply and controlling of primary flow channel and fuel supply to A/B combustion chamber during low consumption modes.
- **RSP-31BT (reheat and jet nozzle controller):** This controller is meant for regulation for A/B modes by changing the fuel supply to reheat combustion chamber and controlling the jet nozzle throat.
- **4033A (reheat initiating unit):** This unit is meant for initializing reheat in A/B.

FUNCTIONS OF KRD-99B:

Based on the functionality of KRD 99B is divided into 12 blocks. Out of 12 blocks, 8 are in front panel of KRD-99B and the remaining four are inside the KRD-99B. Moreover, out of these visible blocks, 6 of them are accessible for regulation and the remaining 2 are in accessible for regulation.

- Regulation of RPM of LPR (N1)
- Regulation of RPM of HPR (N2)
- Regulation of maximum gas temperature of LPT (T4)
- Regulation of alpha-1 vs N1
- Surge protection system
- Automatic start during run down of rotor
- Control reheats engagement
- Issue of signal that ignition takes place
- Continuous automatic monitoring of channels of regulator for sending of signals to warning system in case of their failure
- Blockage of emergency fuel drains on N2 less than equal to 57%
- LimitsT4 during starting of engine
- Generates and receives discrete signal in different rating
- Sending of signal to system "Tester" to the unit of voice information system
- Sending of command for fuel by pass start in case of fuel overheating at intake of regulator pump
- Sending of command "RPM DROP" in case of oil
- Sending "CO" at maximum and minimum oil pressure
- Sending "CO" in case of increase N1=104%.
- Sending "CO" in case of achievement of limiting vibration.

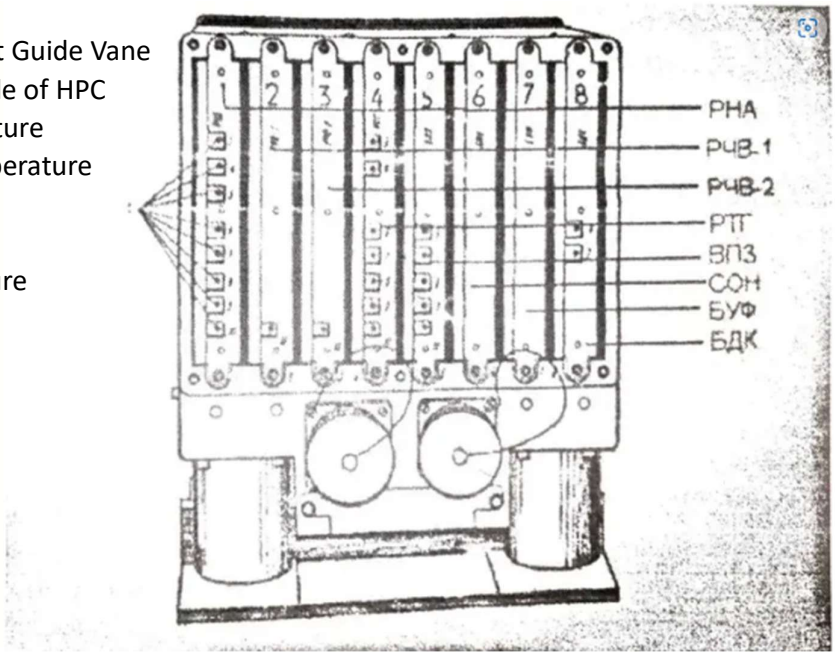
THE VARIOUS REGULATION BLOCKS OF KRD-99B:

SL. NO	BLOCKS	CONTROLLING PARAMETERS
1	РЧВ-1	Channel of regulator of LPR RPM-N1
2	РУВ-2	Channel of regulator of HPR RPM-N2
3	PI	Channel of regulator of gas temperature limitation after LPT
4	РНА	Channel of regulator of LPC
5	БУФ	The control block and the signalling system after burning
6	KYO	Control channel for turbine cooling
7	БДК	The unit of sending digital commands
8	СОН	The fault detection system
9	GAT	Controlling unit of GTDE
10	LUNM	Pulse duration modulator
11	ВИП	The secondary power source
12	ВПЗ	Surge Protection Unit

- Rchbe – 1: Regulation of RPM of LPR (n1).
- Rchbe – 2: Regulation of RPM of HPR (n2).
- Rtege: Regulation of maximum gas temperature of LPT (T4), Limits T4 during starting of engine.
- RNA: Regulation of a1 vs N1.
- Bapaja: Surge protection system (Automatic starting during Run down of rotor).
- Boop: Controls reheats engagement (Issue of signal that ignition takes place).
- Bkete: Monitors health parameters of GTDE.
- Bedeke: Generate and receives discrete signal in different ratings.

