

Multichannel Thickness Gauge Communication Protocol

V3.0 Rev

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1. Introduction

To control BroadSens UT200S, the controller (a Windows PC, a Linux machine or a Mac computer) should use TCP/IP protocol. UT200S functions as a TCP/IP server, and the controller program functions as a TCP/IP client. Wired connection is recommended for reliable operation. Fast and stable WIFI can also be used.

2. Protocol details

2.1 Connection to UT200S and Auto VGC

To control UT200S, controller connects to UT200S through TCP/IP sockets (Figure 1). In the connection, UT200S is the server, and the controller is the client. The TCP/IP port number of UT200S is 8877.

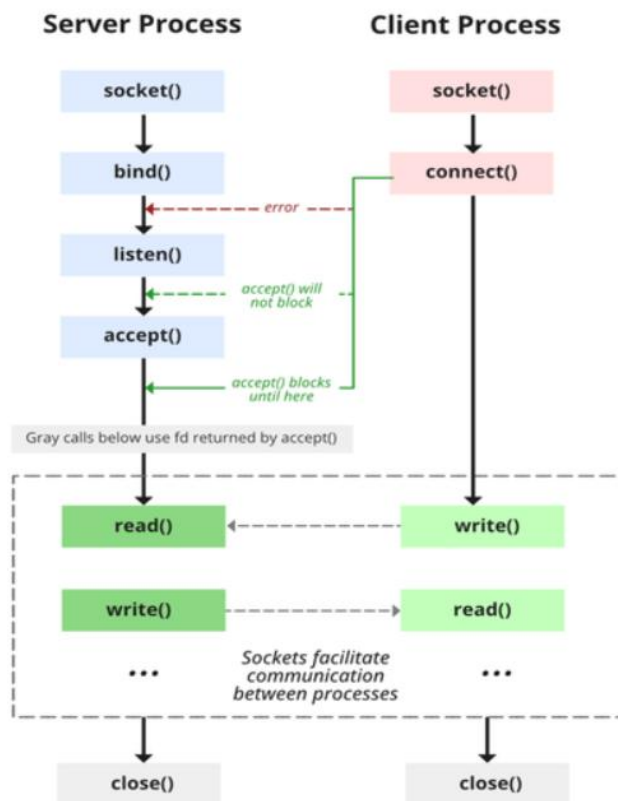


Figure 1 TCP/IP connection to UT200S

2.2 Verify connection

After connecting to UT200S, user should first send the "Auto VGC" command and check the reply message from UT200S. VGC means "Voltage Gain Control", which is the db gain of the receive signal.

Because the ultrasound receive signal vary from structure to structure, the VGC should be adjusted to allow the best signal to noise ratio. The allowable VGC range is from 0 to 23, with unit of dB. 0dB has the minimum gain and 23dB has the maximum gain.

Auto VGC command consists of 5 bytes. Its contents are as follows:

0xAA	0x55	0x11	0xAA	0x55
------	------	------	------	------

When UT200S receives the “Auto VGC” command, it will adjust the VGC gain automatically, and send the new VGC values to the controller. UT200S will limit the maximum value of the auto gain to 20dB to avoid saturating the board. User can increase the dB manually to 23dB if needed. The reply message has 14 bytes, whose contents are as follows:

0xAA	0x55	MAC1 (1 byte)	MAC2 (1 byte)	MAC3 (1 byte)	MAC4 (1 byte)	MAC5 (1 byte)	MAC6 (1 byte)
------	------	------------------	------------------	------------------	------------------	------------------	------------------

Ch1 VGC (1 byte)	Ch2 VGC (1 byte)	Ch3 VGC (1 byte)	Ch4 VGC (1 byte)	0xAA (1 byte)	0x55 (1 byte)
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In the above table, MAC1 to MAC6 are the MAC address of UT200S. If the reply message is received correctly, then UT200S can be controlled with additional commands.

2.3 Data acquisition command

Data acquisition consists of 38 bytes:

0xAA	0x55	Mode (1 byte)	ultrasound speed (2 bytes)	Probe1 delay (3 bytes)	Probe2 delay (3 bytes)	Probe3 delay (3 bytes)	Probe4 delay (3 bytes)	Sample Points (1 byte)
------	------	------------------	----------------------------------	------------------------------	------------------------------	------------------------------	------------------------------	------------------------------

Ch1 VGC (1 byte)	Ch2 VGC (1 byte)	Ch3 VGC (1 byte)	Ch4 VGC (1 byte)	Ch 1 Enable (1 byte)	Ch 2 Enable (1 byte)	Ch 3 Enable (1 byte)	Ch 4 enable (1 byte)
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Send raw data (1 byte)	Trigger mode (1 byte)	Analysis window starting point (2 bytes)	Analysis window ending point (2 bytes)	Delay (1 byte)	Reserved (3 bytes)	0xAA	0x55
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In the above table:

- 0xAA 0x55: two bytes. Fixed value
- Mode: one byte. Thickness measurement mode. 1: echo-echo; 2: first-echo; 3: echo II. For mode 1 and mode 3, probe delays are not used, and will be ignored (disabled).
- Ultrasound speed: two bytes. Unsigned integer 16 bits (two bytes). Default value is 6072. Maximum value is 65,535.
- Probe1 delay: Channel 1 probe delay. Three bytes. Probe delay is only used for first-echo mode.

Integer part has 1 byte, and decimal part has two bytes. The integer part value is from 0-255; decimal part range is from 0-9999. For example, if the probe delay is set at 1.6532 μ s, then the integer part is 1, and decimal part is 6532. The 3-byte value should be: 01 65 32. If the probe delay is set as 2.0356 μ s, then the integer part is 2, and decimal part is 356. The 3-byte value should be: 02 03 56.

- Probe2 delay: Channel 2 probe delay. Similar to probe 1 delay
- Probe3 delay: Channel 3 probe delay. Similar to probe 1 delay
- Probe4 delay: Channel 4 probe delay. Similar to probe 1 delay
- Sample Points: 1 byte. 0: 2,048 points; 1: 4,096 points; 2: 8,192 points. Default value is 1: (4,096 points)
- Ch1 VGC: 1 byte. Range: 0-23 dB. User can manually adjust VGC to fine tune the signal gain
- Ch2 VGC: 1 byte. Range: 0-23 dB. User can manually adjust VGC to fine tune the signal gain
- Ch3 VGC: 1 byte. Range: 0-23 dB. User can manually adjust VGC to fine tune the signal gain
- Ch4 VGC: 1 byte. Range: 0-23 dB. User can manually adjust VGC to fine tune the signal gain
- Ch1 Enable/disable: 1 byte. 0: disable; 1: enable. Default value is 1. If disabled, then the thickness measurement value is 0mm.
- Ch2 Enable/disable: 1 byte. 0: disable; 1: enable. Default value is 1. If disabled, then the thickness measurement value is 0mm.
- Ch3 Enable/disable: 1 byte. 0: disable; 1: enable. Default value is 1. If disabled, then the thickness measurement value is 0mm.
- Ch4 Enable/disable: 1 byte. 0: disable; 1: enable. Default value is 1. If disabled, then the thickness measurement value is 0mm.
- Send raw data. 1 byte. 0: send raw data; 1: send result only. Default value is send raw data.
- Trigger mode. 1 byte. 0: disable; 1: enable. When trigger is enabled, UT200S will wait for hardware trigger from an external source. The trigger signal can come from an encoder that sends out TTL trigger signal to UT200S trigger port. This can be combined with the image function of BroadMTM software to show the thickness map.

In this mode, the controller should wait for the data from UT200S. When data arrives, the controller can decide to take more triggered data, or disconnect from UT200S (return to normal state).

Continue triggering mode command:

0xAA	0x55	0x99	0xAA	0x55
------	------	------	------	------

Return to normal state (disconnect from UT200S):

0xAA	0x55	0x88	0xAA	0x55
------	------	------	------	------

When UT200S receives “return to normal state”(disconnect) command, it will disconnect from the controller, and returns to normal waiting mode. If the controller needs to take measurement again, then it needs to re-connect to UT200S.

- Analysis window start point: 2 bytes. Thickness measurement is only limited to the analysis window. This feature is useful when there are lots of noises, or the signal is very irregular. Default start point is 0. The maximum value of the start point is the number of sample points.
- Analysis window end point: 2 bytes. Default value is 0. When set as zero value, UT200S will use the whole signal to calculate the thickness. The analysis window end point should be larger than the start point, equal or smaller than the sample points.
- DAQ delay. 1 byte. Range is from 0 to 255. Unit is μ s.
- Reserved. 3 bytes.

2.4 Thickness result data file

When UT200S receives data acquisition command, it will measure the thickness one time, and sends the measurement file information packet to the controller. The measurement file length is unsigned 32-bit, Big Endian format:

0xAA	0x55	Length byte0	Length byte1	Length byte2	Length byte3	0xAA	0x55
------	------	--------------	--------------	--------------	--------------	------	------

If the “send raw data” byte is set as 0, then UT200S will send the thickness result plus the raw data. Otherwise, UT200S only sends out the measurement result. The controller should receive the data based on the data file length.

