**ZK-Protocol**

**V1.2**

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# ECU Interface

## Electrical Interface:

TLL、RS232、RS422

# UART：

## UART Format：

UART: 2400/4800/9600/19200/38400/57600/115200（Configurable）

Protocol setup：8 data bist

Parity：no parity

Stop-bit：1/2 stop-bit（Configurable）

## Precautions

1. The ECU closes the remote control signal loss detection, the protocol will automatically send the ECU state after the ECU is working, and the ECU will keep the original running state after the control signal is lost. (This feature is only supported after protocol version 5).。

## Control command packet format

Data direction：flight control -> ECU

The data length is 4 bytes, the data format is as follows, and the command type is distinguished by ID。

**CRC check range：byte 1 to byte 2**

|----------------------------------------------------------------------------------------------|

| byte:0 | byte:1 | byte:2 | byte:3 |

|----------------------------------------------------------------------------------------------|

| 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0|

| Head (0xFF) |Cmd ID: 0 | reserve | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 1 | SW | Throttle | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 2 | reserve | Param | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 3 | reserve | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 4 | reserve | Ignition Pump Voltage | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 5 | reserve | Acceleration curve | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 6 | reserve | RPM\_X | SW | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 7 | set rpm | CRC |

|----------------------------------------------------------------------------------------------|

| Head (0xFF) |Cmd ID: 8 | | air pressure | CRC |

|----------------------------------------------------------------------------------------------|

## Control command data packet

Note the supported protocol version. Please check the ECU status ID6 for the current ECU protocol version

|  |  |  |
| --- | --- | --- |
| CMD ID | Instructions | **Supported Protocol Versions** |
| Cmd ID: 0 | **empty loop**The host does not control the ECU, but the ECU will return the engine status to keep the connection | **1** |
| Cmd ID: 1 | **control engine status (SW)**:0: The UART does not control the engine (PWM input control mode)1: Control the engine into a stop state (overheating without cooling)2：Control the engine into standby mode (over-temperature automatic cooling)3：control engine into running stateNOTE: If the switch is non-zero, the PWM control signal has no effect.**control engine throttle (Throttle)**：Value range ：0~1000 （0.0~100.0%） | **1****1****1****1****1** |
| Cmd ID: 2 | **Control commands, parameters (Param) are as follows：** 1. Drain oil
2. Test the Glowplug
3. Test the main valve
4. Test ignition valve
5. Test the Fuel pump
6. Test the Starter
7. Set the status update rate 20HZ
8. Set the status update rate 50HZ
9. Set the status update rate 100HZ
10. Reset fuel consumption statistics
11. Calibrate the thrust sensor to 0
12. **Open the Fuel pump for a long time**
13. **Close pump**
 | **1****1****1****1****1****1****1****1****1****2****2****5****5** |
| Cmd ID: 3 | **Unlock setting parameters**Cmd ID 4/5 is only valid after unlocking, otherwise ECU will not respond to Cmd ID 4/5 | **1** |
| Cmd ID: 4 | **Set ignition pump voltage (**Ignition Pump Voltage)Numerical unit: 0.02V, ignition voltage = parameter \* 0.02Vvoltage range: 0.0 ~ 5.1V | **1** |
| Cmd ID: 5 | **Set the engine running acceleration curve (**Acceleration curve)Value range：10~70The larger the value, the faster the engine accelerates. Whether you can use higher acceleration, you need to confirm whether the engine body supports it. If it exceeds the engine limit, it will cause rich fuel to stall。 | **1** |
| Cmd ID: 6 | **control engine status (SW)**:0: invalid1: Control the engine into a stop state (overheating without cooling)2: Control the engine into standby mode(over-temperature automatic cooling)3: control engine into running stateNote: If the SW of ID6 is non-zero (1~3), the SW in ID1 is invalid, and the state of this SW is used to control the engine state.**RPM factor（RPM\_X）**Value range：0~6

|  |  |
| --- | --- |
| RPM\_X | Engine control RPM factor |
| 0 | invalid |
| 1 | 0 ~ 40950 |
| 2 | 0 ~ 81900 |
| 3 | 0 ~ 122850 |
| 4 | 0 ~ 163800 |
| 5 | 0 ~ 204750 |
| 6 | 0 ~ 245700 |

注意：如果RPM\_X是非零值，ID1命令无效，使用ID6的SW控制发动机状态，使用ID7的RPM控制发动机转速。RPM\_X数值含义参考ID7的RPM解释。 | **4****4** |
| Cmd ID: 7 | **control engine rpm（RPM）**Value range：0~4095 **Engine rpm = RPM \* 10 \* RPM\_X**Note: Select the proper RPM\_X according to the maximum engine speed. When RPM\_X is 0, the RPM of ID7 is invalid。 | **4** |
| Cmd ID: 7 | **Set Atmospheric Static Pressure（**air pressure**）**Value range：0~1024 air pressure unit: hPa |  |

