ZK-Protocol

V1.2

一、 ECU Interface

1. Electrical Interface:

TLL、RS232、RS422

二、 UART：

1. 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）

2. Precautions

a) 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).。

3. 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

4. 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 state NOTE: 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,	1

<table>
<tr><td></td><td>ignition voltage = parameter * 0.02V
voltage range: 0.0 ~ 5.1V</td><td></td></tr>
<tr><td>Cmd ID: 5</td><td>Set the engine running acceleration curve (Acceleration curve)
Value range: 10~70
The 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。</td><td>1</td></tr>
<tr><td>Cmd ID: 6</td><td>control engine status (SW):
0: invalid
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 state
Note: 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
<table><tr><th>RPM_X</th><th>Engine control RPM factor</th></tr><tr><td>0</td><td>invalid</td></tr><tr><td>1</td><td>0 ~ 40950</td></tr><tr><td>2</td><td>0 ~ 81900</td></tr><tr><td>3</td><td>0 ~ 122850</td></tr><tr><td>4</td><td>0 ~ 163800</td></tr><tr><td>5</td><td>0 ~ 204750</td></tr><tr><td>6</td><td>0 ~ 245700</td></tr></table>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。</td><td>4

4</td></tr>
<tr><td>Cmd ID: 7</td><td>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。</td><td>4</td></tr>
<tr><td>Cmd ID: 7</td><td>Set Atmospheric Static Pressure (air pressure)
Value range: 0~1024
air pressure unit: hPa</td><td></td></tr>
</table>

5. 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

6. 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: VAL = {BYTE3[4:0]} ECode: error code VAL = {BYTE4[1:0],BYTE3[7:5]} Temp: engine exhaust temperature (Celsius) VAL = {BYTE4[4:2],BYTE5[7:0]} - 50 SwSt: The control status of the host (computer, flight control) to the ECU VAL = {BYTE4[6:5]} 0: Stop 1: Standby 2: start/run	1 1 1 1 1
Cmd ID: 2	RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Radio Voltage: control voltage VAL = {BYTE3[7:0]} Unit:0.1V VAL = {BYTE3[7:0]} Unit:0.2V Power Voltage: VAL = {BYTE4[7:0]} Unit:0.1V VAL = {BYTE4[7:0]} Unit:0.2V Pump 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: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Throttle: VAL = {BYTE3[7:0]} Unit:% Pressure: VAL = {BYTE5[7:0],BYTE4[7:0]} * 2 Unit:Pa	1 1 1
Cmd ID: 4	RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Current: electric current (0.1 Ampere) VAL = {BYTE4[0],BYTE3[7:0]} Unit:0.1A Thrust: Engine thrust VAL = {BYTR4[7:1],BYTE5[7:0]} Unit:0.1Kg	1 1 2

Cmd ID: 5	RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Ignition Pump Voltage: Ignition pump voltage VAL = {BYTE3[7:0]} * 2 Unit:0.01v Curve Increase: Engine Acceleration Curve Parameters VAL = {BYTE4[7:0]} Curve Decrease: Engine Deceleration Curve Parameters VAL = {BYTE5[7:0]}	1 1 1 1
Cmd ID: 6	RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Max RPM: engine maximum rpm VAL = {BYTE3[7:0]} * 1000 Unit:RPM Max Pump Voltage: fuel pump maximum voltage VAL = {BYTE4[7:0]} Unit:0.1V VAL = {BYTE4[7:0]} Unit:0.2V Protocol Version: VAL = {BYTE5[7:2]} SRate: Current Data Update Rate VAL = {BYTE5[1:0]} 0: 20Hz 1: 50Hz 2:100Hz	1 1 1 <=3 >=4 1 1
Cmd ID: 7	RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Flow Rate: fuel flow rate VAL = {BYTR4[1:0],BYTE3[7:0]} Unit:0.01L/min Flow Total: cumulative fuel consumption VAL = {BYTE5[7:0],BYTE4[7:2]} Unit:0.1L	2 2 2
Cmd ID: 8	RPM: engine rpm VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 Idle RPM: Engine IDLE RPM VAL = {BYTE3[7:0]} * 1000 Unit:RPM ESR: 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 pressure SCL: Speed closed loop state VAL = {BYTE4[4]} 0: RPM Open loop 1: RPM Closed loop Startup Time: VAL = {BYTE4[3:0], BYTE5[7:0]} Unit:0.1s	3 3 4 4 4
Cmd ID: 9	RPM: engine rpm	5

	VAL = {BYTE2[7:0],BYTE1[7:0]} * 10 ECU Temperature: VAL = {BYTE3[7:0]} - 50 reserve: {BYTE4[7:0]} {BYTE5[7:0]}	 5 5

三、 Control mode::

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

Engine Control: ID1 - SW

Engine Throttle: ID1 – Throttle

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

Engine Control: ID6 - SW

Engine Throttle: ID1 – Throttle

3. 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

四、 CCRC check code：

1. 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;
}
```

2. 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;
}
```

五、 Appendix：

1. 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

2. 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

3. 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

4. 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