**ON A/C ALL

80–00–00–001

STARTING

Introduction

The engine start system provides the means to start the engines on the ground and provide re–starts in the air.

General Description

The engine control system is powered up when the appropriate airframe 28 Vdc Essential Bus is selected ON. Upon being powered up the Full Authority Digital Electronic Control (FADEC) performs a series of initialization tests on internal functions and interfaces and begins transmitting data on ARINC 429 and RS 422 serial data buses.

Refer to Figures 1 and 2.

Select the ignition switch to the NORMAL position. An engine start is then initiated by selecting the engine and activating the starter by pressing the engine START switch and moving the Condition Lever from the FUEL OFF, to START FEATHER position.

Detailed Description

Refer to Figures 3 and 4.

The movement of the Condition Lever out of the "FUEL OFF" position causes the following to occur:

– Condition Lever mounted Start/Shutdown microswitches transition from the closed circuit to the open circuit state (one per channel) resetting the independent Nh OverSpeed (O/S) protection circuitry to unlatch any previous O/S trip

– Wrap–around signals from the Start/Shutdown discretes are input to the FADEC controller, signaling to the software that a start has been commanded

– When Nh is greater than 8% and Condition Lever Angle (CLA) is out of the "FUEL OFF" position, the FADEC begins metering fuel flow with the metering valve. If in flight, the FADEC deenergizes the Fuel Metering Unit (FMU) O/S solenoid. On the ground, the FMU O/S solenoid is normally deenergized (open) when the engine is shutdown unless the FMU is determined to be faulty.

Automatic Engine Starts on the Ground

When the start has been successfully initiated, the FADEC controls the starting sequence in the manner that follows:

– When the starter has increased the generator speed (Nh) to 8%, the FADEC commands ignition ON and schedules fuel flow as a function of Nh, ambient conditions (Temperature and Pressure), and Main Oil Temperature (MOT).

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- Only one of the two ignitors is turned on. If the engine does not light within 8 seconds of fuel flow on, the FADEC turns on both ignitors and logs a fault against the faulty ignitor. Light off of engine is defined as an increase of 20 °C in Indicated Turbine Temperature (ITT)
- During run up to idle, the FADEC switches channels to test the health of the opposite channel.
- When Nh is greater than 50%, the ignitor(s) is automatically turned off
- FADEC controls engine run–up to the commanded Nh idle speed.

During ground starts, to ensure that the engine start does not cause over temperature, the FADEC has active Indicated Turbine Temperature (ITT) limiting. FADEC will reduce the fuel flow below the standard start schedule if necessary to prevent an over temperature.

FADEC will automatically abort the start, and shutdown the engine if any one of the following conditions occur:

- The engine does not light within 16 seconds of fuel flow on. FADEC shuts down the engine and logs the appropriate fault

- ITT limit of 920 °C is exceeded

- NH does not reach 50% within 70 seconds (i.e. hung or slow start).

Automatic Starts in Flight

In–flight starts are similar to ground starts except for the following:

- Both ignitors are commanded ON during the start

- The autoabort features are disabled
- FADEC does not actively limit ITT
- No FADEC channel transfers during the start.

The distinction between Flight Mode and Ground Mode, for the purpose of starting, is if the Calibrated Air Speed is greater than 75 kt (139 km/h) then Flight Mode is set. In fault conditions when CAS is not available, the WOW discrete from the Propeller Electronic Control (PEC) is used to determine Ground/Flight Mode Status.

Ignition Control During Starts

The dual channel ignition system is powered electrically by the aircraft essential buses and activated by the FADEC. The ignition system is configured such that both ignitors can be commanded by each FADEC channel, while maintaining electrical isolation between the FADEC channels and the aircraft essential buses.

The ignition selection from the flight compartment is sent to the FADEC on an ARINC 429 bus through the Engine Cockpit Interface Unit (ECIU).

The FADEC ignition system has two flight compartment selectable modes of operation:

- 1–OFF: The FADEC disables ignition regardless of ground or flight status.
- 2–NORM: FADEC activates ignition during engine starts (ground or flight starts). FADEC commands both ignitors On during flameout and surge accommodation.

In the event of loss of communication from the ECIU, by default the FADEC selects NORMAL ignition.

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Electrical Operation

With the ignition switch set to NORM, the ignition exciter is armed and will start to fire the ignitors when it receives a signal from FADEC that Nh is greater than 8%.