## ECU status data packet format

发送方向：发动机 -> 飞控

Data direction： ECU -> flight control

The data length is 7 bytes, and the data format is as follows

**CRC check range: byte 0 to byte 5**

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//| byte:0 | byte:1 | byte:2 | byte:3 | byte:4 | byte:5 | byte:6 |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//| 7 6 5 4 3 2 1 0| 7 -- 0 | 7 -- 0 | 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0| 7 6 5 4 3 2 1 0|

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 1 | RPM(LSB) | RPM(MSB) |ECode | Engine State | |SwSt | Temp |ECode| Temp | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 2 | RPM(LSB) | RPM(MSB) |Radio Voltage | Power Voltage | Pump Voltage 0~25V | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 3 | RPM(LSB) | RPM(MSB) |Throttle | Pressure (LSB) | Pressure (MSB) | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 4 | RPM(LSB) | RPM(MSB) |Current | Thrust(MSB) |C | Thrust(LSB) | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 5 | RPM(LSB) | RPM(MSB) |Ign Pump Voltage | Curve INC | Curve DEC | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 6 | RPM(LSB) | RPM(MSB) |Max Rpm | Max Pump Voltage |Protocol Version |SRate| CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 7 | RPM(LSB) | RPM(MSB) | Flow Rate | FlowTotal |FlowRate| Flow Total | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 8 | RPM(LSB) | RPM(MSB) |Idle Rpm | |ESR|SCL| Startup Time (0.1s) | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

//|Head (0xF0) | ID: 9 | RPM(LSB) | RPM(MSB) |ECU Temperature | reserve | CRC |

//|-------------------------------------------------------------------------------------------------------------------------------------------------|

## ECU status data packet

Note: The supported protocol version. Please check the ECU status ID6 for the current ECU protocol version

|  |  |  |
| --- | --- | --- |
| 命令ID | 说明 | 支持的协议版本 |
| Cmd ID: 1 | // - RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10[Engine State:](#_引擎状态代码) VAL = {BYTE3[4:0]}[ECode: error code](#_引擎故障代码) VAL = {BYTE4[1:0],BYTE3[7:5]}Temp: engine exhaust temperature（Celsius） VAL = {BYTE4[4:2],BYTE5[7:0]} – 50SwSt: The control status of the host (computer, flight control) to the ECU VAL = {BYTE4[6:5]} 0: Stop 1：Standby 2：start/run | 11111 |
| Cmd ID: 2 | RPM: RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Radio Voltage: control voltage VAL = {BYTE3[7:0]} Unit:0.1V VAL = {BYTE3[7:0]} Unit:0.2VPower Voltage： VAL = {BYTE4[7:0]} Unit:0.1V VAL = {BYTE4[7:0]} Unit:0.2VPump voltage:  VAL = {BYTE5[7:0]} Unit:0.1V VAL = {BYTE5[7:0]} Unit:0.2V | 1<=3>=4<=3>=4<=3>=4 |
| Cmd ID: 3 | RPM: RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Throttle:  VAL = {BYTE3[7:0]} Unit:%Pressure:  VAL = {BYTE5[7:0],BYTE4[7:0]} \* 2 Unit:Pa | 111 |
| Cmd ID: 4 | RPM: RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Current: electric current (0.1 Ampere) VAL = {BYTE4[ 0],BYTE3[7:0]} Unit:0.1AThrust: Engine thrust VAL = {BYTR4[7:1],BYTE5[7:0]} Unit:0.1Kg | 112 |
| Cmd ID: 5 | RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Ignition Pump Voltage: Ignition pump voltage VAL = {BYTE3[7:0]} \* 2 Unit:0.01vCurve Increase: Engine Acceleration Curve Parameters VAL = {BYTE4[7:0]}Curve Decrease：Engine Deceleration Curve Parameters VAL = {BYTE5[7:0]} | 1111 |
| Cmd ID: 6 | RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Max RPM: engine maximum rpm VAL = {BYTE3[7:0]} \* 1000 Unit:RPMMax Pump Voltage: fuel pump maximum voltage VAL = {BYTE4[7:0]} Unit:0.1V VAL = {BYTE4[7:0]} Unit:0.2VProtocol Version：  VAL = {BYTE5[7:2]}SRate: Current Data Update Rate VAL = {BYTE5[1:0]} 0: 20Hz 1: 50Hz 2:100Hz | 111<=3>=411 |
| Cmd ID: 7 | RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Flow Rate: fuel flow rate VAL = {BYTR4[1:0],BYTE3[7:0]} Unit:0.01L/minFlow Total: cumulative fuel consumption VAL = {BYTE5[7:0],BYTE4[7:2]} Unit:0.1L | 222 |
| Cmd ID: 8 | RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10Idle RPM: Engine IDLE RPM VAL = {BYTE3[7:0]} \* 1000 Unit:RPMESR: Request flight controller to send atmospheric static pressure VAL = {BYTE4[5]} 0：No need for flight control to send barometric pressure 1：Need flight control to send barometric pressureSCL: Speed closed loop state VAL = {BYTE4[4]} 0：RPM Open loop 1：RPM Closed loopStartup Time: VAL = {BYTE4[3:0], BYTE5[7:0]} Unit:0.1s | 33444 |
| Cmd ID: 9 | RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} \* 10ECU Temperature: VAL = {BYTE3[7:0]} - 50reserve:  {BYTE4[7:0]}{BYTE5[7:0]} | 555 |

