## 2A-76-10: General

The engine controls system governs engine operation through all phases of flight. This is accomplished by both automatic and manual engine controls.

The engine controls system is composed ot the following subsystems:

- 2A-76-20: Electronic Engine Control System
- 2A-76-30: Engine Thrust Management System

## 2A-76-20: Electronic Engine Control System

**1. General:**

**A. General Description:**

The Tay engine control system, in addition to using the standard mechanical cable and push/pull rod systems, has three automatic controls, as follows:

- $P_3$ Limiter
- LP Governor
- Top Temperature Controller

**2. Description of Subsystems Units and Components:**

**A. $P_3$ Limiter:**

The $P_3$ limiter controls the maximum internal engine pressure to prevent over-boosting of the engine. The system is utilized when 238 PSI (maximum pressure) is exceeded.

**B. LP Governor:**

The LP governor controls the maximum LP spool speed by limiting the fuel flow to the fuel spray nozzle. It activates at approximately 94.6% LP RPM, and attempts to maintain the speed below 95.5% RPM (LP overspeed).

As the speed of the LP compressor shaft approaches the set value, the force caused by the centrifugal governor fly-weights moves the metering plunger against the balance spring which decreases the fuel flow through the governor until the plunger has a balanced condition. This also causes a decrease in pressure across the governor which causes the HP fuel pump to decrease the fuel quantity supplied. This prevents any increase in engine speed. When there is a reduction in the LP shaft speed, the LP governor drops off line and normal engine speed control resumes.

In addition to the LP governor operating as a power limiter or overspeed governor, it may also operate during full power conditions in the event of fuel flow regulator failure. During flight, the governor may also operate if the power settings are set at less than maximum. This is due to the increase of the speed differential between the HP and LP compressors with the increase of altitude and the fall in temperature.

**C. Top Temperature Controller:**

**NOTE:**

Not applicable for aircraft 1000-1319 (with ASC 394 incorporated) or aircraft 1320 and subsequent. The top temperature controller was removed during the above ASC and omitted in production thereafter.

The Top Temperature Controller (TTC) controls the maximum TGT of the engine during high-power operating conditions. The TTC activates at approximately 800° to 805° C and attempts to maintain the TGT below 820° C (maximum overtemperature).

If the temperature control switch in the crew compartment is set to ON, an increase in TGT more than the pre-set limit causes the amplifier to energize the motor in the actuator. The motor turns the output shaft which operates the throttle control mechanism to decrease the quantity of fuel from the HP fuel pump. This decreases the TGT.

When the engine goes to the over-temperature condition (more than the amplifier datum temperature), the TTC actuator is moved in the appropriate direction to decrease the fuel supply.

**NOTE:**

Should manual control of the engine become necessary, an external ON-OFF switch can be selected to OFF. In this condition, the TTC actuator is moved to the no-trim stop. In this position, a full range of control at the throttle levers is available.

**3. Flight Manual Limitations:**

There are no Flight Manual limitations established for the electronic engine control system at the time of this revision.

## 2A-76-30: Engine Thrust Management System

**1. General Description:**

The engine thrust management system provides a means of setting and controlling idle thrust, forward thrust and reverse thrust.

Engine thrust is indicated as a measurement of the ratio of fan pressure to intake total pressure. It is referred to as Engine Pressure Ratio (EPR). The air data computer supplies intake pressure information from four probes in the bypass duct. These signals are sent to a transducer, adjusted to a common EPR/thrust value for the engines and displayed on the EICAS (annunciator page). The engines are set to a predetermined EPR for takeoff, climb and cruise.

**A. Subsystems, Units and Components:**

The engine thrust management system is composed of the following subsystems, units and components:

- Power Levers
- Thrust Reverser Levers
- Airflow Control System

- Autothrottle
- Engine Synchronizer

**2. Description of Subsystems, Units and Components:**

**A. Power Levers:**

The power lever assembly consists of left and right power levers for setting forward thrust. The power levers are mechanically connected to the input lever on the fuel flow regulator to permit manual selection of fuel flow and engine RPM.

