1.0 Introduction to the 40KG Turbojet ECU

The Engine Control Unit (ECU) functions as the central nervous system of the 40KG turbojet engine, managing every aspect of its operation from startup to shutdown. This document serves as an authoritative technical reference for engineers and technicians tasked with system integration. It provides a consolidated overview of the ECU's architecture, connectivity, and operational parameters, based exclusively on the detailed information presented in the engine's operational manuals.

The ECU is a sophisticated control system designed from the ground up for turbine applications, built upon a 32-bit microprocessor. This architecture provides the computational power necessary for real-time monitoring, data logging, and precise control over the engine's complex operational sequences. The following sections will provide a detailed analysis of the ECU's core features, integration requirements, and user-configurable parameters to facilitate safe and successful system integration.

2.0 Core Architecture and Key Features

Understanding the ECU's fundamental design and built-in features is of strategic importance for any integration effort. These capabilities provide the advanced control, safety, and performance monitoring essential for leveraging the full potential of the 40KG turbojet. The ECU is engineered to deliver a robust and user-centric control experience.

The primary benefits offered by the ECU's architecture include:

- **Data Logging**
  - The system records key engine parameters during operation, allowing for post-run analysis and diagnostics.
- **Auto Start**
  - The ECU manages a fully automated start sequence, simplifying operations and ensuring consistent, safe engine starts.
- **Automatic Restart**
  - An optional feature that enables the ECU to automatically attempt an engine restart in the event of a flameout during operation.

- **Color Screen visible in direct sunlight**
  - The associated Ground Support Unit (GSU) features a color display designed for high visibility, even in bright, outdoor conditions.
- **Configurable thrust curve with very fast throttle response**
  - The ECU allows for the customization of the engine's throttle response, enabling fine-tuning for specific airframe or mission requirements.

These features form the foundation of the ECU's advanced capabilities. The next section details the practical aspects of integrating this unit into a broader system, beginning with its physical and electrical connectivity.

3.0 Electrical Integration and Connectivity

Strict adherence to the specified power and connection protocols is mandatory. Deviations present a significant risk of component destruction and system failure. This section details all power supply specifications and physical port connections as defined in the system documentation.

3.1 Power Supply Specifications

The ECU requires two distinct power sources for operation: a main power supply for the engine systems and a separate supply for the receiver. Adherence to these voltage requirements is mandatory.

Power Source	Specification
Main power voltage	3S LiPo battery. The minimum operational voltage is user-programmable via the 'LowVolt' parameter in the Running Menu. The manual references a minimum of 14.5 volts.
Receiver voltage	Nominal 5V. It is critical to maintain a stable supply, as the ECU will exhibit erratic operation if the voltage drops below 5V. The GSU screen will begin to fade as the voltage approaches 4V.

3.2 ECU Port Connections

The ECU features several clearly labeled ports for connecting the engine, fuel pump, power supply, and control interfaces. The following table provides a comprehensive overview of each primary connection.

ECU Port Label	Connects To	Technical Notes & Warnings
`motor`	Yellow MR30 Engine Port (via MR30 black cable)	This port provides a composite DC power and signal connection to the engine.
`Power Cable`	3S LiPo Battery (via XT60 connector)	Connects via the yellow XT30 (ECU side) to XT60 (battery side) power cable. **Observe correct polarity. As per the manual, reverse polarity will "instantly destroy the ECU," and this damage is not covered by warranty.**
`PPM`	Receiver Throttle Output	Connects via a standard servo cable for receiving throttle commands from the radio control system.
`pump`	Fuel Pump	Connects to the brushless fuel pump. **CRITICAL WARNING:** Do not mix up the engine (`motor`) and `pump` connections. The pump output is a 3-phase AC signal, while the engine connection is composite DC. Interchanging these connections will destroy the pump and may damage the ECU.
`GSU`	Ground Support Unit (GSU)	Connects to the GSU terminal for system configuration and monitoring. **Observe correct polarity:** The orange signal wire must be oriented toward the top of the ECU for proper operation.

3.3 Telemetry Connections

The ECU supports telemetry output for real-time data transmission to compatible radio systems. The provided manual diagrams should be consulted for specific cabling instructions and connection details related to various transmitter brands.

Once the ECU is correctly wired and powered, the next step in the integration process is to configure its operational parameters using the Ground Support Unit (GSU)

interface.

4.0 GSU Interface and System Parameterization

The Ground Support Unit (GSU) is the primary human-machine interface for the ECU. It provides access to a comprehensive suite of menus and parameters that allow engineers to monitor real-time data, perform diagnostics, and configure the engine's operational behavior. A thorough understanding of each menu and its function is essential for tuning the engine for optimal performance and safety.