# Control mode::

## Throttle control mode - the throttle and engine status are in the same control command

Engine Control：ID1 - SW

Engine Throttle：ID1 – Throttle

## Throttle control mode – the state of throttle and transmitter is controlled by different control commands

Engine Control：ID6 - SW

Engine Throttle：ID1 – Throttle

## RPM Control mode

Engine Control：ID6 - SW

Engine RPM： ID7 – RPM

RPM factor：ID6 – RPM\_X （RPM\_X: Non-zero, enter speed control mode）

Target RPM = [ID7:RPM] \* [ID6:RPM\_X] \* 10

# CCRC check code：

## Non-table look-up method

t\_u8 crc8(t\_u8 \*puchMsg,t\_u8 crc\_len, t\_u8 seed)

{

 t\_u8 i,k,crc8 = seed;

 for(i = 0; i < crc\_len; i++)

 {

 k = puchMsg[i] ^ crc8;

 crc8 = 0;

 if (k & 0x01) crc8 ^= 0x5e;

 if (k & 0x02) crc8 ^= 0xbc;

 if (k & 0x04) crc8 ^= 0x61;

 if (k & 0x08) crc8 ^= 0xc2;

 if (k & 0x10) crc8 ^= 0x9d;

 if (k & 0x20) crc8 ^= 0x23;

 if (k & 0x40) crc8 ^= 0x46;

 if (k & 0x80) crc8 ^= 0x8c;

 }

 return crc8;