The data file format is as follows:

Line 1: Year-month-date hour:minute:seconds

Line 2: Device ID (MAC address)

Line 3: UT200S firmware version number

Line 4: Sample points VGC1 VGC2 VGC3 VGC4 probe1Delay probe2Delay probe3Delay probe4Delay

Line 5: channel1Thickness channel2Thickness channel3Thickness channel4Thickness mode
delay ultrasoundSpeed analysisWindowStartPoint analysisWindowEndPoint

Line 6: channel1Data1 channel2Data1 channel3Data1 channel4Data1

Line 7: channel1Data2 channel2Data2 channel3Data2 channel4Data2

...

Line N+5: channel1DataN channel2DataN channel3DataN channel4DataN

Where N is the number of sample points

When the probe is not connected or there is measurement error, the thickness value is 0.

2.5 Disconnect from UT200S

If the controller wants to continue measurement, then it can send out data acquisition command again. Otherwise, the controller should send out the following disconnect command to release the resources:

0xAA	0x55	0x88	0xAA	0x55
------	------	------	------	------

If the controller needs to take measurement again, then it needs to re-connect to UT200S.

3. Example program

A C client program (runs at the controller) called "control.c" is provided to show how to connect UT200S and send different commands to UT200S. Source codes of the program is provided. User can modify the program or use other programming language to control UT200S. The example program follows the TCP/IP socket connection standard (Figure 2).

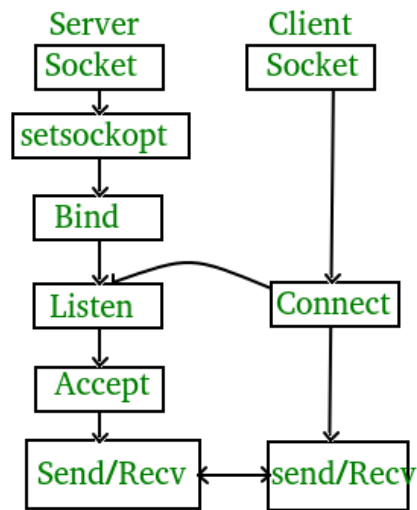


Figure 2 C example of TCP/IP socket connection

The example program is written for Linux environment. The functions used are standard C functions, which makes it easy to be converted to Windows or Mac environment. At the beginning, a socket is created at the client (controller side):

```

sockfd = socket(AF_INET, SOCK_STREAM, 0);
if (sockfd < 0)
{
    perror("Can't allocate sockfd");
    exit(1);
}
  
```

Then the client program connects to the UT200S:

```

if (connect(sockfd, (const struct sockaddr *) &serveraddr, sizeof(serveraddr)) < 0)
{
    perror("Connect to server Error");
    exit(1);
}
  
```

If the connection is successful, then the program sends Auto VGC command, and waits for the receiving message.

```

if (send(sockfd, buff, MAXLINE, 0) == -1)
{
    perror("Can't send configuration command\n");
    exit(1);
}
  
```

If the received message matches the format, then we know that the connection is successful. User can follow the program and write their own control codes.

Appendix 1. UT200S Thickness Measurement Program

UT200S's ultrasonic thickness measurement program is called "utmtrigger" (For UT200S version 1.0 board, the program is called "utmtcp"), which is installed under directory "home/pi/ultrasound". When UT200S boots up, the "utmtrigger" program automatically runs.

User can also manually run the program by entering the following command:

```
sudo utmtrigger
```

When "utmtrigger" program starts, it reads in the contents of "DAQ.ini" file under "home/pi/ultrasound" directory. The format of "DAQ.ini" file is as follows:

Line 1: mode selection (1: echo-echo; 2: first-echo; 3: echo-II)

Line 2: ultrasound speed (please refer to Appendix for typical speed. Unit in m/s)

Line 3: probe 1 delay (unit: μs)

Line 4: probe 2 delay (unit: μs)

Line 5: probe 3 delay (unit: μs)

Line 6: probe 4 delay (unit: μs)

When thickness measurement mode is 1 or 3, then probe delays will be ignored. Mode 1 and 3 only need sound speed in the measurement material.

If "DAQ.ini" file does not exist, then the following default values are used:

Mode: 1

Ultrasound speed: 6072

Probe delays: 0

Ultrasound data are saved under the directory "home/pi/ultrasound/datax", in which "datax" is from "data0" up to "data9". Each folder can hold a maximum number of 5,000 data files. When the number of files reaches 5,000, then the next folder is created automatically. There is a circular folder structure that controls the number of data files inside UT200S, so that the storage will not run out of space. When "data9" folder is full, then data file under folder "data0" will be overwritten. The data file structure circles around.