70.00 CONTENTS

GENERAL

R The RR RB 211 TRENT engine is a high bypass ratio turbofan.

DESCRIPTION

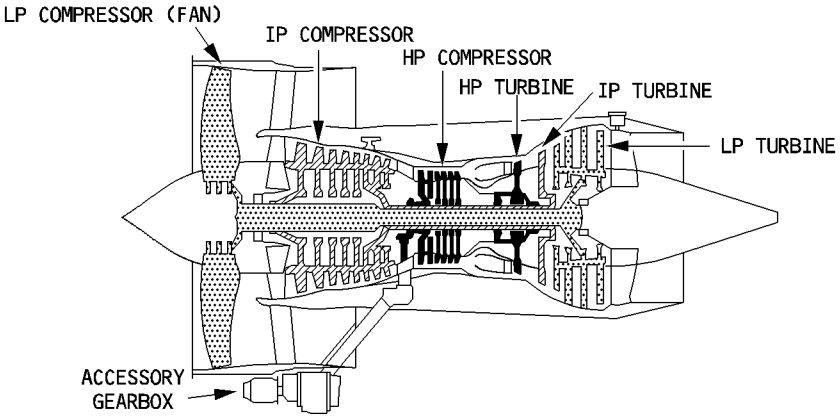
– **Low-pressure (LP) compressor / turbine**
The low-speed rotor (N1) consists of single stage LP compressor (front fan) connected to a four stage LP turbine.

– **Intermediate pressure compressor / turbine**
The intermediate speed rotor (N2) consists of a eight-stage intermediate pressure compressor connected to a single-stage IP turbine.

– **High-pressure (HP) compressor / turbine**
The high-speed rotor (N3) consists of a six-stage HP compressor connected to a single-stage HP turbine.

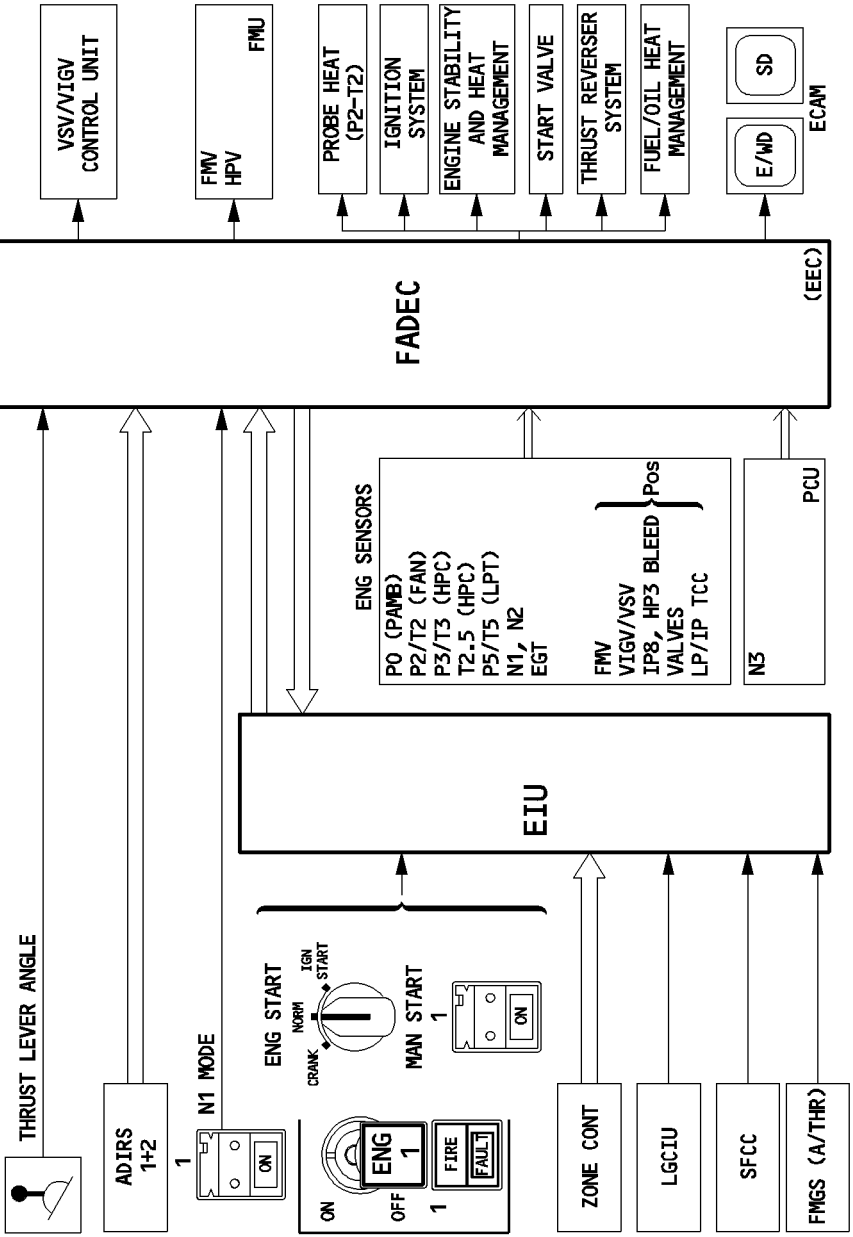
– **Combustion chamber**
The annular combustion chamber is fitted with 24 fuel nozzles and 2 igniters.

– **Accessory gearbox**
The accessory gearbox, located at the bottom of the fan case, receives torque from horizontal HP rotor drive shaft and drives gearbox mounted accessories.



GENERAL

Each powerplant has a FADEC (Full Authority Digital Engine Control) system.
FADEC, also called the electronic engine control (EEC), is a digital control system that performs complete engine management.
FADEC has two-channel redundancy, with one channel active and one in standby.
If one channel fails, the other automatically takes control.
The system has a magnetic alternator for an internal power source.
FADEC is mounted on the fan case.
The engine interface unit (EIU) transmits to FADEC the data it uses for engine management.



GFC5-01-7020-002-A050AA

FUNCTIONS

The FADEC system performs the following functions:

Control of gas generation
- control of fuel flow
- acceleration and deceleration schedules
- variable stator vanes/variable inlet guide vanes and IP/HP bleed valve schedules.
- control of turbine clearance
- idle setting

Protection against engine exceeding limits
- protection against N1, N2 overspeed (controlled by the overspeed protection unit)
- turbine overspeed
- monitoring of EGT during engine autostart on ground.

Power management
- automatic control of engine thrust rating
- automatic reversion to N1 mode
- computation of thrust parameter limits
- manual management of power as a function of thrust lever position
- automatic management of power (A/THR demand).

Automatic engine starting sequence
- control of :
  - the start valve
  - the HP fuel valve
  - the fuel flow
  - the ignition
- monitoring of N1, N3, FF and EGT
- initiation of abort and recycle (on the ground only)
- auto relight and quick relight functions.

Manual engine starting sequence
- passive monitoring of the engine
- control of:
  - the start valve
  - the HP fuel valve
  - the ignition

Thrust reverser control
- Actuation of the blocker cowls.
- Engine setting during reverser operation

Transmission of engine parameters and engine monitoring information to cockpit indicators
- The primary engine parameters,
- The starting system status,
- The thrust reverser system status,
- The FADEC system status,
- Secondary engine parameters (oil temperature, nacelle temperature, oil filter clogging and fuel filter clogging).

Computation of fuel used
- Integration of fuel flow.

Management of engine heat
- Control of turbine case, bearing and gearbox cooling.

Cooling of FADEC

Detection, isolation and recording of failures

Protection against fan stall

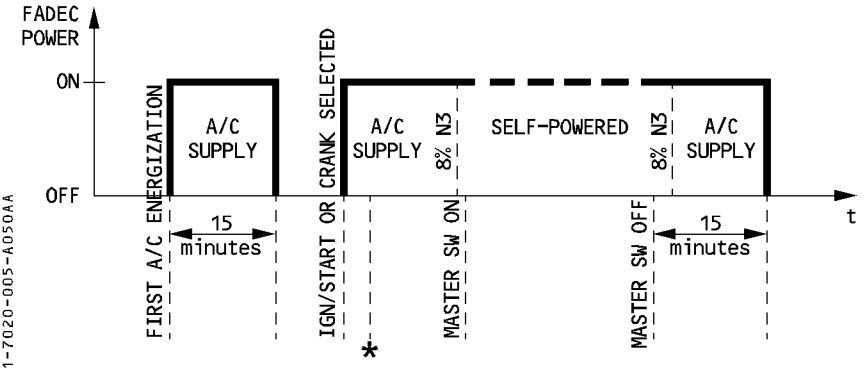
R
- Modified Engine Acceleration Schedule for Take Off (MEASTO) : A logic that ensures a progressive thrust is automatically set during the takeoff roll. Engine acceleration is controlled with an "EPR/second" rate in EPR mode.
- Stall recovery logic : When a fan stall is detected, a logic is triggered to clear this fan stall. The fuel flow is forced to idle and remains idle until engine shut down.

POWER SUPPLY

The FADEC system is :

- Powered by the aircraft's electrical circuit below 8 % N3, via the Power Control Unit (PCU) which converts 115 VAC into 22 VDC.
- Self-powered above 8 % N3.

R FADEC ELECTRICAL SUPPLY LOGIC

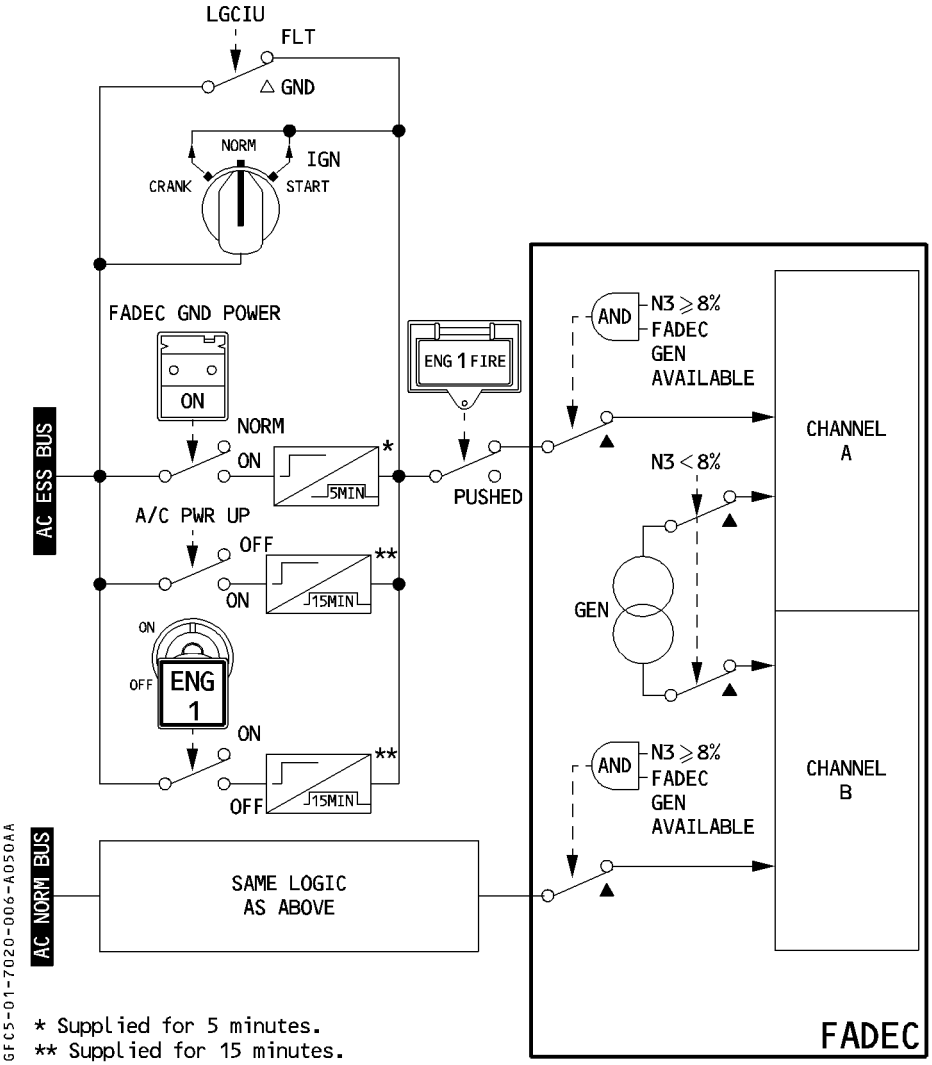


* : If the ENG START selector is set to the NORM position before engine start, FADEC supply is cut off.

FADEC POWER SUPPLY

FOR INFO

R



GF65-01-7020-006-A050AA

* Supplied for 5 minutes.
** Supplied for 15 minutes.

GENERAL

A FADEC dedicated to each engine controls thrust.
The pilot uses the thrust levers to set the thrust in manual mode, and the FMGS sets the thrust in automatic mode.
The FADEC prevents the thrust from exceeding the limit for the thrust lever position in both manual and automatic modes.
The engine thrust setting is made through control of the Engine Pressure Ratio (EPR).
EPR = low pressure turbine exhaust pressure (P5)/ Engine air inlet pressure (P2).

