US5
DEVELOPMENT
MANUAL
(ALPHA)
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1 WORKING MECHANISM

1.1 Model

US5 system has 3 working modes: IO mode, UART mode, and UART REQ mode. The output frequencies are all 100Hz.

- **IO mode**: When the US5 is powered on, the default is IO mode. When a soft material is recognized, the TX output is low; when a hard material is recognized, the TX output is high. The output frequencies is 100Hz.
- **UART mode**: When the US5 enters the UART mode, it outputs the specified data according to the communication protocol. The output frequencies is 100Hz.
- **UART mode**: The user sends a command to query the output results. The maximum query frequency is 100Hz.

1.2 Measuring Principle

This product is based on the ultrasonic time-of-flight (ToF) principle, and is equipped with related acoustics, electricity and algorithm design, and realizes high-precision distance measurement through the energy difference of ultrasonic echo signals on the surface of different materials, and output millimeter-level distance information and its echo energy intensity value, and can also output flag bits to distinguish soft and hard materials.

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

US5 communicates commands and data with external devices through the serial port. When an external device sends a system command to US5, US5 resolves the system command and returns a corresponding reply message. According to the command content, US5 switches the corresponding working status. According to the content of the message, the external system can parse the message and obtain the response data.

Note: The US5 data communication adopts the little-endian mode, least significant bit first.

![FIG 1 US5 SYSTEM COMMUNICATION](image-url)
2.2 Communication Protocol

CHART 1 US5 COMMUNICATION DATA PROTOCOL

<table>
<thead>
<tr>
<th>Packet Header</th>
<th>Command Code</th>
<th>Response Length</th>
<th>Data Segment</th>
<th>Check Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Bytes</td>
<td>1 Byte</td>
<td>1 Byte</td>
<td>...</td>
<td>1 Byte</td>
</tr>
</tbody>
</table>

The command message and the working message are formulated according to the data protocol in Table 1, and the communication baud rate is 115200.

2.3 Command Message

The external system can set the corresponding working status of US5 and obtain corresponding data by sending related system commands. The system commands issued by US5 to external are as follows:

CHART 2 US5 SYSTEM COMMAND

<table>
<thead>
<tr>
<th>System Command</th>
<th>Description</th>
<th>Answer Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x40</td>
<td>Reset module</td>
<td>No response</td>
</tr>
<tr>
<td>0xF8</td>
<td>Set to IO mode</td>
<td>Single response</td>
</tr>
<tr>
<td>0xFE</td>
<td>Set to UART mode</td>
<td>Single response</td>
</tr>
<tr>
<td>0xFA</td>
<td>Set to UART REQ mode</td>
<td>Single response</td>
</tr>
<tr>
<td>0xFC</td>
<td>Obtaining measurement data in UART REQ mode</td>
<td>Single response</td>
</tr>
</tbody>
</table>

Setting the IO mode:

```
Packet Header   Command Code  Response Length  Data Segment  Check Code
0xAA 0xAA  0x01 0x4F  0x00 0x53
```

Setting the UART mode:

```
Packet Header   Command Code  Response Length  Data Segment  Check Code
0xAA 0xAA  0x01 0xFE  0x00 0x53
```

Setting the UART REQ mode:

```
Packet Header   Command Code  Response Length  Data Segment  Check Code
0xAA 0xAA  0x01 0xFA  0x00 0x53
```
Obtaining measurement data in UART REQ mode:

<table>
<thead>
<tr>
<th>Packet Header</th>
<th>Command Code</th>
<th>Response Length</th>
<th>Data Segment</th>
<th>Check Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xAA</td>
<td>0xFC</td>
<td>0x01</td>
<td>0x00</td>
<td>0x51</td>
</tr>
</tbody>
</table>

### 2.4 Response Message

The response message is the message returned by the system according to the received command. Different commands have different response content of the response message, and the response message is a single response; No response means that the system did not receive and parse the system command correctly.

Response message:

<table>
<thead>
<tr>
<th>Packet Header</th>
<th>Command Code</th>
<th>Response Length</th>
<th>Data Segment</th>
<th>Check Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xAA</td>
<td>0xFF</td>
<td>0x01</td>
<td></td>
<td>CS</td>
</tr>
</tbody>
</table>

- **Data**: The command code in the command message parsed by the US5: 0xF8, 0xFE in Chart 2.
2.5 Data Message

Data message is the message that the system outputs the measurement results, which will be output at a rate of 100Hz in the UART mode. In UART REQ mode, every time a 0xFC command is sent, a measurement result is returned.

- **Data**: The meaning is as follows:

<table>
<thead>
<tr>
<th>Packet Header</th>
<th>Distance Value</th>
<th>Intensity Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Byte</td>
<td>2 Bytes</td>
<td>1 Byte</td>
</tr>
</tbody>
</table>

- **Blanket sign**: 1 means with blanket, 0 means no blanket;
- **Distance value**: the unit is mm;
- **Intensity value**: a numerical value representing the strength of the ultrasonic signal;

For example:

- **Blanket not detected (0x00);**
- **The distance is 37mm (0x25 + 0x00<<8);**
- **Intensity value is 150 (0x96).**
2.6 Frequency Calibration

The frequency of the ultrasonic transducer has been calibrated at the factory, and usually does not need to be calibrated again. If necessary, a hard material object can be placed 19mm in front of the end face of the module, such as steel plate, wood board, etc., and ensure that the end face is parallel to the plane of the hard material object, and then operate according to the following steps.

1. Sending the calibration mode command

```
Packet Header  Command Code  Response length  Data Segment  Check Code
0xAA  0xAA  0xD0  0x01  0x00  0x25
```

Note that this instruction needs to be sent three times in a row for the reply packet to occur.

2. Staring the calibration mode command:

```
Packet Header  Command Code  Response length  Data Segment  Check Code
0xAA  0xAA  0xDC  0x01  0x00  0x31
```

3. Check whether calibration has completed:

```
Packet Header  Command Code  Response length  Data Segment  Check Code
0xAA  0xAA  0xEC  0x01  0x00  0x41
```

4. Query response for calibration completion:

```
Packet Header  Command Code  Response length  Data Segment  Check Code
0xAA  0xAA  0xFF  0x01  0x00  CS
```

A value of 0 indicates that the calibration is not complete, while a value of 1 indicates that the calibration is complete.
2.7 Check Code

The check code uses single-byte accumulation to verify the current data packet. Only the check code itself does not participate in the check operation. The check code solution formula is:

\[
\text{Checksum} = \text{ADD}^{\text{end}}(C_i) \quad i = 1, 2, \ldots, \text{end}
\]

\(\text{ADD}^{\text{end}}\) is an accumulation formula, which means to accumulate the numbers from subscript 1 to end in the element.
3 ATTENTION

1) There may be a jump in the output result at the critical point of the range, and the host side needs to judge the data.
2) Avoid splashing water in the use environment, which will cause abnormal output results.
## REVISION

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Writer</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021-12-09</td>
<td>0.1.0</td>
<td>Leo</td>
<td>The 1st release</td>
</tr>
<tr>
<td>2022-02-10</td>
<td>0.1.1</td>
<td>Leo</td>
<td>1) Add an example of data packet parsing; 2) The check code indicates that it is changed from ADD8 to CS</td>
</tr>
<tr>
<td>2022-11-24</td>
<td>0.2.0</td>
<td></td>
<td>1) Add reset instructions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2) Add the UART REQ mode description</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) Add frequency calibration instructions</td>
</tr>
</tbody>
</table>