4.1 GSU Screen and Button Functions

The GSU displays critical engine data across two primary screen layouts: the Initial Screen and a Large Font Running Screen for improved visibility. The Initial Screen provides a dashboard view of key metrics:

- **RPM:** Current engine speed
- **Temp:** Current Exhaust Gas Temperature (EGT)
- **Curr:** Electrical current being used
- **Cap:** Main battery capacity that has been consumed
- **ACC:** Engine response time from idle to max thrust (in seconds)
- **Pump:** Pump output voltage
- **RC:** Current RC throttle position (0-100%)

Navigation and data entry are handled by a simple four-button interface:

Button	Function
OK	Enters a menu or confirms a parameter change.
C	Exits a menu, clears a screen, or toggles between screen layouts.
+	Increments a numerical value or navigates up in a menu.
-	Decrements a numerical value or navigates down in a menu.

4.2 Main Menu Overview

Pressing the `OK` button from the initial GSU screen provides access to the main menu, which is organized as follows:

- `StartUp`
- `Running`
- `StudyRC`
- `Starter`
- `Cooling`
- `Other`
- `Test`
- `DataChart`
- `Language`

4.3 Analysis of Configuration Menus

The following subsections detail the parameters available within each of the core configuration menus.

4.3.1 StartUp Menu Parameters

These parameters exclusively govern the automated start sequence and have no influence on engine performance after it has achieved a stable idle state.

Parameter	Function	Guidance / Typical Values
PumpVoltage	Sets the initial pump voltage during the ignition phase to control fuel flow.	Calibrate to achieve a slow, distinct drip rate during the test sequence. Initial adjustments should be in increments of 0.02-0.04V to avoid flooding.
RPM StartUp Ramp %	Sets the ramp profile for how quickly the engine accelerates during startup.	Typical values range from 60% to 100%. Higher values result in a faster start sequence. Tune for a clean, consistent start without excessive EGT.
PumpStartUp Ramp	Adjusts the rate of fuel flow increase during the "Fuel ramp" phase.	Typical values range from 0 to 5. Increase for faster acceleration to idle; decrease for hot starts to prevent over-temperature events.
GlowPlug	Sets the voltage applied to the glow plug.	Typical value: 5.5V to 6.8V. Set to the lowest value that achieves a reliable and consistent start to maximize glow plug service life.
GasValve	Controls the duty cycle to the gas (plug) solenoid, regulating heat during preheat.	Typical value: 50% to 70%. Higher values yield a longer duty cycle and more heat. Tune for stable preheating and transition to fuel ramp.
Ignition RPM	Sets the engine RPM at which the ignition phase begins.	Must be set according to the engine's factory default specification.
Preheat RPM	Sets the engine RPM at which the preheat phase begins.	Must be set according to the engine's factory default specification.
RPM Starter Off	Sets the engine RPM at which the starter motor disengages.	Set to the lowest RPM at which the engine is confirmed to be self-sustaining to minimize starter motor wear.

4.3.2 Running Menu Parameters

These parameters control the engine's behavior during normal operation, from idle to maximum thrust.

| Parameter | Function | Guidance / Typical Values | | --- | --- | | **RPM Acceleration/Deceleration** | Sets the throttle response time of the engine. | This parameter dictates throttle response latency. Increase the value for faster acceleration/deceleration; decrease for a smoother, more stable response. The factory default of 30 provides a balanced starting point for tuning. | | **Max RPM** | Sets the maximum operational RPM. | This value is limited by the ECU firmware and cannot be set to exceed the engine's design limits. | | **Idle RPM** | Sets the engine's idle speed. | Application-specific. Set according to airframe requirements and minimum self-sustaining speed. | | **Min RPM** | Sets the minimum RPM threshold below which the engine will automatically shut down. | Set to a value safely below idle RPM to prevent nuisance shutdowns while ensuring a positive engine stop. | | **MaxTemp (EGT)** | Sets the maximum running EGT. The ECU will limit fuel to prevent exceeding this value. | Set according to the engine manufacturer's specified maximum EGT limit to prevent thermal damage. | | **LowVolt** | Sets the threshold for the low main battery voltage warning. | Set based on the 3S LiPo battery's specifications to ensure a safe operational margin before cell damage occurs. | | **Restart** | Enables ("valid") or disables ("invalid") the automatic restart feature after a flameout. | An operational choice based on mission requirements. Enable for applications where an in-flight restart is desirable. | | **Restart Glow Plug** | Sets the glow plug voltage for an automatic restart attempt. | Typically set ~0.2V higher than the normal `GlowPlug` start voltage to overcome the higher temperatures of a hot-start scenario. | | **PumpLimit** | A safeguard that sets a maximum voltage limit for the fuel pump output. | Set this value approximately 20% higher than the maximum pump voltage observed during full-throttle operation to prevent over-pressurization of the fuel system. | | **IdlePumpStab** | Sets a pump stabilization delay when the engine returns to idle RPM. | Sets a stabilization delay for the fuel pump when returning to idle. Must be tuned empirically for the 40KG engine to prevent flameout or instability upon rapid throttle reduction. |

