ENGINE IGNITION & STARTING

IGNITION SYSTEM OVERVIEW

The Ignition System supplies a spark to ignite the fuel/air mixture in the combustor. Ignition occurs during engine start, engine relight, and when conditions require a continuous ignition to prevent the risk of flameout.

Each engine has two independent ignition systems designed for continuous operation. Normally the systems alternate, but they can be used simultaneously under these conditions:

- manual start
- when a second attempt to auto start the engine is required
- inclement weather, including rain and hail
- when the aircraft is in landing mode (at approach idle)
- if surge or flameout is detected during take-off or flight.

The Electronic Engine Control (EEC) commands the Ignition System in both manual and automatic start modes.

Auto start is the normal condition, and manual mode is used if auto start fails.

Each of the two systems includes an ignition exciter, igniter plug cables, and igniter plugs.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

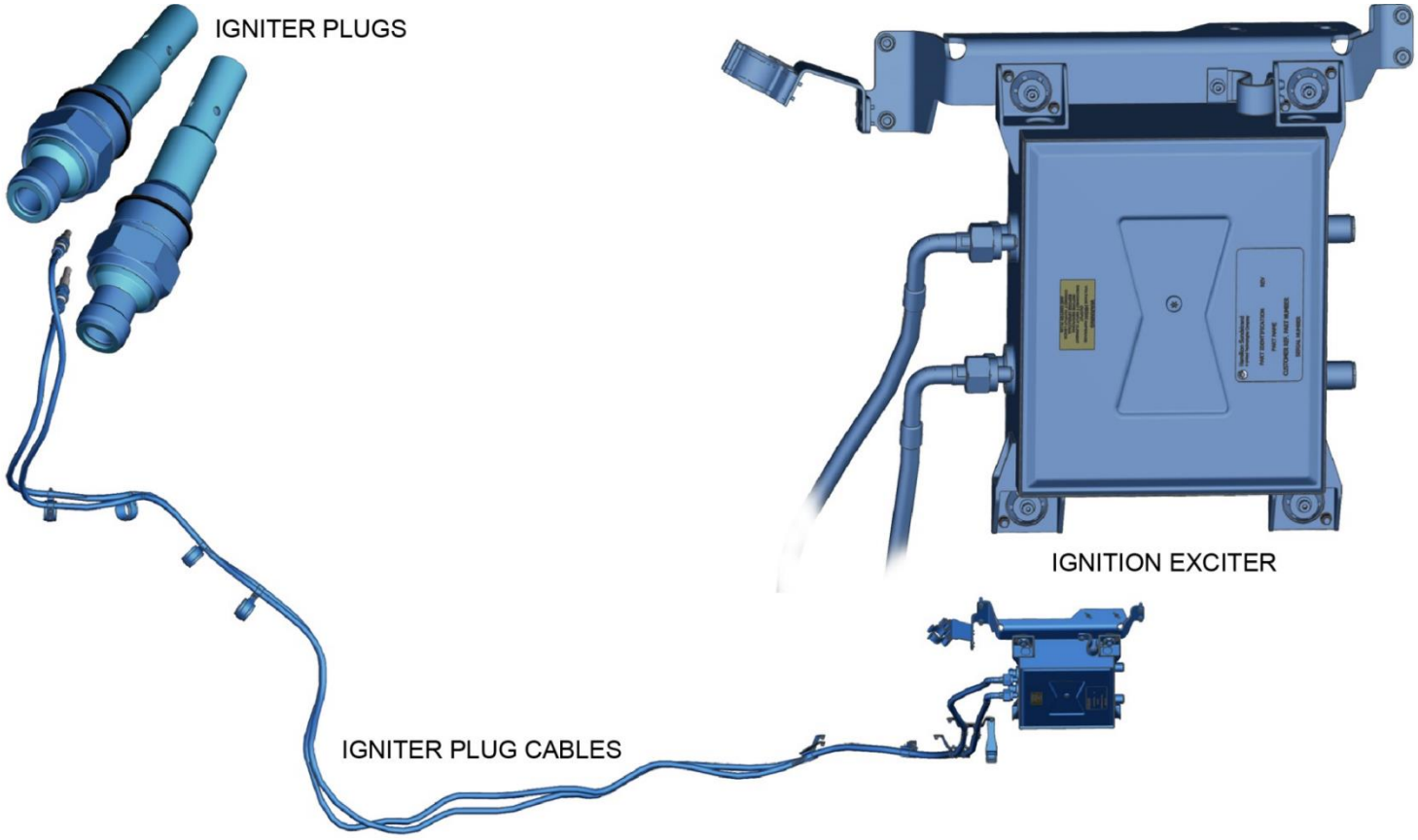
REFER TO THE MSDS FOR ALL MATERAIL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

THE IGNITION SWITCH MUST BE IN THE OFF POSITION BEFORE YOU REMOVE IGNITION COMPONENTS. SOME MINUTES MUST GO BY BEFORE IT IS SAFE TO REMOVE IGNITION COMPONENTS. AFTER YOU REMOVE THE IGNITER PLUG CABLE FROM THE IGNITER PLUG, IMMEDIATELY TOUCH THE CABLE TERMINCAL TO A GOOD GROUND TO LET ALL OF THE ELECTRICAL ENERGY OUT OF THE SYSTEM. THE IGNITION SYSTEM VOLTAGE IS DANGEROUSLY HIGH. IF YOU DO NOT DO THIS PROCEDURE, INJURY OR DEATH CAN BE THE RESULT.

USE NECESSARY PRECAUTIONS WHEN YOU DO WORK ON THE IGNITION SYSTEM. THIS SYSTEM HAS HIGH ENERGY AND CAN CAUSE INJURY OR DEATH BY ELECTRICAL SHOCK.

CAUTION

DO NOT TWIST IGNITION CABLE WHEN YOU TURN THE COUPLING NUT. THIS COULD DAMAGE THE CABLE.


IGNITER PLUGS
IGNITION EXCITER
IGNITER PLUG CABLES

STARTING SYSTEM OVERVIEW

The Starting System provides the means for motoring the engine to starting rpm whether on the ground or in flight.

Ground start can be accomplished using air supplied from any of these sources:

- aircraft Auxiliary Power Unit APU
- another engine
- ground cart.

The Starting System consists of the components below.

The EEC controls operation through the cockpit engine start selector switch and the fuel run/off switch position.

FADEC controls all aspects of engine starting and motoring.

In-flight windmill starts may require starter assistance in the form of APU or cross-bleed engine air.

Safety Conditions

WARNING

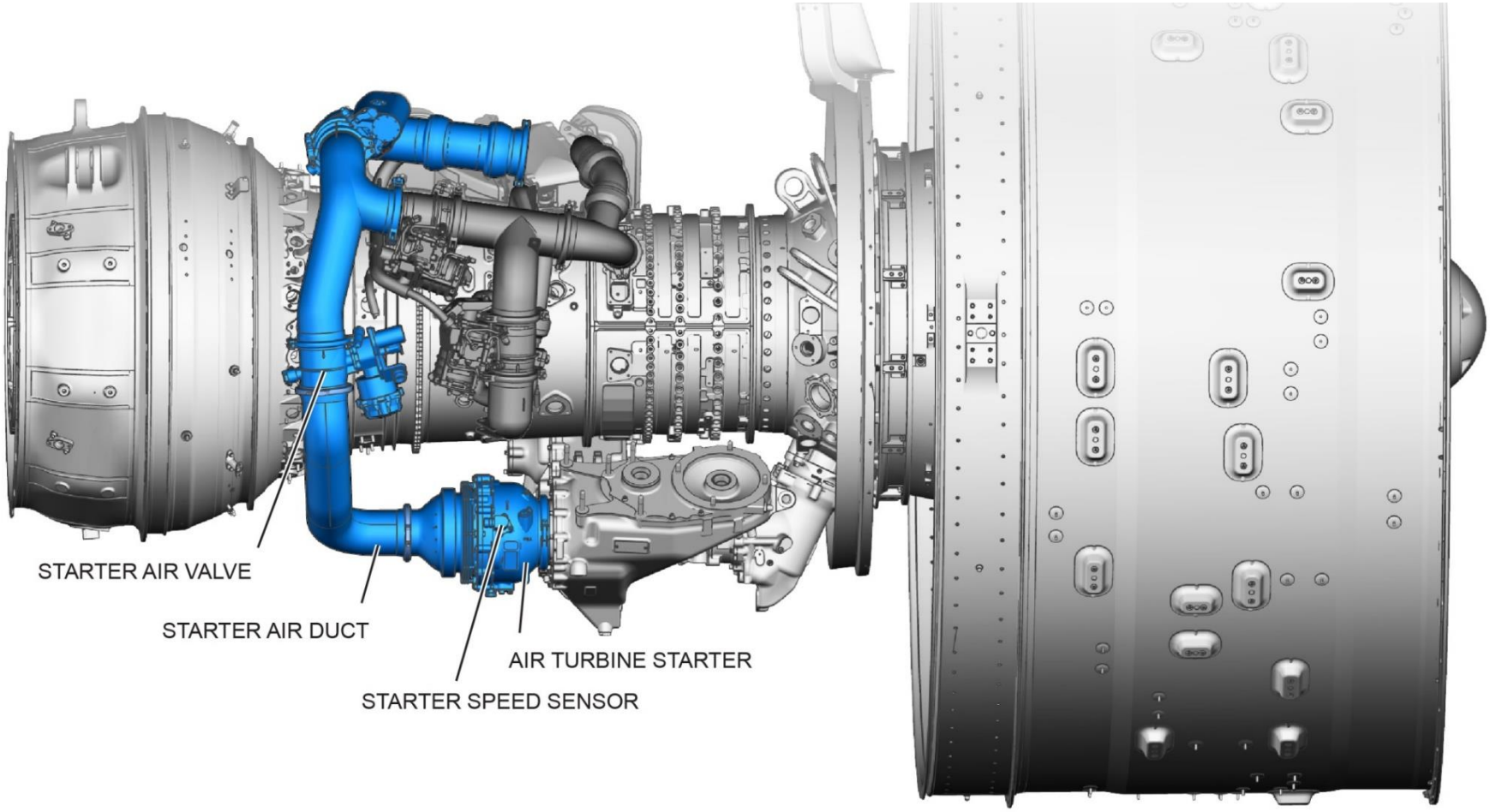
BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN.

THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME.

IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

REFER TO THE MSDS FOR ALL MATERIAL USED AND THE MANUFACTURER’S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED.

IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.


STARTER AIR VALVE
STARTER AIR DUCT
AIR TURBINE STARTER
STARTER SPEED SENSOR

IGNITION & STARTING SYSTEM

GENERAL

The Ignition system provides the electrical spark needed to start or continue engine combustion.

The ignition system is made up of two independent systems.

The Ignition system includes an ignition exciter, two coaxial shield ignition leads and two igniter plugs.

The Starting system drives the engine High Pressure (HP) rotor at a speed high enough for a ground or in flight start to be initiated.

The start system is made up of the electrically controlled Starter Air Valve (SAV) and the pneumatic starter.

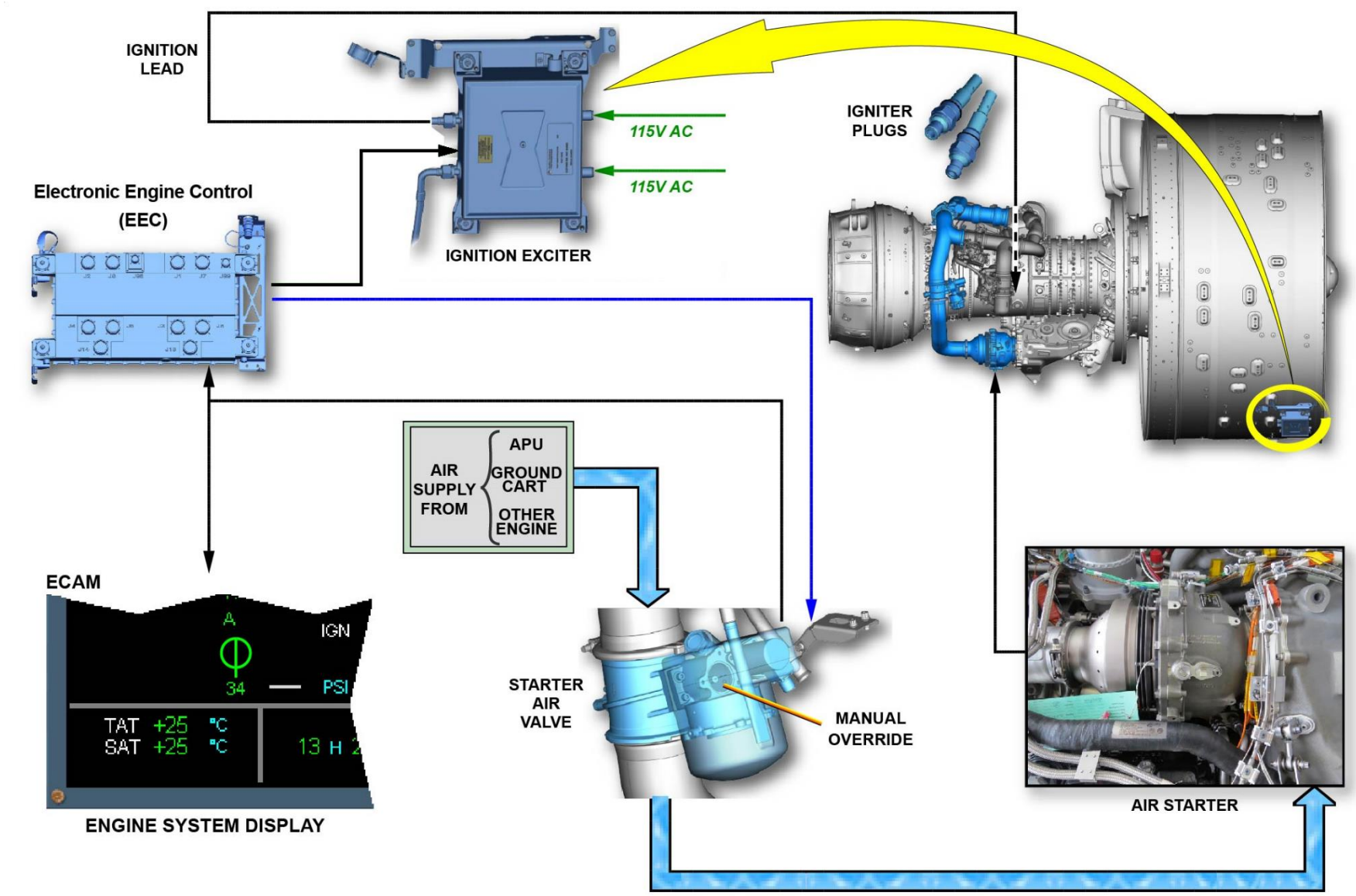
Air bleed is taken from the aircraft pneumatic system for engine start (Auxiliary Power Unit (APU) bleed, external pneumatic cart, or opposite engine bleed).

CONTROL AND INDICATING

The Electronic Engine Control (EEC) controls the ignition during automatic start and manual start. 115 V AC from aircraft electrical system is supplied to the ignition exciter which provides the necessary voltage to the igniter plugs to generate the spark for combustion.

The EEC controls the starting through the SAV during automatic start and manual start.

The operation of the SAV and of the ignition system is displayed on the ENGINE ECAM page.


IGNITION LEAD
115V AC
115V AC
IGNITION EXCITER
IGNITER PLUGS
Electronic Engine Control (EEC)
AIR SUPPLY FROM
APU
GROUND CART
OTHER ENGINE
ECAM
A
IGN
34
PSI
TAT +25 °C
SAT +25 °C
13 H
ENGINE SYSTEM DISPLAY
STARTER AIR VALVE
MANUAL OVERRIDE
AIR STARTER

AUTOMATIC START

During an automatic start, the EEC opens the SAV to motor the engine for start.

The ignition exciter is then energized when the HP rotor speed is nominal. The EEC provides full protection during the start sequence.

When the automatic start is completed, the EEC closes the SAV and cuts off the ignition.

In case of an incident during the automatic start the EEC makes a second attempt or aborts the start procedure.

MANUAL START

During a manual start, the SAV opens when the engine MANual START P/B is pressed in, then the ignition system is energized when the MASTER control lever is set to the ON position.

NOTE: there is no automatic shutdown function or second attempt in MANUAL START.

CRANKING

Engine motoring could be performed for dry cranking or wet cranking sequences.

NOTE: during cranking ignition is inhibited.

CONTINUOUS IGNITION

With engine running, continuous ignition can be selected via the EEC either manually using the rotary selector or automatically by the Full Authority Digital Engine Control (FADEC) during specific conditions.

SAFETY PRECAUTIONS

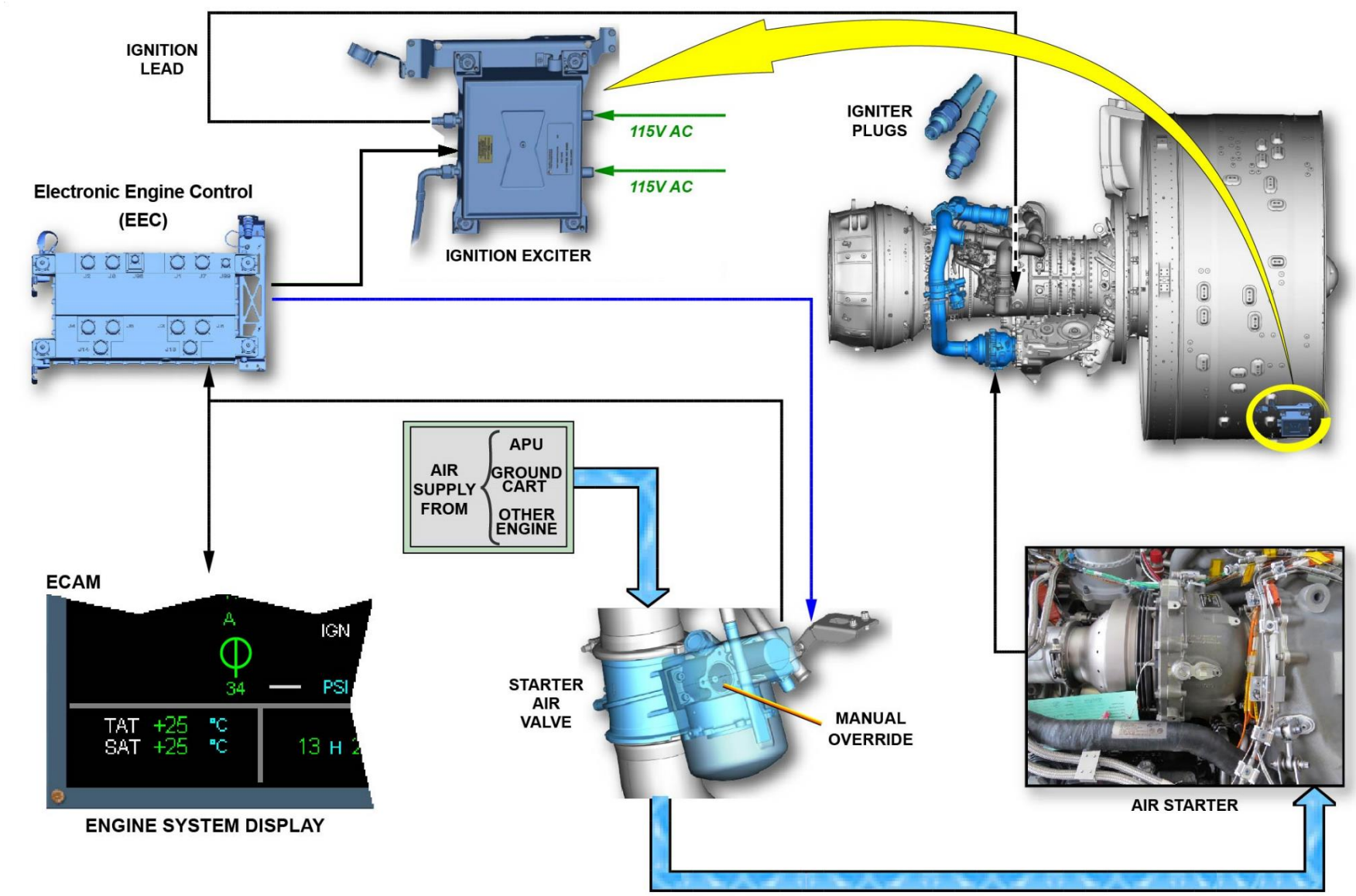
Safety precautions have to be taken prior to working in this area.

WARNING: THE IGNITION EXCITER PROVIDES HIGH ENERGY PULSES THROUGH THE IGNITION LEADS TO THE 2 IGNITERS PLUGS.

MAINTENANCE PRACTICES

To increase A/C dispatch reliability, the SAV is equipped with a manual override.

For this manual operation, the mechanic must be aware of the engine safety zones.


IGNITION LEAD
115V AC
115V AC
IGNITION EXCITER
IGNITER PLUGS
Electronic Engine Control (EEC)
AIR SUPPLY FROM
APU
GROUND CART
OTHER ENGINE
ECAM
A
IGN
34
PSI
TAT +25 °C
SAT +25 °C
ENGINE SYSTEM DISPLAY
STARTER AIR VALVE
MANUAL OVERRIDE
AIR STARTER

GENERAL

The Electronic Engine Control (EEC) controls and monitors the Starting and Ignition systems for engine starting, cranking, and ignition selection, on ground and in flight.

For engine starting, two modes are available: automatic or manual.

Both modes can be used on ground or in flight, but in-flight sequence are less protective to enhance the restart capability.

For engine cranking, two sequences can be manually selected: dry or wet.

The EEC controls the starting and ignition components according to cockpit commands and protective logics.

The main engine parameters to be monitored during starting are displays on the E/WD (N1, EGT, N2, Fuel Flow) and on the SD (Oil Press, IGN system, Starter Air Valve position and available pneumatic pressure).

The ignition system is composed of a dual channel ignition exciter supplying two spark igniter plugs.

Each plug and corresponding circuit (identified as system A and system B) can be used at the same time or alternately to detect dormant failures.

The EEC controls the ignition by providing command signals to the internal relays of the ignition exciter, whereas the EIU supplies 115 Volt power supply to the ignition exciter.

The starting system consists of a Starter Air Valve (SAV), air duct and an Air Turbine Starter (ATS).

The SAV is electrically controlled by the EEC and pneumatically operated.

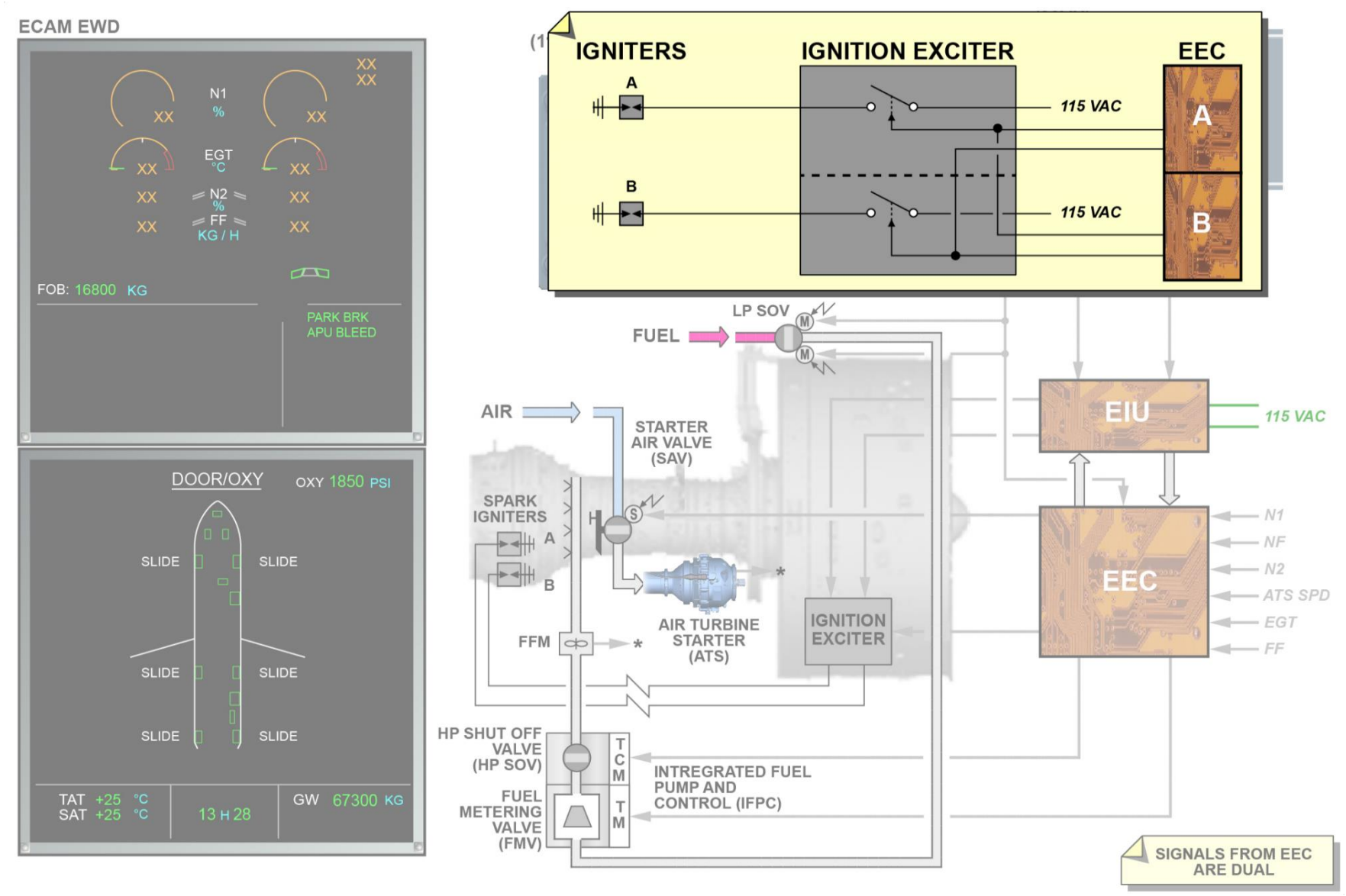
The ATS is attached to the aft of the main gearbox at the 5 o'clock position. It is fitted with a speed sensor which is used for system control and monitoring by the EEC.