The START SELECT switch S1 is a three position switch, spring loaded to and lever locked in the center OFF position. The switch is supplied with 28 Vdc through a circuit breaker from the left essential bus.

When No.1 engine is selected, 28 Vdc is supplied through switch S1 contacts 4 and 6 to send 28 Vdc through the normally closed contacts C2 and C3 of relay K1 and diode CR1 to the hold coil of switch S1. The hold coil magnetically holds the START SELECT switch in the No.1 position until the start sequence is complete. Diode CR1 also supplies 28 Vdc to pin C1 of time delay relay K3, which energizes to activate the amber SELECT light and applies voltage to the current limit pin HH of No.1 GCU. This enables the GCU to limit starting current to approximately 400 amps during the start cycle plus 6 seconds after completion. Time delay relay K3 remains energized until the voltage is removed from pin C1. The start select sequence is now complete.

The push START switch, that has been armed by S1, when pressed applies 28 Vdc to the start control pin N of No. 1 GCU to energize contactor K1. No.1 starter/generator now starts to rotate the engine. The coil of control relay K1 is also energized. Contacts B1 and B2 close to keep power on K1 coil and to supply a sustaining voltage on GCU pin N. Contacts C1 and C2 close to energize the START light. Contacts A1 and A2 close to give a ground signal to the Electrical Power Control Unit (EPCU) which will verify the status of contactor K1, when the system reverts to generator mode. An output from pin Q of the GCU keeps relay K3 in the energized condition.

When the starter has accelerated the engine to 8% Nh, FADEC signals the ignition exciter which fires the ignitors and No.1 engine starts. When the engine reaches a steady acceleration FADEC terminates ignition. As the engine becomes self–sustaining, the GCU field current reduces the starter/generator torque, to keep a positive starting torque. This equates to a steady input current of approximately 400 amps.

At 50% Nh the speed sensor in the starter, signals the GCU to terminate the output from pin Q. This removes power from the hold coil of START SELECT switch S1 and the switch returns to the OFF position. Power is also removed from pin C1 of time delay relay K3, but because of the time delay, will retain current limiting for a further 6 seconds. This is to prevent a high current inrush to the batteries, due to the partial discharge following an engine start.

Ignition Control During Flameout and Engine Surge

In addition to controlling the ignitors during starting, the Control System can determine that the engine has suffered a flameout within 1 second (rapid decrease of EGT and NH). The FADEC activates the ignition circuitry for both ignitors as soon as the flameout has been detected and will cancel it when the engine has recovered.

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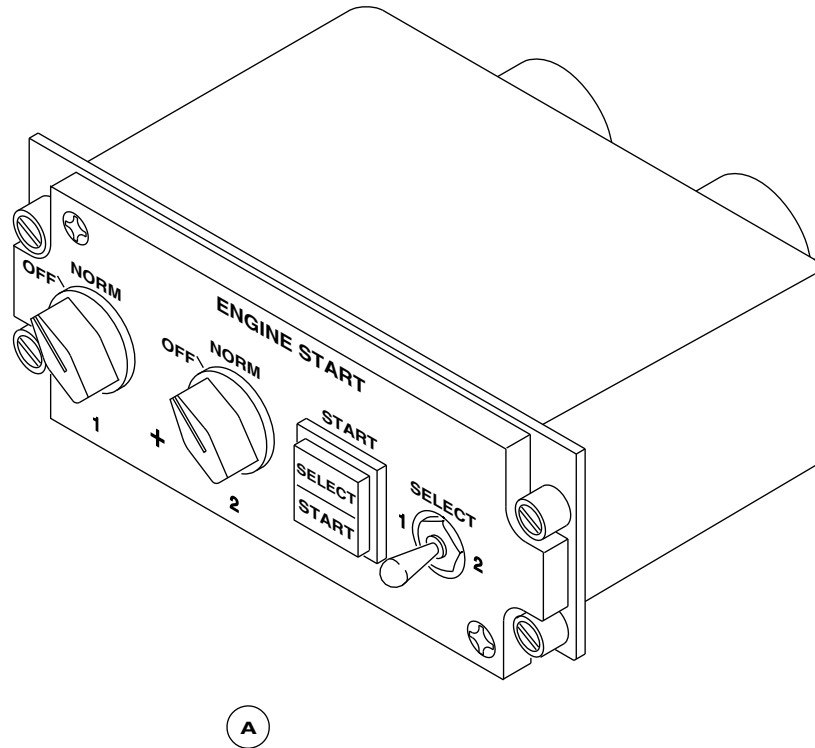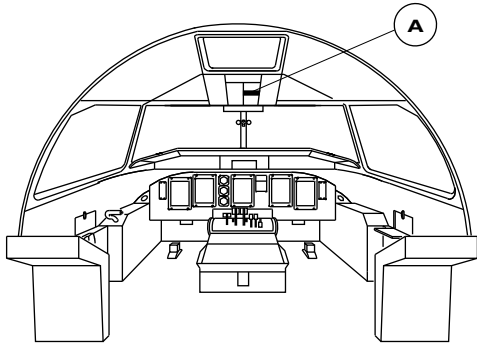
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Engine Start Control Panel Locator
Figure 1