ENGINE POWER SETTING

Two modes of power setting, EPR and N1 modes are used for engine control depending on the availability of air data inputs to the FADEC which are used for rating computation.
Two sources of air data are used by the FADEC :

– either engine data : P0 static pressure
P2 total air pressure
T2 total air temperature
– or ADIRS 1 or 2 data : Ps equal to engine P0
Pt equal to engine P2
Tt equal to engine T2

Thrust computation for both engines is mainly based on one ADIRS data. This ensures engine thrust symmetry.
A comparison between ADIRS 1, ADIRS 2 and engine data is made by the FADEC to determine the source to be validated and the mode to be used.

EPR MODE

EPR mode is the normal mode to control the thrust.
The required EPR is set by controlling the fuel flow.
The FADEC computes the command EPR as a function of :
– Thrust Lever Angle (TLA)
– Altitude
– Mach number
– Air data (static pressure, total air pressure/temperature)
– Service bleed.

Note : During reverse operation, the thrust is controlled as a function of N1.

N1 MODE

In the event of no EPR available the affected FADEC will automatically revert to N1 mode. At the reversion to N1 mode, an equivalent thrust to that achieved in EPR mode is provided until a thrust lever position change.
Autothrust control is no more available. ALPHA FLOOR protection is lost.
In case of dispatch in N1 mode, flex take-off is not available. ALPHA FLOOR protection is lost.
Depending on the failure case leading to EPR mode loss the FADEC will revert to either rated or unrated N1 mode.

RATED N1 MODE

An automatic reversion to rated N1 mode occurs when :
– engine P2 and/or P5 are not available,
– or, engine P2 lower than ADIRS Pt.
The FADEC will compute an EPR COMMAND depending on TLA, then convert it into a N1 COMMAND as a function of Mach.
The rated N1 mode can also be manually selected through the ENG N1 MODE pushbutton on the overhead panel.

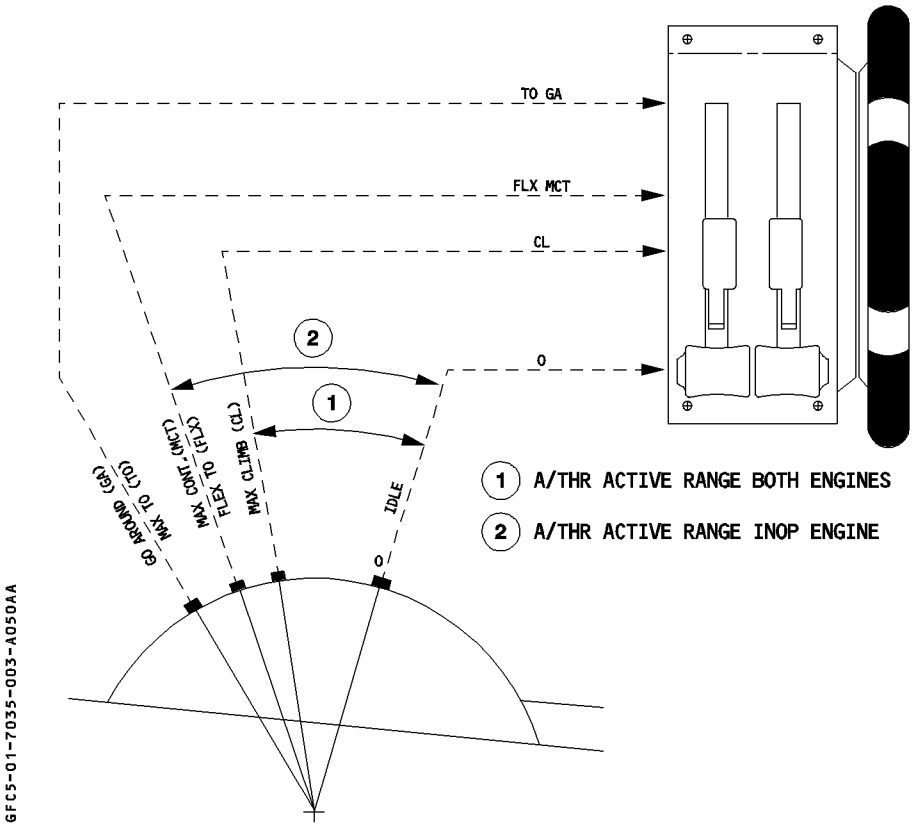
UNRATED N1 MODE

An automatic reversion to unrated N1 mode occurs when :
– engine P2 and ADIRS 1 + 2 Pt are not available,
– or, engine T2 and ADIRS 1 + 2 Tt are not available,
– or, engine P0 and ADIRS 1 + 2 Ps are not available.
The N1 is defined as a function of TLA and altitude and is limited by the FADEC to either the smaller of N1 max or N1 redline (if T2 is available) or N1 redline (if T2 is not available).
The N1 rating limit, N1 TLA and N1 max indications on ECAM E/WD are lost.

EPR RECOVERY LOGIC

With the FADEC in either rated or unrated N1 mode, switching OFF the ENG N1 MODE pushbutton on the overhead panel will permit to return to the EPR mode if the failure has disappeared.

THRUST LEVERS

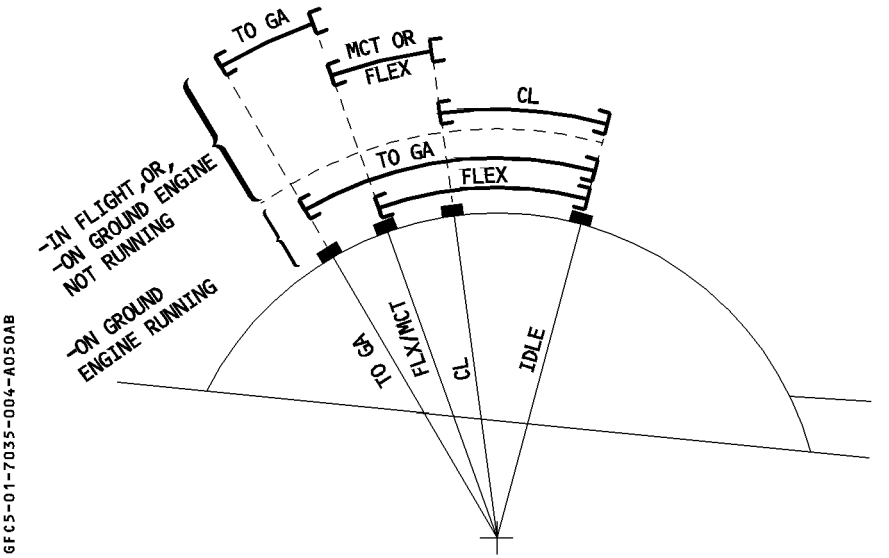


The thrust levers can only be moved manually.
They move over a sector that is divided into 3 operating segments.
The sector has 4 positions defined by detents or stops.
Thrust lever position is transmitted to the FADEC which computes and displays the thrust rating limit and the EPR for that Thrust Lever Angle (TLA).

THRUST RATING LIMIT

The FADEC computes the thrust rating limit for each thrust lever position, as shown below.
If the thrust lever is set in a detent, the FADEC selects the rating limit corresponding to this detent.
If the thrust lever is set between two detents, the FADEC will select the rating limit corresponding to the higher detent.

EPR RATING LIMITS :



GFC5-01-7035-004-A050AB

THRUST CONTROL

MANUAL MODE

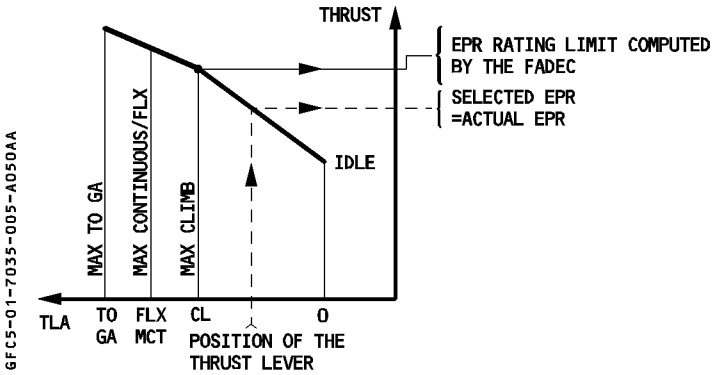
The engines are in the manual mode, provided the A/THR function is:

– Not armed, or

– Armed and inactive (thrust lever not in the A/THR operating range and no alpha floor).

In these conditions, each engine is controlled its thrust lever position.

The pilot controls thrust by moving the thrust lever from IDLE to TOGA positions. Each
R thrust lever position within these limits corresponds to an EPR.
R When the thrust lever is in a detent, the corresponding EPR is equal to the EPR rating limit, computed by the FADEC for this engine.



When the thrust lever is set in FLX-MCT detent :

– **On the ground :**

The engine runs at the flex takeoff thrust rating, if the MCDU has selected a flex takeoff temperature that is higher than the current total air temperature (TAT).
Otherwise, the engine produces maximum continuous thrust (MCT).

Note : A FLEX TEMP change during takeoff has no effect on thrust.

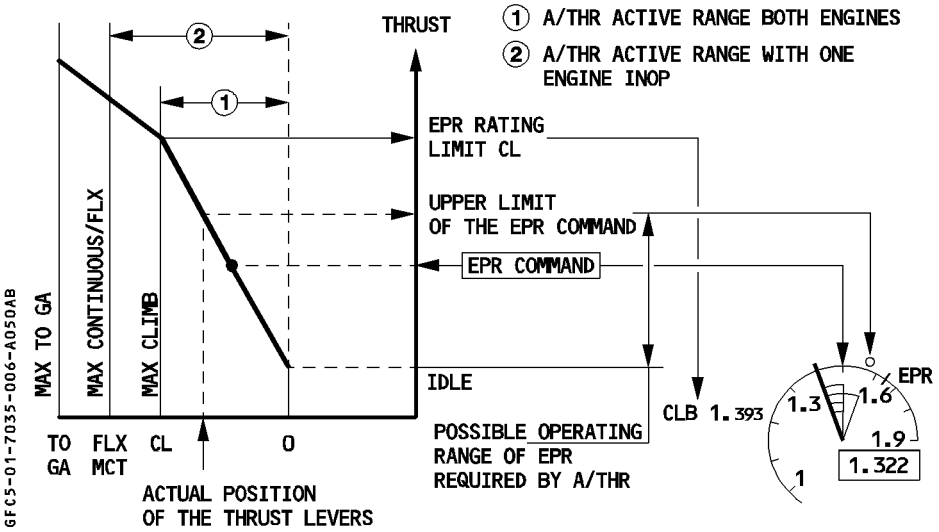
– **After takeoff:**

The pilot can change from FLX to MCT by moving the thrust lever to TOGA or CL, then back to MCT. After that, he cannot use the FLX rating.
The pilot can always get MAX TO thrust by pushing the thrust lever all the way forward.

Note : Setting the thrust lever out of the FLX MCT detent, without reaching TOGA or CL detent, has no effect.

AUTOMATIC MODE

In the autothrust mode (A/THR function active), the thrust is computed by the FMGC and is limited to the value corresponding to the thrust lever position (except if the alpha-floor mode is activated).