**B. Thrust Reverser Levers:**

The thrust reverser lever assembly for each engine is mounted in the cockpit control pedestal. It consists of a power lever (forward thrust lever) and a smaller lever called the reverse thrust lever, mounted and pivoting on the upper portion of the throttle lever. Both levers operate a bellcrank common to both levers through an interconnecting link assembly. The bellcrank, in turn, is connected to a cable sector wheel (at the cockpit floor line) by a push-pull rod. This makes it possible to utilize the same cable run, push-pull rods, and bellcranks when selecting engine speed. To prevent one lever from being moved when not desired, an interlocking mechanism is provided. This consists of a roller attached to the interconnecting link assembly riding in a contoured slot. The design permits moving the power lever from its IDLE position toward the maximum forward thrust position without moving the reverse lever. The roller in the slot is locked from following the contour of the power lever track. Only when the power lever is moved back to its IDLE position, can the reverse lever be moved in its upward/aft direction. This, in turn, moves the bellcrank in the same direction, thereby preventing it from being moved due to the roller being in the slot. Moving the reverse thrust lever from its stow (IDLE) position towards its maximum reverse thrust position will allow for an increase in HP compressor speed.

**C. Airflow Control System:**

The airflow control system is designed to prevent compressor stalls or surges during stable and transitioning compressor speeds. The system includes variable Inlet Guide Vanes (IGVs) located forward of the first stage of the HP compressor and a bleed strap surrounding the 7th stage of the HP compressor.

The varying positions of the IGVs ensure correct airflow to the first stage of the compressor. The bleed strap prevents “choking” of the HP compressor rear stage. This is accomplished by opening and dumping compressor air into the bypass and increasing airflow through the HP compressor front stages at the same time, thus preventing stalls.

The variable guide vanes and bleed valve are controlled by an airflow regulator and actuator. This unit responds to changes in EPR which is a function of HP compressor inlet temperature $T_{26}$ and HP RPM. The actuator operates the inlet guide vanes and bleed valve through signals from the $T_{26}$ and HP RPM.

**D. Autothrottle:**

(See Figure 1.)

**NOTE:**

On aircraft SN 1214 and subsequent, engine synchronization is a function of the autothrottle system. With the autothrottle engaged and ENGINE SYNC selected, The autothrottle will sync the engines when engine power is at limit EPR for CLB, CRZ or MCT ratings. With engines at limit EPR, the autothrottle will reduce RPM on the “high” engine to match either LP or HP RPM. The other engine will remain at the limit EPR.

(1) The PZ-800 performance computer aids the pilot in determining and selecting the optimum airspeed/engine setting for any given flight condition. The performance computer functions as an autothrottle computer to directly control aircraft throttle settings and allows the pilot to optimize thrust management.

The autothrottle uses the selected EPR rating as an upper limit for control in all modes of operation. Automatic rating selection is available, where the PZ-800 performance computer chooses the engine rating based on the phase of flight. Also, minimum engine limits are observed to avoid the nonlinear flat response area near idle throttle settings.

(2) The following is a brief description of how the autothrottle system operates in LP, HP and EPR synchronization:

- With autothrottles engaged, engine synchronizer functions are performed through performance computers, not the synchronizer system.
- When FLCH mode is selected or directed by climb power or idle (as appropriate) and autothrottles are engaged, engines are synchronized to EPR by performance computers regardless of engine synchronizer selection. If engine synchronizer is selected ON in this mode, the appropriate lights will be illuminated even though LP and HP synchronizers are inhibited. When not in FLCH mode with autothrottles and engine synchronizer selected to ON, engines are synced to LP or HP by performance computers through switch selection.
- When not in FLCH mode and engine synchronizer is not selected, engines will default to EPR synchronizer with autothrottles selected ON.

(3) Autothrottle Control:

There are two types of autothrottle control modes:

Speed:

- Cruise
- Pitch hold, climb or descent

- Vertical speed, climb or descent
- V path

Power:

- FLCH climb or descent
- FLCH takeoff
- FLCH go-around

When autothrottle is engaged in a speed mode, performance computers will equalize EPR unless LP or HP synchronizer is selected ON.