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OVERHEAD CONSOLE

ENGINE START

IGNITION

NORM   NORM   START   SELECT

OFF   OFF

SELECT   1   2

START

1   +   2

1   2   3
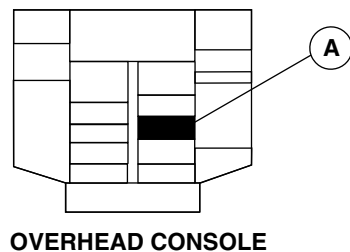
LEGEND

1. Engine Ignition Switches.
2. Select and Start Switchlight.
3. Engine Start Select Switch.

A
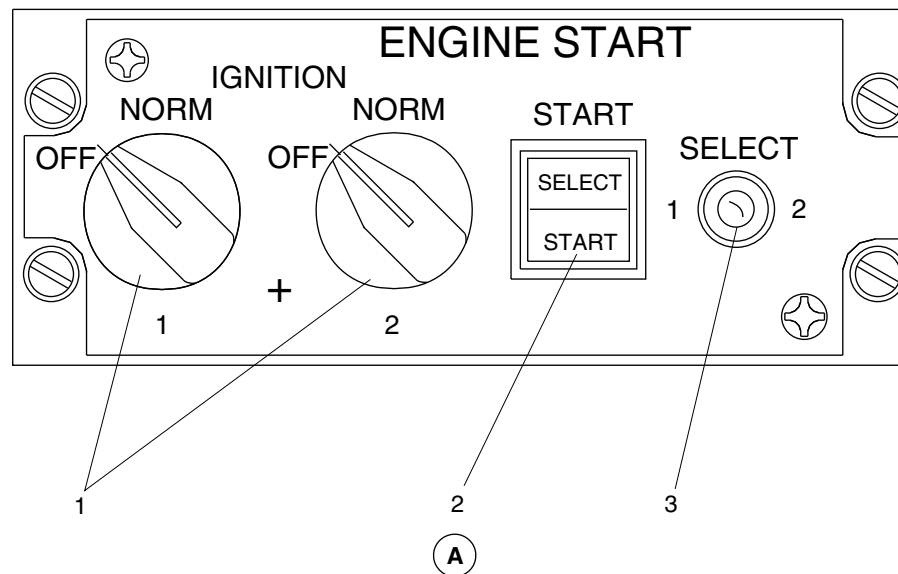
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Engine Start Control Panel Detail
Figure 2