INDICATIONS ON FMA

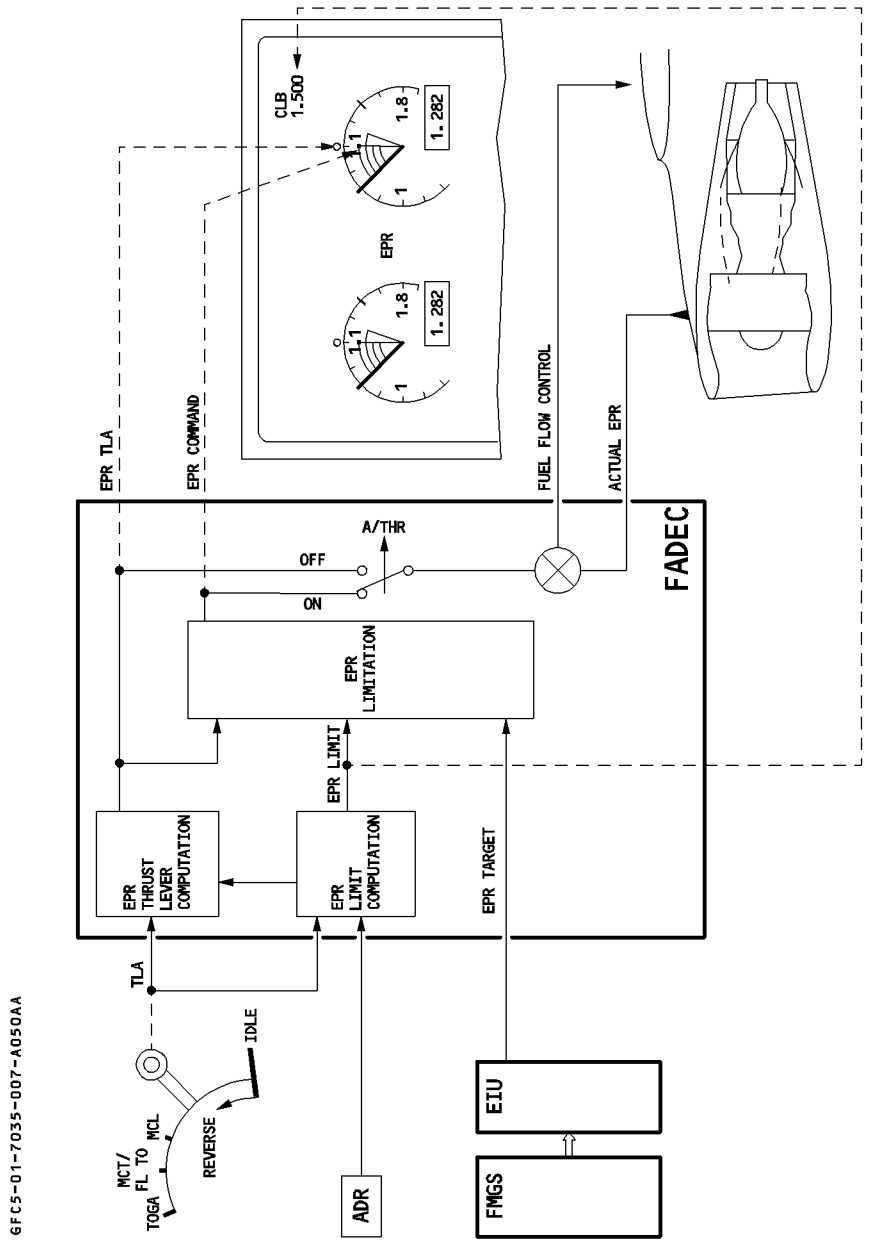
The FADECs monitor the positions of the thrust levers, and trigger appropriate indications on the FMA :

LVR ASYM : appears in amber (third line on the FMA) if, with A/THR active and both engines running, one thrust lever is set out of CLB detent.

LVR CLB : flashes white (3rd line on the FMA) if the thrust levers are not in CL position while the aircraft is above the altitude of thrust reduction with both engines running.

LVR MCT : flashes white (3rd line on the FMA) if the thrust levers are not in MCT position after an engine failure (with speed above green dot).

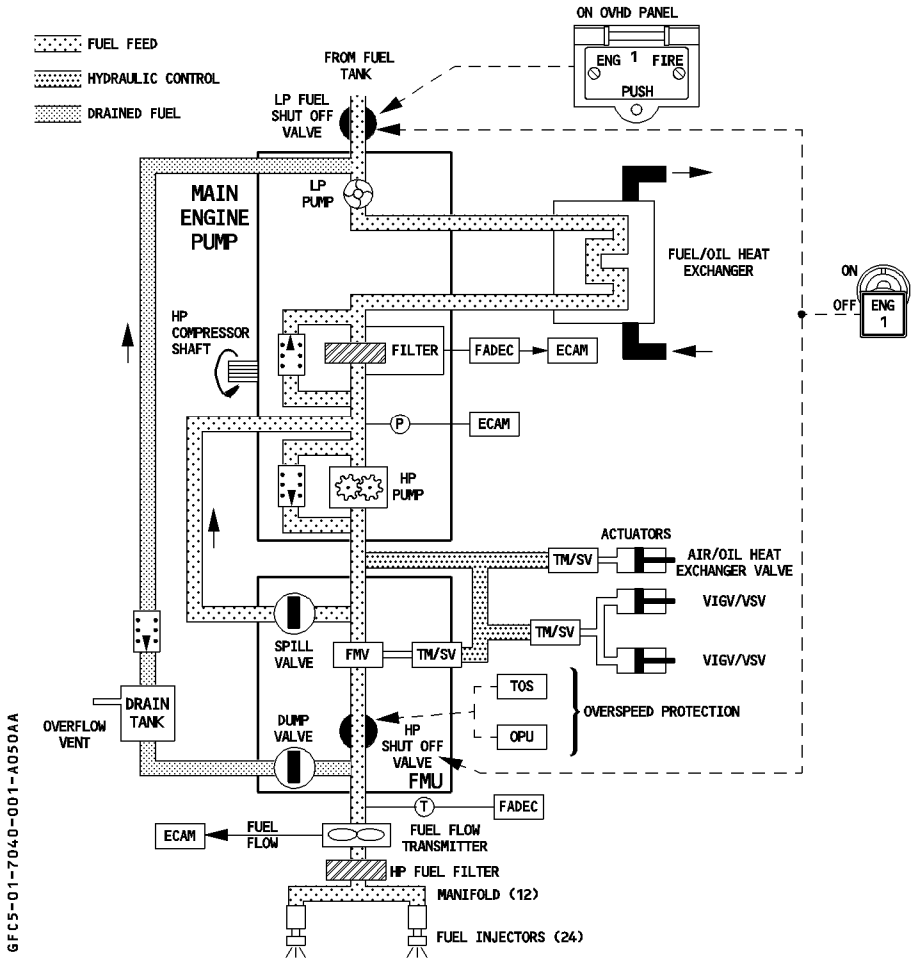
THRUST CONTROL



GENERAL

The fuel system supplies fuel to the combustion chamber at the required flow rate, pressure and temperature.
The fuel flows from the tank, via the Main Engine Pump and the fuel/oil heat exhanger, to the Fuel Metering Unit (FMU) and to the fuel nozzles.
Control of fuel supply is made by the FADEC via the FMU. High pressure fuel is also used to provide pressure for some engine component actuators.

FOR INFO



MAIN ENGINE PUMP

The HP compressor shaft drives the HP fuel pump assembly. Fuel flows through the LP pump then through the fuel/oil heat exchanger, a filter, and the HP pump. Fuel then divides into two flows, one for the servo-valve actuators, and one for the metering valve of the FMU.

SHUTOFF VALVES

Moving the ENG1 (ENG2) MASTER switch to OFF directly commands the closing of the LP and HP fuel shutoff valves for that engine's fuel system.
At closure of the HP fuel shutoff valve the dump valve opens which permits to purge any remaining fuel from the burners to the drain tank. During engine starting fuel from the tank is returned to the LP fuel pump.

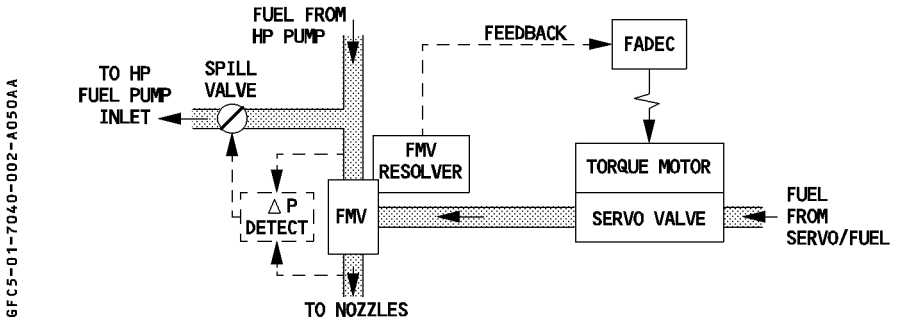
FUEL METERING UNIT

The FMU is controlled by the FADEC and performs :
- control of fuel flow to engine combustion chamber through the Fuel Metering Valve (FMV)
- overspeed protection by closing the HP shutoff valve
- actuation of the HP shutoff valve to start or stop the engine.

FUEL FLOW

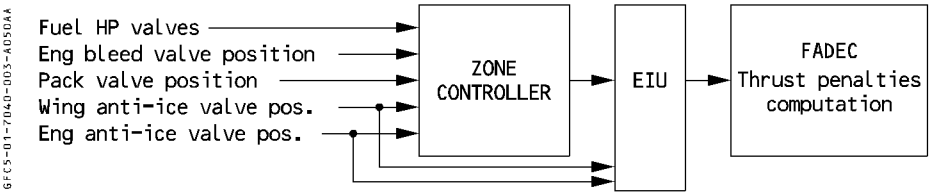
FOR INFO

The fuel metering valve (FMV) transforms FADEC orders through a torque motor and servo valve into fuel flow to the engine fuel nozzles.
The FMV resolver generates a feedback signal proportional to the FMV position.
The bypass valve maintains a constant pressure drop across the FMV to ensure that the metered fuel flow is proportional to the FMV position.



The FADEC computes the fuel flow that will maintain the target EPR.
As the FADEC maintains this EPR, it allows N3 to vary while remaining between N3 minimum and N3 maximum. The FADEC also controls the engine parameters to :

- Limit acceleration and deceleration
- Avoid engine stall or flameout
- Limit maximum EPR, N1, N2 and N3
- Maintain air bleed pressure requirement.
  The FADEC computes N3 correction according to the bleed configuration.



OVERSPEED PROTECTION

Turbine Overspeed Protection (TOS)

The FADEC provides protection against LP turbine overspeed, due to LP shaft breakage between compressor and turbine. If it occurs, the engine is shut down by closing the HP shut-off valve.

Overspeed Protection Unit (OPU)

Independent of the FADEC, the engine is fitted with the N1/N2 overspeed protection unit. In the event of overspeed condition detected by the OPU, which occurs when N1 reaches 110 % or N2 reaches 117 %, the OPU controls the engine shutdown by closing the HP shut-off valve.

IDLE CONTROL

The FADEC has three idle modes :

Modulated idle

R
- Is regulated according to :
  - Bleed system demand
  - Oil temperature
  - Mach number
- Is selected :
  - In flight, when the flaps are retracted, and the gear is up.
  - On ground, provided reverse is not selected.

Approach idle

R
- Is regulated according to aircraft altitude, regardless of bleed system demand.
- Selected in flight, when the flaps are extended to FLAP 2, FLAP 3 or FULL, or when the landing gear is down.
- Allows the engine to rapidly accelerate from idle to go-around.

Reverse idle
- Selected on ground, when reverse thrust is selected.
- Slightly higher than forward idle thrust.

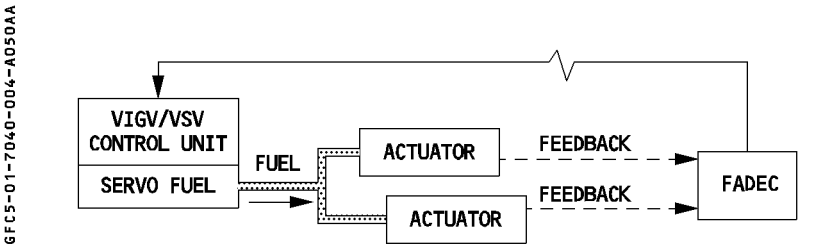
FUEL HYDRAULIC SIGNALS

FOR INFO

Fuel hydraulic signals are sent to :

- ***Air/Oil heat exchanger Control Valve***

- ***Variable Stator Vanes (VSVs) and Variable Inlet Guide Vanes (VIGVs)***
  The FADEC controls the VSV/VIGV system which positions the compressor variable vanes to provide optimum intermediate pressure, and high pressure compressor efficiency to prevent surge during transient engine operations.
  VSVs/VIGVs are fully closed at low engine power and are fully open at high power.
  VIGVs are controlled closed, if the FADEC detects an intermediate pressure or low pressure turbine overspeed.

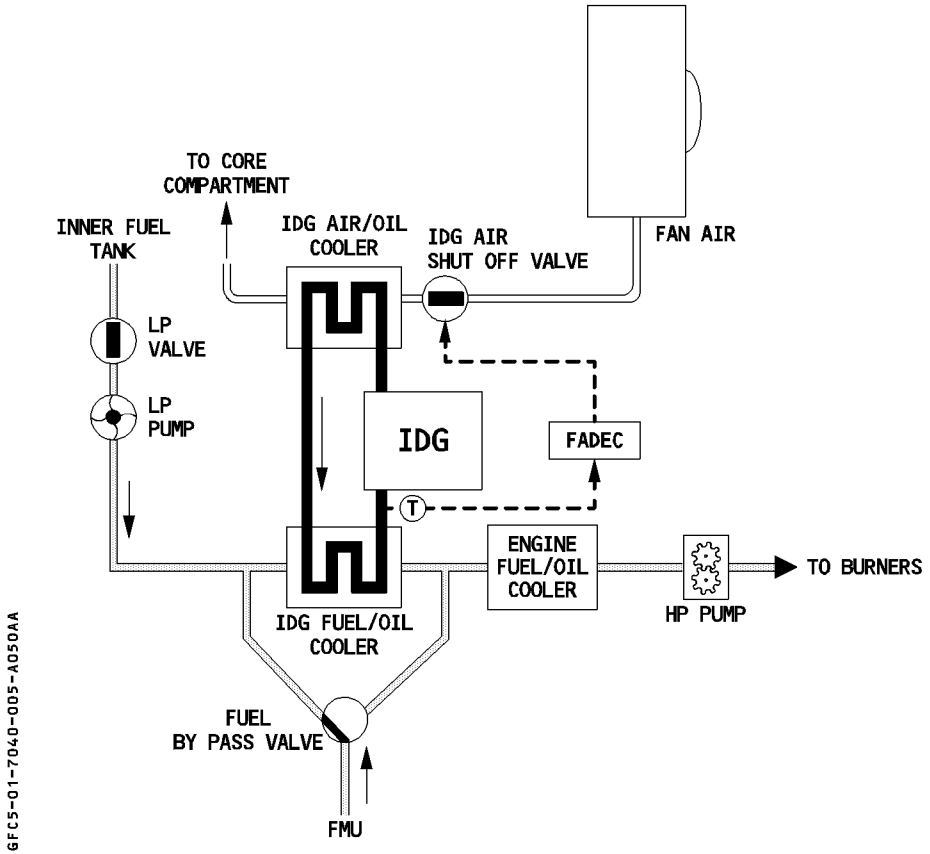


GFC5-01-7040-004-A050AA

IDG OIL COOLING SYSTEM

IDG oil cooling is ensured by the IDG fuel/oil heat exchanger using fuel flow :
– from the fuel pump unit and,
– from the FMU through the fuel bypass valve at low engine power only.
At low fuel flows or high IDG oil temperature the IDG oil is cooled with fan discharge air thru an air/oil cooler.
The air is extracted from the fan by opening the air/oil cooler valve controlled by the FADEC.