The pressurized air supply to the starting components is provided by one of the following sources:

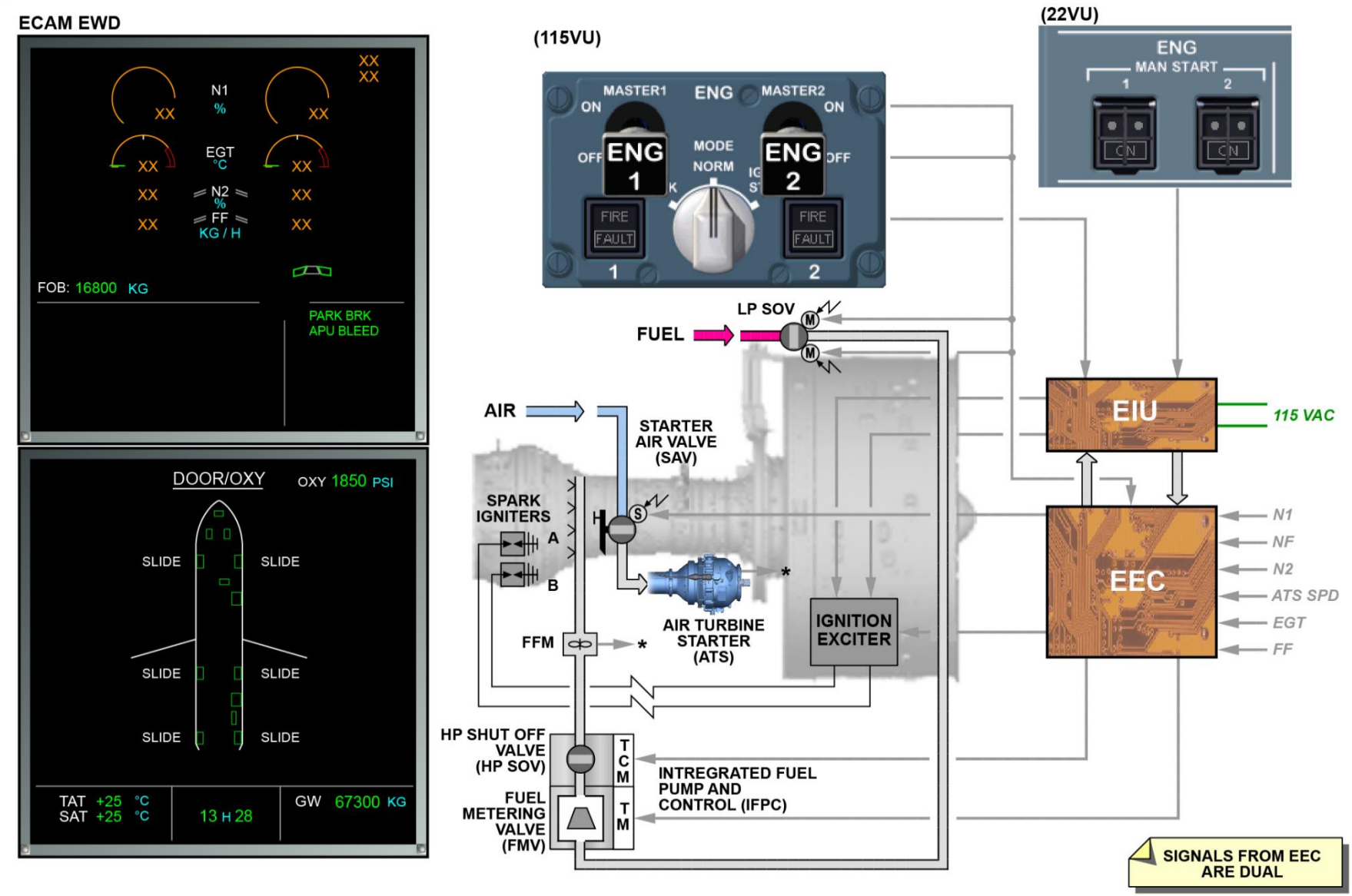
Auxiliary Power Unit (APU) bleed,

external pneumatic ground cart,

engine bleed from the opposite engine.


ECAM EWD
N1
%
EGT
°C
N2
%
FF
KG / H
XX
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(1
IGNITERS
IGNITION EXCITER
EEC
A
B
115 VAC
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
FFM
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
TCM
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

INTENTIONALLY BLANK


ECAM EWD
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
MODE
NORM
ENG 2
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
FUEL
LP SOV
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

AUTOMATIC START

The EEC shall enter the automatic start mode when all the following conditions are true:

the engine is not running, and

the selected rotary selector is set to IGN/START, and

the selected ENG MASTER lever is set to ON, and

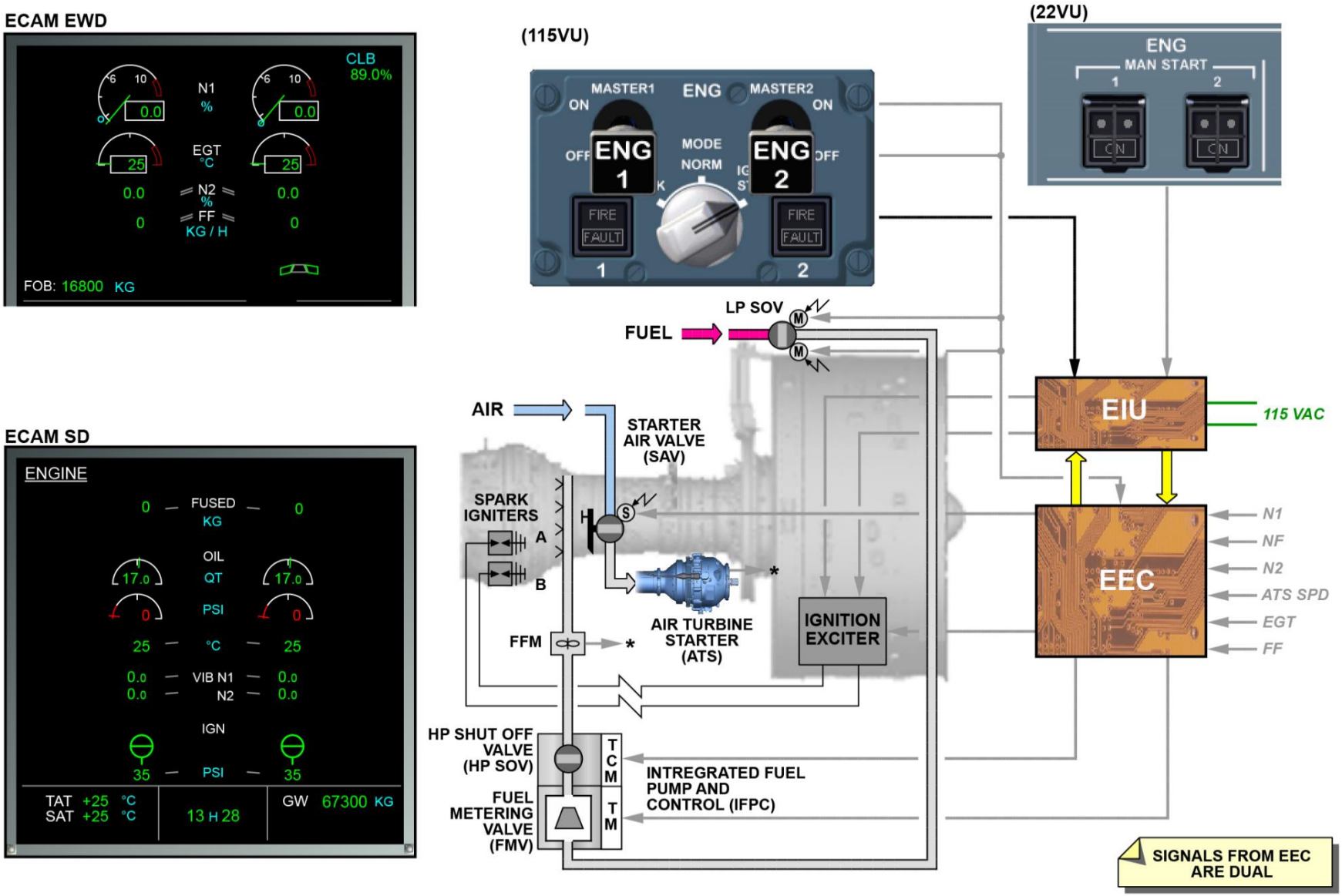
the ENG MAN START pushbutton is OFF.

When the ENG MODE rotary selector is set to IGN/START position, FADEC is powered up.

The ENGINE page is automatically shown on the System Display (SD) page of the ECAM system.

The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.

At the same time, the APU bleed demand will increase and the pack valves will close.


ECAM EWD
CLB
89.0%
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
OIL
QT
PSI
°C
VIB N1
N2
IGN
PSI
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
A
B
FFM
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
TCM
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

As soon as the ENG MASTER lever is set to ON position, the LPSOV opens and the automatic starting sequence begins.

The EEC will automatically control the:

Thrust Control Malfunction (TCM) cutback test,

HPC active bleed valve (opening and closing),

Hydraulic pump depressurizing (via EIU) if necessary during in flight restart,

SAV (opening and closing),

Igniters (one or two, on and off),

Fuel Flow (FMV and HPSOV opening).

First, the EEC energizes the SAV solenoid.

This supplies the starter with aircraft pneumatic pressure.

The position of the SAV is confirmed open at the bottom of the ENGINE page thanks to the ATS speed sensor feedback.

Consequently, the N2 begins to increase.

NOTE: BEFORE IGN & FUEL ADDED THE EEC WILL HOLD N2 AT 10% FOR THE COOL DOWN PERIOD THAT CAN LAST UP TO TWO AND A HALF MINUTES. THS IS BASED ON HOW LONG ENGINE HAS BE SHUT DOWN FOR AND EGT

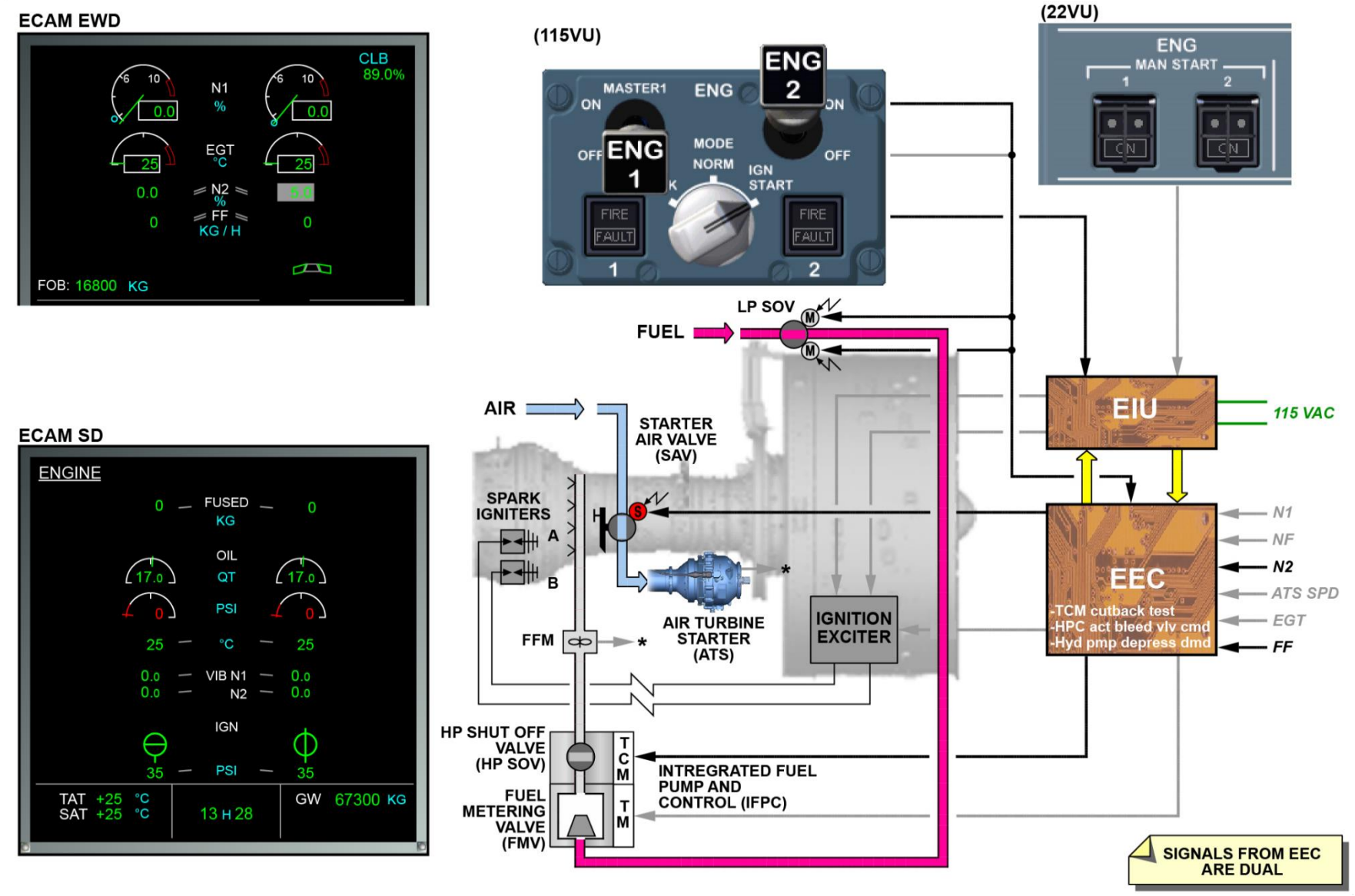
COOL DOWN TIME IS INDICATED ON EWD WHEN IGN/START IS SELECTED

Pulsing GREEN: When engine cooling is ACTIVE

Steady GREEN when COOLING needed, and the engine COOLING is inactive

Engine cooling counter is displayed below the COOLING message in green when COOLING needed is active and cooling counter is valid.

Otherwise nothing is displayed.


ECAM EWD
CLB
89.0%
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
OIL
QT
PSI
°C
VIB N1
N2
IGN
PSI
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
-TCM cutback test
-HPC act bleed vlv cmd
-Hyd pmp depress dmd
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

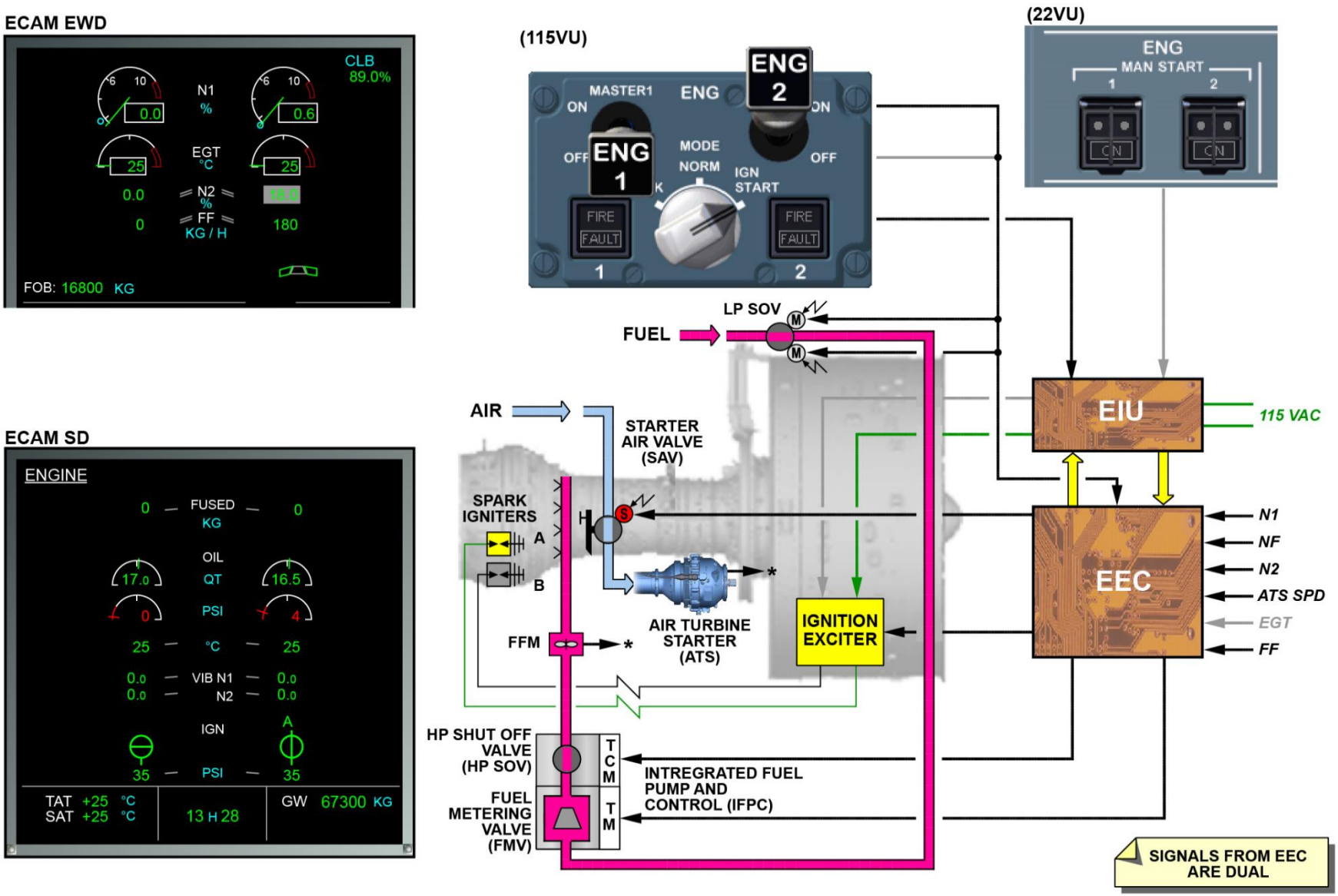
When the engine reaches the minimum fuel pressurization speed (18% N2), the EEC activates one igniter and controls the appropriate fuel flow to the burner.

On the SD ENGINE page, the corresponding spark igniter system (A or B) controlled by the EEC comes into view.

On the E/WD, the FF increases.

Fuel is sent to the burner via the Fuel Metering Valve (FMV) and the High Pressure Shut Off Valve (HPSOV) in the Integrated Fuel Pump and Control (IFPC).

The EEC monitors the Exhaust Gas Temperature (EGT) and N2 according to their schedules to provide the correct fuel flow for a good acceleration.


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
18.0
0
FF
KG / H
180
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
A
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
1
FIRE
FAULT
2
(22VU)
ENG
MAN START
1
2
CN
CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

When N2 reaches 55% N2, the automatic start sequence ends when the EEC controls the SAV to close and the igniter to OFF.

The engine continues to accelerate and stabilizes at idle speed.

The usual standard parameters are:

N1 = 19%,

N2 = 58%,

EGT = 440 ºC,

FF = 227 kg/h. (500 lbs/h)

If the second engine has to be started, the ENG MODE rotary selector should stay on the IGN/START position.

This will avoid activating the continuous ignition on the running engine if the selector is cycled to NORM and again to IGN/START.

When both engines are running, the selector is set back to NORM, the WHEEL page will appear instead of the ENGINE page if at least one engine running.

Automatic start abort:

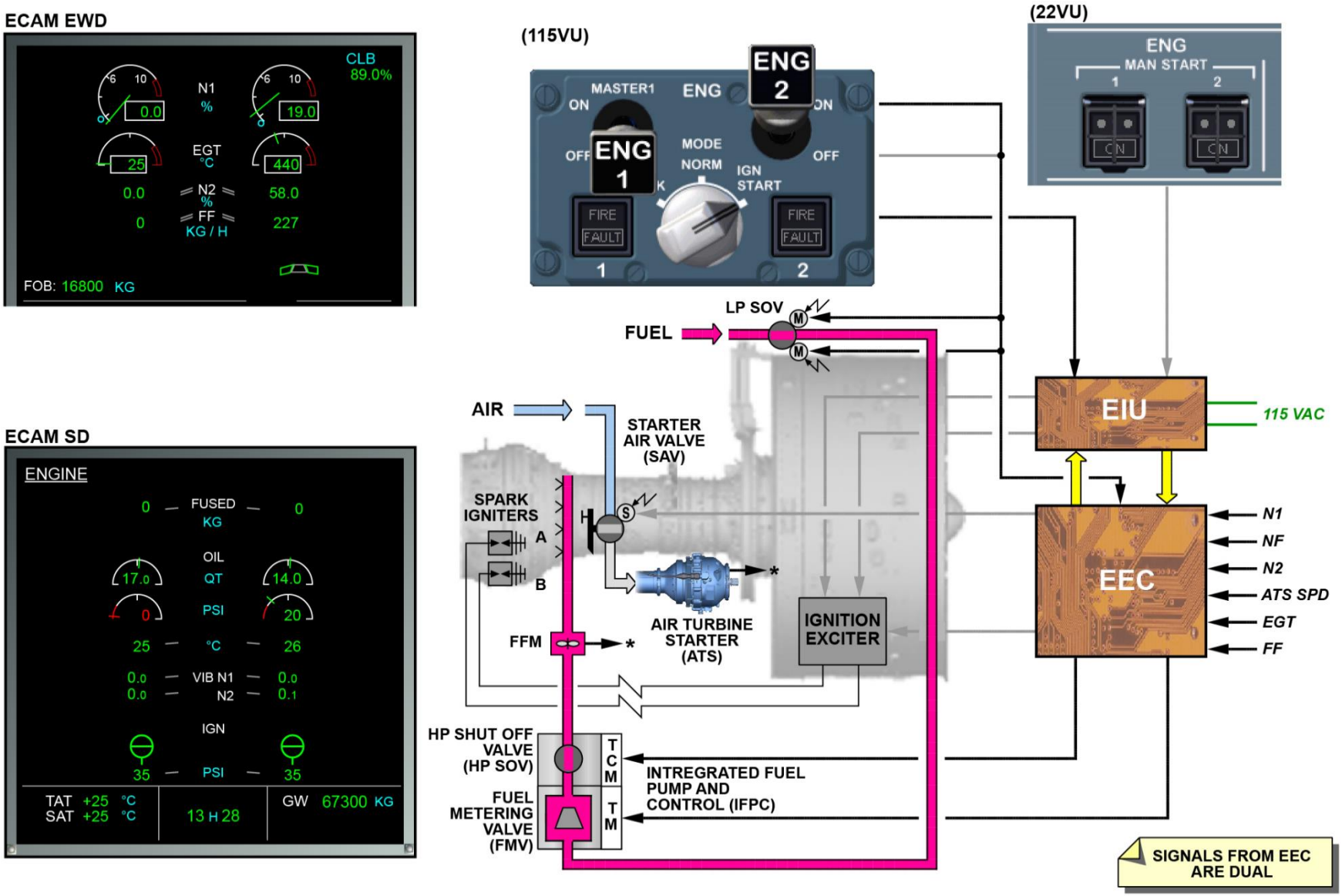
The EEC has the authority to abort a start only on the ground.