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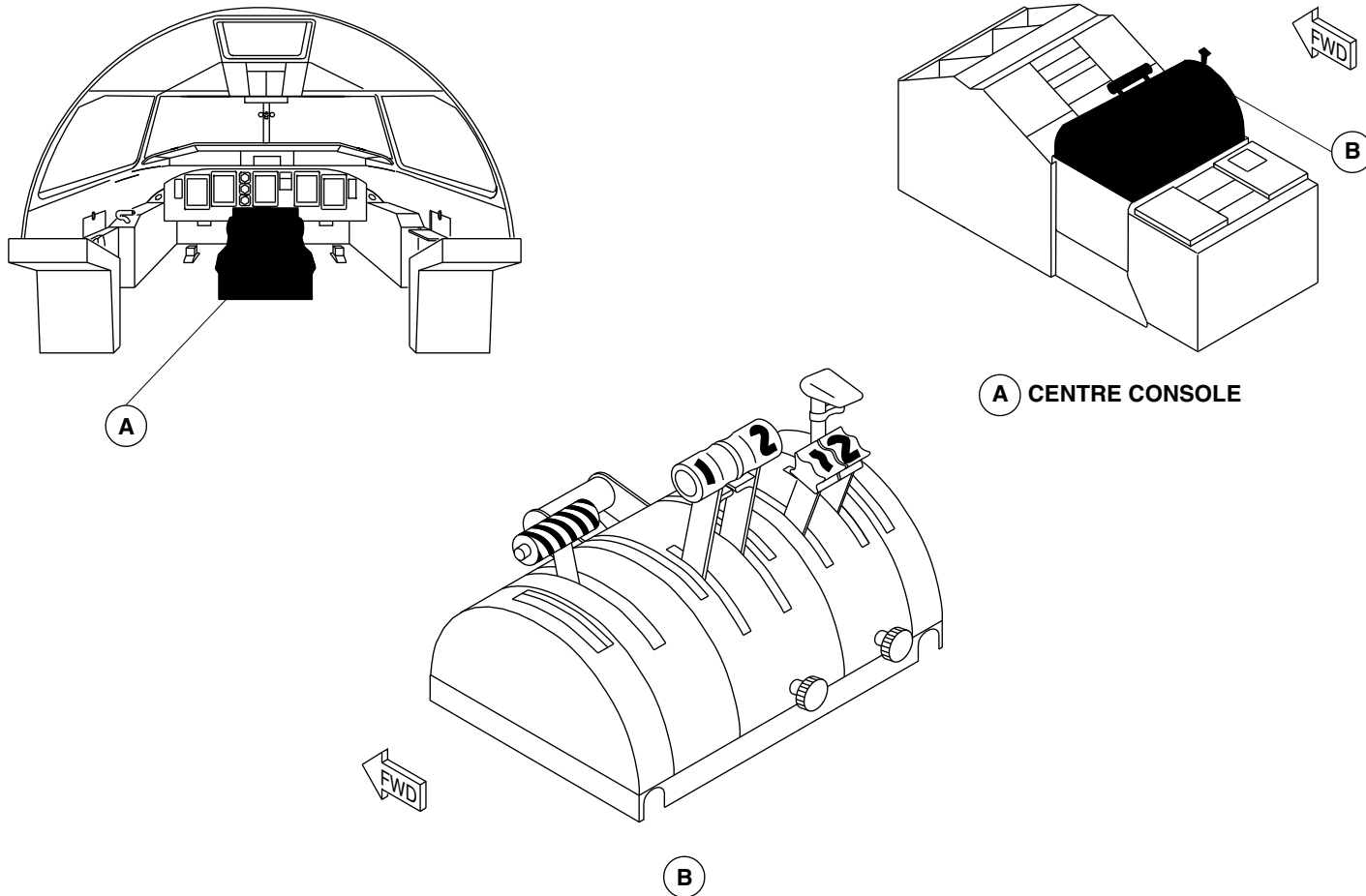
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Power and Condition Levers Quadrant Locator
Figure 3

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CENTRE CONSOLE

A

ELEVATOR TRIM

ND

TO

NU

EMERG BRAKE
PARK

OFF
CONTROL LOCK
ON

RATING **POWER** RATING
FLIGHT
IDLE

1   **2**

MAX
REV

OFF
CONTROL LOCK
ON

MAX
1020

PROP
900   900

MIN
850

START &
FEATHER

1   **2**

FUEL
OFF

FLAPS
0^0
5^0
10^0
15^0
35^0
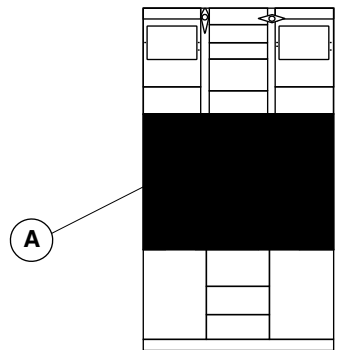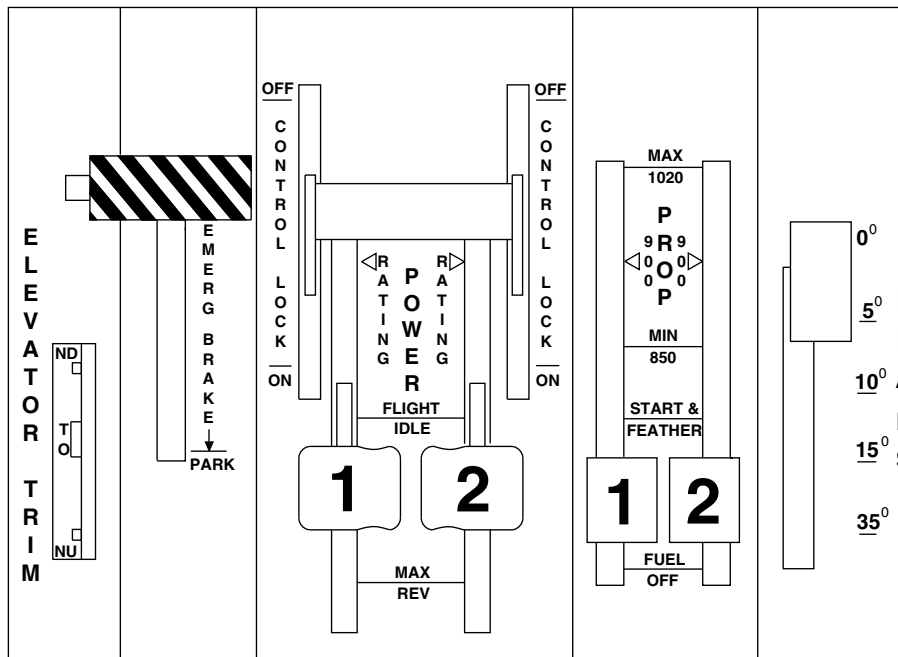
A