PARAMETERS USED IN KRD-99B:

- N1-RPM of LPCR
- N2-RPM of HPCR
- ALPHA 1 - angle of Inlet Guide Vane
- ALPHA 2 - angle of guide of HPC
- TO1 - inlet air temperature
- TO4 - exhaust gas temperature
- PO1 - inlet air pressure
- Pm - oil pressure
- Pck - differential pressure
- RTM - oil temperature
- RTT - fuel temperature



POWER SUPPLY:

The control unit takes power from a single-wire two-channel DC power-supply system with rated voltage of 27Vthrough the decoupling diodes installed inside the KRD.

Note: Signalling system and VIRS circuits takes power through the self-contained protective devices.

In the emergency operation conditions of power-supply system, the KRD continues to operate until the voltage decreases to minimum 18 V. In these conditions, the tolerance for the KRD parameters increases by 50%. The KRD consumes maximum 10-A current, the current for the actuators is included in this value. The KRD becomes ready for operation after 1 sec from connection to 27-V power supply.

IN CASE OF KRD FAILURE:

Limitation of engine parameters in maximum and after burner modes is provided by the centrifugal limiter of (n2) in aggregate H.P.

During normal operation the centrifugal limiter is adjusted above the KP LIMITER AND DOES NOT interfere with the operation of KRD.

In case of failure of KPA, THE CENTRIFUGAL limiter is automatically lowered Apart from these sensors, some of the sensors used are:

Differential pressure indicator CM-0.4T:

Purpose: dropping of pressure in fuel filters and in oil fillers.

Working: during clogging of filtering elements of filters, drop of pressure on filtering elements increases and at **P=0.4 kg/cm^2** working unit of drop. Sp.0.4 et-1cuts in (shorting of contacts).

Species: insulation resistance > 20 ohms.

Location: on casing of filter of fuel system of low pressure.

Temperature sensor:

Purpose: temperature of fuel at inlet of engine & temp of oil.

Principle: change in resistance depending upon temperature.

Working: between pin 1&2, 3&4 location in pipeline of fuel outlet from 24H to filter of fuel system of low pressure.

Vibration sensor mv-27-1:

Purpose: to measure the vibration of engine casing.

Principle: electromagnetic induction coil rigidly connected to the casing of sensor. When centralized located permanent magnet moves in response to the vibration the voltage is induced in the coil which is sent to KRD.

Surge sensors (SPT-88-2.2U):

Location: bypass duel casing.

Purpose: to sense the magnitude and sign of dynamic pressure change in terms of electrical signal and fed to KRD.

Principle: electromagnetic induction.

Operation: translation of sensed dynamic air pressure differential in to the movement of the switch sensing element (membrane) the deflection of the membrane changes the gap between the armature and magnetic circuit of the differential transformer there by changing the magnitude of the mutual induction between the primary and secondary winding.

Ionization flame sensor:

Purpose: indication of presence of ignition in after burner chamber. It sends "Reheat ON signal KRD".

Principle: ionization of gas results into higher values of current.

Operation: when the A/B is ON ionized gas flows between the flame detector electrode. The high frequency ac voltage would ionize the gas in between resulting in the large value of current.

Location: in afterburner casing

Electrical control system: LOOM/LOMB its used to interconnect all types of electrical aggregates or components. For their interconnection some special types of wires will be used for this purpose. Primary connections will be ade on printed circuit board of 72 pins.

There exist 2 types of LOMBS:

1. Auxiliary loom can electrically control the nozzle system.

2. Main loom can electrically control the engine.

CONCLUSION:

KRD-99Bis an electronic control unit. HINDUSTAN AERONAUTICS LIMITED, being only the Sukhoi 30MKI engine manufacturer in the Eastern India, which are the frontline fighters & are backbone to the INDIAN AIRFORCE. This project report has covered the electronics overview, electrical overview, various sensors and panels and details of control and instrumentation required in theKRD-99B controller of the engine.