The EEC will abort the start, dry motor the engine for 30 seconds and attempt a single start for the following reasons:

no light up (EGT low and constant),

no N2 acceleration (hung start),

EGT reaches starting limit (impending hot start).


ECAM EWD
CLB
89.0%
N1
%
0.0
19.0
EGT
°C
25
440
0.0
N2
%
58.0
0
FF
KG / H
227
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
17.0
QT
14.0
PSI
0
20
25
°C
26
0.0
VIB N1
0.0
0.0
N2
0.1
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
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CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
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AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
TCM
FUEL
METERING
VALVE
(FMV)
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

NOTE: The maximum EGT during start sequence is 1083 ºC.

The EEC will abort a start, dry motor the engine for 30 seconds and not attempt a restart for the following conditions:

Failure of automatic restart,

N1 locked rotor,

EEC unable to command both igniters,

Loss of EGT indication (T5 sensors failed),

EEC unable to control fuel flow.

The EEC will also abort a start, will not dry motor the engine and will not attempt a restart if the starter duty cycle is exceeded.

Manual start abort:

The automatic start sequence can be manually aborted by selection of the ENG MASTER lever to OFF position.

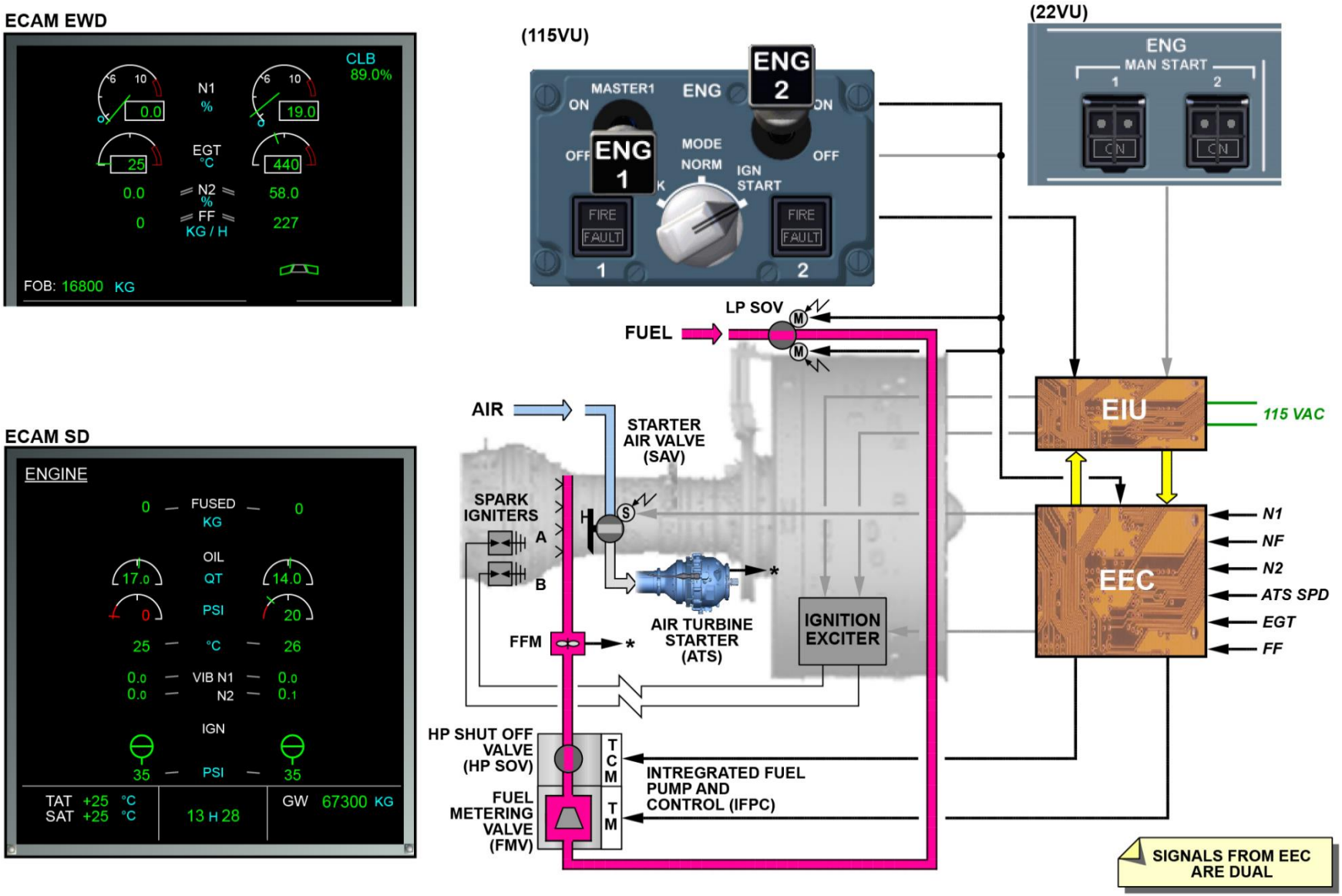
This leads to:

SAV closure,

Igniter(s) off,

FMV, LP and HP fuel shut-off valves closure.

NOTE: EEC does not dry motor the engine when an automatic start is manually aborted.

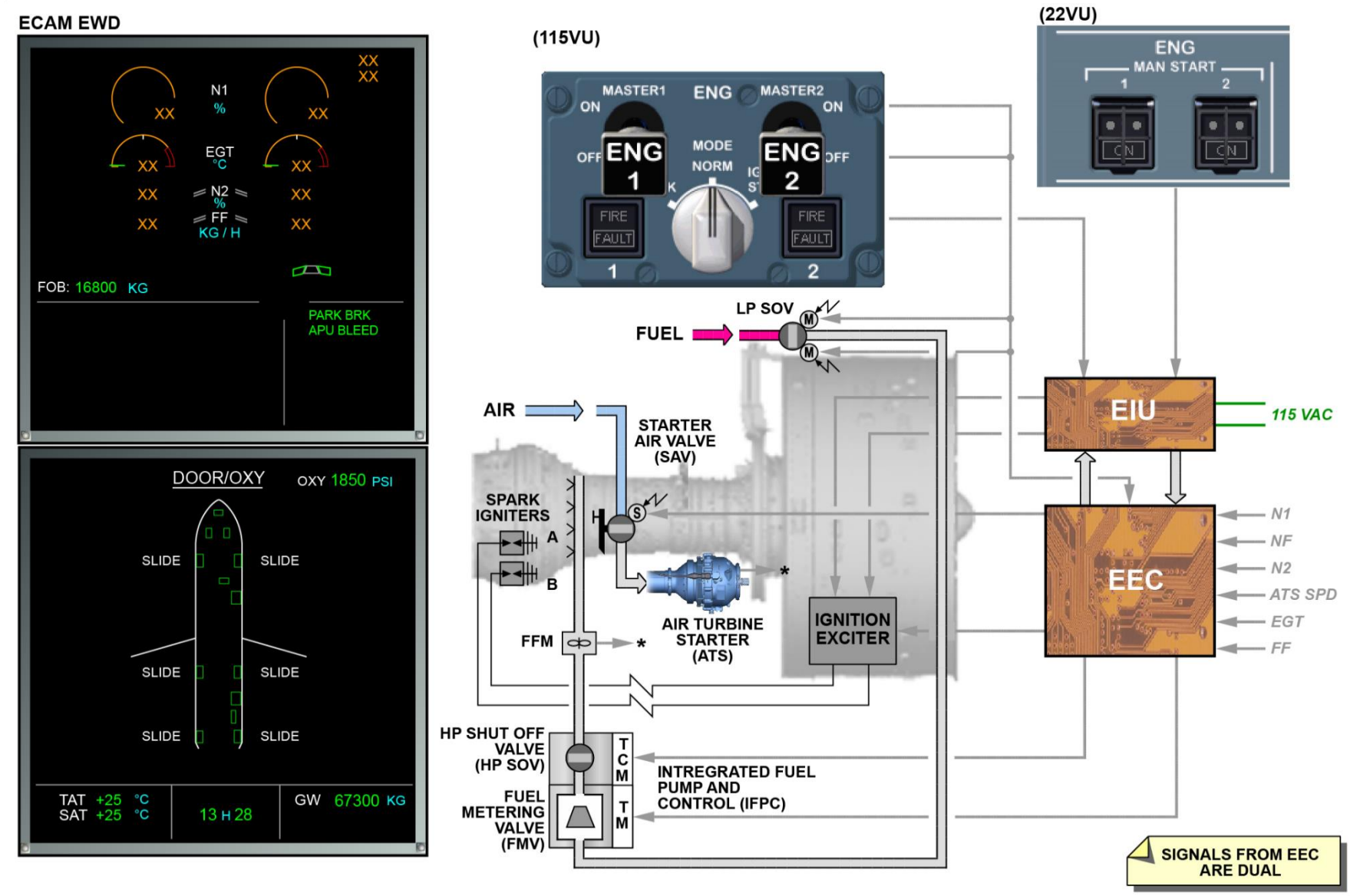

ECAM EWD
CLB
89.0%
N1
%
0.0
19.0
EGT
°C
25
440
0.0
N2
%
58.0
0
FF
KG / H
227
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
17.0
QT
14.0
PSI
0
20
25
°C
26
0.0
VIB N1
0.0
0.0
N2
0.1
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
H
S
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
TCM
FUEL
METERING
VALVE
(FMV)
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

MANUAL START

A manual engine start procedure is included in the EEC engine starting logic.

In the manual start mode, engine starting control is under limited authority of the EEC.

The SAV, fuel, and ignition are controlled from the cockpit via the EEC.

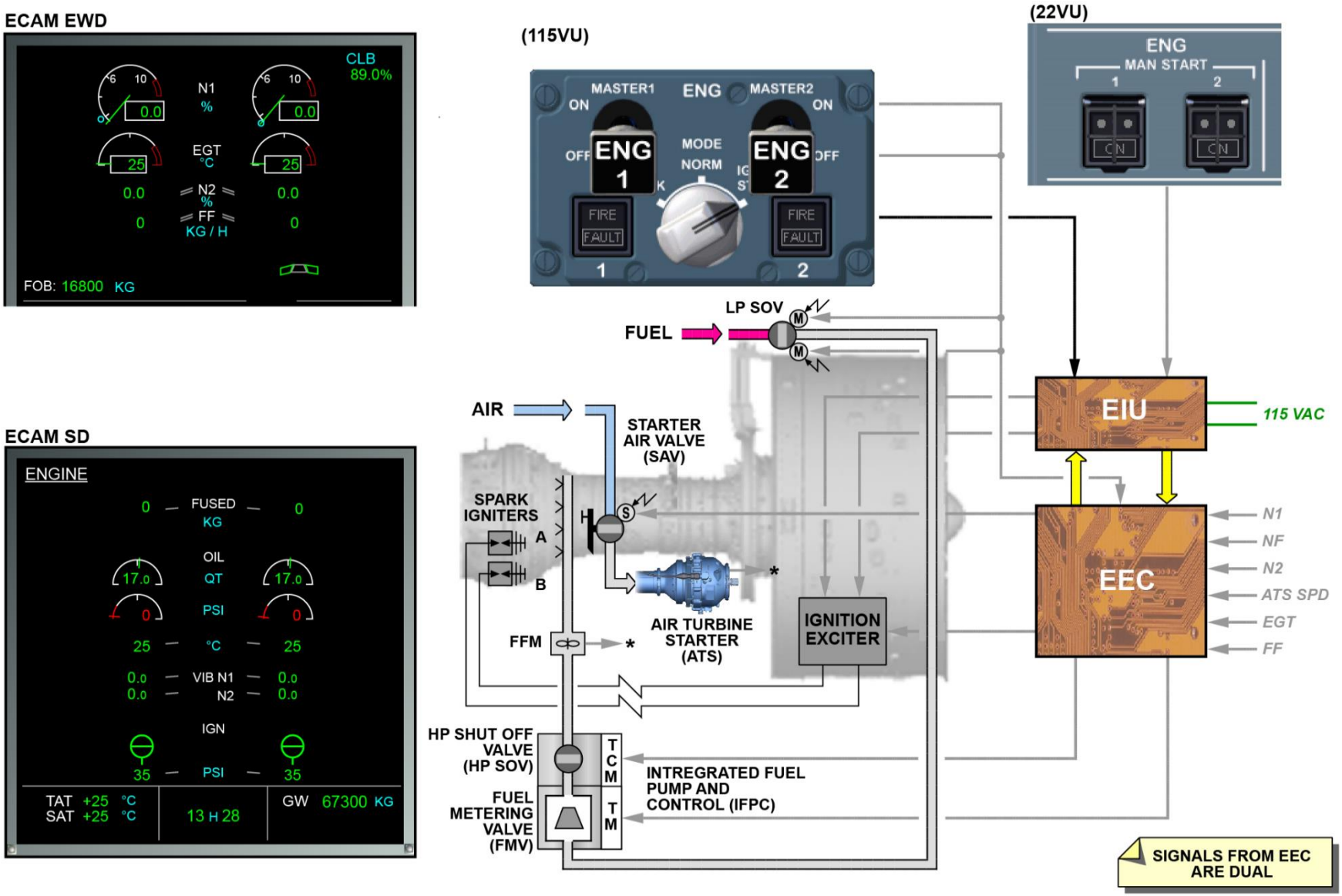

ECAM EWD
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
MODE
NORM
ENG 2
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
FUEL
LP SOV
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

Bleed air source being available, a manual start sequence is commanded by first setting the rotary selector to the IGN/START position to power and signal the EEC.

The ENGINE page appears on the SD page of the ECAM.

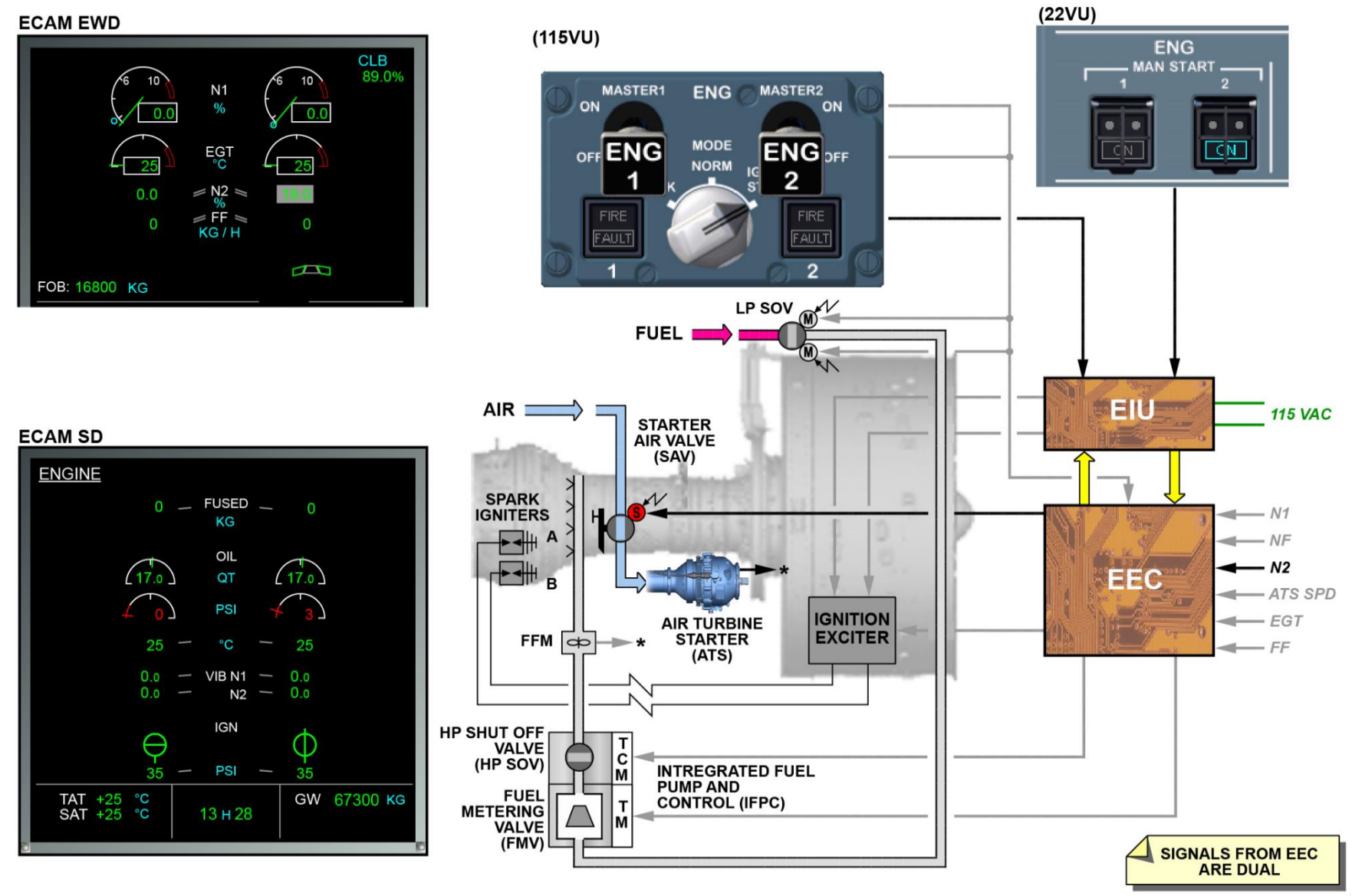
The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.

At the same time, the APU bleed demand will increase and the pack valves will close.


ECAM EWD
CLB
89.0%
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
OIL
QT
PSI
°C
VIB N1
N2
IGN
PSI
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
A
B
FFM
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
TCM
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

The next action is to engage the ENG MAN START push-button to the ON position.

This will lead the EEC to open the SAV.


ECAM EWD
CLB
89.0%
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
OIL
QT
PSI
°C
VIB N1
N2
IGN
PSI
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
A
B
FFM
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
HP SHUT OFF VALVE (HP SOV)
FUEL METERING VALVE (FMV)
TCM
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

When N2 is above the minimum fuel pressurization speed (on-ground approximately 18% N2), the ENG MASTER lever is set to the ON position.

The EEC commands fuel flow and both igniters simultaneously.

The EEC monitors the EGT and N2 according to their schedules to provide the correct fuel flow but EGT limit protection is inactive.

When N2 reaches 55% N2, the manual start sequence automatically ends when the EEC controls the SAV to close and the igniters to OFF.

The engine continues to accelerate and stabilizes at idle speed.

If the second engine has to be started, the ENG MODE rotary selector should stay on the IGN/START position.

This will avoid activating the continuous ignition on the running engine if the selector is cycled to NORM and again to IGN/START.

When both engines are running, the selector is set back to NORM, the WHEEL page will appear instead of the ENGINE page if at least one engine running.

Manual start abort:

When a manual engine start has been initiated on ground or in flight, it shall be interrupted by either:

de-selecting the ENG MAN START push-button before the ENG MASTER lever is commanded ON, or

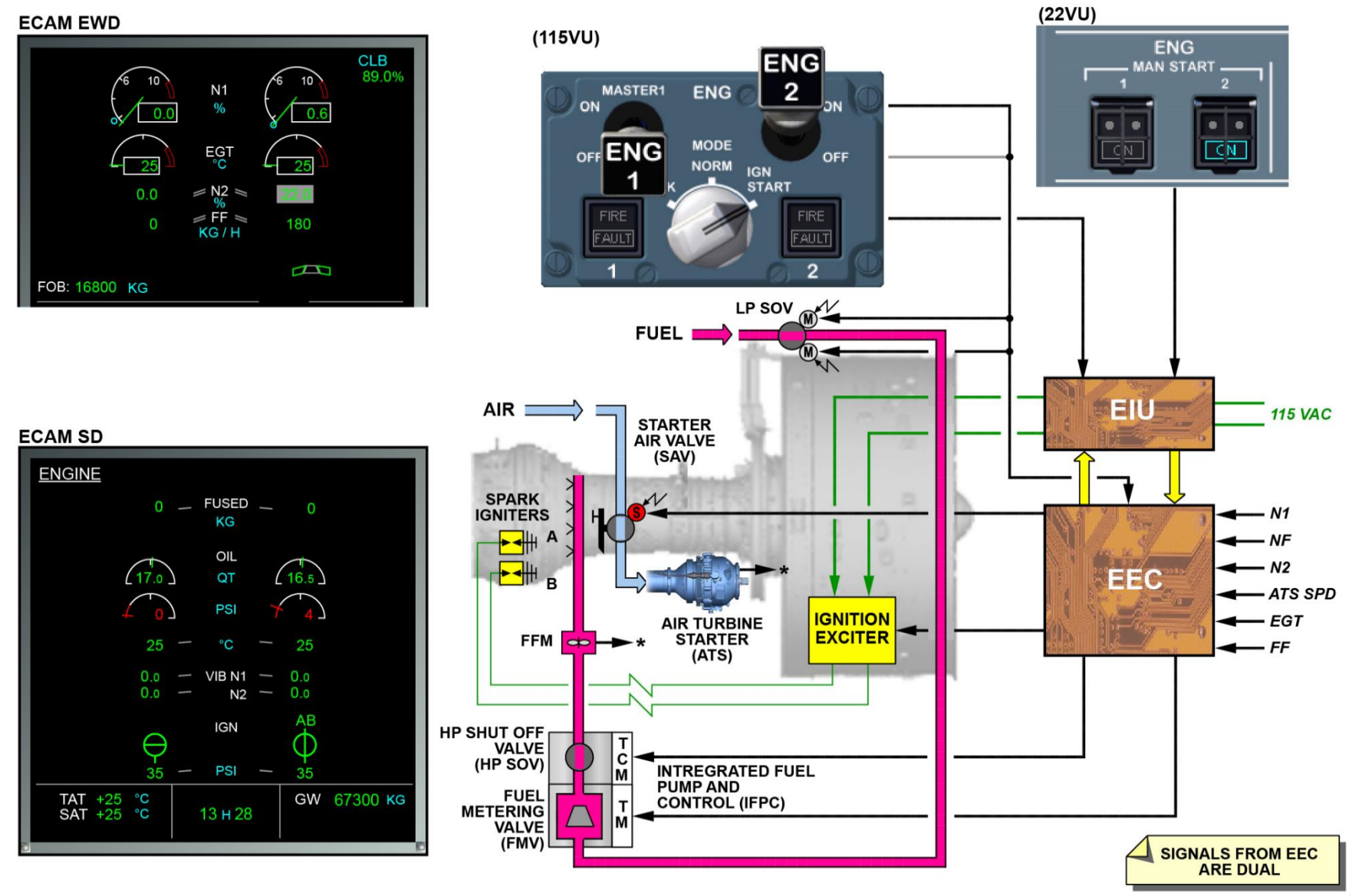
selecting ENG MASTER lever back to OFF position after it has already been selected ON.

Interruption of a manual start shall result in the following EEC commands:

SAV closure,

igniters off,

FMV and HP fuel shut-off valve closure.


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
22.0
0
FF
KG / H
180
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
AB
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

CONTINUOUS IGNITION

Continuous ignition is manually selected or automatically controlled by the FADEC.

During continuous ignition both igniters are active.

Manual command:

Once the engine is running and above idle, the pilot can manually command continuous ignition at any time by moving the rotary selector to the IGN/START position.

Following a ground start, the rotary selector must be moved back to NORM before continuous ignition can be manually selected by moving it back to IGN/START position.

Continuous ignition shall remain commanded by the EEC until the rotary selector is moved back to NORM.

If the data position of the rotary selector sent by Engine Interface Unit (EIU) to EEC is not available or invalid, the EEC shall use the last valid value of the rotary selector position if the aircraft is on ground until a valid configuration is received again.