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Power and Condition Levers
Figure 4

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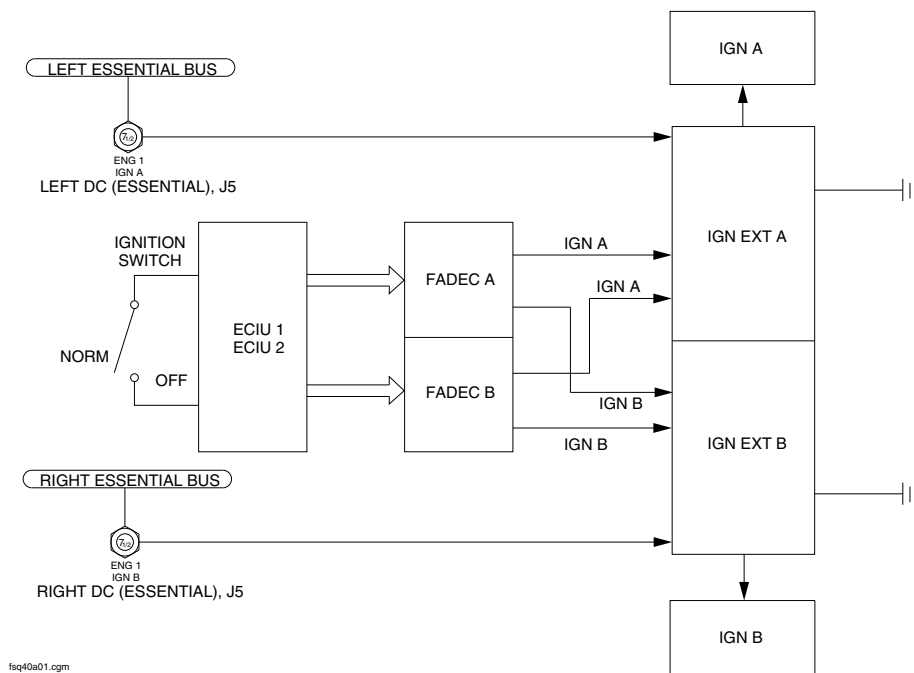
Ignition System Electrical Block Diagram
Figure 5