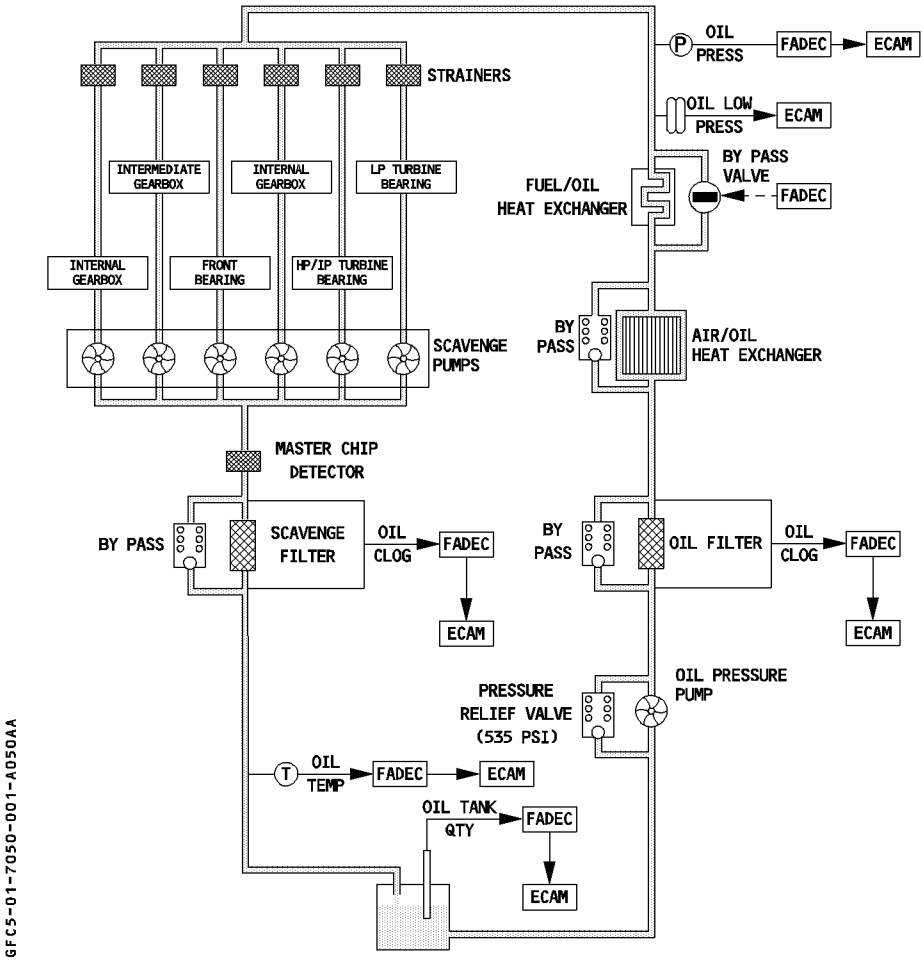
FOR INFO



GENERAL

The oil system lubricates the engine components.
It contains :
– the oil tank
– the lube and scavenge pump modules
– the fuel/oil and air/oil heat exchangers
– the filters, pressure relief and bypass valves.

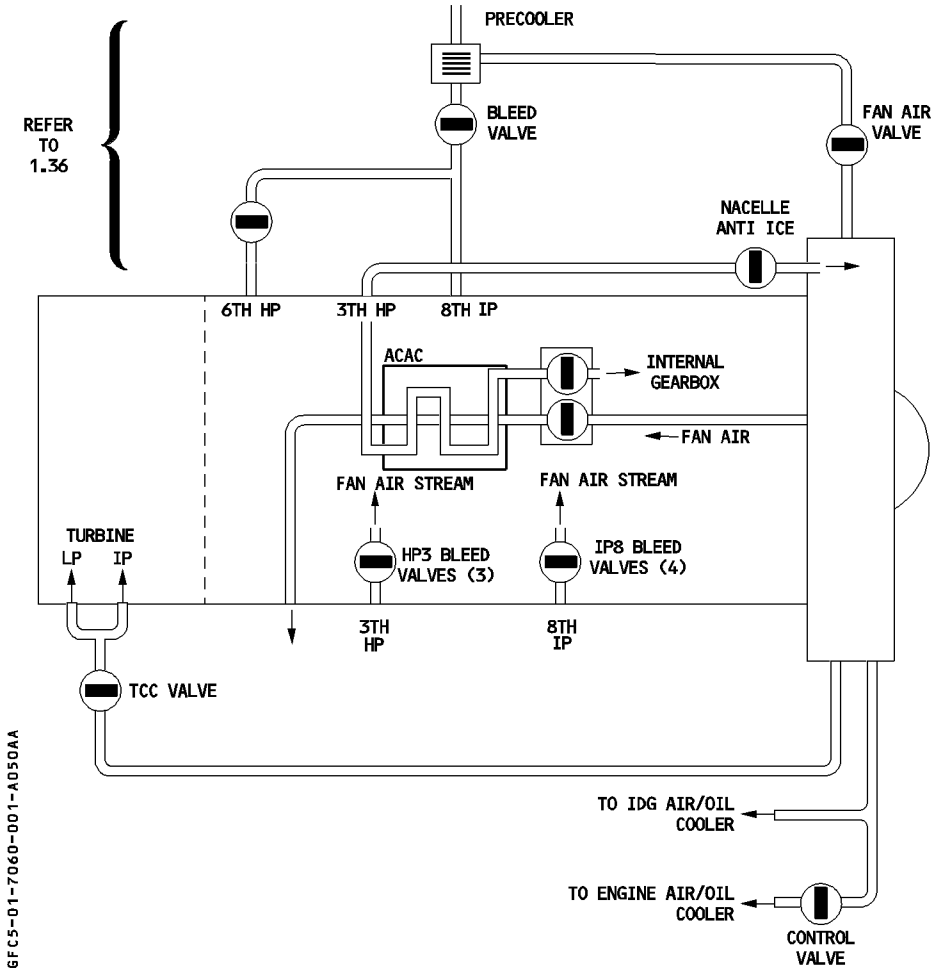
FOR INFO



GENERAL

The air bleed system is provided for various aircraft uses.
It is used for :

- pneumatic system (Refer to 1.36)
- cooling the engine compartment and the turbine
- cooling the engine and IDG oil
- engine stability



COOLING

TURBINE CASE COOLING (TCC)

The TCC system is controlled by the FADEC to improve the engine performance by controlling the intermediate pressure turbine blade tip clearance and cooling the intermediate pressure and low pressure turbine cases.
The TCC valve is controlled by the FADEC to modulate the air flow depending on flight conditions.
The valve is fully open in cruise for optimal engine performance.

INTERNAL GEARBOX COOLING

The internal gearbox cooling system is controlled by the FADEC to regulate air pressure and temperature within the engine center bearing. The HP 3 air to gearbox is cooled in the Air Cooled Air Cooler (ACAC) using fan air and modulated by a dual valve controlled by the FADEC. The valve is fully open during hot day take-off and climb conditions.

IDG COOLING

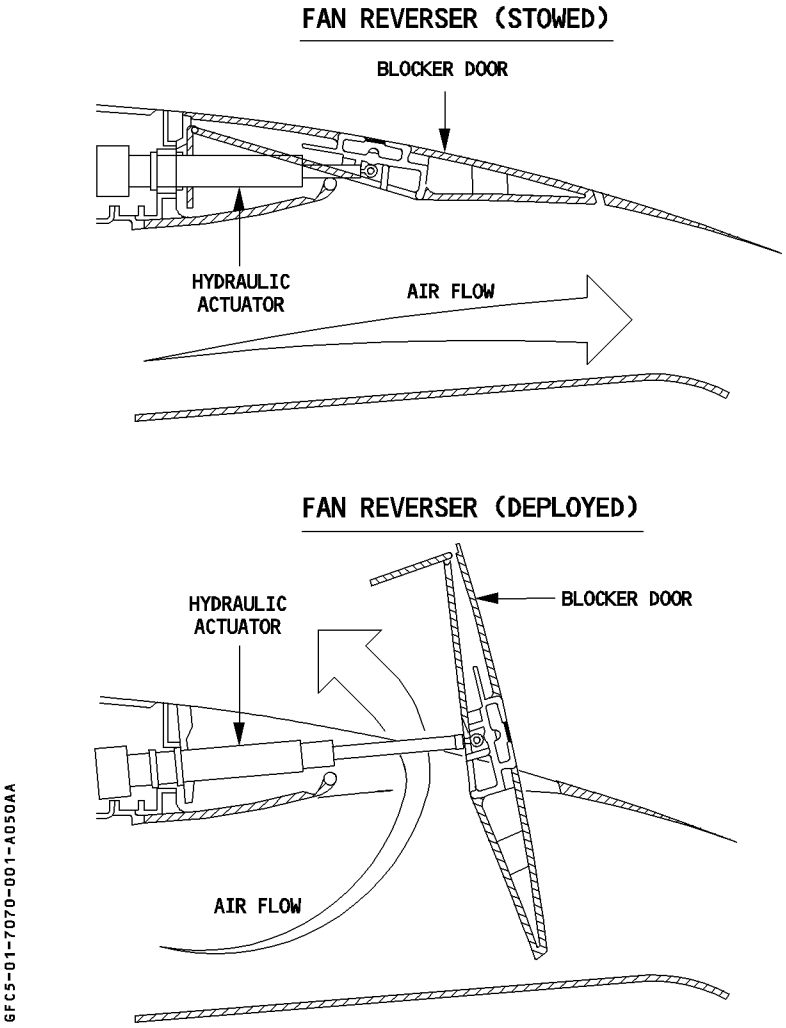
Fan air is used to cool the IDG oil through the air/oil cooler. A bypass valve opens when oil is too cold and cannot flow easily through the cooler.

ENGINE STABILITY

Two air bleed systems provide greater compressor stability in different flight phases. The volume of airflow through the intermediate pressure and low pressure compressors is regulated by four intermediate pressure stage 8 and three high pressure stage 3 bleed valves controlled by the FADEC. At low engine speed the bleed valves are open to prevent engine stall.

GENERAL

The aircraft reverses engine thrust by using four pivoting blocker doors on each engine to deflect the fan airstream.



A hydraulic door jack positions each door.
- the blue circuit powers the doors on engine 1.
- the yellow circuit powers the doors on engine 2.

The thrust reverser system is independently controlled for each engine by the associated FADEC. It is controlled and monitored by each FADEC channel.
The blocker doors are hydraulically actuated.
The thrust reverser system on each engine includes :
– 4 pivoting blocker doors each activated by an hydraulic actuator.
– an hydraulic isolation valve controlled by the FADEC.
– a directional control valve which directs hydraulic pressure to 4 hydraulic locks and to the deploy or stow line
– 4 independant electrical locks controlled by the FADEC
– 4 stow proximity switches and 4 lock switches to monitor whether the translating cowls are deployed or stowed and locked
R – 4 tertiary locks (one for each of the pivoting doors) allowing to maintain the reverse in
R locked position through a door pin. During engine reverse thrust, a solenoid allows to
R release the door pin.

ACTUATION LOGIC

Deployment requires :
– TLA reverse signals from FADEC and from the flight control primary computer (PRIM 1 or PRIM 3)
– one FADEC channel operating with its associated throttle reverse signal
– aircraft on ground signal from at least one LGCIU
During deployment, engine reverse thrust is limited to reverse idle until the reversers are deployed by more than 70%. Then, FADEC will command full reverse thrust to be available when reversers position are more than 90% deployed.