Automatic command:

The EEC automatically commands continuous ignition at the following conditions:

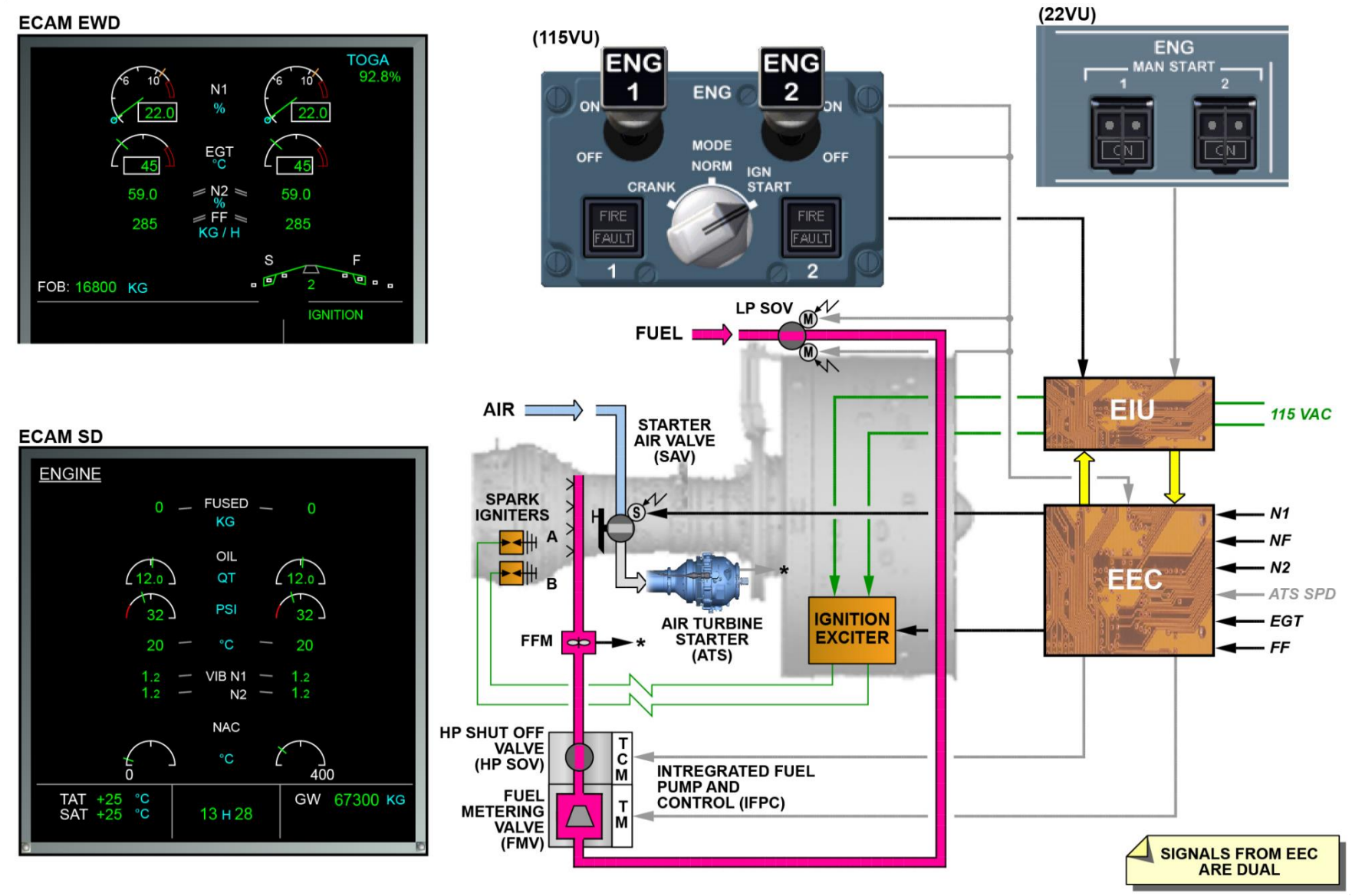
If an engine flameout is detected in flight, or during take-off, igniters are kept on for a minimum of 30 seconds after the engine has recovered from the flameout and reached idle,

If a surge is detected in flight or during take-off, igniters are powered until 30 seconds after the surge recovers,

If the EEC detects a quick relight (Master Lever cycled from ON to OFF and back to ON in flight),

If TCM Cutback is commanded.

Automatic continuous ignition shall be inhibited if the burner pressure (PB) is above 150 psi (the nominal deteriorated igniter quench point) to preserve igniter life.


ECAM EWD
TOGA
92.8%
N1
%
22.0
22.0
EGT
°C
45
45
59.0
N2
%
59.0
285
FF
KG / H
285
S
F
2
FOB: 16800 KG
IGNITION
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
12.0
12.0
PSI
32
32
20
°C
20
1.2
VIB N1
1.2
1.2
N2
1.2
NAC
°C
0
400
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
ENG 1
ENG
ENG 2
ON
OFF
MODE
NORM
IGN
START
CRANK
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
SIGNALS FROM EEC
ARE DUAL

ENGINE CRANK

DRY CRANK

Cranking function is used to motor the engine on the ground for a short time with the use of the starter.

There are two cranking modes:

dry cranking,

wet cranking.

The dry cranking procedure is used to motor the engine to remove unburned fuel from the combustion chamber or cool down the engine or for some fuel or oil leak tests.

The EEC shall enter the engine dry crank sequence when all of the following conditions are true:

the engine is not running and,

the aircraft is on ground and,

the rotary selector is set to CRANK.

This will power up the EEC and isolate both ignition systems.

The ENGINE page appears automatically on the ECAM SD.

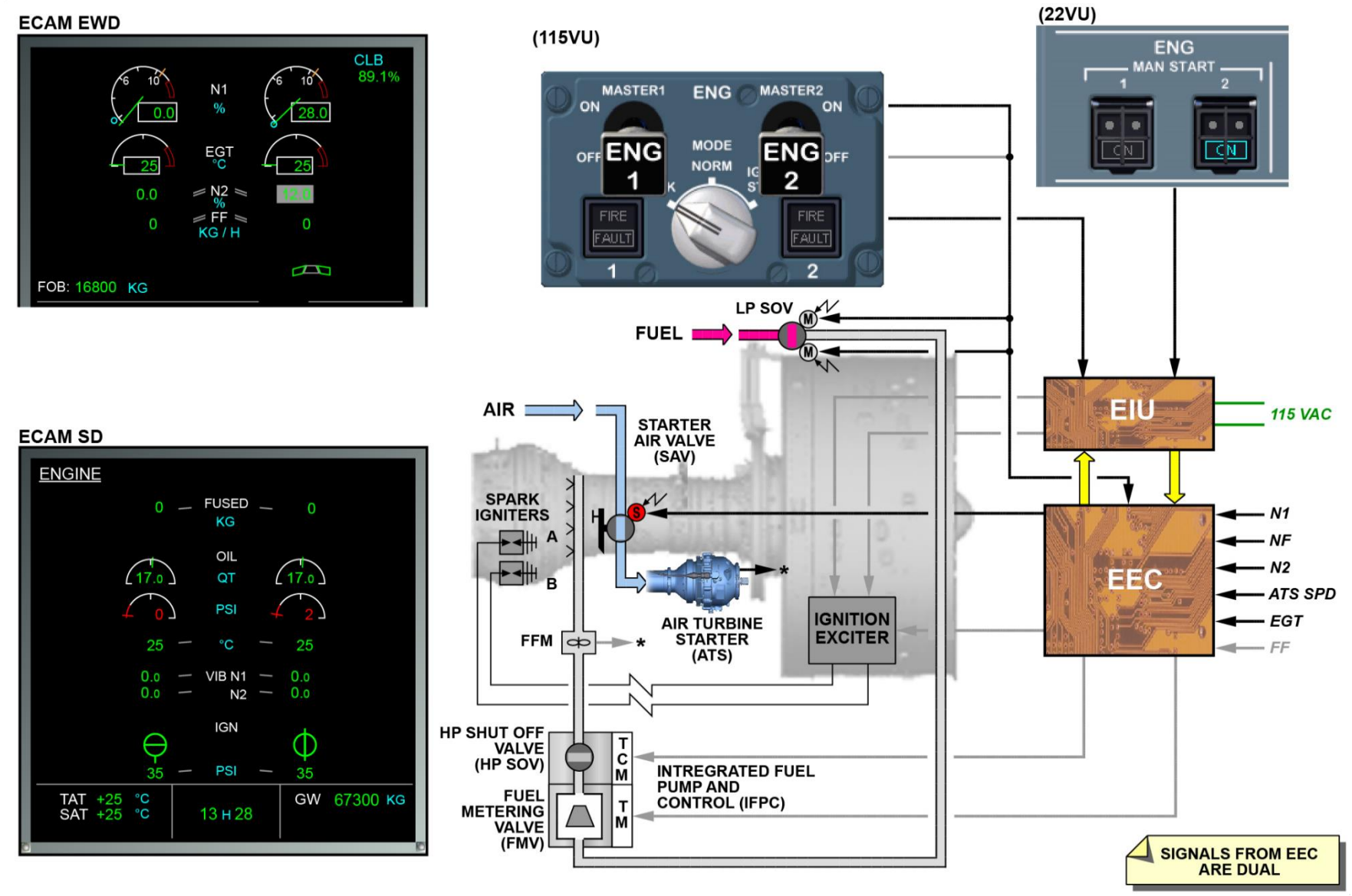
When the ENG MAN START P/B is set to ON, the EEC commands the SAV to open.

The dry motoring can be interrupted at any time by pushing the ENG MAN START pushbutton to OFF or positioning the ENG MODE rotary selector to NORM position.

The usual starter duty cycle is 3 starter crank cycles or 4 minutes maximum of continuous cranking.

A 30 minutes cool down period is necessary for additional use.

WARNING: the EEC is able to initiate a start sequence immediately following a dry motoring sequence by setting the ENG MODE rotary selector to IGN/START position and the ENG MASTER control lever to ON position.


ECAM EWD
CLB
89.1%
N1
%
0.0
28.0
EGT
°C
25
25
0.0
N2
%
12.0
FF
KG / H
0
0
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
17.0
PSI
0
2
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ON
ENG
MASTER2
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
CN
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

WET CRANK

The wet cranking procedure is used to motor the engine for specific fuel or oil leak tests.

The fuel flow is commanded but both ignition systems are isolated.

The fuel goes through the IFPC to the actuator fuel pressure lines, the engine fuel manifolds (primary fuel lines only), and nozzles.

Fuel is then sprayed in the combustion chamber.

The first steps of the wet crank sequence are the same as the ones for the dry crank:

the engine is not running,

the aircraft is on ground,

the rotary selector is set to CRANK (EEC powered, both ignition systems isolated, ENGINE page appears),

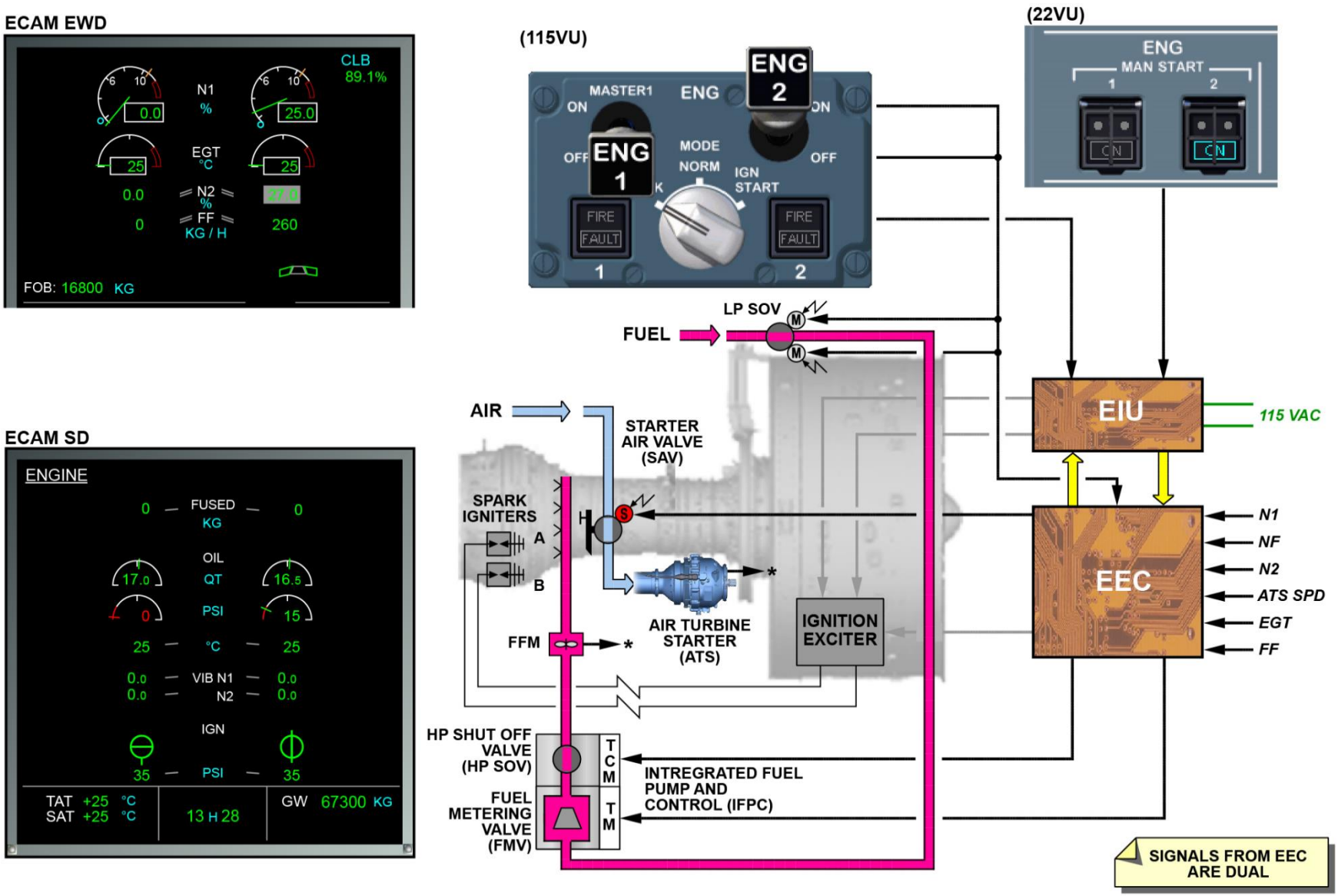
the ENG MAN START P/B is set to ON. (SAV opening).

When N2 speed stabilizes, the ENG MASTER lever is set to the ON position to command the fuel flow.

After 15 seconds, the ENG MASTER lever is set to the OFF position to cut the fuel supply.

The SAV command is maintained 30 seconds to blow all the fuel from the engine.

The wet motoring ends by pushing the ENG MAN START pushbutton to OFF or/and positioning the ENG MODE rotary selector to NORM position.


ECAM EWD
CLB
89.1%
N1
%
0.0
25.0
EGT
°C
25
25
0.0
N2
%
27.0
0
FF
KG / H
260
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
17.0
QT
16.5
0
PSI
15
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
LP SOV
FUEL
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

START FAILURES

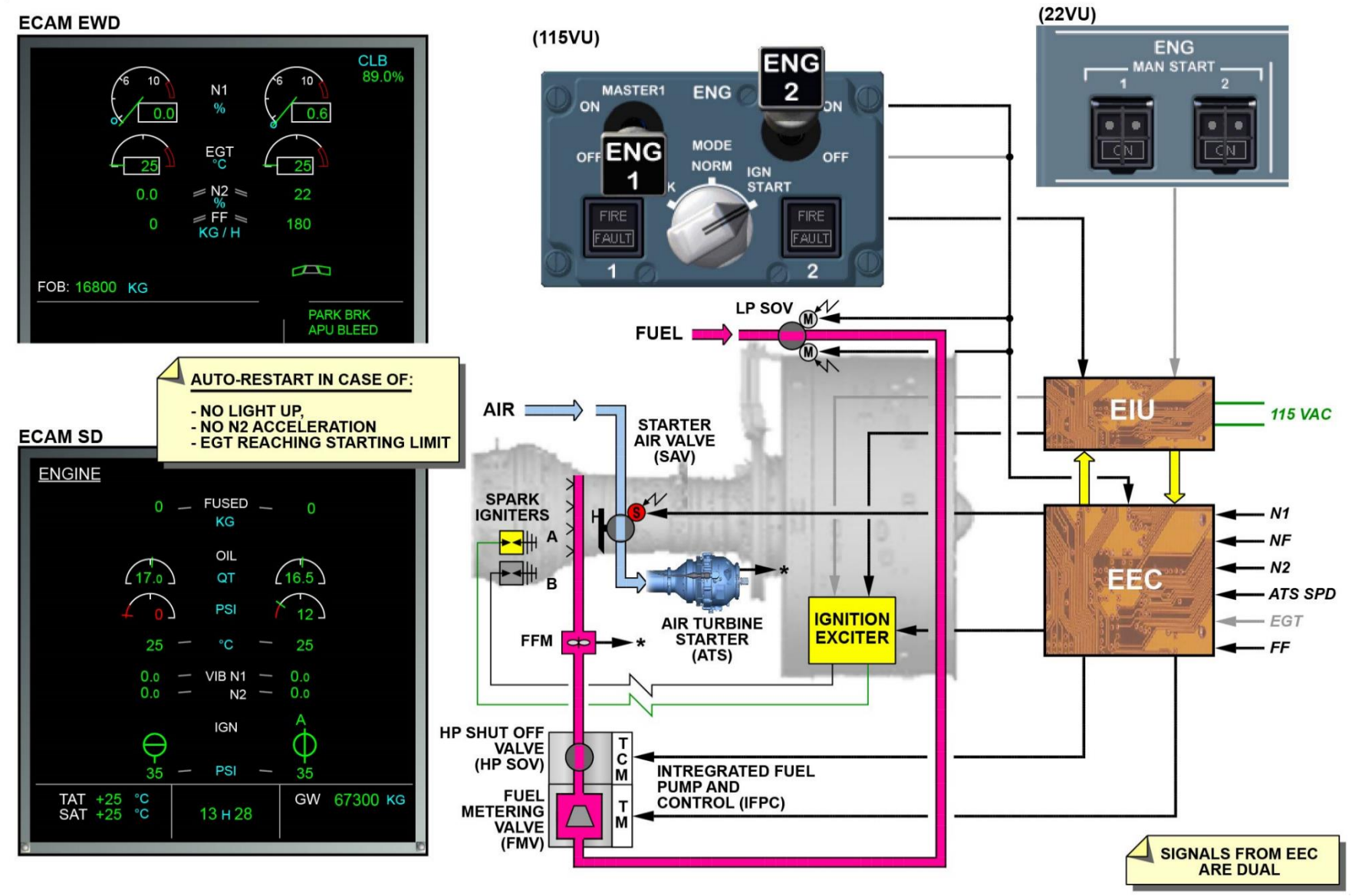
AUTO-RESTART

The Electronic Engine Computer (EEC) will abort the automatic start, dry motor the engine for 30 seconds and attempt a single auto-restart for the following reasons:

No light up (Exhaust Gas Temperature (EGT) low and constant),

No N2 acceleration (hung start),

EGT reaches starting limit (impending hot start or surge).


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
22
0
FF
KG / H
180
FOB: 16800 KG
PARK BRK
APU BLEED
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
17.0
QT
16.5
PSI
0
12
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
A
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
AUTO-RESTART IN CASE OF:
- NO LIGHT UP,
- NO N2 ACCELERATION
- EGT REACHING STARTING LIMIT
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
FUEL
LP SOV
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

NO LIGHT UP

If during an automatic start, the EEC identifies a low EGT:

It shuts down the fuel supply and the selected igniter,

It generates the ECAM alert "ENG x IGN A(B) FAULT",

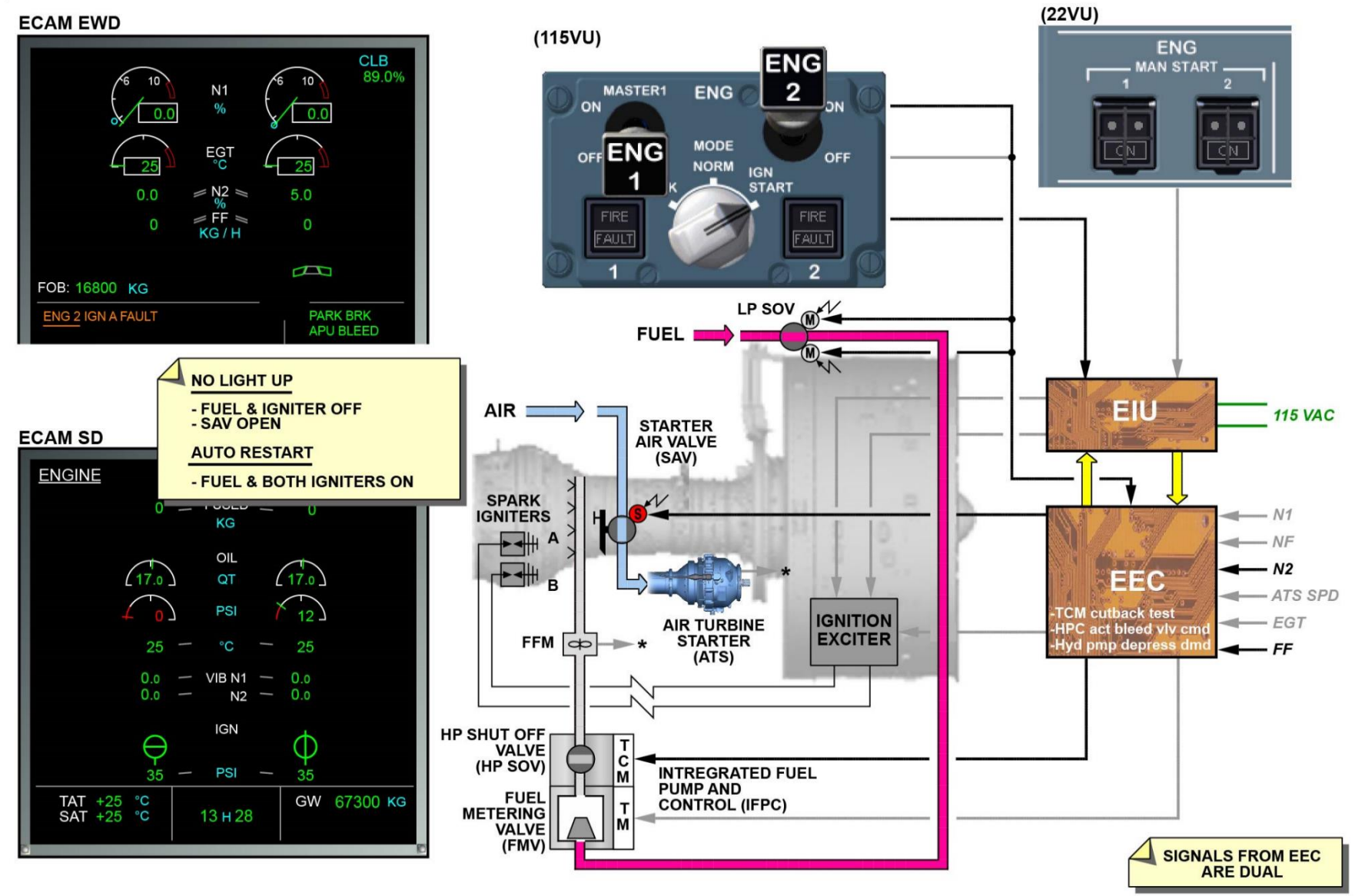
It maintains the Starter Air Valve (SAV) open to clear fuel vapours and cool the turbine for 30 seconds,

Then it controls simultaneously the fuel flow and both igniters,

When N2 reaches the starter cut-out speed (or the light up is confirmed), it switches the igniters off and controls the SAV closure 1 seconds after (or 1 seconds after the starter duty cycle is exceeded).

The engine continues to accelerate and stabilizes at idle speed.

If this auto-restart attempt fails, the start is aborted and the EEC will generate the ECAM alerts "ENG x START FAULT (IGNITION FAULT)" and "ENG x IGN A+B FAULT".