When autothrottle is engaged in a power mode, performance computers will equalize EPR regardless of LP or HP synchronize selection.

**E. Engine Synchronizer:**

(See Figure 2.)

**NOTE:**

Prior to activating the sync system, the engines should be manually synchronized by using the power levers and the engine RPM indicators.

- Aircraft 1000 thru 1213 excluding 1183:

  The engine synchronization system provides a means to automatically match the LP or HP RPM of the left (slave) engine to the right (master) engine over a limited, predetermined range. This limited range prevents the left engine from losing more than a fixed amount of RPM should the right engine be throttled back, shut down or otherwise lose RPM. The engine synchronizing system consists of an amplifier which is supplied with RPM signals from the HP and LP tach generators. These signals are computed and an output signal is sent to an actuator on the left engine. The actuator, in turn, moves the RPM/FUEL lever on the fuel regulator to either increase or decrease the RPM of the left engine to match the right engine. The left engine power lever is not affected by actuator motion.

- Aircraft 1183, 1214 and Subsequent:

  Engine synchronization is a function of the autothrottle system. When FLCH mode is selected or directed by climb power or idle, as appropriate, and autothrottles are engaged, engines are synchronized to EPR by performance computers regardless of engine synchronizer selection. If engine synchronizer is selected ON in this mode, the appropriate lights will be illuminated even though LP and HP synchronizers are inhibited. LP or HP sync will only be active when the autothrottle is in the Speed Control Mode, e.g., CRUISE, V/S, VPATH or PITCH HOLD mode.

**3. Controls and Indications:**

**A. Circuit Breakers (CBs):**

The engine thrust management system is protected by the following CBs:

| Circuit Breaker Name: | CB Panel: | Location: | Power Source: |
|---|---|---|---|
| L SEC LOCK | P | G-7 | ESS DC Bus |

| Circuit Breaker Name: | CB Panel: | Location: | Power Source: |
|---|---|---|---|
| R SEC LOCK | P | H-7 | ESS DC Bus |
| L T/REV CONTROL | P | I-7 | ESS DC Bus |
| R T/REV CONTROL | P | J-7 | ESS DC Bus |
| L T/R EMER STOW | P | K-7 or L-7 **(1)** | ESS DC Bus |
| R T/R EMER STOW | P | K-7 or L-7 **(1)** | ESS DC Bus |
| ENG SYNC | P | K-9 | R MAIN DC Bus |
| L EPR 115V | CP | A-9 | ESS AC Bus |
| R EPR 115V | CP | B-9 | ESS AC Bus |
| A/T SERVO #1 | CPO | C-9 | L MAIN DC |
| A/T SERVO #2 | CPO | D-9 | R MAIN DC |

**NOTE(S):**

**(1)** Depending on effectivity.

**B. Crew Alerting System (CAS) Messages:**

The HP SYNC or LP SYNC annunciator lights are available on the Engine Instruments Display page (EICAS). Illumination of either annunciator indicates which tach generators (HP or LP) are currently being used.

Caution (Amber) Messages:

| CAS Message: | Cause or Meaning: |
|---|---|
| AT OFF | Autothrottle disconnected |

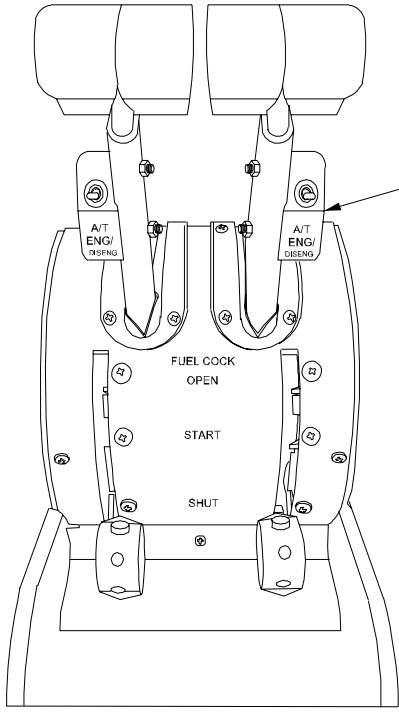
Advisory (Blue) Messages:

| CAS Message: | Cause or Meaning: |
|---|---|
| AT ENGAGE INHIBIT | Attempt is made to engage autothrottle under any of the following conditions:<br>• A/T disconnect button active<br>• A/T not armed on flight guidance control panel<br>• Both engines not running<br>• EPR below 1.17<br>• Isolation valve open |
| AT 1-2 FAIL | Indicated autothrottle has failed, autothrottle will disconnect. |
| AT NOT IN HOLD | Airplane speed has exceeded 60 KCAS with autothrottle engaged on takeoff and autothrottle servos are not in hold. |

**4. Limitations:**

**A. Flight Manual Limitations:**

Engine synchronizer must be OFF for takeoff and landing.




A/T ENG/DISENG

ENG (ENGAGED):

- Default SYNC is EPR
- HP or LP SYNC active only if autothrottle is in a speed control mode
- During takeoff, enters HOLD mode at 60 knots and remains until 400 feet AGL
- All engine SYNC functions (HP, LP EPR) are performed through the autothrottle computers
- When not in FLCH mode and engine synchronizer is not selected, engines will default to EPR synchronizer

DISENG (DISENGAGED):

- Disengages autothrottle system allowing for manual operation

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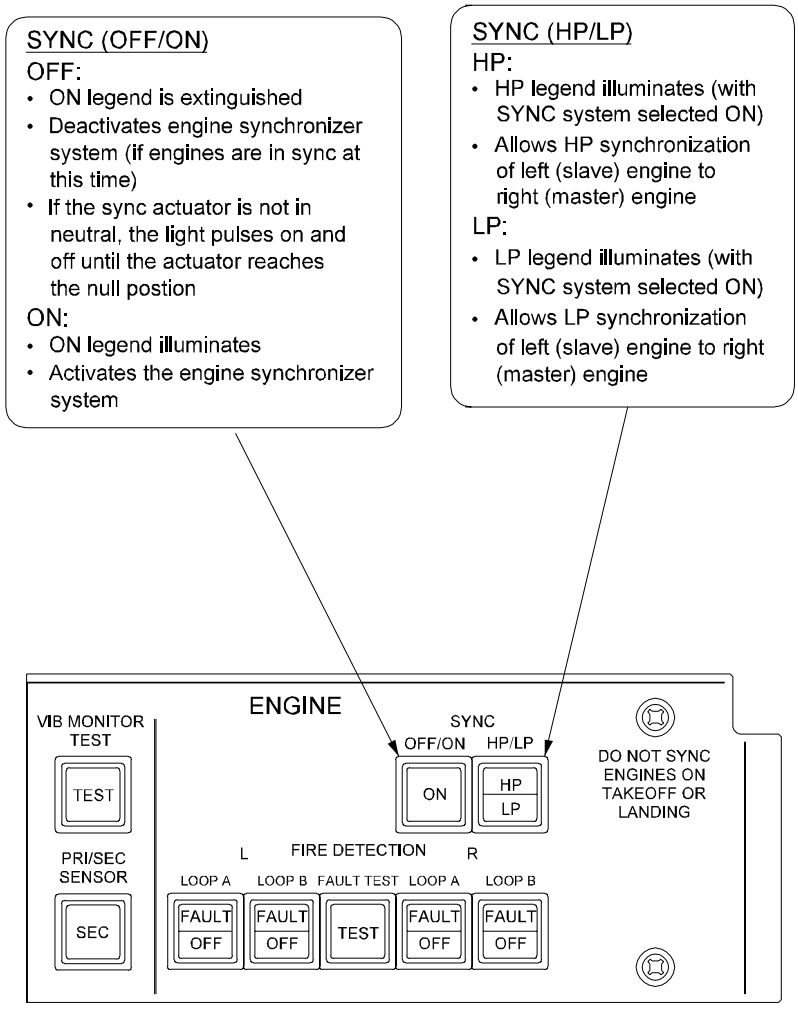
Autothrottle Control
Figure 1




Engine Sync Control Panel
Figure 2