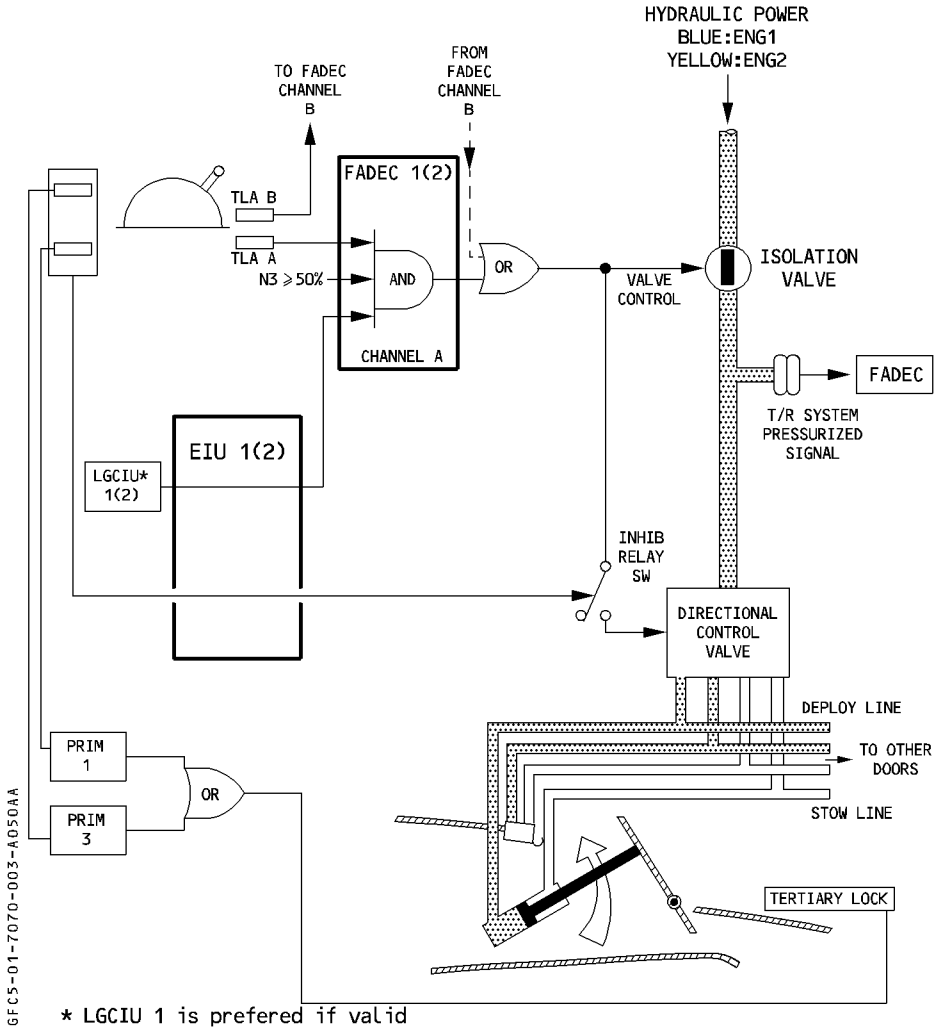
PROTECTION

– AUTO RESTOW FUNCTION AND IDLE PROTECTION
The FADEC will automatically command the engine to idle and the reverser to stow if at least one door is unstowed by more than 5 % and reverse thrust is not selected while engine is running. The affected reverser will remain pressurized after affected door is locked back.
If the door is still detected unstowed the engine will remain at idle for the rest of the flight.

SCHEMATIC

FOR INFO

R

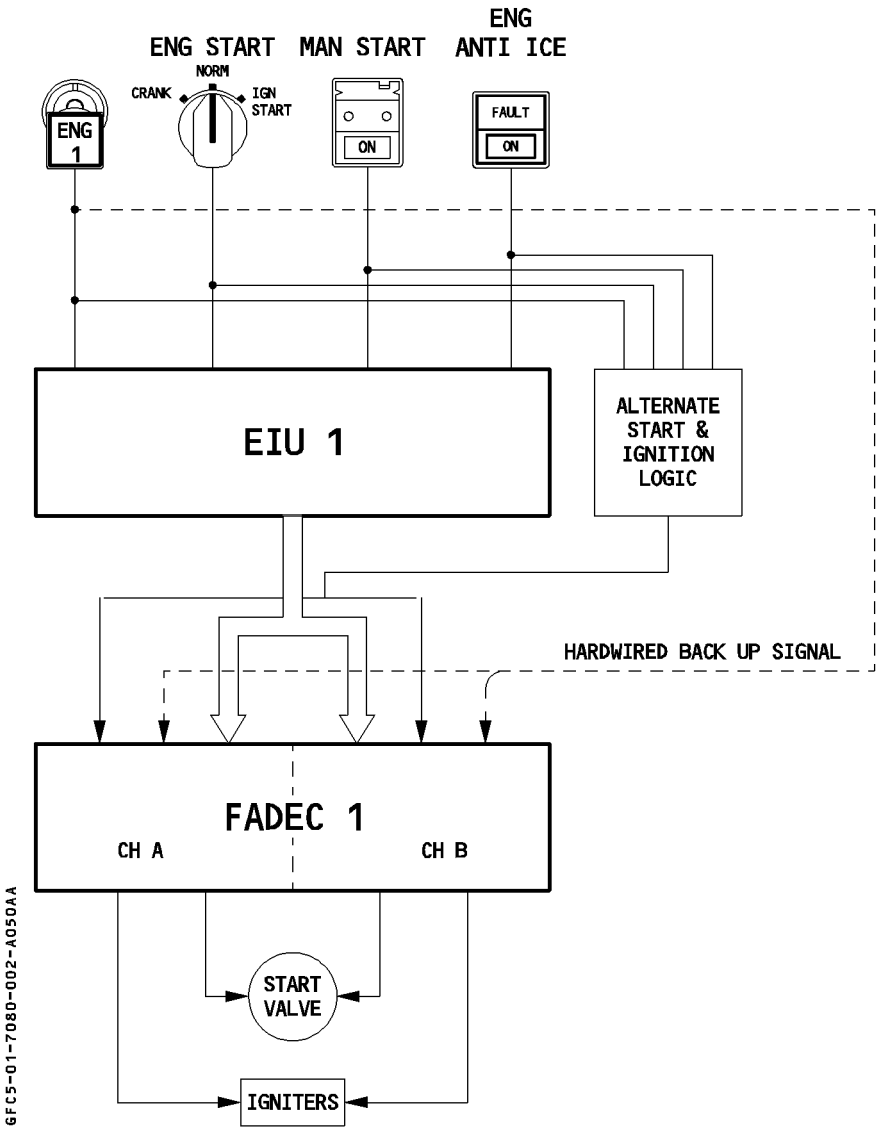


GENERAL

The ignition and starting system is controlled by the FADEC according to :
- engine start selector position
- engine master switch position
- ENG MAN START pusbutton position
- ENG ANTI ICE pushbutton position
- flight/ground aircraft condition.

In normal operation, the FADEC receives its inputs from the EIU.
In the event of EIU signal loss, all the functions, except man start and wet crank, will remain available by using both a back up signal from the engine master switch, and the alternate start/ignition signal.

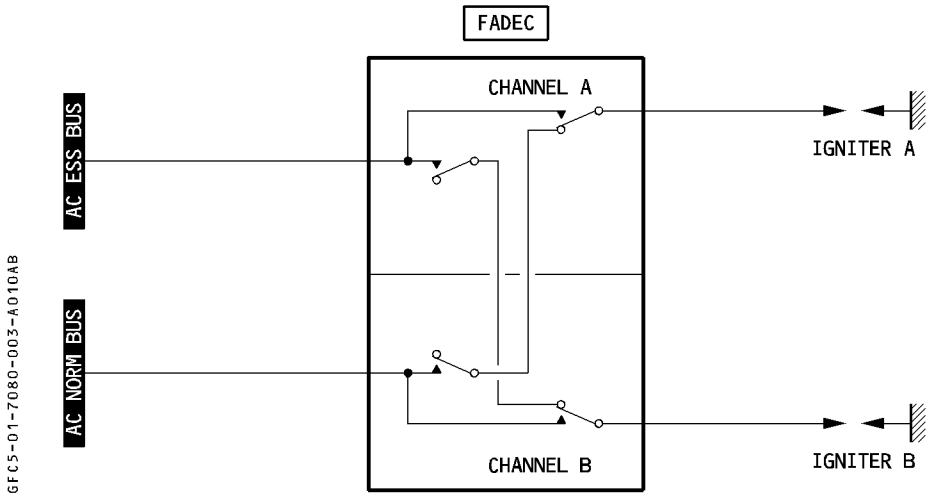
ARCHITECTURE



IGNITION SYSTEM

The ignition system is used to start the engine on ground and to restart it in flight.
It consists of two identical independent circuits for each engine, normally controlled by the FADEC's channel A, with channel B on standby. Each FADEC channel can control both igniters.

FOR INFO



IGNITION FOR STARTING

ON GROUND

During an automatic start only one igniter is supplied. The FADEC automatically alternates the igniters used on successive starts, and also the power supply source.
When residual EGT is above 100°C, both igniters are supplied.

R *Note : In case of automatic restart attempts following an automatic start abort, both igniters are supplied when the EGT decreases below 150°C.*

The ignition is automatically selected, when N3 is between 25 % and 30 %.
It is automatically cut off, when N3 reaches 50 %.
During a manual start, both igniters are supplied, when the engine MASTER switch is ON.
Both stop firing, when N3 reaches 50 %.

IN FLIGHT

Both igniters are supplied by the AC ESS BUS, when the engine MASTER switch is ON.

CONTINUOUS IGNITION

Continuous ignition is either selected manually or automatically to protect engine combustion.

MANUAL SELECTION

In flight, continuous ignition is selected when the ENG START selector is on IGN/START provided the related engine is running.
Only one igniter is selected (if failed : both igniters are automatically selected).
On ground, after starting, since ignition is automatically cut off, it is necessary to cycle the ENG START selector to NORM, then back to IGN/START, to select the continuous ignition.

AUTOMATIC SELECTION

Continuous ignition (igniters A + B) is automatically selected :
- if engine anti-ice is selected on and relevant EIU is inoperative
- for 10 seconds in the event of engine flame out condition detected by the FADEC
- for 10 seconds in the event of inadvertent cycling of the Master lever with the engine running provided N3 is above 50 %.

AUTO RELIGHT FUNCTION

If the FADEC detects a flame out condition on ground or in flight, both igniters A + B will be automatically energized for 10 seconds.

QUICK RELIGHT FUNCTION

In case of in flight flame out, provided the MASTER sw is selected OFF then ON within 30 seconds and N3 is above 10 %, the quick relight function will immediately open the HP fuel valve and energize boh igniters A + B regardless of ENG START selector position.

ENGINE STARTING SYSTEM

GENERAL

The engine starting system consists of an air turbine starter and a start valve.
The start valve admits air supplied by the pneumatic system to operate the starter.
The FADEC controls the start valve electrically. On the ground, in the event of electrical control failure the start valve can be manually operated by a handle.

AUTOMATIC STARTING

This sequence is under the full authority of the FADEC which controls :
- the start valve
- the igniter(s)
- the fuel HP valves.

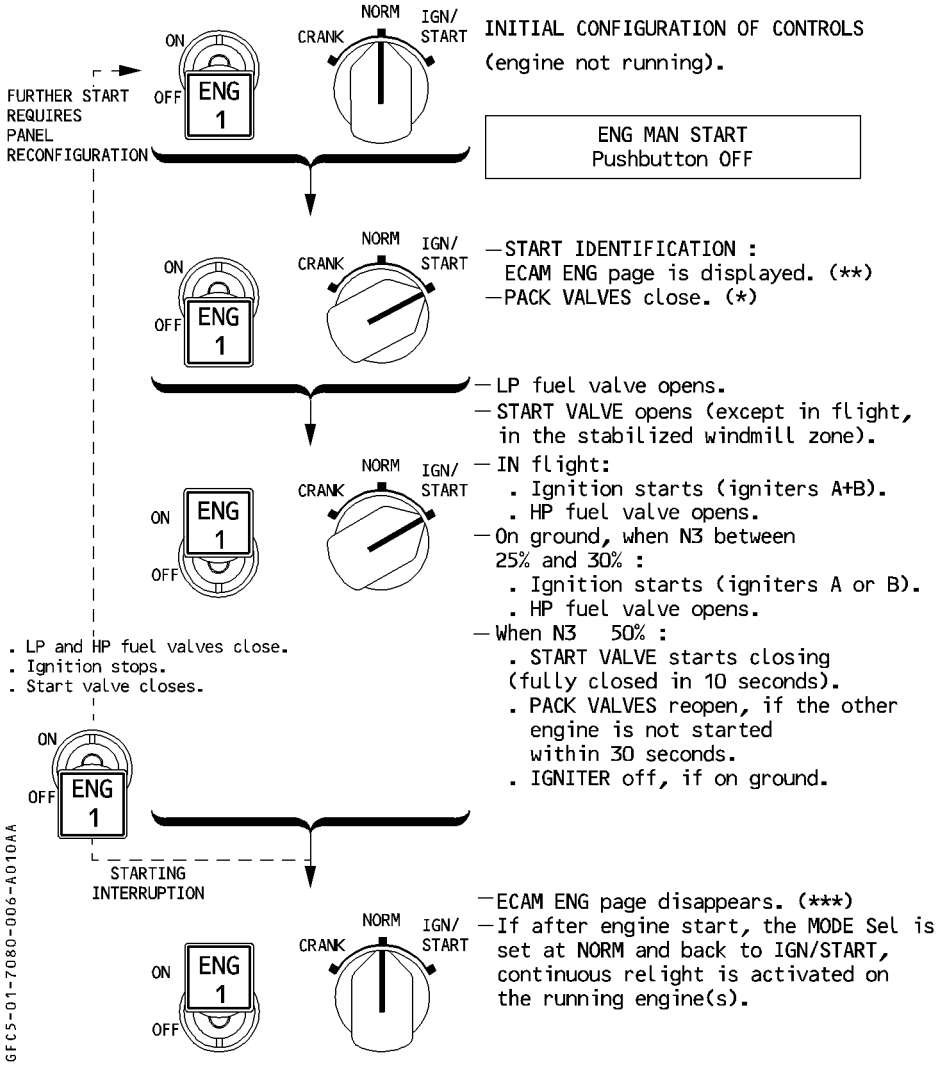
It provides:
- detection of hot start, hung start, surge, no light up or N1 rotor locked.
- FAULT announcement with specific ECAM message.
- start abort on ground (high pressure valve closure, start valve closure, ignition stopped) and automatic engine dry crank after start abort.