ECAM EWD
CLB
89.0%
N1
%
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
ENG 2 IGN A FAULT
PARK BRK
APU BLEED
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
(22VU)
ENG
MAN START
CN
NO LIGHT UP
- FUEL & IGNITER OFF
- SAV OPEN
AUTO RESTART
- FUEL & BOTH IGNITERS ON
ECAM SD
ENGINE
OIL
QT
PSI
°C
VIB N1
N2
IGN
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
FUEL
LP SOV
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
FFM
AIR TURBINE
STARTER
(ATS)
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
-TCM cutback test
-HPC act bleed vlv cmd
-Hyd pmp depress dmd
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

IMPENDING HOT START

If during an automatic start, the EEC identifies an impending hot start, it maintains the SAV open, the selected igniter on and controls a fuel de-pulse procedure:

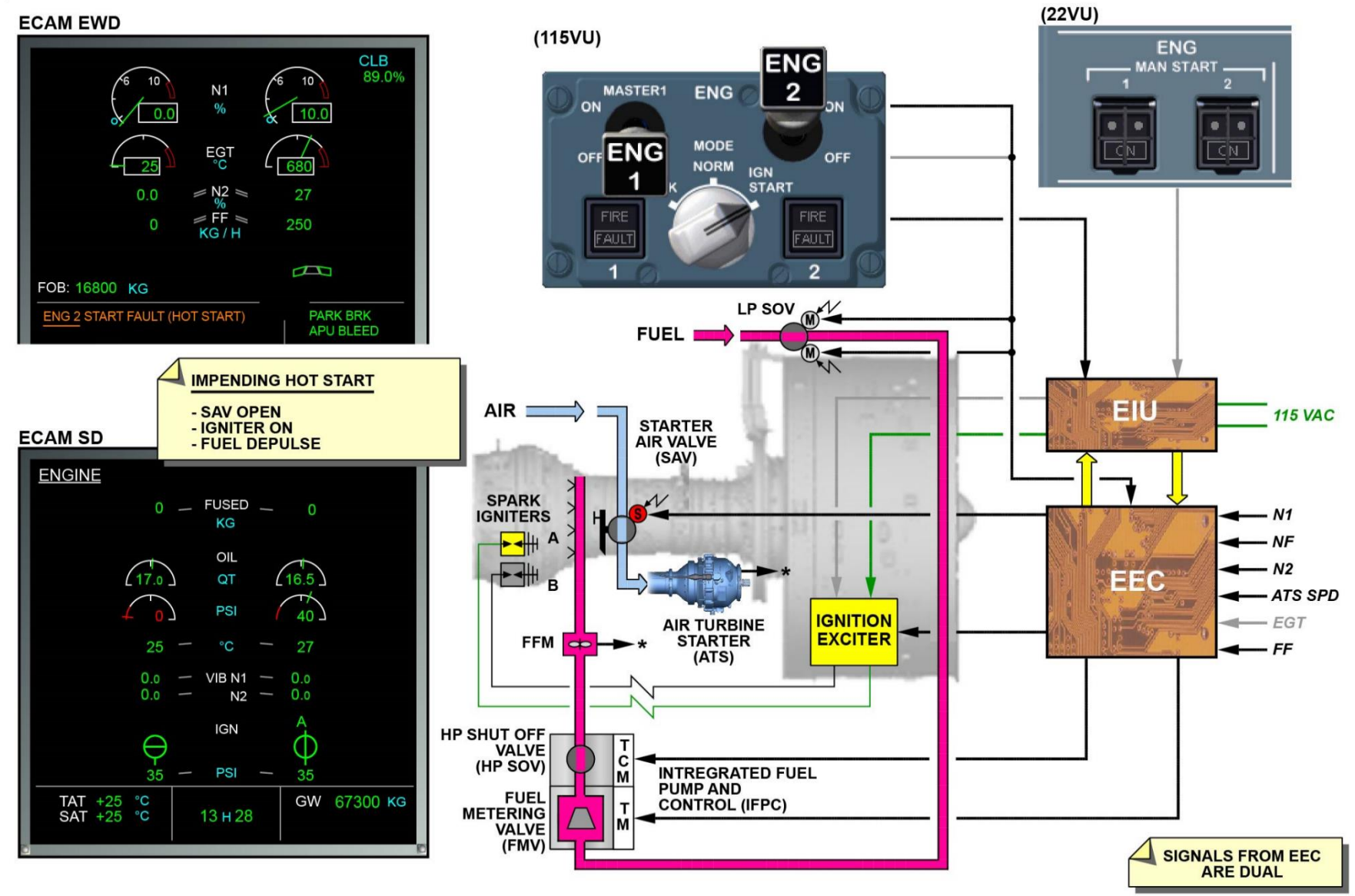
- it cycles fuel off for 2 seconds and back on for 12 seconds via the Fuel Metering Valve (FMV) for a maximum of 28 seconds to lower EGT below the limit.

The EEC will generate the ECAM alert "ENG x START FAULT (HOT START)".

If the fault disappears, the starting sequence goes on normally up to the engine stabilizes at idle speed.

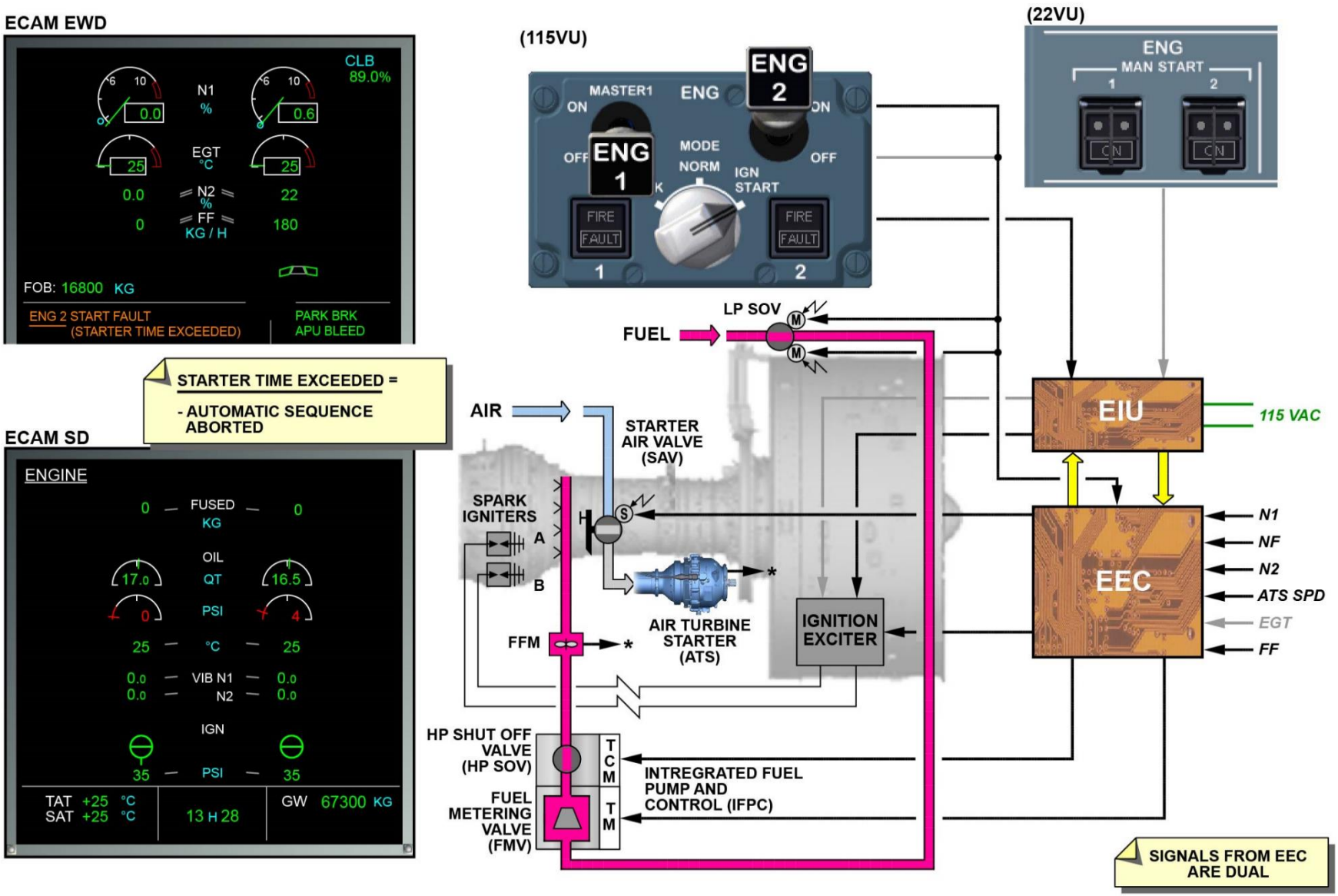
If the fault is still present, the EEC shuts down the fuel supply and the igniter, performs a dry motor for 30 seconds and attempts a single auto-restart.

If this auto-restart attempt fails, the start is aborted and the EEC will generate the ECAM alert "ENG x START FAULT (EGT OVERLIMIT)"


ECAM EWD
CLB
89.0%
N1
%
0.0
10.0
EGT
°C
25
680
0.0
N2
%
27
0
FF
KG / H
250
FOB: 16800 KG
ENG 2 START FAULT (HOT START)
PARK BRK
APU BLEED
IMPENDING HOT START
- SAV OPEN
- IGNITER ON
- FUEL DEPULSE
ECAM SD
ENGINE
FUSED
KG
OIL
QT
17.0
16.5
PSI
0
40
°C
25
27
VIB N1
N2
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
CN
FUEL
LP SOV
AIR
STARTER
AIR VALVE
(SAV)
SPARK
IGNITERS
A
B
AIR TURBINE
STARTER
(ATS)
FFM
IGNITION
EXCITER
HP SHUT OFF
VALVE
(HP SOV)
FUEL
METERING
VALVE
(FMV)
TCM
TM
INTREGRATED FUEL
PUMP AND
CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC
ARE DUAL

STARTER TIME EXCEEDED

If during a start or a crank sequence, the EEC identifies an excessive starter duty, it will generate the ECAM alert "ENG x START FAULT (STARTER TIME EXCEEDED)" and abort the automatic sequence.


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
22
0
FF
KG / H
180
FOB: 16800 KG
ENG 2 START FAULT
(STARTER TIME EXCEEDED)
PARK BRK
APU BLEED
STARTER TIME EXCEEDED =
- AUTOMATIC SEQUENCE ABORTED
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
17.0
QT
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
CN
LP SOV
FUEL
AIR
STARTER AIR VALVE (SAV)
SPARK IGNITERS
A
B
FFM
AIR TURBINE STARTER (ATS)
IGNITION EXCITER
HP SHUT OFF VALVE (HP SOV)
TCM
FUEL METERING VALVE (FMV)
TM
INTREGRATED FUEL PUMP AND CONTROL (IFPC)
EIU
115 VAC
EEC
N1
NF
N2
ATS SPD
EGT
FF
SIGNALS FROM EEC ARE DUAL

IGNITION SYSTEM OPERATION

Electrical power is supplied to the exciter box by two independent aircraft 115 VAC sources:

Essential bus power, Ignition System 1
Normal bus power, Ignition System 2.

Exciter box circuit relays are controlled via ignition commands from the integrated cockpit control panel to the EEC.

The electrical energy from the ignition exciters is then sent through the ignition cables to the igniter plugs.

When using the Manual Start Ignition selection, the EEC energizes both igniters based on the logic and aircraft inputs of flap position, cowl anti-ice status, and/or continuous ignition commands.

The EEC includes an Automatic Ignition System as an integral part of its ignition function. It also features an Automatic Relight System, which energizes both igniters within two seconds of engine flameout detection.
.
During an auto start on the ground, the exciters are alternated every two start attempts:

EEC Channel A - Igniter1, EEC Channel B - Igniter 1
EEC Channel A - Igniter 2, EEC Channel B - Igniter 2.

Alternating the igniters every two start attempts instead of every start attempt allows each channel to be tested with each igniter every four starts.

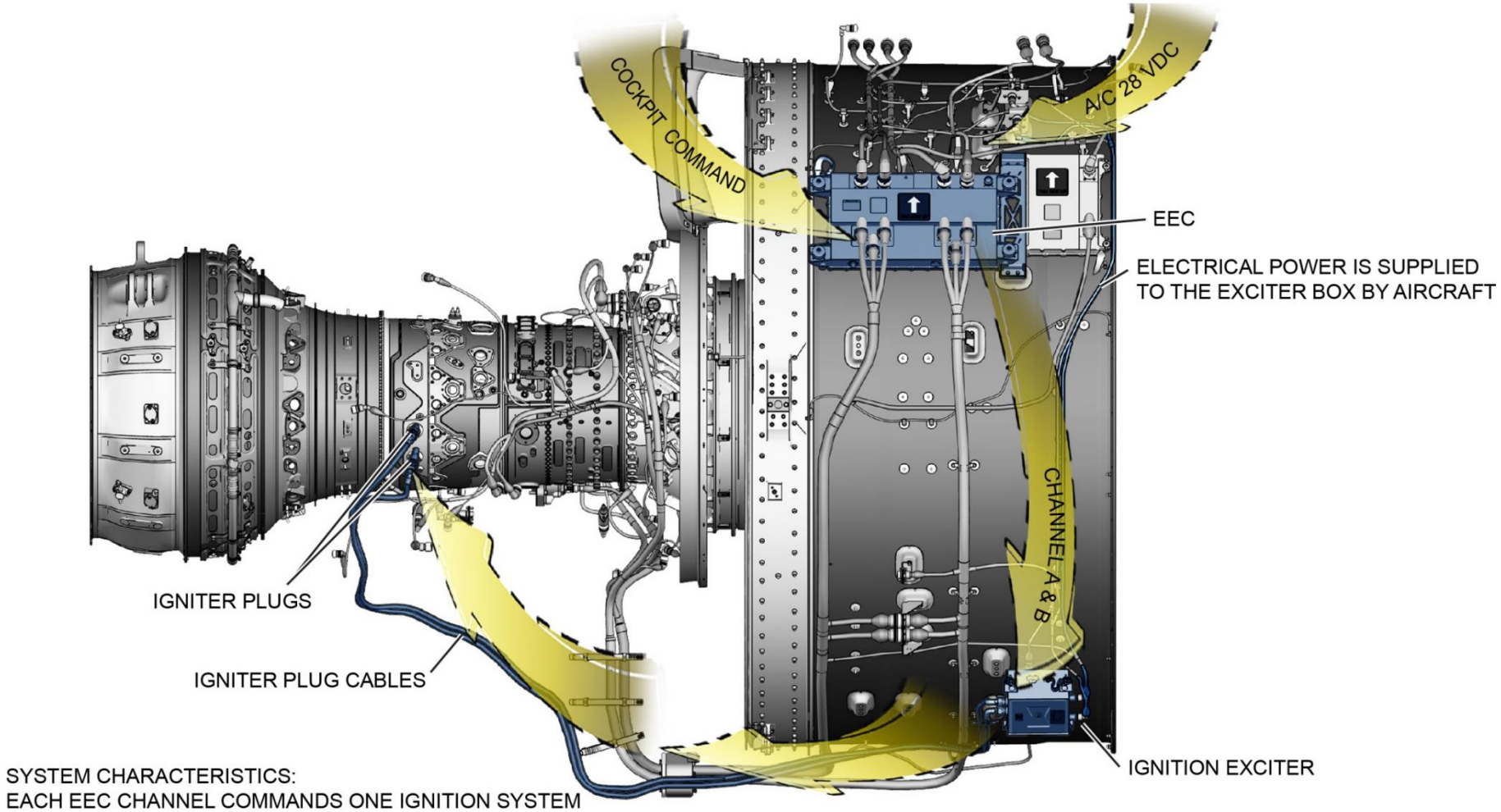
The EEC will automatically select dual-igniter continuous ignition in the conditions below.

An engine flameout is detected in flight or during take-off.

A surge is detected in flight or during take-off. Igniters will be powered until 30 seconds after the surge recovers.

The EEC detects a quick relight.

The Thrust Control Malfunction (TCM) cutback (flare/approach or take-off) is commanded. to ensure the engine stays running after the rapid fuel cutback.


COCKPIT COMMAND
A/C 28 VDC
EEC
ELECTRICAL POWER IS SUPPLIED
TO THE EXCITER BOX BY AIRCRAFT
CHANNEL A & B
IGNITER PLUGS
IGNITER PLUG CABLES
IGNITION EXCITER
SYSTEM CHARACTERISTICS:
EACH EEC CHANNEL COMMANDS ONE IGNITION SYSTEM

COMPONENTS

Ignition Exciter

Purpose:

The ignition exciter supplies the voltage necessary for igniter plug operation.

Location:

The exciter is attached by anti-shock mounts to a bracket on the fan case at 5:00.

Description:

The exciter receives 115V AC electrical input power from the aircraft to ignite the fuel/air mixture in the combustor.

Operation:

The ignition exciter supplies 5 kilovolts to the igniter plugs to ignite the fuel/air mixture in the combustor. The exciter duty cycle varies between 1–3 sparks per second.

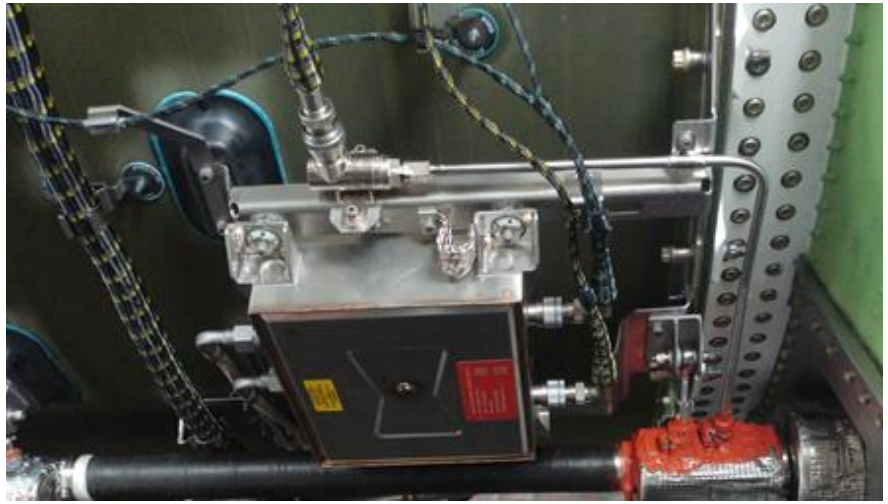
An EEC command activates the exciter circuits when ignition is requested from the flight deck.

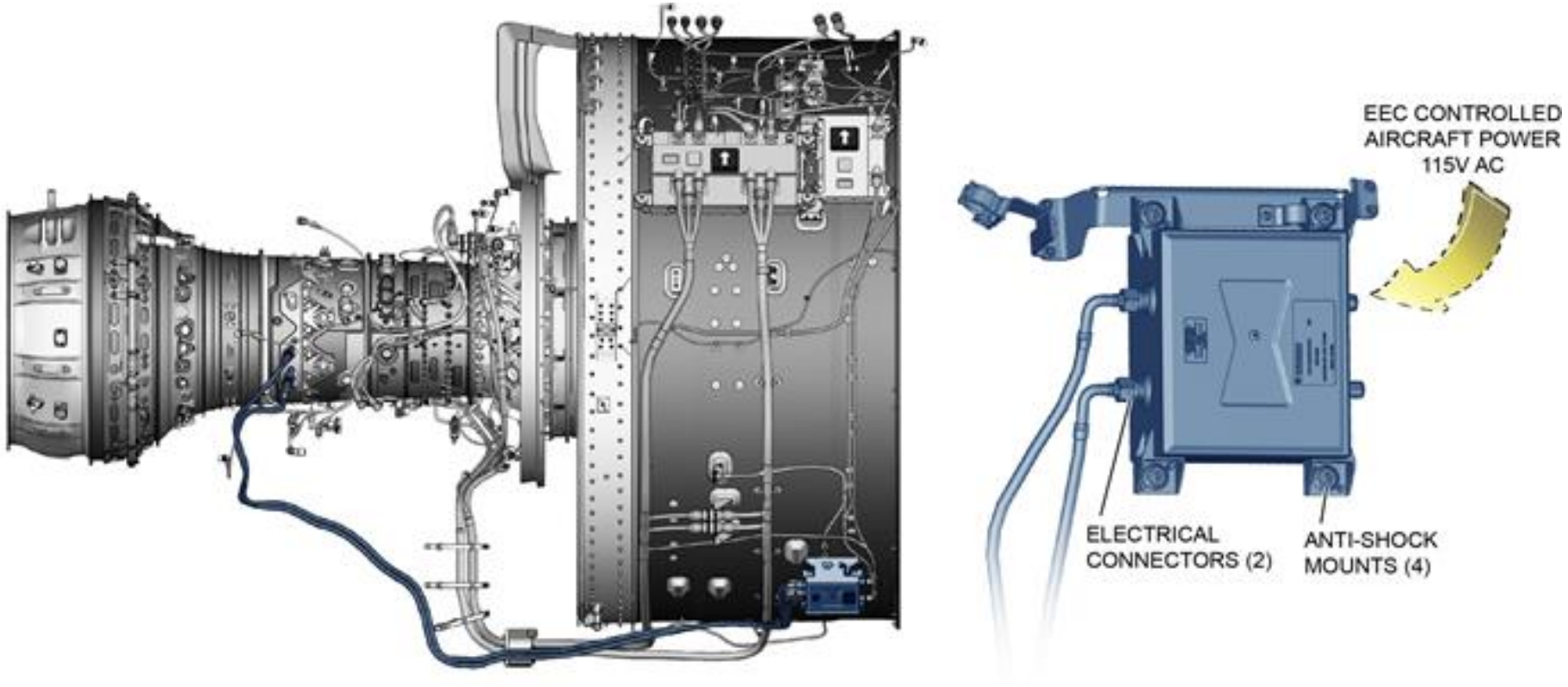
The ignition exciter has an energy delivery capacity of 0.9 joules / channel. Fan compartment air flows over the hermitically sealed exciter box to provide cooling for the unit.

Safety Conditions

CAUTION

BE SURE TO TIGHTEN IGNITION CONNECTOR NUTS TO THE CORRECT TORQUE. IF THE TORQUE AT EITHER THE IGNITER PLUS OR IGNITION EXCITER END OF THE CABLE IS NOT SUFFICIENT, THIS CAN CAUSE ELECTRICAL NOISE FROM THE IGNITION SYSTEM IN THE AIRCRAFT RADIO EQUIPMENT.




EEC CONTROLLED
AIRCRAFT POWER
115V AC
ELECTRICAL
CONNECTORS (2)
ANTI-SHOCK
MOUNTS (4)

Igniter Plug Cables

Purpose:

Igniter plug cables distribute electricity from an exciter to an igniter plug.

Location:

Cables are routed from the ignition exciter on the left side of the engine fan case at 5:00, to the igniters installed on the diffuser case at 3:00 and 4:00 on the right side of the engine.

Description:

The interchangeable cables are flexible braided-steel conduits with ceramic insulated terminals at the plug end.

Operation:

The igniter plug cables send 5 kilovolts of electricity from an exciter to an igniter plug.

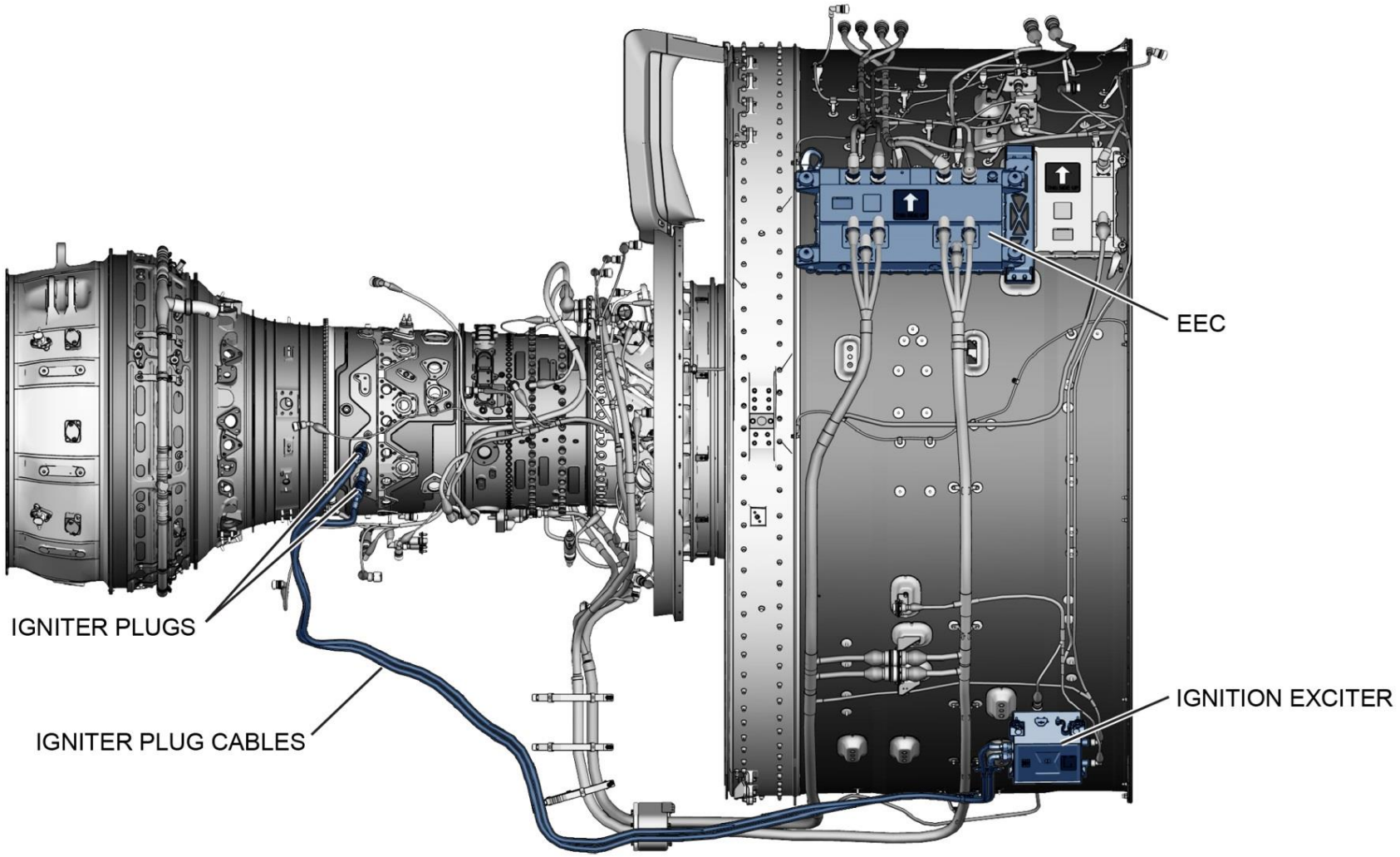
Safety Conditions

WARNING

IGNITION SYSTEM VOLTAGE IS DANGEROUSLY HIGH. THE IGNITION SWITCH MUST BE IN THE OFF POSITION BEFORE REMOVING OR INSTALLING ANY IGNITION COMPONENTS. AFTER DISCONNECTING CABLE FROM IGNITER PLUS, DISCHARGE CURRENT BY GROUNDING CABLE TERMINAL TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM THE SYSTEM. FAILURE TO FOLLOW THIS PROCEDURE COULD RESULT IN SEVERE INJURY TO PERSONNEL.

