Information regarding the Lockheed F-104 Starfighter

F-104 Electronic Systems

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1. ELECTRONIC SYSTEMS

When the F-104G was evolved from earlier versions of the Starfighter, the principal area of new design and development was in its lightweight, integrated, multipurpose electronic system. The electronic system comprises approximately 7% of the Starfighter's weight empty, and represents approximately one-third of its material cost. The integrated system includes the following sub-systems:

Communication and Identification
UHF (Ultra High Frequency) Communication Radio
Emergency UHF Radio
Identification of Friend or Foe (IFF)

Navigation and Basic Flight Reference
Inertial Navigator
Air Data Computer
Position Homing Indicator System (PHI)
Tactical Air Navigation (TACAN)
Gyro Compass System
Emergency Attitude Indicator

Automatic Flight Control System (AFCS)
Automatic Pilot
Three-Axis Stability Augmentation
Automatic Pitch Control

Fire Control
Search and Ranging Radar (NASARR), with modes for air-to-air and air-to-ground operation.
Optical Director, Computing-type Sight
Infrared Tracking Sight
Missile In-range Computer
Bombing Computer or LABS Dual Timer
GAM 83A (Bull Pup) Guidance Control

Several electronic sub-systems perform a principal function of supplying data to other sub-systems. Nearly all of the sub-systems are interconnected into at least one other sub-system.
This integration of the electronic system components was necessary to meet size and weight limitations. It was also necessary to meet the need for precise basic data in navigation, automatic flight control, and fire control computations. The concept of system integration precluded redundant installations, and permitted the single system to be designed to more rigid precision and reliability criteria. Some of the sub-systems are discussed in the following paragraphs.

1.1 UHF communication

A command radio provides voice transmission and reception in the UHF (Ultra High Frequency) range, 225 to 399 megacycles. The set provides 3,500 channels, 27 of which may be pre-set in order that often-used channels can be selected quickly. A separate emergency UHF transceiver that can be powered from the battery bus is also provided. Two flush-mounted antennas, one on the top of the fuselage and one on the bottom, are controlled by a selector circuit, which automatically selects the antenna receiving the stronger signal. The pilot can also select the antennas manually.
Part of the UHF radio is an interphone system that provides amplification and control of all audio signals transmitted and received by the various systems. It also provides communication between the cockpit and the ground crew.
An emergency UHF communication radio is provided for two-way communication in the 242-mc to 244-mc frequency band, in case the primary UHF system should fail to work. The emergency system is packaged in a console-mounted unit. Two or three channels can be selected, depending on the particular unit installed. One of these channels is the 243-mc-guard channel. The system operates with 28 volt DC power, and can transmit or receive, using the airplane batteries.

1.2 Identification (IFF) System

A pulse type IFF transponder automatically transmits identification signals whenever interrogation stations challenge it. It is capable of transmitting SIF (Selective Identification Feature) replies. The IFF system is controlled from two panels on the pilot's right-hand console.

1.3 Inertial Navigator

See above

1.4 Position and Homing indicator (PHI) System

See above

1.5 Tactical Air navigation (TACAN) system

The TACAN system consists of a receiver-transmitter unit installed in the E-compartment, a control panel on the pilot's right console, and an antenna system shared with the IFF. (Both systems operate in the 1,000-megacycle band.) The TACAN provides continuous bearing and range to any selected station up to approximately 300 nautical miles, line-of-sight distance. Visual range and bearing are read on the position and homing indicator mounted on the pilot's main instrument panel.

1.6 C2-G Compass

A magnetic-slaved directional gyro provides stabilized magnetic heading as a back-up source of heading information. The system consists of a gyro amplifier, a compass control panel, a power converter, and a flux valve-sensing unit. This system also can be operated as a directional gyro at the pilot's discretion. The display is on the PHI system indicator. F-104's are being fitted with a device that automatically selects C2-G heading information for dead reckoning navigation if the inertial reference source should malfunction.

1.7 Back-up Attitude Indicator

Some Starfighters are being equipped with an independent, self-contained, attitude gyro indicator. This system will back-up the inertial navigator (See last Zipper) in the event of a power failure. Several different back-up systems have been selected for the F-104's being produced by various Air Forces.