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┌──────────┐  ┌──────────┐  ┌──────────┐  ┌──────────┐  ┌──────────┐  ┌──────────┐  ┌──────────┐  ┌──────────┐  ┌──────────┐
│ CIRCUIT  │──│  START   │──│   HOLD   │──│  K3 C1   │──│  GCU HH  │──│  START   │──│  RELAY   │──│   GEN    │──│  GCU Q   │
│ BREAKER  │  │ SELECT SW│  │   COIL   │  │          │  │          │  │  SWITCH  │  │   K1     │  │ CONTROL  │  │ K3 HOLD  │
│    1     │  │          │  │          │  │          │  │          │  │          │  │          │  │  UNIT N  │  │          │
└──────────┘  └──────────┘  └──────────┘  └──────────┘  └──────────┘  └──────────┘  └──────────┘  └──────────┘  └──────────┘
                                                                                                                       │
                                                                                                                ┌──────────┐
                                                                                                                │CONTACTOR │
                                                                                                                │    K1    │
                                                                                                                │  (EPGS)  │
                                                                                                                └──────────┘
                                                                                                                       │
                                                                                                                ┌──────────┐
                                                                                                                │  START   │
                                                                                                                │  LIGHT   │
                                                                                                                └──────────┘
                                                                                                                       │
                                                                                                                ┌──────────┐
                                                                                                                │ STARTER  │
                                                                                                                │GENERATOR │
                                                                                                                └──────────┘
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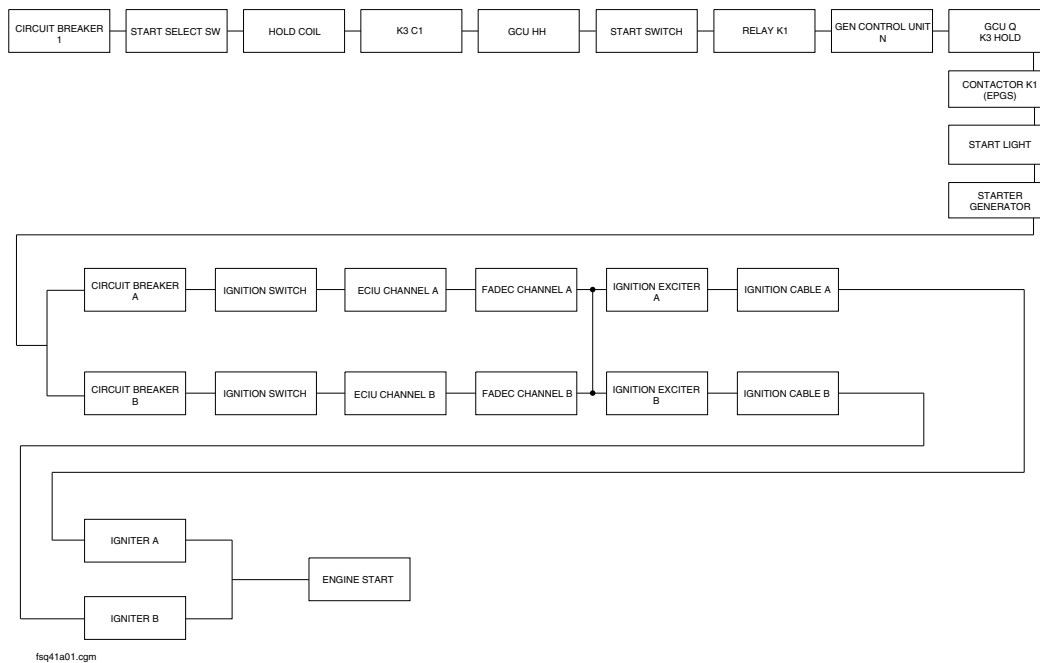
Start Electrical Control Block Diagram
Figure 6

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To Left Essential Bus

CB1

5 6 Select Sw 1
4   No 1 Eng

K1 C2
C1 C3

B3 Start Push
    Sw
B1   B2
        K1   B1
        B3

A2
K3 A1
A3

B2
K3   B1
B3

CR1

Start Term
┌─┐
│G│
│C│
│U│
└─┘
   Q

N
┌─┐
│G│
│C│
│U│
└─┘
Start

To EPCU J1 pin 110
→

A3   A1
K1
     A2

Select Lt

HH
┌─┐
│G│
│C│
│U│
└─┘
Current Limit

Start Lt

Hold Coil
Sw 1

K3

K1

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Start System Shown De–energized
Figure 7

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NOTE

Select Sw Holding Coil is energized to maintain switch
in No 1 position .
K3 energized to light Select Lt and apply current limiting
to GCU.

To Left Essential Bus

CB1

5 6 Select Sw 1
4   No 1 Eng

K1 C2
C1 C3

CR1

Start Lt

Hold Coil
Sw 1

K3

Start Term

G
C
U
        Q

N

G
C
U

Start

K1

B3 Start Push
    Sw
B1   B2
    K1   B1
    B3

A3 A1
K1
A2

To EPCU J1 pin 110

A2
K3 A1
A3

Select Lt

B2
K3   B1
B3

HH

G
C
U

Current Limit

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Start System Shown N0.1 Engine Selected
Figure 8

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NOTE

K1 is energized and maintained by contacts B2, B1. Contacts A1, A2 send diagnostic to EPCU. Contacts C1, C2 lights Start Lt. K3. is maintained energized by GCU Start Term signal. On the Engine reaching 50 per–cent NH Start Term signal is removed and the Control System reverts to de–energized state.

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Start System Shown After Operation of Start Switch
Figure 9

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