CAUTION

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWISE OR DAMAGE THE TUBES.


EEC
IGNITER PLUGS
IGNITER PLUG CABLES
IGNITION EXCITER

Igniter Plugs

Purpose:

Igniter plugs are used to ignite the fuel/air mixture for engine start.

Location:

The plugs are attached to the diffuser case at 3:00 and 4:00.

Description:

Each igniter plug has shielded centre electrodes. Classified spacers are installed under a mounting boss.

The spacers and boss are installed to the diffuser case assembly and are not removed during replacement of the igniter plugs.

Operation:

The spacers control immersion depth of the igniter plug tip inside the combustion chamber.

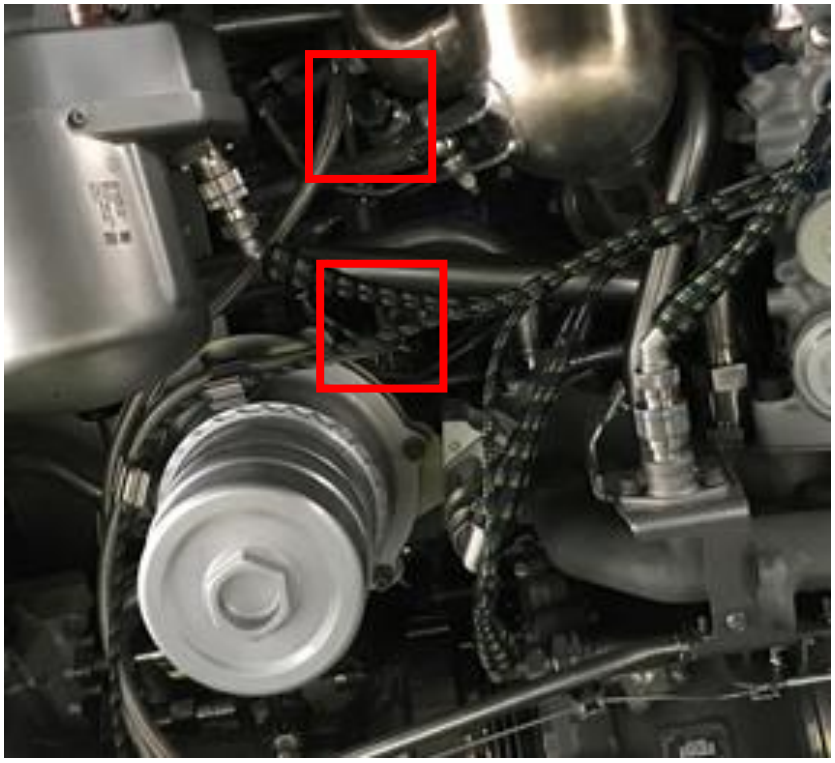
Each igniter plug uses 5 kilovolts from an exciter to make an electrical spark across the igniter plug gap. The spark from the plug ignites the fuel/air mixture.

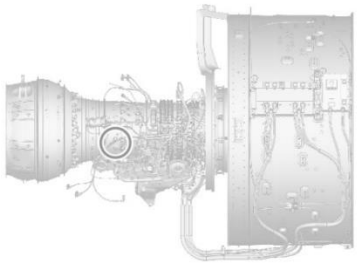
Safety Conditions

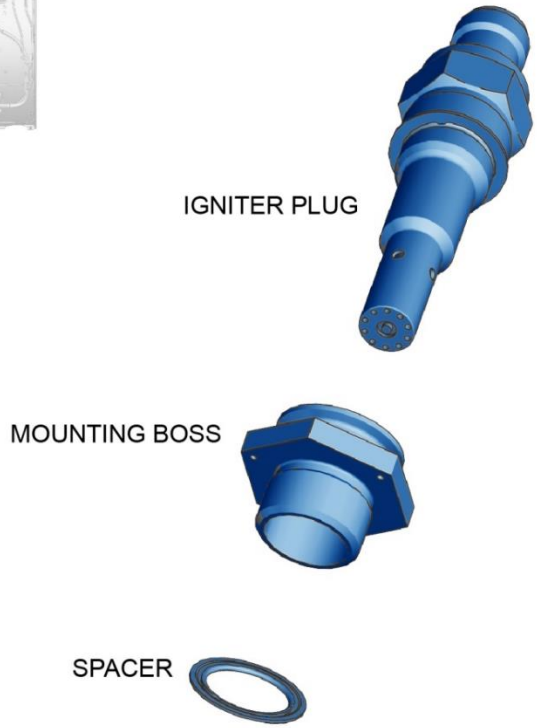
WARNING

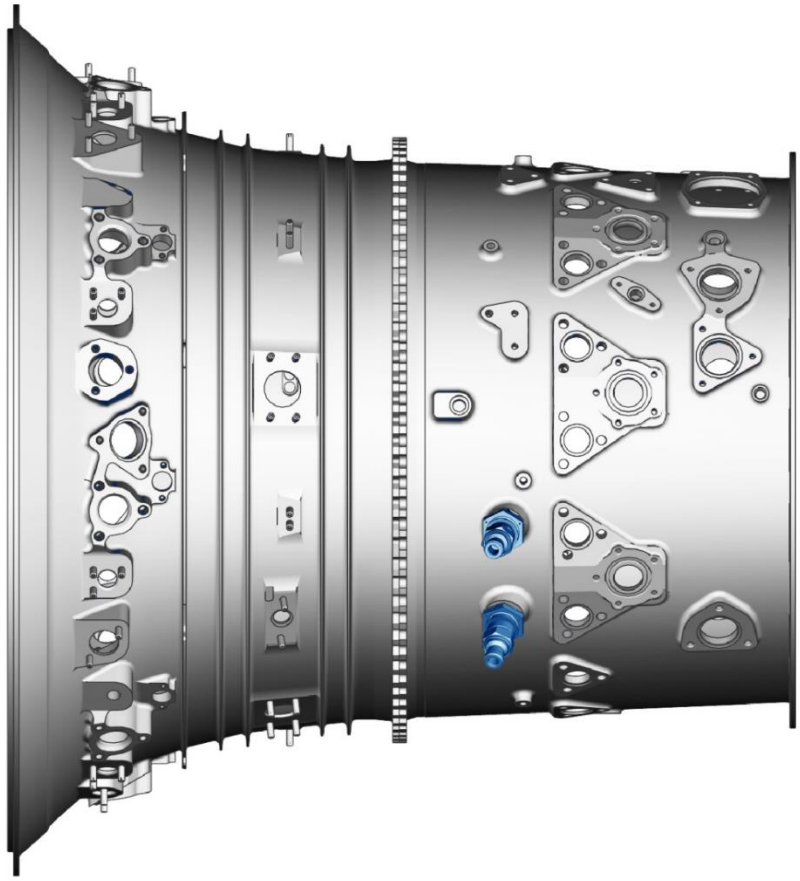
THE IGNITION SWITCH MUST BE IN THE OFF POSITION FOR TWO MINUTES MINIMUM BEFORE YOU REMOVE IGNITION COMPONENTS. YOU MUST WAIT THE TWO MINUTES TO LET ALL OF THE ELECTRICAL ENERGY OUT OF THE SYSTEM.

THE IGNITION SYSTEM VOLTAGE IS DANGEROUSLY HIGH. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.






IGNITER PLUG
MOUNTING BOSS
SPACER

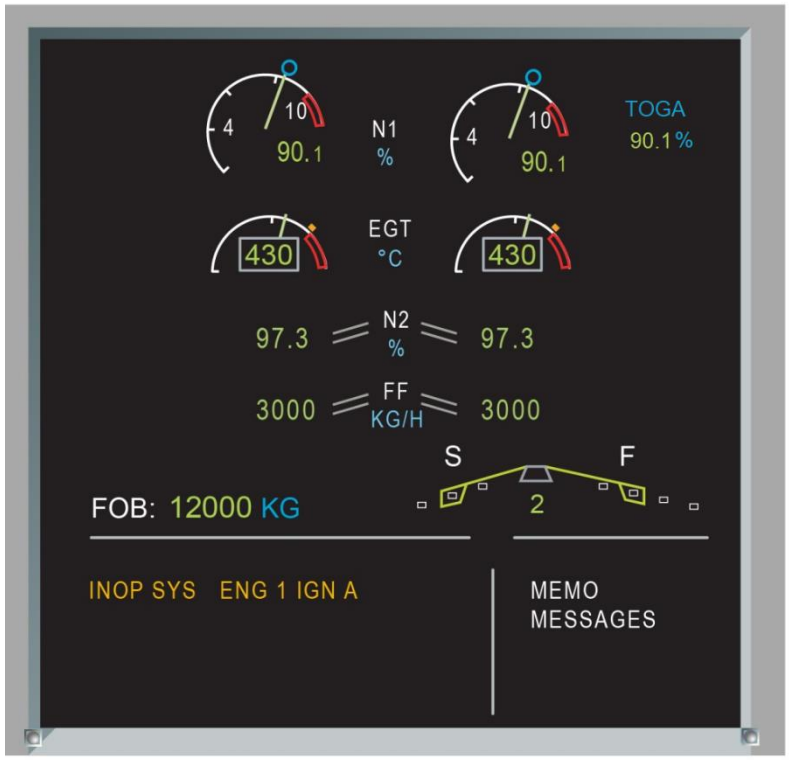


IGNITION SYSTEM FAULT DISPLAY

The Electronic Centralized Aircraft Monitor (ECAM) receives fault messages from the Ignition System and displays them on the flight deck.

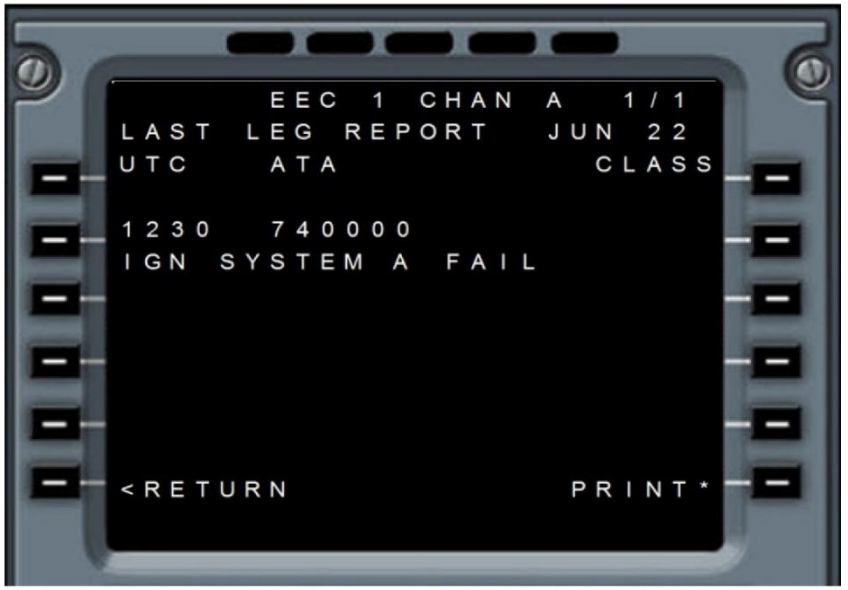
See the following page for a sample of Crew Alerting Messages (CAM) for the Ignition System.

FLIGHT CREW INITIAL WARNING



ENGINE/WARNING DISPLAY

INTERACTIVE MODE FOR MAINTENANCE ACTION



MULTIPURPOSE CENTRALIZED DISPLAY UNIT (MCDU)

SAMPLE ECAM MESSAGES FOR ATA 74

Air Turbine Starter (ATS)

Purpose:

The Air Turbine Starter converts airflow to power in the form of torque that drives the Main Gearbox.

The gearbox then applies this energy to rotate the turbine.

Location:

The starter is located on the rear of the Main Gearbox at 5:00.

Description:

The starter is mounted to a Quick Attach/Detach (QAD) ring with a single V-band clamp. The QAD ring is mounted to the Main Gearbox.

The starter incorporates a single stage turbine wheel, single piece output shaft, and a ratchet and pawl clutch.

The starter gears and bearing are splash lubricated from the engine Lubrication System. Fill and drain ports are provided on the housing for servicing.

A magnetic plug assembly is also fitted that consists of an inner magnetic probe and an outer fitting.

The inner magnetic probe can be removed to check for metallic chips without draining the oil.

A check valve in the outer fitting prevents the loss of oil when the magnetic probe is removed.

A starter speed sensor is provided to detect starter rotation and speed.

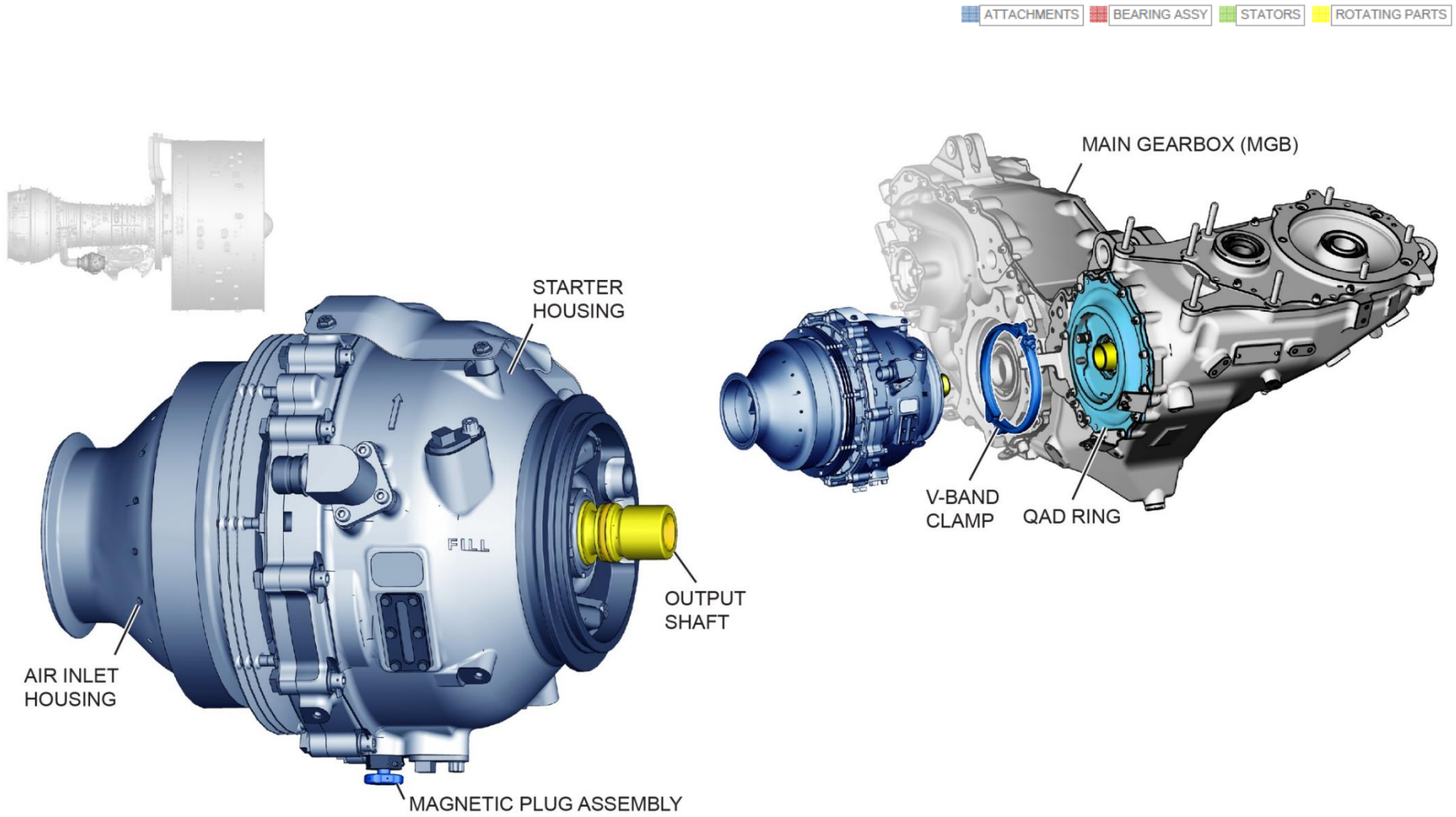
Operation:

1. Air is provided by an external source, such as an Auxiliary Power Unit, Ground Power Unit, or cross bleed.

2. The air flows into the starter, spinning the turbine that is connected to the output shaft by means of a gear, ratchet and pawl clutch.

3. This power is transmitted through the gearbox shafts to the N2 rotor.

Once N2 reaches a sufficient speed, the starter clutch disengages the starter turbine from the output shaft.


ATTACHMENTS
BEARING ASSY
STATORS
ROTATING PARTS
MAIN GEARBOX (MGB)
STARTER HOUSING
FILL
OUTPUT SHAFT
AIR INLET HOUSING
MAGNETIC PLUG ASSEMBLY
V-BAND CLAMP
QAD RING

Starter Oil Distribution

The Air Turbine Starter uses the engine oil system to lubricate the starter gears and bearings.

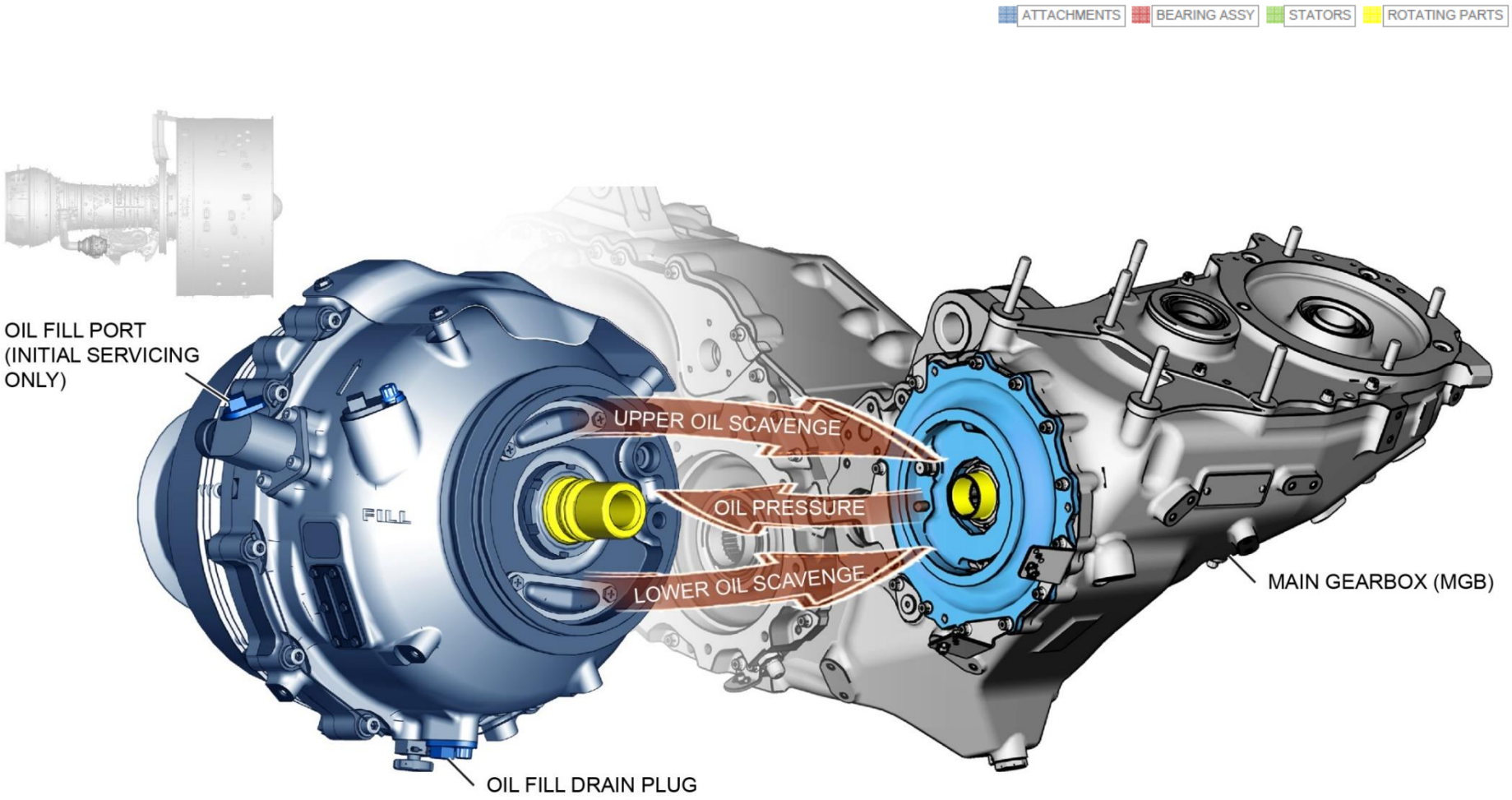
Oil from the MGB enters the starter through a transfer tube and is then distributed to the bearings through internal oil passages.

Oil jets direct the flow of oil to the bearings. An oil slinger lubricates the gears. Oil from the bearings and gears is scavenged back to the MGB through a second transfer tube.

When a new or an overhauled starter unit is installed, a small quantity of oil needs to be added through the fill port in the inlet housing.

This ensures that the bearing and gears are sufficiently lubricated during the first engine start.

A drain port in the transmission housing allows for draining the oil prior to removal of the ATS.


ATTACHMENTS
BEARING ASSY
STATORS
ROTATING PARTS
OIL FILL PORT
(INITIAL SERVICING
ONLY)
FILL
UPPER OIL SCAVENGE
OIL PRESSURE
LOWER OIL SCAVENGE
MAIN GEARBOX (MGB)
OIL FILL DRAIN PLUG

Starter Speed Sensor

Purpose:

The starter speed sensor detects the speed of the Air Turbine Starter and transmits the data to the EEC and PHMU for failure analysis.

Location:

The sensor is located on the ATS housing at 3:00.

Description:

The starter speed sensor is a one-piece hermetically sealed unit consisting of a dual channel magnetic speed sensor, utilizing a single permanent magnet, two separate coils and one electrical connector.

Information transmitted from the sensor speed signal is sent first to the EEC and then to the PHMU for detection of fail conditions that could include:

SAV failure in open position during start
uncommanded opening of SAV after start
shearing of starter drive shaft.