}

## Check table method

 const t\_u8 crc\_array[] = {

 0x00, 0x5e, 0xbc, 0xe2, 0x61, 0x3f, 0xdd, 0x83,

 0xc2, 0x9c, 0x7e, 0x20, 0xa3, 0xfd, 0x1f, 0x41,

 0x9d, 0xc3, 0x21, 0x7f, 0xfc, 0xa2, 0x40, 0x1e,

 0x5f, 0x01, 0xe3, 0xbd, 0x3e, 0x60, 0x82, 0xdc,

 0x23, 0x7d, 0x9f, 0xc1, 0x42, 0x1c, 0xfe, 0xa0,

 0xe1, 0xbf, 0x5d, 0x03, 0x80, 0xde, 0x3c, 0x62,

 0xbe, 0xe0, 0x02, 0x5c, 0xdf, 0x81, 0x63, 0x3d,

 0x7c, 0x22, 0xc0, 0x9e, 0x1d, 0x43, 0xa1, 0xff,

 0x46, 0x18, 0xfa, 0xa4, 0x27, 0x79, 0x9b, 0xc5,

 0x84, 0xda, 0x38, 0x66, 0xe5, 0xbb, 0x59, 0x07,

 0xdb, 0x85, 0x67, 0x39, 0xba, 0xe4, 0x06, 0x58,

 0x19, 0x47, 0xa5, 0xfb, 0x78, 0x26, 0xc4, 0x9a,

 0x65, 0x3b, 0xd9, 0x87, 0x04, 0x5a, 0xb8, 0xe6,

 0xa7, 0xf9, 0x1b, 0x45, 0xc6, 0x98, 0x7a, 0x24,

 0xf8, 0xa6, 0x44, 0x1a, 0x99, 0xc7, 0x25, 0x7b,

 0x3a, 0x64, 0x86, 0xd8, 0x5b, 0x05, 0xe7, 0xb9,

 0x8c, 0xd2, 0x30, 0x6e, 0xed, 0xb3, 0x51, 0x0f,

 0x4e, 0x10, 0xf2, 0xac, 0x2f, 0x71, 0x93, 0xcd,

 0x11, 0x4f, 0xad, 0xf3, 0x70, 0x2e, 0xcc, 0x92,

 0xd3, 0x8d, 0x6f, 0x31, 0xb2, 0xec, 0x0e, 0x50,

 0xaf, 0xf1, 0x13, 0x4d, 0xce, 0x90, 0x72, 0x2c,

 0x6d, 0x33, 0xd1, 0x8f, 0x0c, 0x52, 0xb0, 0xee,

 0x32, 0x6c, 0x8e, 0xd0, 0x53, 0x0d, 0xef, 0xb1,

 0xf0, 0xae, 0x4c, 0x12, 0x91, 0xcf, 0x2d, 0x73,

 0xca, 0x94, 0x76, 0x28, 0xab, 0xf5, 0x17, 0x49,

 0x08, 0x56, 0xb4, 0xea, 0x69, 0x37, 0xd5, 0x8b,

 0x57, 0x09, 0xeb, 0xb5, 0x36, 0x68, 0x8a, 0xd4,

 0x95, 0xcb, 0x29, 0x77, 0xf4, 0xaa, 0x48, 0x16,

 0xe9, 0xb7, 0x55, 0x0b, 0x88, 0xd6, 0x34, 0x6a,

 0x2b, 0x75, 0x97, 0xc9, 0x4a, 0x14, 0xf6, 0xa8,

 0x74, 0x2a, 0xc8, 0x96, 0x15, 0x4b, 0xa9, 0xf7,

 0xb6, 0xe8, 0x0a, 0x54, 0xd7, 0x89, 0x6b, 0x35,

} ;

t\_u8 crc8(t\_u8 \*puchMsg,t\_u8 crc\_len, t\_u8 seed)

{

 t\_u8 i,crc8 = seed;

 for(i = 0 ; i < crc\_len; i++)

 {

 crc8 = crc\_array[crc8^puchMsg[i]];

 }

 return crc8;

}

# Appendix：

## Engine Status Codes

|  |  |
| --- | --- |
| ID | Status |
| 0 | Stop |
| 1 | Standby/auto cooling |
| 2 | ignition (requires minimum throttle） |
| 3 | ignition |
| 4 | preheat |
| 5 | Fuelramp |
| 6 | Running (Learning mode, requires maximum throttle) |
| 7 | Running (Learning mode, requires minimum throttle) |
| 8 | Running (Learning Idle) |
| 9 | Running (minimum throttle) |
| 10 | Running (warning, fuel pump at limit) |
| 11 | Running |
| 12 | Cooling |
| 13 | restart |
| 14 | Test Glowplug |
| 15 | Test the main valve |
| 16 | Test ignition valve |
| 17 | Test pump |
| 18 | Test Starter |
| 19 | Fuel exhaust air |

## Engine error codes

|  |  |
| --- | --- |
| ID |  |
| 0 | No error |
| 1 | Time out |
| 2 | Voltage low |
| 3 | Glowplug failure |
| 4 | Pump failure |
| 5 | Starter failure |
| 6 | RPM low |
| 7 | RPM Instability |
| 8 | Exhaust temperature is high |
| 9 | Exhaust temperature is Low |
| 10 | Exhaust gas temperature sensor failure |
| 11 | Ignition valve failure |
| 12 | Main valve failure |
| 13 | Loss of control signal |
| 14 | Starter controller temperature is too high |
| 15 | Pump controller temperature is too high |
| 16 | Clutch failure |
| 17 | Current overload |
| 18 | Engine offline |

## Control command data instance

example 1：0xFF 0x14 0x64 0xD3

 Cmd ID: 1

 SW: 1

 Throttle: 100

example 2：0xFF 0x1D 0xF4 0x70

 Cmd ID: 1

 SW: 3

 Throttle: 500

## ECU State data instance

example 1：0xF1 0x00 0x00 0x00 0x00 0x4C 0xA0

 ID: 1

 RPM: 0 Engine RPM

 Engine State: 0 Engine State (stop)

 ECode: 0 Error code

 Temp: 26℃ Exhaust gas temperature（Celsius）

SwSt: 0 The control status of the host (computer, flight control) to the ECU (engine stop)

example 2：0xF6 0x00 0x00 0xA0 0x00 0x10 0xAB

 ID: 6

 RPM: 0 Engine RPM

 Max RPM: 160000 Engine maximum RPM

 Max Pump Voltage: 0.0V Fuel pump maximum voltage

 Protocol Version: 4 protocol version

SRate: 20Hz Current Data Update Rate