R One further automatic start attempt will be initiated by the FADEC after cranking except in case of N1 rotor locked. If this start attempt fails, the start will be aborted.

In flight, the FADEC identifies the windmilling or starter assisted airstart conditions according to engine parameters and the flight environmental parameters.
This sequence may be interrupted by selecting the engine master switch to OFF.
Automatic start abort is inhibited on ground when N3 is above 50% or in flight.

AUTOMATIC STARTING SEQUENCE

R



Note : (*) If after 30 seconds the engine MASTER switch is not ON, the pack valves will reopen.

(**) At first engine start, if after IGN/START selection no further action is applied, the ECAM ENG page will automatically disappear after 30 seconds.

(***) If ENG START selector is not switched to NORM, the ENG page is automatically replaced by the WHEEL page 15 seconds after 2nd engine start.

MANUAL STARTING

Manual starting is under limited authority by the FADEC which controls :
- start valve opening when the ENG START selector is set to IGN/START and the MAN START pushbutton is depressed
- high pressure fuel valve and operation of both igniters when the engine master switch is set to ON.
- start valve closure and, on ground, ignition cut off when N3 ≥ 50 %.

The FADEC provides a passive survey of the engine during the starting sequence.
The sequence may be interrupted :
- before engine master switch set to on by selecting MAN START pushbutton to OFF.
- after engine master switch set to on by selecting it back to OFF. In this case a dry crank shall be selected by the crew.

Note : When the engine master switch is set to on, selecting the MAN START pushbutton to off has no effect.

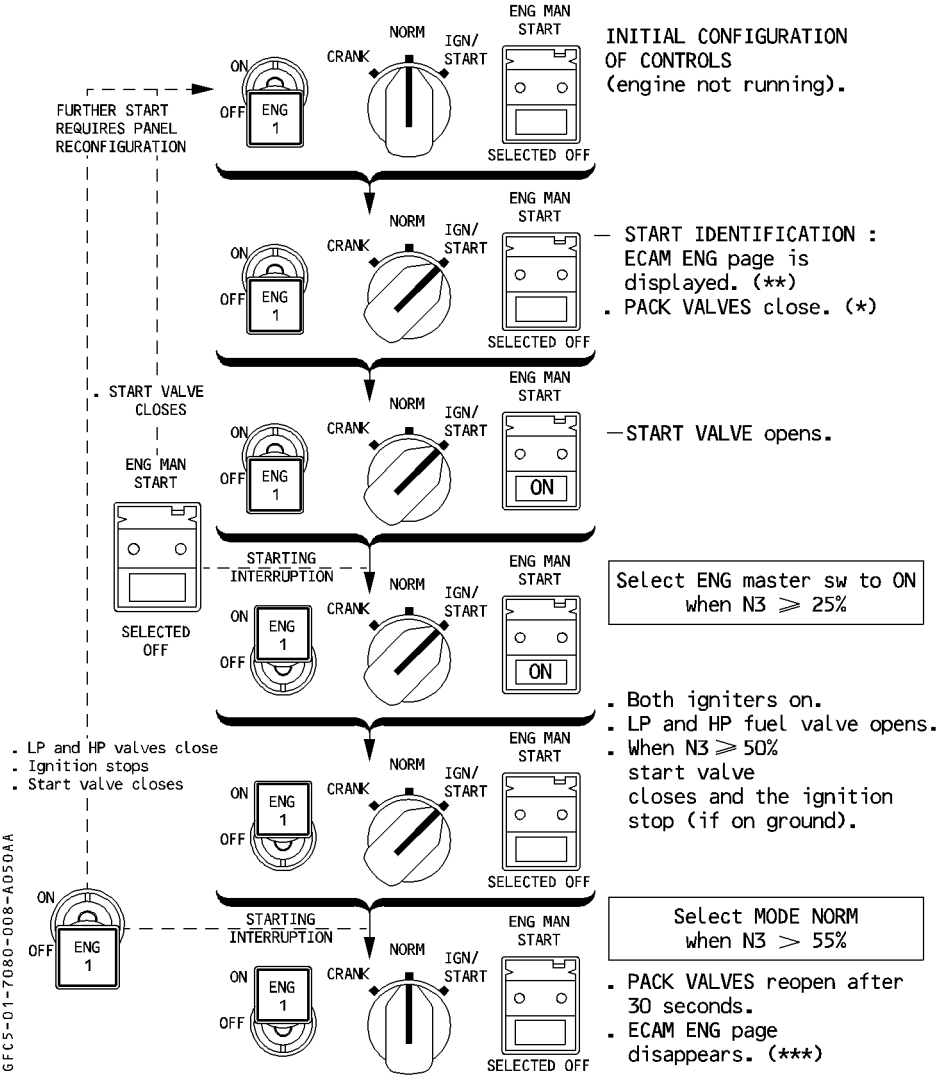
In flight, the FADEC always commands a starter assisted airstart unless the N3 is above the start valve closure value (50 % N3).

ENGINE VENTILATION (Dry cranking)

A dry cranking cycle enables the engine to be ventilated to remove fuel vapors after an unsuccessfull start attempt on the ground.
Cranking can be manually selected by setting the ENG START selector to CRANK and the MAN START pushbutton to ON (engine master switch off). It is stopped by setting the MAN START pushbutton to off or selecting the ENG START selector to NORM.
A manual start sequence can be initiated immediately following a dry crank sequence by selecting the ENG START selector to IGN/START and engine master switch to ON.

MANUAL STARTING SEQUENCE

R



R *Note : (*) If after 30 seconds the ENG MAN START pushbutton is not switched ON, the*
R *pack valves will reopen.*
(**) At first engine start, if after IGN/START selection no further action is applied, the ECAM ENG page will automatically disappear after 30 seconds.
(***) If ENG START selector is not switched to NORM, the ENG page is automatically replaced by the WHEEL page 15 seconds after 2nd engine start.

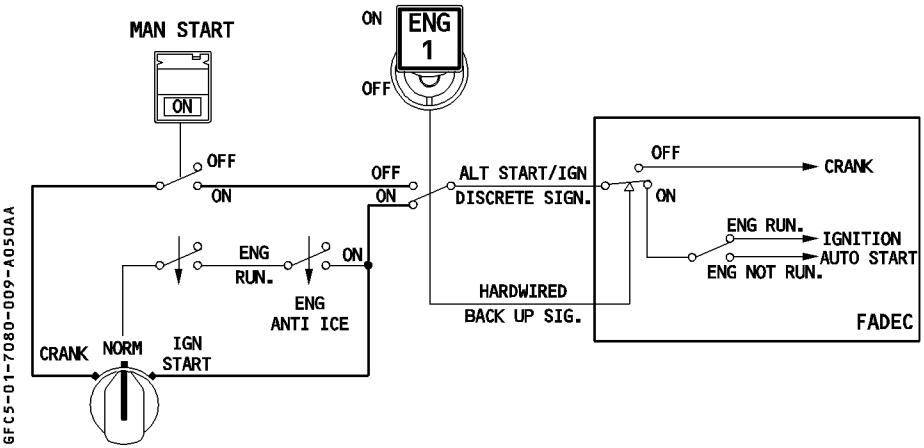
ALTERNATE START / IGNITION INFORMATION

In case of EIU failure, the FADEC uses a backup signal from the engine master switch and the alternate start/ignition signal to control :

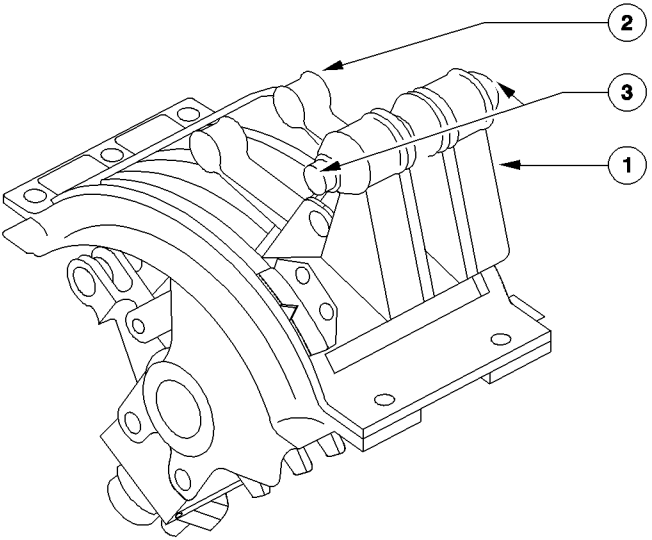
- an automatic starting,
- a dry crank or
- the continuous ignition

Manual starting is no longer available.

FOR INFO



PEDESTAL



GFC5-01-7095-001-A050AA

(1) Thrust levers

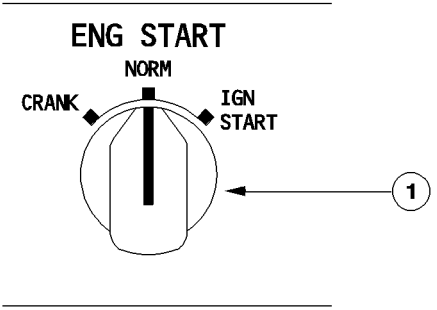
R (Refer to 1.70.35)

(2) Reverse control levers

When the thrust levers are not at idle, the reverse control levers are mechanically locked in the stowed position.
When the thrust levers are at idle, thrust reverse operation can be controlled by pulling backward the reverse control levers.
A detent indicates to the crew the reverse idle position.
For reverse thrust application the reverse control levers are pulled rearward as required.
For stowage of reverse the levers are moved forward then pushed down.

(3) Autothrust instinctive disconnect pb

(Refer to 1.22.30).



GFC5-01-7095-002-A050AA

(1) ENG START selector :

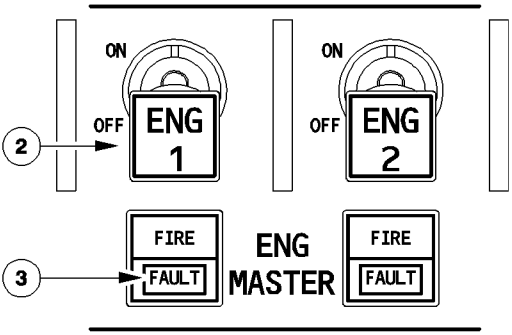
CRANK : The start valve opens, provided the MAN START pushbutton is ON.
R Ignition is not supplied. Both pack flow control valves close when
R CRANK is selected, provided the MAN START pushbutton is ON.

NORM : Continuous ignition A + B is automatically selected :
- The ENG ANTI ICE pushbutton is ON and relevant EIU is inoperative.
- For 10 seconds, in the event of an engine flame-out condition, detected by the FADEC (auto-relight function)
- For 10 seconds, in the event of inadvertent cycling of the Master lever with the engine running, provided N3 is above 50 % and Master lever has been returned to the ON position.

IGN START : - If the engine master switch is ON, and N3 ≥ idle, continous ignition is selected.
- During an automatic start, the ignition will be selected :
  · On ground, when N3 ≥ 25 %
  · In flight, at start sequence initiation (engine master switch selected ON).
- During a manual start, the ignition is selected when the engine master switch is selected ON.

R Both pack flow control valves automatically close during the start sequence (Refer to 1.21.20). APU speed (if used) increases.