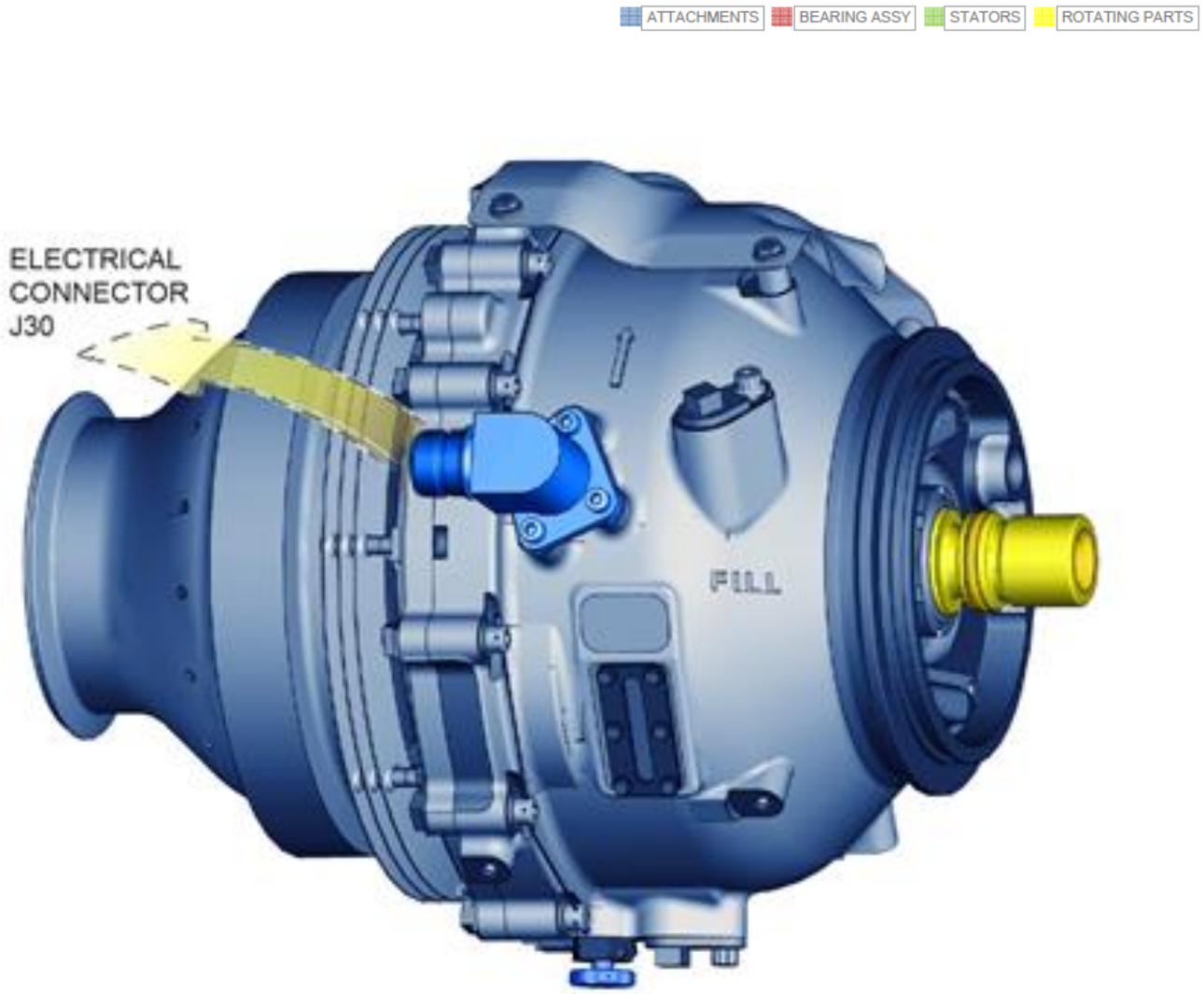
Operation:

The starter speed sensor detects the starter ring gear speed by detecting each tooth as it passes the tip of the magnetic probe.

The teeth of the ring gear passing by the face of the magnet produce a change in the magnetic field.

The time-varying electrical pulse signal is processed by the EEC and PHMU and converted to a rotational speed.

This rotational speed is compared with EEC input from N2 to determine if the starter has failed.


ATTACHMENTS
BEARING ASSY
STATORS
ROTATING PARTS
ELECTRICAL
CONNECTOR
J30
FILL

Starter Air Valve (SAV)

Purpose:

The Starter Air Valve ports duct air to the Air Turbine Starter on EEC command.

Location:

The SAV is next to the High-Pressure Turbine case at 4:00.

Description:

The Starter Air Valve is a butterfly valve that is pneumatically actuated, and solenoid controlled.

It is connected to upper and lower starter air ducts with V- band clamps.

The valve is equipped with a cooling shroud to protect temperature-sensitive parts.

A cooling tube supplies fan bypass air to the shroud.

A 3/8” square drive is provided for manual override capability.

The valve failsafe position is closed.

Operation:

The EEC commands the valve open or closed using a dual-coil SAV solenoid. Controlled by the EEC, the solenoid is dual channel.

It provides discrete (on/off) control of starter air pressure sent to the SAV actuator to open and close the SAV.

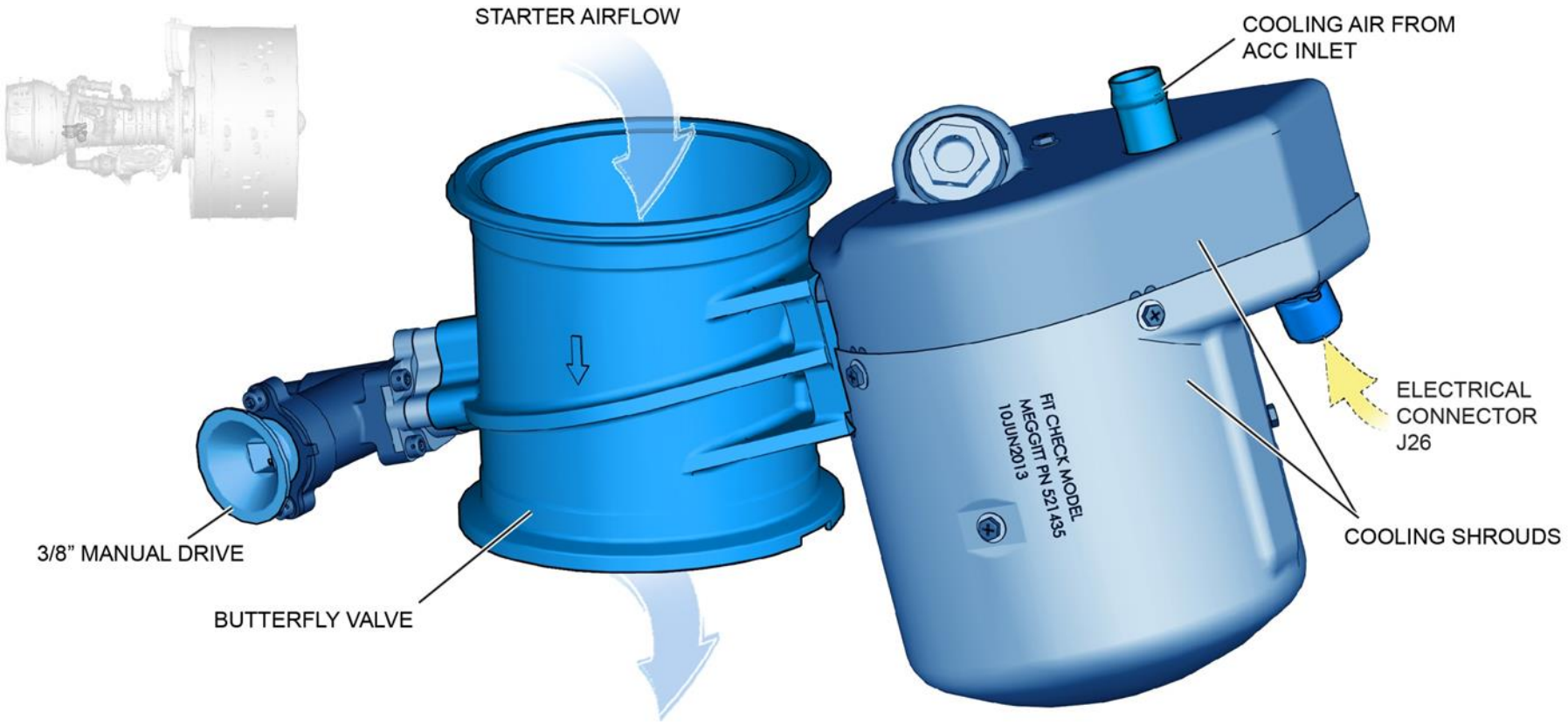
Valve position is determined by N2 speed signal to the EEC.

When the solenoid is de-energized, the valve is closed, shutting off the air pressure to the actuator and holding the butterfly valve in the closed position by the spring.

When the solenoid is energized, the valve is open, allowing air pressure to flow to the backside of the actuator piston (Chamber B).

During manual operation, there must be duct pressure before opening.

The valve should be opened and closed slowly to prevent damage.


STARTER AIRFLOW
COOLING AIR FROM
ACC INLET
ELECTRICAL
CONNECTOR
J26
COOLING SHROUDS
3/8" MANUAL DRIVE
BUTTERFLY VALVE
FIT CHECK MODEL
MEGGITT PN 521435
10JUN2013

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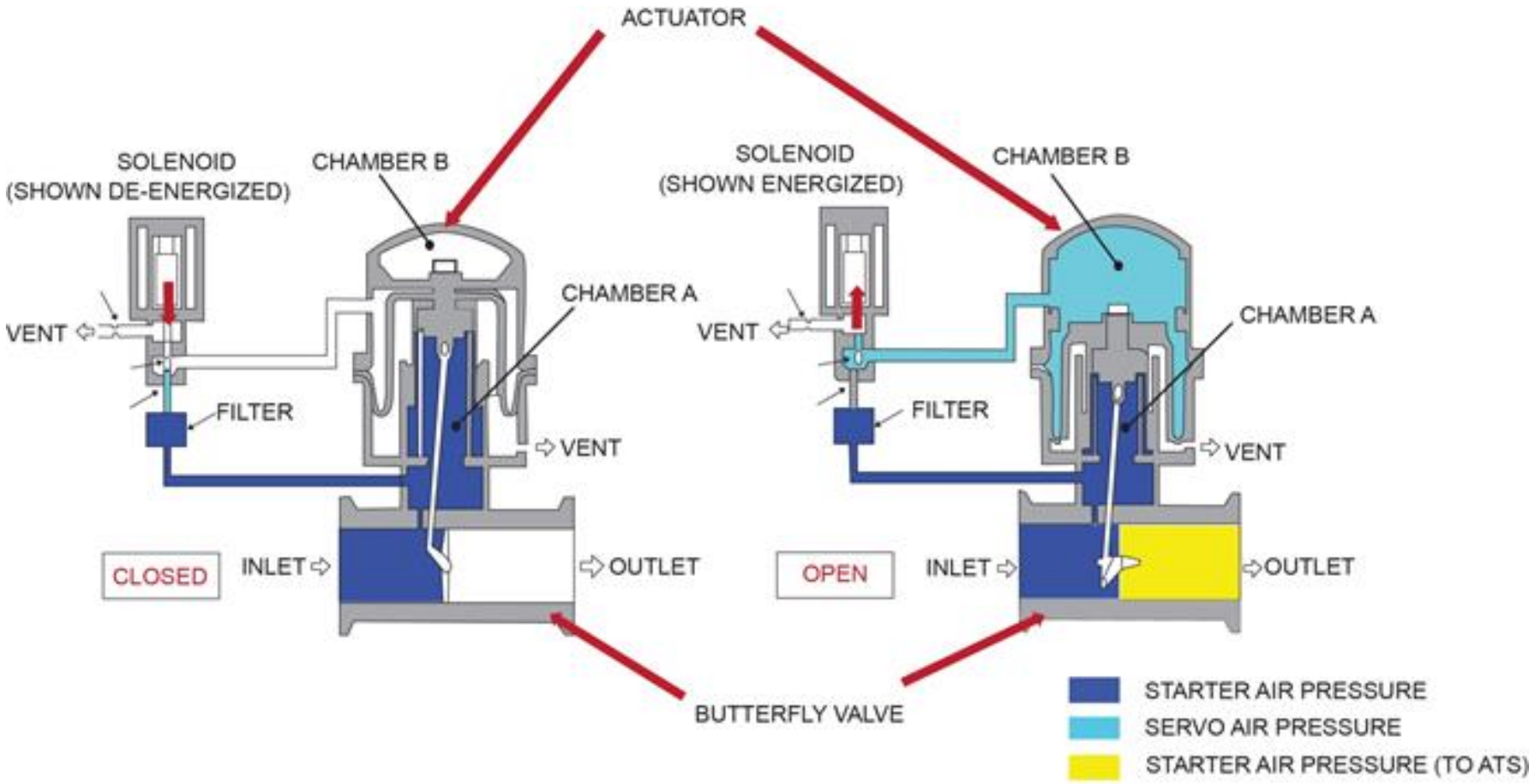


STARTER AIR VALVE SCHEMATIC

Starter Air Duct

Purpose:

The starter air duct is a flow path for pressurized air that turns the pneumatic starter.

Location:

The duct is located aft of the starter at 8:00.

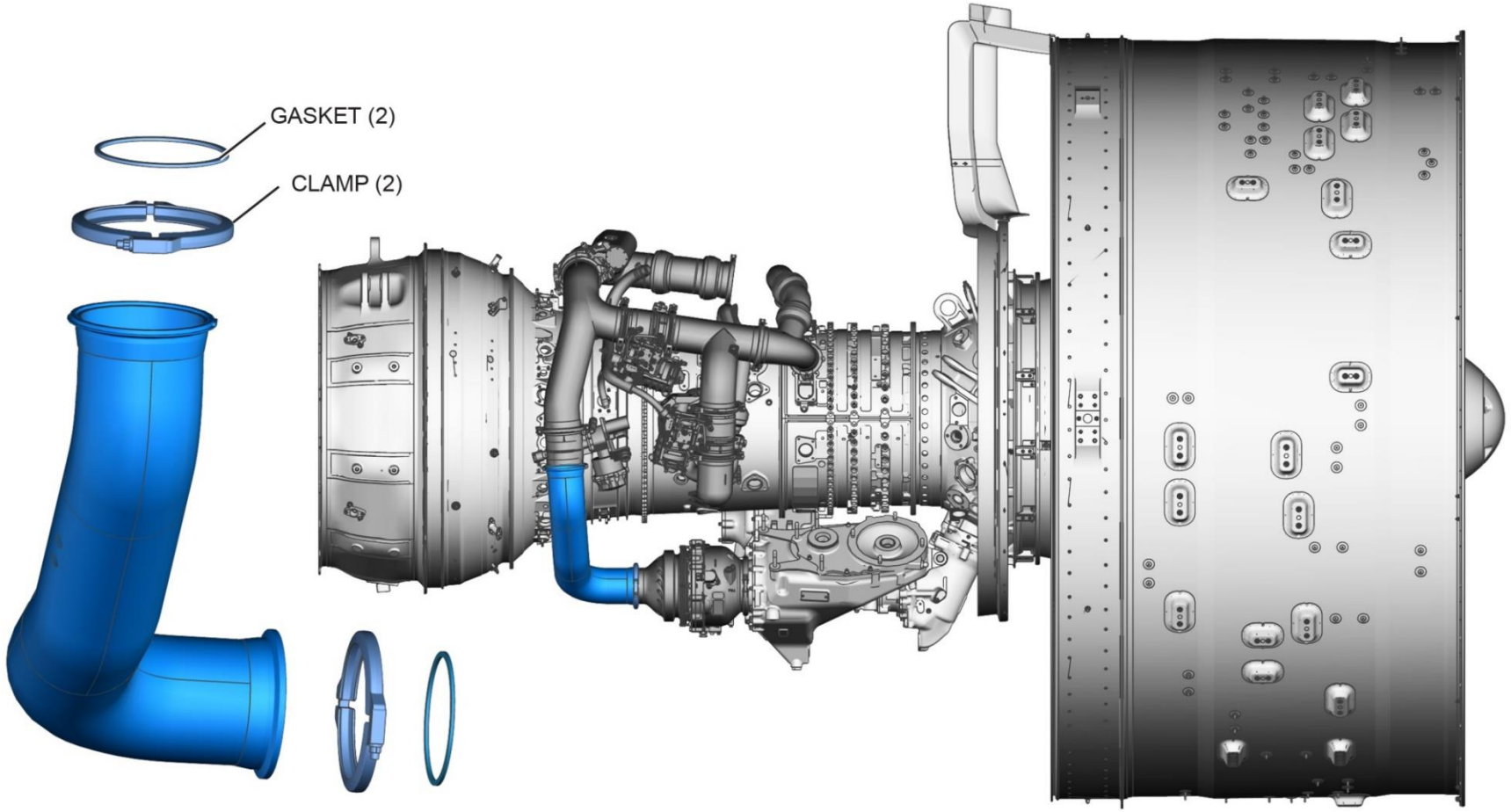
Description:

The duct is made of welded metal with flanges on either end, and is attached with clamps to the Air Turbine Starter and Starter Air Valve.

Gaskets are placed between the flanges of the duct and the component to eliminate air leakage.

The duct has an air fitting mounted to it for a pneumatic control line.

The duct must be removed for starter removal and replacement.


GASKET (2)
CLAMP (2)

SYSTEM OPERATION

During engine start, the supply of air to the starter is controlled by the Starter Air Valve (SAV).

The valve is opened and closed automatically by the EEC or manually by the flight/maintenance crew.

Mode of operation is chosen through the manual or automatic start knob selector position, and the engine fuel cut-off ON/OFF switch.

Engine start is usually done using EEC automatic start sequencing logic, which puts control of the igniters, fuel and SAV in complete control of the EEC.

A manual start permits the start sequence to be controlled by the crew.

If an electrical or mechanical failure occurs, the Starter Air Valve can be manually opened and closed on the ground by maintenance personnel.

Steps for auto start are shown below.

1. The START knob is rotated to the AUTO position. The L or R ENG switch is turned to ON.

2. The EEC commands the SAV open.

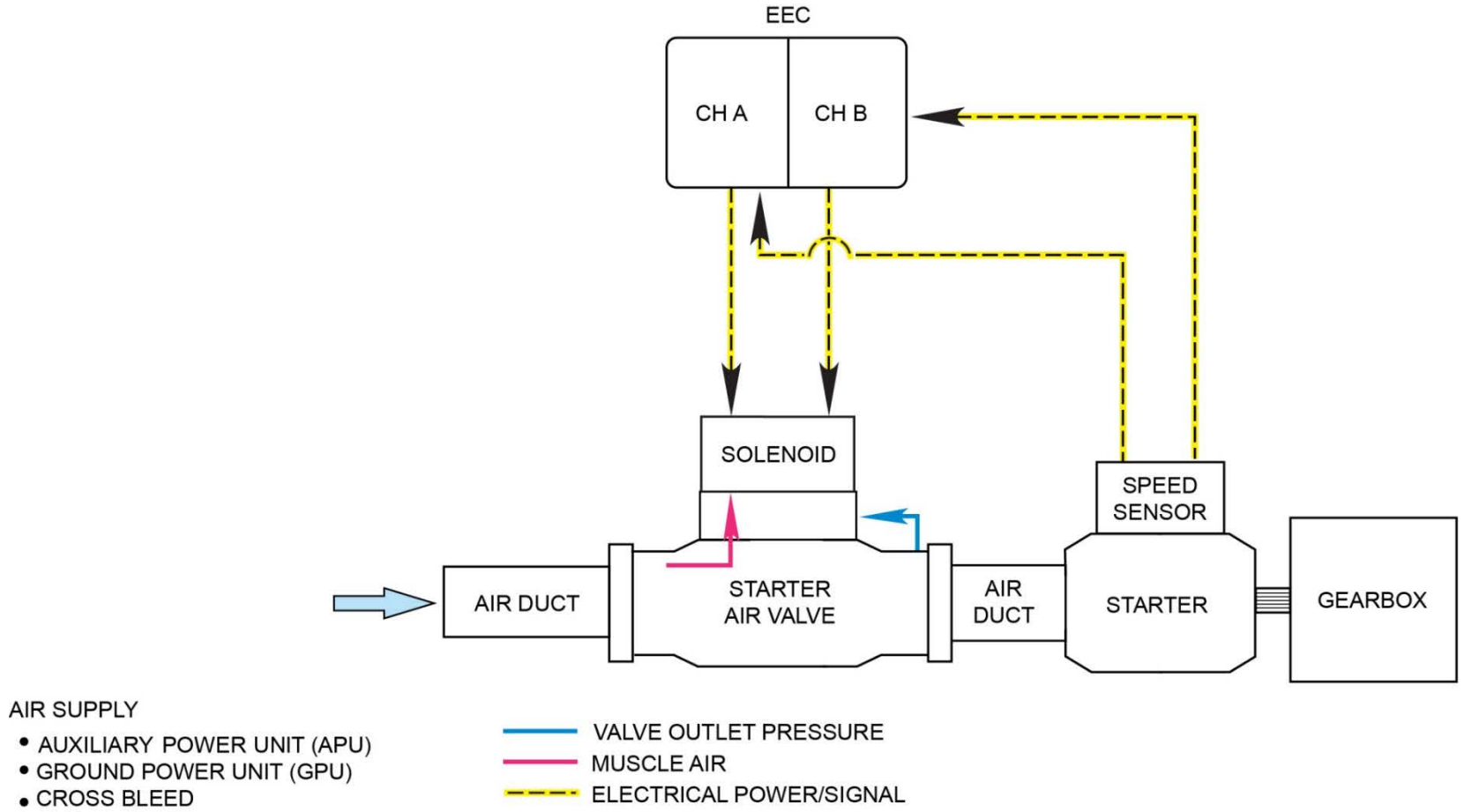
3. The starter turns and the EEC senses rotation through the starter speed sensor.

4. N2 speed increases and the EEC senses N2 rotation.

5. N2 speed reaches greater than 18% and the EEC commands fuel and ignition ON.

6. N2 speed reaches greater than 55% and the EEC commands the SAV closed and ignition OFF.

Note that the EEC alternates ignition systems every two start attempts.


EEC
CH A
CH B
SOLENOID
SPEED SENSOR
AIR DUCT
STARTER AIR VALVE
AIR DUCT
STARTER
GEARBOX
AIR SUPPLY
• AUXILIARY POWER UNIT (APU)
• GROUND POWER UNIT (GPU)
• CROSS BLEED
VALVE OUTLET PRESSURE
MUSCLE AIR
ELECTRICAL POWER/SIGNAL

STARTER SYSTEM SERVICING

Check Starter Oil

Use the procedure below to check the oil.

1. Locate the starter installed to the rear of the Main Gearbox at 8:00.

2. Make sure that you remove and install protection covers as necessary to prevent damage to the engine.

3. Use a flashlight to check the oil level. If the oil level is at the full mark, do not add any oil.

Refill Starter Oil

If the level is below the full mark, refill oil as follows.

1. Put the fluid drain collector/container (approximately 5 gallons/20 L) under the starter to catch the starter oil.

2. Loosen the bolts at the fill port and over-fill port plugs.

3. Turn the plugs from under the bolt heads and remove them from the starter.

4. Discard the packings from the plugs.

5. Slowly add engine oil to the fill port until oil comes out of the over-fill port. The sight glass will now indicate that the starter is full.

6. Use a clean, lint free cotton cloth to wipe the plugs clean.

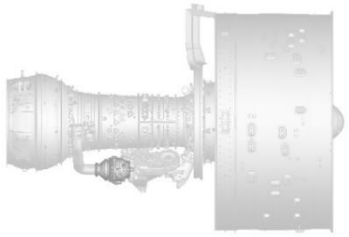
7. Install the new packing to each of the plugs.