4.3.3 StudyRC Menu Parameters

This menu is used to calibrate the radio control transmitter's throttle channel with the ECU.

| Parameter | Function | Guidance / Typical Values | | --- | --- | | **Max** | Calibrates the maximum throttle position. | Calibrate with the transmitter's throttle stick and trim set to their maximum positions. | | **Idle** | Calibrates the idle throttle position. | Calibrate with the transmitter's throttle stick at its minimum position and the trim set to its neutral or up position. | | **Min** | Calibrates the engine stop/shutdown position. |

Calibrate with the transmitter's throttle stick and trim set to their minimum positions. | | **FailSafeTime** | Sets the time in seconds before the ECU initiates a failsafe shutdown after signal loss. | Set according to radio controller capabilities and operational safety requirements. | | **[BUS] Throttle cha** | Sets the throttle channel when using a BUS mode input. | Configure to match the channel assignment on the BUS-compatible receiver. | | **[BUS] Switchcha** | Sets a switch channel for startup when using BUS mode input. | When enabled, PPM input is disabled. Assign to a switch channel for BUS-based start initiation. | | **TelemetryMode** | Sets the telemetry mode. | Set to 1/1 for a standard single-engine installation. |

4.3.4 Cooling Menu Parameters

This menu contains a single parameter that governs the post-shutdown cooling sequence.

- **Function:** Sets the RPM for the starter motor during the automated cool-down cycle. This same RPM is used when the starter is manually activated via the Test Menu.
- **Critical Note:** The ECU will not automatically initiate a cool-down sequence following a failsafe shutdown or an in-operation flameout. This must be initiated manually if conditions permit.

4.3.5 Starter Menu Parameters

This menu allows for fine-tuning the behavior of the electric starter motor.

| Parameter | Function | Guidance / Typical Values | | --- | --- | | **Eject Time** | Sets the duration of a reverse voltage pulse used to disengage the starter clutch. | Calibrate based on starter motor and clutch behavior to ensure clean disengagement without excessive strain. | | **Eject Voltage** | Sets the voltage of the reverse pulse. | Calibrate in conjunction with Eject Time for effective starter clutch disengagement. | | **Run Voltage** | Sets the primary voltage applied to the starter motor during the startup sequence. | Tune for reliable engine rotation during startup, balancing speed with starter motor temperature and current draw. | | **RPM Stable** | Sets the adjustment rate of the starter motor RPM. | A tuning parameter for the starter control loop. Adjust based on system testing to achieve stable starter RPM operation. |

4.3.6 Other Menu Parameters

This menu provides access to utility functions and system information.

| Parameter | Function | Guidance / Typical Values | | --- | --- | | **Clear Battery used** | Resets the consumed battery capacity (`Cap`) counter to zero. | Execute this command before each operational session to accurately monitor battery consumption. | | **Adjust Temp** | Calibrates the EGT reading. | Not normally required. Use only with a calibrated reference EGT probe if a significant discrepancy is verified. | | **Temp Unit** | Switches the temperature display between Centigrade and Fahrenheit. | Set to the desired unit of measure for local operational procedures. | | **Pump Unit** | Sets the pump type (DC or BL - Brushless). | Must be set to BL (Brushless) to match the pump hardware supplied with the 40KG engine system. | | **Firmware Version** | Displays the current firmware versions for the TCU, ECU, and GSU. | For informational and diagnostic purposes only. Not a user-configurable parameter. |

Once these parameters have been configured, the ECU is equipped to execute its automated operational sequences based on user commands and real-time sensor data.

5.0 Automated Operational Sequences

A key strength of the ECU is its ability to synthesize user-configured parameters and real-time sensor data to manage the engine's entire operational lifecycle. This automation simplifies operator workload and ensures repeatable, safe procedures for starting, running, and shutting down the engine.

5.1 Automated Start Sequence

After a start is initiated by the operator (raising the throttle stick to full then returning to minimum), the ECU executes a precise, multi-phase sequence:

1. **Ignition:** The starter motor spins the engine to the `Ignition RPM`. The ECU activates the glow plug and provides minimal fuel flow, governed by the `PumpVoltage` parameter. The GSU will display rising pump energy, and a sizzling sound indicates the initial burning of