Note : On ground, the ignition is automatically cut off at the end of the start sequence (N3 ≥ 50 %)



GFC5-01-7095-003-A050AA

(2) ENG MASTER sw 1 (2)

ON : Low pressure fuel valve opens (if the ENG FIRE pushbutton is in).
- During an automatic start, the High-Pressure (HP) fuel valve opens if :
  · The ENG START selector is at IGN / START
  · N3 is above 25 %
- During a manual start, the HP fuel valve opens, if :
  · The ENG START selector is at IGN / START
  · The MAN START pushbutton is ON

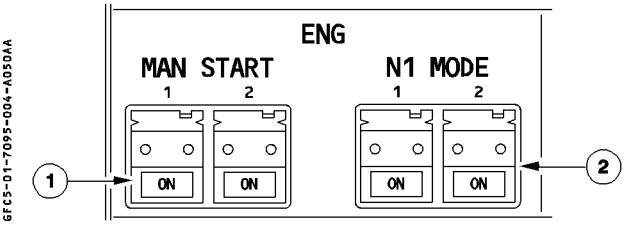
OFF : A Closure signal is sent directly to the HP fuel valve and the LP fuel valve. This controls the reset of both channels of the FADEC.

R *Note : Releasing the ENG FIRE pushbutton allows flight crew to shut down the engine by closing the LP fuel valve. There is a time delay of about 80 seconds at ground idle (the time delay is due to fuel left between the LP valve and the nozzles)*

(3) FIRE FAULT lt 1 (2)

FAULT lt : Comes on in amber, and is associated with an ECAM caution, in case of:
- An automatic start abort
- A disagree between the HP fuel valve position and its commanded position.

OVERHEAD PANEL



(1) ENG MAN START pb sw

ON : The start valve opens provided ENG START selector is set to CRANK or IGN/START.
Both pack valves close during the start sequence.

Note : The start valve closes automatically when N3 reaches 50 %.

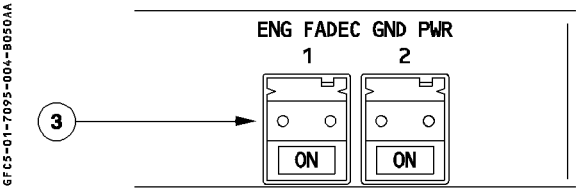
ON light illuminates blue.

Off : When the ENG MAN START pushbutton is set OFF during a manual engine start, the start valve closes provided the engine master switch is at OFF position.

(2) N1 MODE pb sw

ON : Thrust control reverts from EPR mode to N1 rated mode. Following an automatic reversion to N1, rated or unrated mode, pressing the pushbutton confirms the mode.
ON light illuminates blue.

Off : The FADEC controls the engine in EPR mode, if available.



(3) ENG FADEC GND PWR pb sw

ON : The FADEC is supplied by the aircraft network for 5 minutes (except if the ENG FIRE pushbutton is released out, or if FADEC Generator is available). The ON light illuminates with a delay of 2 seconds.

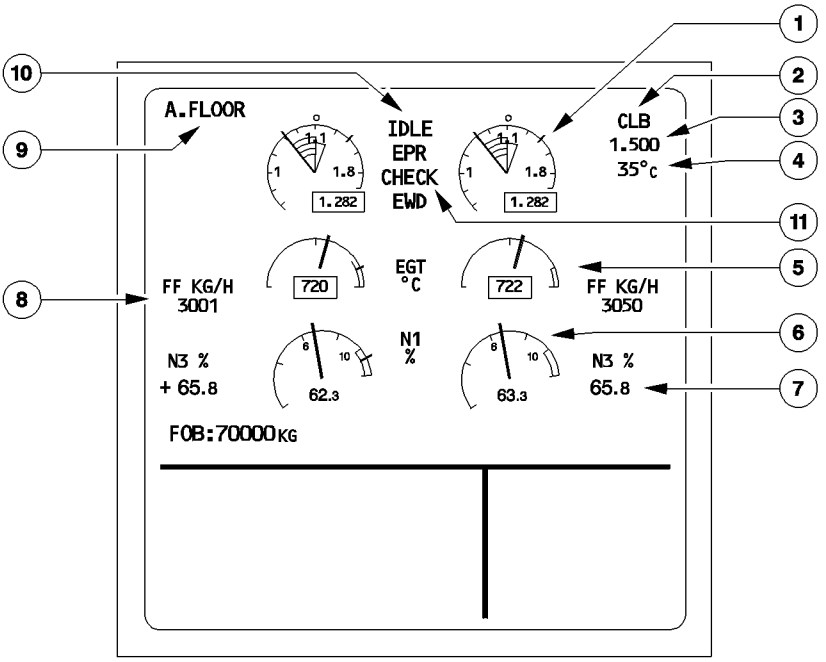
ECAM

GENERAL

The engine primary parameters are permanently displayed on the upper ECAM E / WD.
The secondary parameters are displayed on the lower ECAM SD when selected automatically or manually.
EPR mode is the normal mode. In the event EPR is not available an automatic reversion to N1 mode occurs. Engine primary parameters are then differently displayed.
In case of all DMC ECAM channel failure the engine primary parameters can be displayed on each ND using the ND selector on the EFIS control panel.

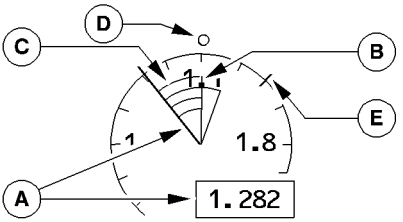
PRIMARY PARAMETER

EPR MODE ACTIVE



GFCS-01-7095-005-A050AA

R (1) Engine Pressure Ratio (EPR)



GFCS-01-7095-006-A05DAA

(A) Actual EPR
The EPR needle and EPR digital indication are in green.

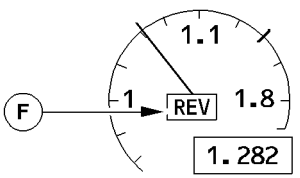
(B) EPR Command (EPR trend)
The green needle corresponds to the EPR demanded by the FADEC. In addition, next to the EPR trend needle, a green triangle indicates the direction of EPR tendency. These symbols are displayed when A/THR is active.

(C) Transient EPR
Symbolizes the difference between the EPR command and the actual EPR. It is only displayed when A/THR is active.

(D) EPR TLA (blue circle)
EPR corresponding to the thrust lever position (predicted EPR).

(E) EPR MAX
The EPR MAX amber index is the EPR limit value corresponding to the full forward R position of the thrust levers.

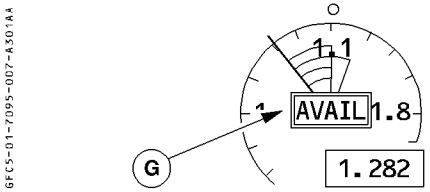
R (F) REV indication
The REV indication appears in amber, when at least one reverser cowl is unstowed or unlocked. It changes to green and is overbrightened when the reversers cowls are fully deployed and reverse mode is selected.
(If unlocked in flight, the indication first flashes for 9 seconds and then remains steady).



GFCS-01-7095-006-B05DAA

(G) AVAIL indication

This is displayed in green to indicate a successful engine start on ground.
It pulses in green to indicate a successful engine relight in flight.
It triggers, when the engine is at or above idle.



(2) Thrust limit mode

TOGA, FLX, CLB, MCT, limit mode selected by the thrust lever are displayed in blue.
If a derated takeoff has been selected by the crew, D04, D08, D12, D16, D20 or D24 will be displayed.
DCLB1 or DCLB2 is displayed during the climb phase, if the crew has selected a derated climb through the MCDU PERF CLB page.

(3) EPR rating limit

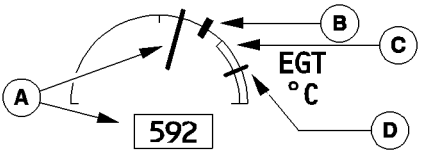
Is computed by the FADEC according to the thrust lever angle, and displayed in green. The highest thrust rating mode and associated EPR limit value of the both engines is displayed.

Note : – On ground, with the engines running, the displayed EPR rating limit corresponds to the TOGA thrust limit, regardless of the thrust lever position.
– On ground, with the engines running and if FLEX mode is selected, FLEX EPR is displayed, regardless of the thrust lever position between IDLE and FLX / MCT.

(4) FLEX temperature

If a FLEX temperature has been entered through MCDU and validated by the FADEC, this temperature is displayed in blue.

(5) EGT indicator



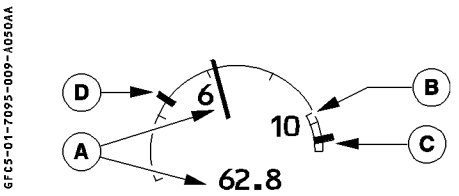
(A) Actual EGT
- It is normally green.
- It becomes amber above :
  · 700°C during ground start sequence, or
  · 850°C (except at takeoff).
- It becomes red, if EGT exceeds :
  · 900°C for 20 seconds,
  · 920°C.

(B) EGT Max (amber)
It is 700°C at engine ground start, then 850°C. It is not available, when either takeoff thrust is applied, or alpha floor is active, or reversers are selected.

(C) Max permissible EGT
The EGT redline is at 920°C. A red arc is displayed above 920°C to the end of the scale.

(D) EGT exceedance
If 920°C is exceeded, a red mark appears at the max value achieved. It will
R disappear after a new start on ground.

(6) LP rotor speed N1



(A) Actual N1
- It is normally green.
- It becomes red, if the actual N1 exceeds the max permissible N1 (99 %).

(B) Max permissible N1
The N1 redline is represented by a red arc at the end of the scale beginning at 99%.

(C) N1 exceedance
If 99 % is exceeded, a red mark appears and remains at the max value achieved.
R It will disappear after a new start on ground.

(D) N1 max
It is only displayed in reverse mode.
The N1 max corresponds to the N1 reached in full reverse (amber).

(7) HP rotor speed N3

Digital indication, normally green, is doubly bright during engine start and located in a grey background box.
When the N3 is above 100 %, the indication becomes red, and a red cross appears next
R to the digital indication. The red cross will only disappear after a new start on ground.
When the N3 value is degraded (in case of loss of sensed N3), the last digit is amber dashed.

(8) Fuel flow

It is indicated in green.

(9) A FLOOR message

It is displayed in amber, when the ECUs receive the corresponding signal from the FMGS.

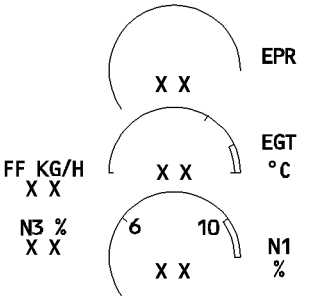
(10) IDLE message

This legend appears in green, when both engines are at idle. It flashes for 10 seconds, then remains steady.

(11) CHECK EWD message

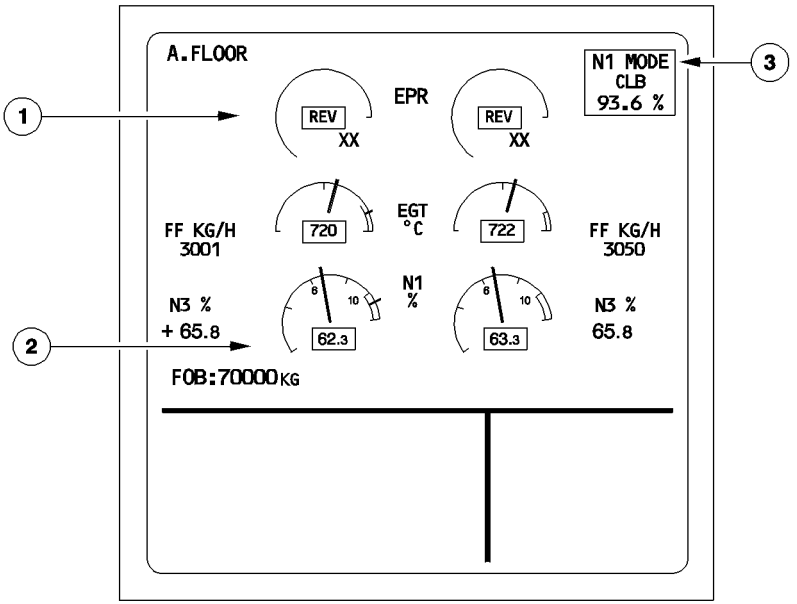
Is displayed amber on the EWD and on both ND in case of discrepancy between EPR, N1, N2, N3, EGT, FF values on FADEC-DMC bus and corresponding displayed information.

Note : When one parameter becomes invalid, two amber crosses replace the associated digital indication. For EPR, EGT and N1 parameters, the needle and the box around the digital display disappear.



GFC5-01-7095-010-A050AA

REVERSION TO N1 MODE

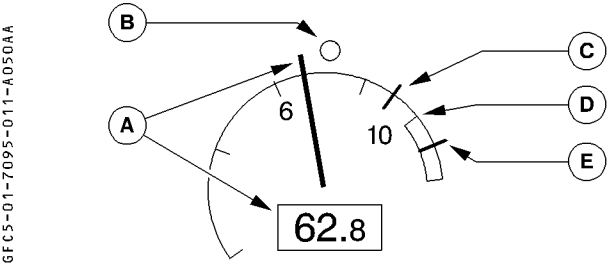


GFC5-01-7095-010-B050AA

(1) Engine Pressure Ratio (EPR)

The EPR needle is removed and the digital indication is replaced by two amber crosses. The REV indication remains available.