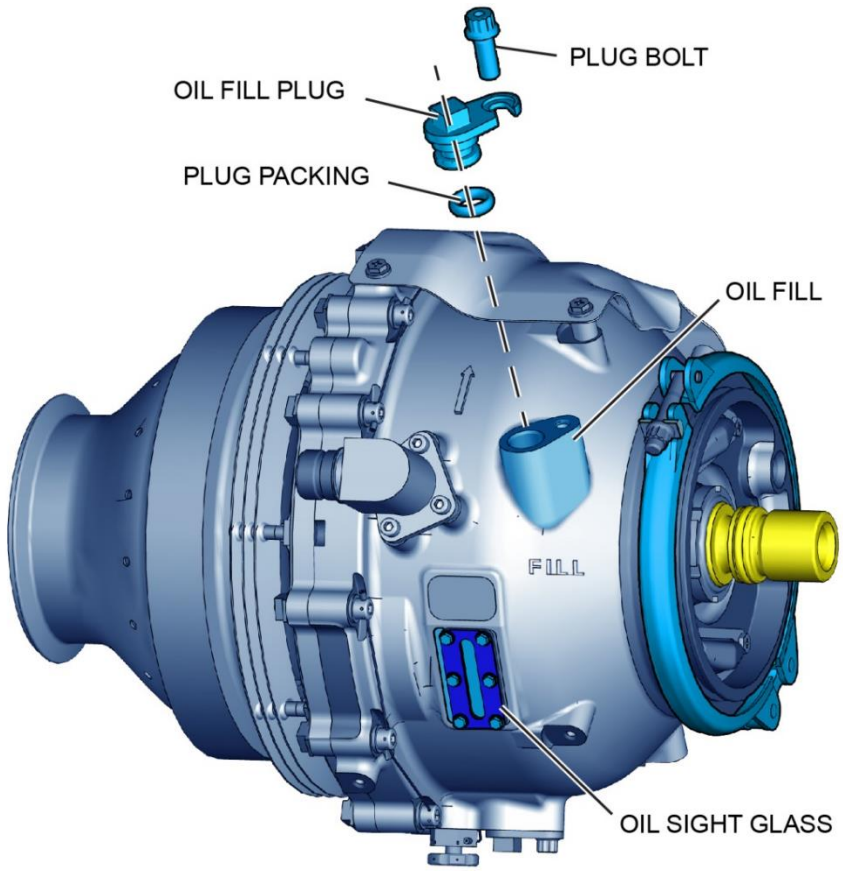
8. Apply engine oil to the packings.

9. Install the plugs to the fill and over-fill ports and turn them to engage under the bolt heads.

10. Torque the two bolts to AMM specifications.

11. Wipe the starter clean and install all necessary protective covers.




ATTACHMENTS
BEARING ASSY
STATORS
ROTATING PARTS
PLUG BOLT
OIL FILL PLUG
PLUG PACKING
OIL FILL
FILL
OIL SIGHT GLASS

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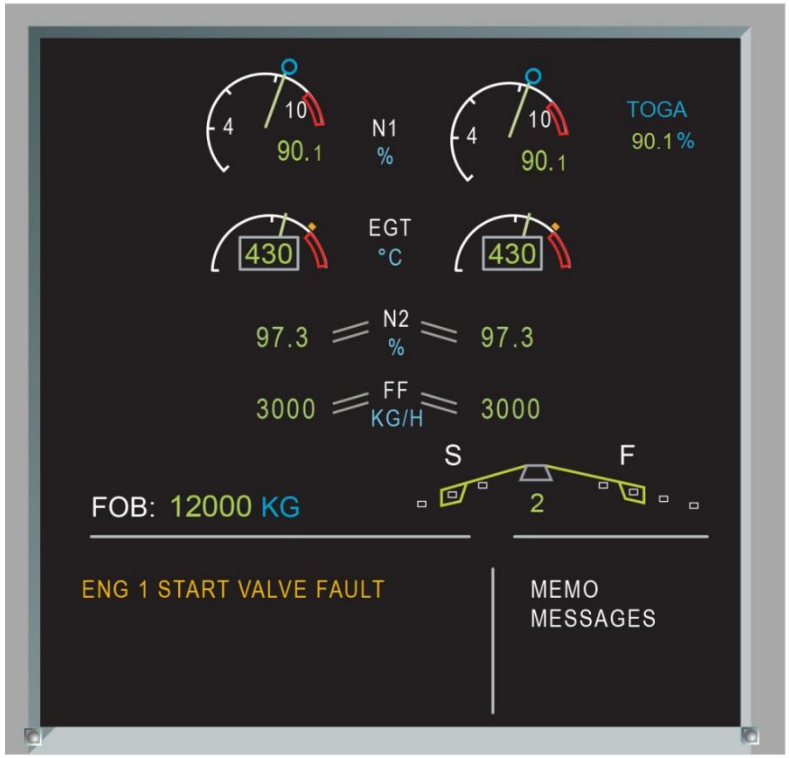
FLIGHT CREW INITIAL WARNING



ENGINE/WARNING DISPLAY

INTERACTIVE MODE FOR MAINTENANCE ACTION

MULTIPURPOSE CENTRALIZED DISPLAY UNIT (MCDU)

SAMPLE ECAM MESSAGE FOR ATA 80

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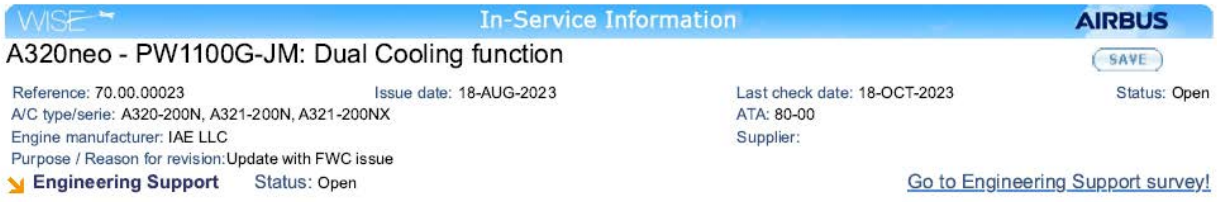
DUAL COOLING SYSTEM


WISE In-Service Information AIRBUS

A320neo - PW1100G-JM: Dual Cooling function

SAVE

Reference: 70.00.00023 Issue date: 18-AUG-2023 Last check date: 18-OCT-2023 Status: Open
A/C type/serie: A320-200N, A321-200N, A321-200NX ATA: 80-00
Engine manufacturer: IAE LLC Supplier:
Purpose / Reason for revision: Update with FWC issue
Engineering Support Status: Open Go to Engineering Support survey!

Applicability:

A320neo/A321neo aircraft powered with PW1100G-JM engine type.

References:

Please refer to the "SOLUTION" chapter of this article.
AMM 80-11-00-00 CONF 21 - Engine Starting - Description and Operation.
FCOM DSC-70-80-40, Ignition and Starting - Engine Starting System.
FCOM PRO-NOR-SOP-08, Standard Operating Procedures - Engine Start.

Starting from May rev 23 rev:
FCOM PRO-ABN-ABN-RESET-B. System Reset Table-ENG
QRH PRO-ABN-02.[RESET] SYSTEM RESET-B. System Reset Table-ENG

Background:

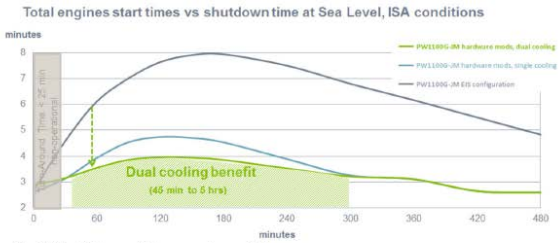
To face the High Pressure Compressor (HPC) bow rotor phenomenon, EEC Motoring-to-Start logic (MtS) was developed and set-up to protect the engine.

- MtS was put in place to harmonize HPC rotor thermal patterns prior to starting to idle. It leads the EEC to cycle **S**tart **A**ir **V**alve (**SAV**) to limit N2 up to 12% with a dedicated display on ECAM "COOLING" memo during this sequence (Refer FCOM DSC-70-80-40).
- This protection logic consequently increases engine start times, with operational impacts for operators.

Notes: COOLING time display on ECAM during engine starting sequence (rotary selector to IGN/CRANK) is corresponding to the Motoring-to-Start (dry motoring to cool the engine down and prevent bow rotor HPC rubbing).
Motoring-to-Start (MtS) time is computed by the EEC upon engine thermal status (key parameter being time since shut down).
MtS time is displayed on ECAM as COOLING. COOLING time is displayed only if above 20 sec.

Description:

Dual cooling function is a system logic to perform simultaneous Motoring-to-Start on both engines. This involves A/C computers and wiring, APU boost performance required, as well as associated EEC logic in software FCS3.1.
It aims to reduce the overall time to start both engines on A320neo family aircraft (PW1100G-JM) as reflected in the graph below.



The ISI article provides operators with:
- More details regarding the dual cooling function
- All Service bulletins required to embody this function
- The misbehaviors covered in the Airbus documentation.

All the aircraft currently delivered have the "dual cooling function" modification embodied.

Solution:

All required Service Bulletins and their associated references to embody the dual cooling function are listed in the below table:

Modification	SB reference	mod reference	release date
Activate the engine dual cooling on A320neo with PW engines.	72-1039	161854 P15967 161921 P20056	04-Jan-2017
Install wiring provisions for engine dual cooling pushbutton on A320neo with PW engines.	73-1110	161818 P15996	05-Dec-2017
EEC software FCS3.1	73-1108	161922 P15994	01-Dec-2016
EIU software S3.1	73-1111	161923 P15983	
Install A429 links between MMR/Clock and EIU for A320neo PW (concurrent change with EIU S3.1).	73-1109	161783 P15997	03-Nov-2016
Bleed Monitoring Computer - Introduce BMC SW 4.1	36-1069	161745 G1142	
FWC H2-F9D std	31-1490	161397 P14826 161790 P15991 161832 P15992	03-Nov-2016
EIS 2 S13.2 std	31-1481	161392 P14825 161789 P15998 161829 P20029	16-Jun-2016

Estimated time to perform all above DUAL COOLING modifications: 32 man Hours.

Additional Note:

The above Service Bulletins provide the minimum computer standards where 'DUAL COOLING FUNCTION' is activated. Subsequent standards will improve this function.

Issues

DUAL COOLING function is a function to reduce the starting time. "ENG DUAL COOLING NOT AVAIL" ECAM alert cannot be considered as AOG situation.
Indeed, both engines can be started using the normal automatic procedure (or manual mode), MtS for each engine being processed in sequence, as mitigation action. Engines can be started either in normal automatic mode or manual mode.

Following issues have been noticed during Airbus Flight Tests activities and in-service while DUAL COOLING function is activated:

1. **Engine cooling and envelope :** "ENG DUAL COOLING NOT AVAIL" ECAM memo displayed during initial sequence (when DUAL COOLING overhead panel pushbutton-switch selected and Master Lever ON).

There are specific conditions to launch appropriately the DUAL COOLING function. Refer FCOM DSC-70-80-40 (Engine cooling and envelope), FCOM PRO-NOR-SOP-08 (Automatic engine start).

Those conditions are summarised below:
- Automatic engine start mode is selected, through ENG MODE selector set to IGN/START (ENG MAN START overhead panel pushbutton staying OFF).
- COOLING time is displayed on both engines, before DUAL COOLING pushbutton set to ON.
- DUAL COOLING pushbutton is set to ON by the flight crew before the auto start sequence is launched.
- Engine Oil Temperature needs to be above either 15 deg.C or 30 deg.C (upon APU type, refer FCOM dual cooling envelope) on both engines.

In summary, DUAL COOLING can be operative (available) if:
- Both engines require cooling (COOLING memo and time displayed)
- Dual cooling envelope FCOM conditions fulfilled.
- FCOM procedure is followed.

COOLING is not displayed when MtS is below 20 sec, DUAL COOLING pushbutton is not selected.
Motoring-to-Start (MtS) time is computed by the EEC upon engine thermal status (key parameter being time since shut down).

For Dual Cooling function, APIC APS3200 APU allows Engine Oil Temperature down to 15 deg.C.

For Dual Cooling function, Honeywell 131-9A APU allows Engine Oil Temperature:
- down to 30 deg.C,
- or down to 15 deg.C if dedicated EIU wiring is removed as per modification 164724/P21030 or Airbus SB 73-1131.

2. **DUAL COOLING NOT AVAIL for aircraft equipped with F13/F14:** ENG DUAL COOLING - NOT AVAIL ECAM alert and DUAL COOLING amber memo triggered during initial automatic engine start sequence (when Master Lever OFF and DUAL COOLING overhead panel pushbutton-switch selected ON).

FWS F13 introduces a new monitoring system related to the reception of the DUAL COOLING signals from both EIU1 and EIU2. If FWS detects a DUAL COOLING signal sent by one EIU and not by the other EIU within 600ms, FWS will trigger ENG DUAL COOLING - NOT AVAIL ECAM alert and the DUAL COOLING amber memo.

Mitigation: Dual cooling function reset procedure will be introduced in FCOM/QRH for all A320F equipped PW1100G-JM, and Dual Cooling function and FWS F13 standard (target for publication FCOM/QRH revision : May 2023).

Fix: The logic in FWS 15B will be improved in order to avoid any spurious due to desynchronization between EIU1 and EIU2 (Certification by 2024).

3. **Cooling time required after a long shut-down time**

COOLING time can be displayed on one engine and not on the opposite while both engines shut-down at the same time/slot, or after a long shut-down time whereas cooling is not necessary. This can occur for the first start of the day, especially when bow effect is low or null, considering engine thermal status. In that case, it would have been expected to not have any required engine cooling or MtS.
This is due to MtS failsafe value set, caused by engine OFF counter validity lost.
The clock disagree is the main issue leading to inconsistent MtS, like failsafe value while not required due to long TAT.
This clock disagree can mainly occur at either A/C power OFF or at A/C power ON. Identified causes are:

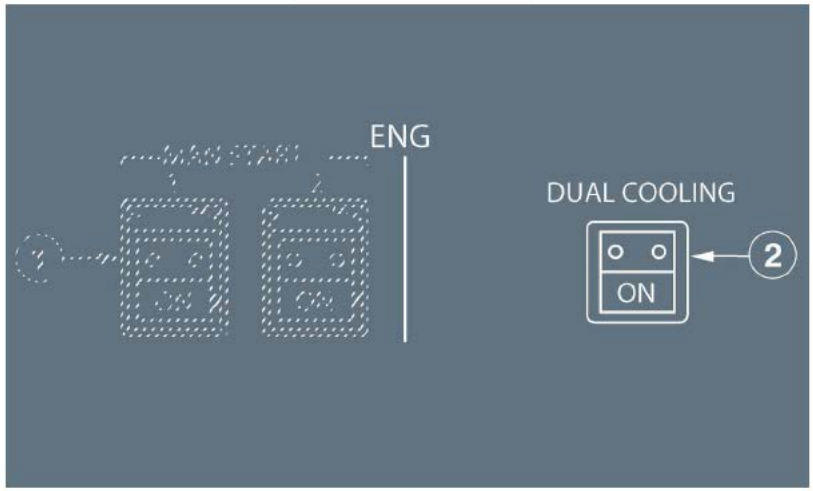
ENG DUAL COOLING PANEL

Applicable to: MSN 07047-11160

Ident.: DSC-70-90-10-26-00020022.0001001 / 21 OCT 16

3

ENG DUAL COOLING Panel



Ident.: DSC-70-90-10-26-00020023.0001001 / 21 OCT 16

4

ENG DUAL COOLING pb-sw

L12

Off — The dual cooling function is not armed.
If dual cooling is in progress, the FADEC stops the automatic dry cranking on the engine that is not commanded to start.

L12

ON (in blue) — Arms the dual cooling function.
If required, the FADEC can command an automatic dry cranking of both engines simultaneously, when the flight crew initiates the automatic start of the first engine.

ENG DUAL COOLING (Cont'd)
NOT AVAIL

Ident.: PRO-ABN-ENG-DK-00020039.0001001 / 21 OCT 16

72

DUAL COOLING..... OFF

ENG DUAL COOLING
NOT AVAIL

Applicable to: MSN 11052-11160

Ident.: PRO-ABN-ENG-DK-00020038.0003001 / 09 APR 18

73

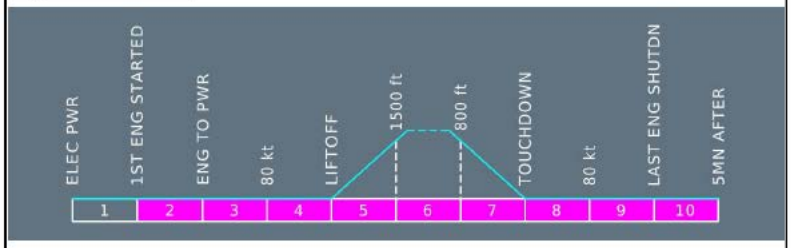
ANNUNCIATIONS

Triggering Conditions:

L2

This alert triggers on ground with the dual cooling function armed but not available, i.e. when out of the dual cooling envelope or with low starter air pressure. *Refer to DSC-70-80-40 Automatic Engine Start with Dual Cooling - Envelope*

Flight Phase Inhibition:



Ident.: PRO-ABN-ENG-DK-00020039.0003001 / 09 APR 18

74

NOT AVAIL
DUAL COOLING..... OFF

ENG 1(2) CTL VALVE FAULT (Cont'd)

Ident.: PRO-ABN-ENG-Q-00018709.0001001 / 21 MAR 16

MAX N2.....96 %

L2 *Retard associated thrust lever to limit N2 to 96 %.*

Ident.: PRO-ABN-ENG-Q-00012233.0001001 / 17 AUG 10

STATUS

MAX ENG (AFFECTED) N2.....96 %

ENG DUAL COOLING NOT AVAIL

Applicable to: MSN 07047-09598

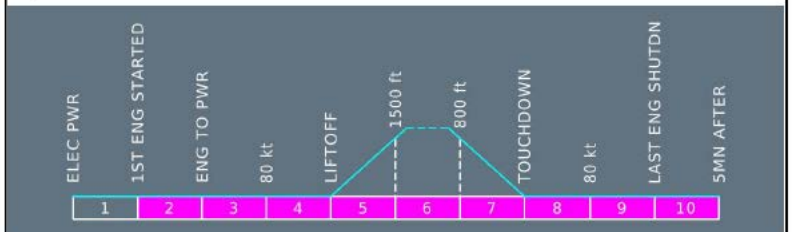
Ident.: PRO-ABN-ENG-DK-00020038.0001001 / 21 OCT 16

ANNUNCIATIONS

Triggering Conditions:

L2 This alert triggers on ground with the dual cooling function armed but not available, i.e. when out of the dual cooling envelope. *Refer to DSC-70-80-40 Automatic Engine Start with Dual Cooling - Envelope*

Flight Phase Inhibition:



Note: *A bowed rotor can occur when engine internal components cool at different rates, leading to unequal thermal expansion. This can cause some deflection (or bow) of the rotor shaft.*

The engine cooling time depends on the engine temperature at shutdown, the length of time the engine has been shutdown, the current ambient, and the engine oil temperature.
When the FADEC is powered and if engine cooling is required, a COOLING indication appears on the E/WD for both engines with the expected engine cooling time indicated.
Refer to DSC-70-90-40 Engine Warning Display
When the engine cooling process is completed, the COOLING indication and the expected engine cooling time disappear.

Note: *The FADEC takes into account the previous dry cranking operation to reduce the engine cooling time during the subsequent engine start.*

The FADEC does not initiate any automatic dry cranking during an in-flight engine start.

DUAL COOLING:

Dual cooling is commanded via the DUAL COOLING pb-sw on the overhead panel.
Refer to DSC-70-90-10 ENG DUAL COOLING Panel
The dual cooling function enables that during an automatic start sequence on ground, when the ENG MASTER lever is set to ON, the FADEC commands the cooling on both engines simultaneously (if cooling is required).
The dual cooling function is available in a dedicated envelope of use depending on the APU performance, and on engine oil temperature.
Refer to DSC-70-80-40 Automatic Engine Start with Dual Cooling - Envelope

Note: *The dual cooling function is available if the COOLING message is indicated for both engine on the E/WD.*

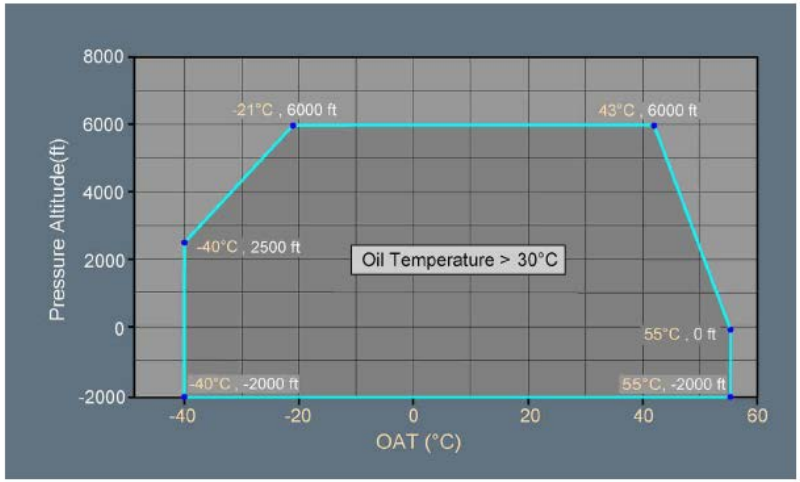
AUTOMATIC ENGINE START WITH DUAL COOLING - ENVELOPE

Ident.: DSC-70-80-40-00020229.0020001 / 04 JUN 19
Applicable to: MSN 07047-08382, 08458-08503, 08613-08720

When engine cooling is required, the dual cooling function enables the crew to perform an automatic dry cranking on both engines simultaneously. The function is available in a dedicated envelope of use depending on both the APU performance and the engine oil temperature.

CAUTION	The dual cooling function is designed for use with APU bleed air only.

Dual Cooling Assisted by APU



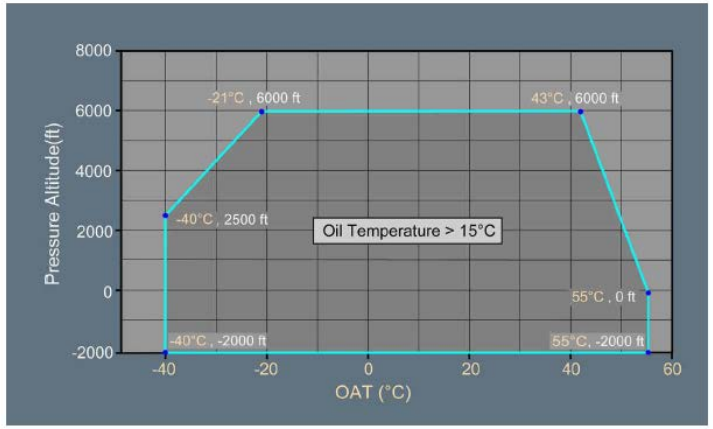
AUTOMATIC ENGINE START WITH DUAL COOLING - ENVELOPE

Ident.: DSC-70-80-40-00020229.0023001 / 04 JUN 19
Applicable to: MSN 08445, 08583, 08736-11160

When engine cooling is required, the dual cooling function enables the crew to perform an automatic dry cranking on both engines simultaneously. The function is available in a dedicated envelope of use depending on both the APU performance and the engine oil temperature.

CAUTION	The dual cooling function is designed for use with APU bleed air only.

Dual Cooling Assisted by APU



80-11-00-00 CONF 21 - ENGINE STARTING - DESCRIPTION AND OPERATION

2. Component Description

***** ON A/C FSN 251-266, 268-313, 315-315, 321-322, 324-327, 331-331, 333-333, 336-344, 346-350, 401-415, 417-420, 422-450***

C. Dual Cooling

(1) Conditions to launch the DUAL COOLING function:

(a) "ENG DUAL COOLING NOT AVAIL" ECAM is a memo displayed when DUAL COOLING overhead panel pushbutton is selected and dual cooling not available. There are specific conditions to launch appropriately the DUAL COOLING function once activated (Ref. FCOM DSC-70-80-40 and Ref. FCOM PRO-NOR-SOP-08). These conditions are as follow:

1 Engine oil temperature needs to be above either 15 deg.C (59.0 deg. F) or 30 deg.C (86.0 deg.F) (upon APU type) (Ref. FCOM Dual Cooling Envelope) on both engines, before engage DUAL COOLING overhead panel pushbutton.

2 Automatic engine start mode is selected, through ENG MODE selector set to IGN/START (ENG MAN START overhead panel pushbutton staying OFF).

3 COOLING time is displayed on both engines.

4 DUAL COOLING pushbutton is pushed by the flight crew before auto start sequence launched.

(b) In summary, DUAL COOLING can be available if:

1 Both engines require cooling (COOLING memo and time displayed)

NOTE: COOLING is not displayed when Motoring-to-Start is below 20 sec and DUAL COOLING pushbutton is not selected.

NOTE: Motoring-to-Start time is calculated by the EEC upon engine thermal status (key parameter is the time since engine shut down).

2 Dual cooling envelope FCOM conditions fulfilled.

3 FCOM procedure is followed.

4 An automatic engine start mode is commanded (function not available in case of Manual start).

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