1.8 Air Data Computer

The air data computer is another system installed in the electronics compartment. It accepts input of total temperature, angle of attack, pitot pressure and static pressure .It computes electrical signal outputs proportional to air density ratio, angle of attack, impact pressure, total pressure, altitude, and true air speed. It supplies this information to other systems in the form of electrical analog signals tailored to the requirements of each of those systems. It is also designed so that no malfunction of one system could feed back through the computer, and affect the function or accuracy of any other system.

1.9 Automatic Flight Control System

The automatic flight control system consists of a computer installed in the electronics compartment, a cockpit control panel, a roll rate gyro, a pitch yaw rate gyro, and aileron and stabilizer parallel servos. This system gives the pilot several modes of operation, varying from limited control to completely automatic flight control. One feature is control stick steering, which allows the pilot to manoeuvre without disengaging the system. The autopilot is so arranged that it will disengage should any malfunction develop in the unit itself or in its related systems. In the event of a malfunction, a visible warning light will signal to the pilot. The pilot can over-ride the system with a 5 to 8 pound force exerted on the control stick. Interlocks are included to prevent engagement of conflicting operational modes, and to provide function priority. The system is designed to provide roll and pitch attitude stabilization, altitude hold, Mach number hold, standard turns, TACAN homing, inertial homing, heading hold, and automatic pitch trim.

1.10 Fire Control

The Starfighter's fire control and navigation search and ranging radar is a lightweight, multipurpose system designed by the North American Aviation Company. It is called NASARR, which stands for North American Search And Ranging Radar. The system functions in two basic modes: air-to-air and air-to-ground. Search, tracking, lock-on, and range information are all-available in the air-to-air mode. Lead-angles for firing the gun or unguided rockets, together with breakaway distances, are computed by the systems armament control computer and displayed on the radarscope. This element is not used in air-to-ground operation. The air-to-ground modes of operation include ground mapping, contour mapping, and terrain avoidance. These modes allow low –altitude blind penetration, en route navigation, and target identification. The radar locates the target and supplies range, range rate, relative bearing, and elevation analog signals to the computer. The computer uses this information, together with roll and pitch data from the inertial platform, and information from the air data computer, to automatically solve for release and firing times. The computer also produces visual steering signals, which enable the pilot to place the aircraft in firing position.

The radar antenna, transmitter, and receiver are mounted inside the glass filament nose cone. Its computer, power supply, and electronic control amplifier are installed in the electronic compartment. The control panel is on the pilot's left console, and the indicator mounts in the lower centre of the pilot's forward instrument panel.

1.11 Sight and Missile range Computer

The optical sight, servo amplifier, infrared sight, and gun sight camera are all mounted forward of the main instrument panel, with the sight combining glass extended upward in front of the centre windshield panel.

The integrated sighting system consists of the optical director (computing type) sight and an infrared tracking sight. When attacking with the gun the NASARRR system armament control computer can provide computed lead-angle information to the director sight for positioning the sight reticle on the combining glass. The pilot positions the airplane so that the target is centred in the reticle, and fires when the range cursor indicates the target is within range. The infrared tracking sight projects a representation of the target on the sight combining glass so that actual visual contact with an airborne target is unnecessary. The gun-sight camera photographs the sight picture through an optical periscope.

The optical sight can also be used for dive-bombing and strafing by caging the reticle in a fixed position and lowering its position to compensate for the vertical speed component imparted to the weapon at its release. The pilot has a manual control for setting the reticle to various depressed positions, depending on the weapon and mode of attack. The missile in-range computer supplies in-range data to the radar system and the sight for attack with sidewinder 1A missiles. The computer automatically determines the launch range and G limits within which the missile can be effectively released. These computations are based on range and range-rate inputs from NASARR.

1.12 Bombing Systems

A bomb computer is installed in some F-104G's It is located in the electronics compartment with its control panel on the pilot's right console. This equipment is integrated with the rest of the armament system to give the Starfighter a capability for high level and low level bombing plus the bomb tossing techniques, and the capability of blind bombing. Other F-104G's may be equipped with provisions for a LABS dual timer which supplies information for certain pre-planned bomb delivery manoeuvres.