(2) LP Rotor speed (N1)



(A) Actual N1 (digits boxed grey)
- It is normally green.
- It becomes amber, if the actual N1 is above N1 MAX (See C).
- It becomes red, if the actual N1 exceeds the max permissible N1 (99 %).

(B) N1 TLA (blue circle)
The N1 corresponding to the thrust lever position (predict N1). It is not displayed in reverse mode.

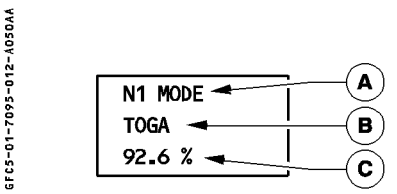
(C) N1 MAX
It is only displayed in N1 rated mode or reverse mode.
The N1 MAX amber index is the N1 limit value corresponding to the full forward, or full reverse position of the thrust levers.

(D) Max permissible N1
The N1 redline is represented by a red arc at the end of the scale begining at 99 %.

(E) N1 exceedance
If 99 % is exceeded, a red mark appears and remains at the max value achieved.
R It will disappear after a new start on ground.

③ N1 MODE and N1 rating limit

Displayed in a white box



Ⓐ N1 MODE is displayed in white when both engines are in back up N1 mode.

Ⓑ Thrust limit mode
TOGA, CLB, MCT limit mode selected by the thrust lever is displayed in blue.

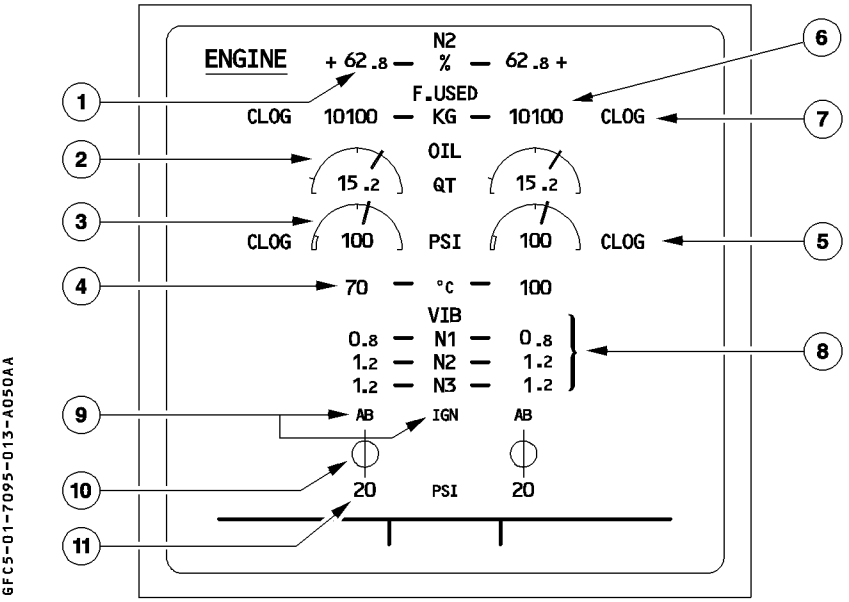
Note : Flex takeoff is not allowed in N1 mode.

Ⓒ N1 rating limit
It is only computed in N1 rated mode by the FADEC according to the thrust lever angle and is displayed in green.
The highest N1 mode and associated N1 limit value of the both engines is displayed.

Note : On ground, if at least one engine is controlled in N1 unrated mode, the thrust limit mode and the N1 rating limit are replaced by amber crosses.

SECONDARY PARAMETERS

START CONFIGURATION



(1) IP rotor speed N2

Digital indication, normally green, is doubly bright during engine start and located in a grey background box.
When the N2 is above 103.3 %, the indication becomes red, and a red cross appears next to the digital indication. The red cross will only disappear after a new start on
R ground.
When the N2 value is degraded (in case of a triple N2 sensors failure), the last digit is amber dashed.

(2) Oil quantity indication

The needle and the digital indication are normally green.
The digital indication pulses, if the oil quantity drops below 4 quarts.
(Also displayed on ECAM CRUISE page).
Advisory is inhibited :
— At takeoff, or go-around ;
— When reversers are selected ;
— In alpha floor mode.

(3) Oil pressure indication

The needle and the digital indication are normally green.
The needle and the digital indication are red if the oil pressure drops below 25 psi.

Note : During stabilized engine operation the indication may fluctuate within a range of ± 6 psi without any adverse effect.

(4) Oil temperature indication

Normally green
The indication becomes amber if temperature exceeds 185°C

(5) Oil filter clog indication

CLOG message appears in amber in case of excessive pressure loss accross the main or scavenge oil filter.

Note : This is not an indication that the bypass valve is open.

(6) Fuel used indication

The fuel used value computed by the FADEC is displayed in green.
After a transmission interruption by the FADEC, if the displayed value is 100 kg less than the actual value it is crossed by 2 amber dashes.
It is reset at engine start on ground.
Also displayed on ECAM CRUISE page and ECAM FUEL page.
R An overread of about 1.5 % must be considered.

(7) Fuel filter clog indication

CLOG message appears in amber in case of excessive pressure loss accross the fuel filter.

(8) VIB indications

The indication is green.
It pulses in case of advisory (N1 Vib > 3.3 units, N2 Vib > 2.6 units, N3 Vib > 4 units).
Also displayed on ECAM CRUISE page.

(9) Ignition indication

IGN is displayed in white during the start sequence.
The selected ignitors "A" or "B" or "AB" are displayed in green when supplied.

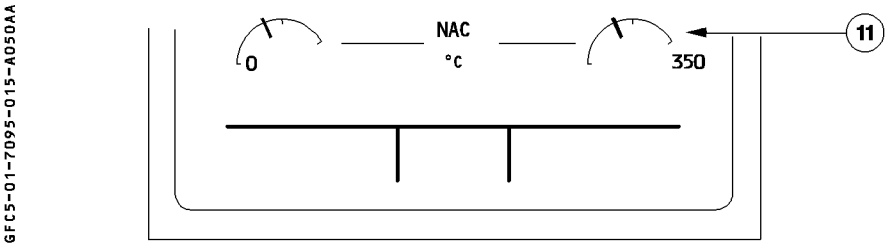
(10) Start valve position indication

⏀ green valve fully open
⊖ green valve fully closed.
⏀ amber valve abnormally fully open
⊖ amber valve abnormally fully closed

(11) Engine bleed pressure

Bleed pressure upstream of the precooler is normally displayed in green.
It becomes amber below 15 psi with N3 ≥ 8 % or in case of overpressure.

AFTER START CONFIGURATION

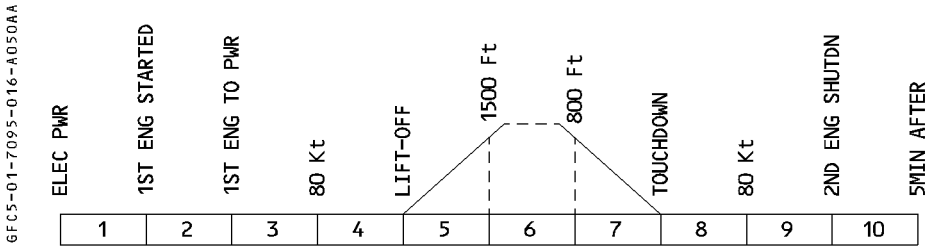


(12) Nacelle temperature indication

Nacelle temperature needles are displayed in green. Becomes pulsing if the temperature exceeds 260°C.
The advisory threshold is indicated by a small mark on the arc.
NAC is displayed in white.
Nacelle temperature indications are removed during engine start.

Note : In case of invalidity of any parameter, the associated digital indication is replaced by two amber crosses.
For OIL QTY, OIL PR and NAC TEMP the needle is removed.

WARNINGS AND CAUTIONS



R

E / WD: FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNING	FLT PHASE INHIB
ALL ENG FLAME OUT Both engines flameout	CRC	MASTER WARN	NIL	NIL	NIL
N1 OVERLIMIT N1 above 99 %					4, 8
N2 OVERLIMIT N2 above 103.3 %					
N3 OVERLIMIT N3 above 100 %					
Turbine OVHT IP turbine overheat detected					
EGT OVERLIMIT EGT above 920°C or 900°C for more than 20 seconds	SINGLE CHIME	MASTER CAUT			
ENG 1(2) EPR MODE FAULT FADEC has reverted to the N1 mode.					4,5
OIL LO PR Oil pressure low (< 25 PSI)	CRC	MASTER WARN	ENG		1, 10
MINOR FAULT Engine short time limited dispatch.	NIL	NIL	NIL		4, 5, 7, 8
CTL SYS FAULT VSV/VIVG failure or loss of FMV, VSV/VIVG position	SINGLE CHIME	MASTER CAUT			4, 5, 7, 8
BLEED STATUS FAULT Bleed status not received by active FADEC channel.					3, 4, 5, 7, 8
ENG FAIL Eng core speed below idle, with master sw ON, and fire pb not pushed.					NIL
ENG SHUT DOWN Eng master OFF in phases 3 to 8, or eng fire pb pushed in phases 1, 2, 9 and 10.					
THR LEVERS NOT SET Thrust levers set between CLB and MCT at takeoff. Flex. takeoff mode not selected by at least one FADEC					1, 4 TO 10
ENG T.O. THRUST DISAGREE One FADEC, at least, selects a different thrust at T.O.					
ENG STALL Stall detected.			ENG		4, 5, 7, 8
ENG 1(2) SHAFT FAILURE Turbine Overspeed detected.			NIL		NIL

E / WD: FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNING	FLT PHASE INHIB
EIU FAULT Data bus between EIU and FADEC failed. Engine vib indication is lost.	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 8
FADEC SYS FAULT One NOGO failure affects one or both channels. Channel failure, or alternate fault, or overspeed protection fault, or sensor failure.		NIL			4, 5, 6, 7, 8
FADEC FAULT Data bus between FADEC and ECAM failed		MASTER CAUT	ENG		4, 5, 7, 8
FADEC OVHT			NIL		3, 4, 5, 7, 8
FADEC COOLING FAULT			ENG		
FUEL FILTER CLOG					
IGN A+ B FAULT Both ignition circuits are failed.			NIL		
IGN A(B) FAULT Ignition circuit A or B failed.	NIL	NIL			
TYPE DISAGREE Disagree between pin programming on FADEC and on FWC (engine rate).	SINGLE CHIME	MASTER CAUT			3 to 10
REV FAULT Loss of thrust reverser on one engine.			NIL		3, 4, 5
REV PRESSURIZED Reverser system is pressurized, while rev doors are stowed and locked, with no deploy order (on ground).					1, 8,
REV UNLOCKED One reverser door not locked in stowed position, with no deploy order.					8
REV INHIBITED Reverser is inhibited by maintenance action.	NIL	NIL			3 to 8
THR LEVER FAULT Both resolvers on one thrust lever failed.	SINGLE CHIME	MASTER CAUT			8
THR LEVER DISAGREE Disagree between both resolvers of a thrust lever.					4, 5, 8
AIR EXCHANGER FAULT Air/Oil heat exchanger valve failed					3 to 8
OIL LO TEMP Engine oil temp < 20°C (on the ground before takeoff)			ENG		3 to 9
OIL HI TEMP Engine oil temp above 190°C.					4, 5, 7, 8
OIL FILTER CLOG			NIL		3, 4, 5, 7, 8
THRUST LOCKED The thrust is frozen on one or both engines, after an involuntary A/THR disconnection. This caution is recalled every 5 seconds, until thrust levers are moved.					2, 3, 4, 8, 9
LP SHAFT PROT LOSS The LP shaft sensor is failed	NIL	NIL			3 to 8

R

E / WD: FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNING	FLT PHASE INHIB
XWIND PROT FAULT The thrust application logic for the automatic rolling takeoff is failed.	SINGLE CHIME	MASTER CAUT	NIL	NIL	1, 3, 4, 5, 8, 10
ENG THRUST LOSS The actual bleed configuration is not in accordance with the bleed configuration requested by the crew.					1, 4 to 10
START VALVE FAULT The start valve is either stuck closed, or stuck open, or no starter air pressure is available (valve disagree).			ENG	Associated FAULT lt on ENG panel on pedestal (except in case of starter time exceeded)	3, 4, 5, 7, 8
START FAULT Start fault due to : . Starter time exceeded, or . Stall, or . EGT overlimit, or . No light up, or . Low N1, or . THR levers not at idle.					
HP FUEL VALVE Fuel valve failed closed, or open.					

MEMO DISPLAY

The IGNITION message is displayed in green, either when selected automatically by the FADEC, or manually by the crew.

BUS EQUIPMENT LIST

			NORM			EMER ELEC		
			AC	DC	DC BAT	AC ESS	DC ESS	HOT
FADEC	CHANNEL A					X		
	CHANNEL B		AC2					
EIU (BOTH ENGINES)					X			
HP VALVES							X	
OIL PRESS		ENG 1		DC1				
		ENG 2		DC2				
IGNITION	A	Both ENG				X		
	B	ENG 1 ENG 2	AC1 AC2			X (1)		

(1) When in flight.