# Logic Analyzer Application Manual

# （Based on Saleae）

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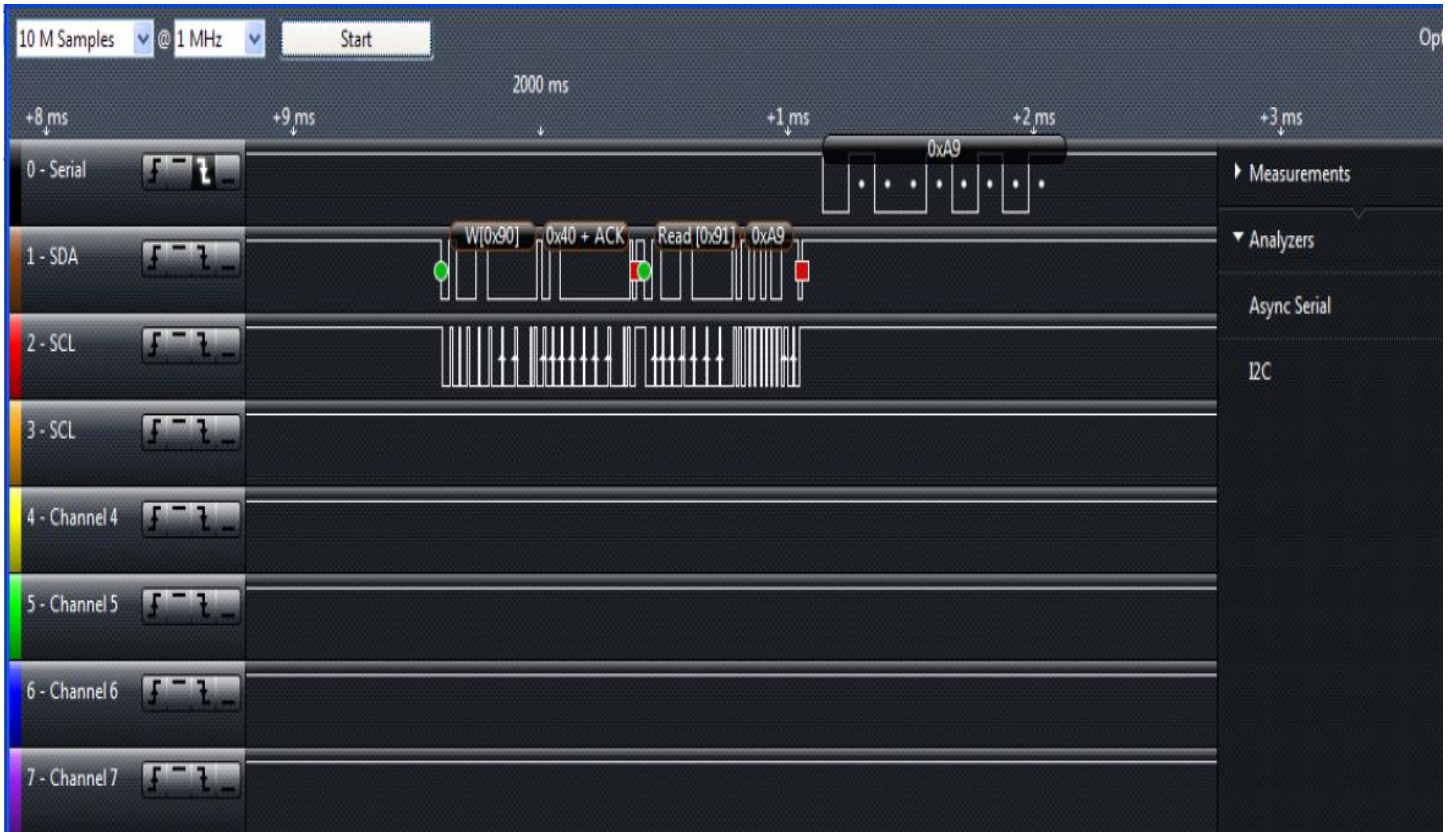
# 1. What is a logic analyzer

The logic analyzer is a kind of waveform test equipment. It collects the specified signal and displays it to the user through graphical or statistical data. The user analyzes the error in the hardware or software according to the protocol through these graphical timing sequence signals.

The logic analyzer is an indispensable device in the design, through which users can quickly locate errors, find and solve problems. Especially when analyzing timing sequence, such as 1wire, I2C, UART, SPI, CAN, etc., applying a logic analyzer can solve the problem quickly.

The following is a typical example of Saleae analyzing a UART communication sequence and an IIC timing:

From the figure we can clearly see that the UART communication is below the baud rate of 9600, clearly showing the hexadecimal number 0xA9, while the lower The timing sequence of a read data of the IIC signal, channel 1 is SDA, channel 2 is SCL, and is clearly displayed in 1 channel. The first one is to write data to the device address of 0x90 (w is the meaning of write), the second Indicates that the address to be read is 0x40, the third data is the retransmitted device address and is the read data, and the fourth byte is the read data 0xA9. Is it very convenient and fast?



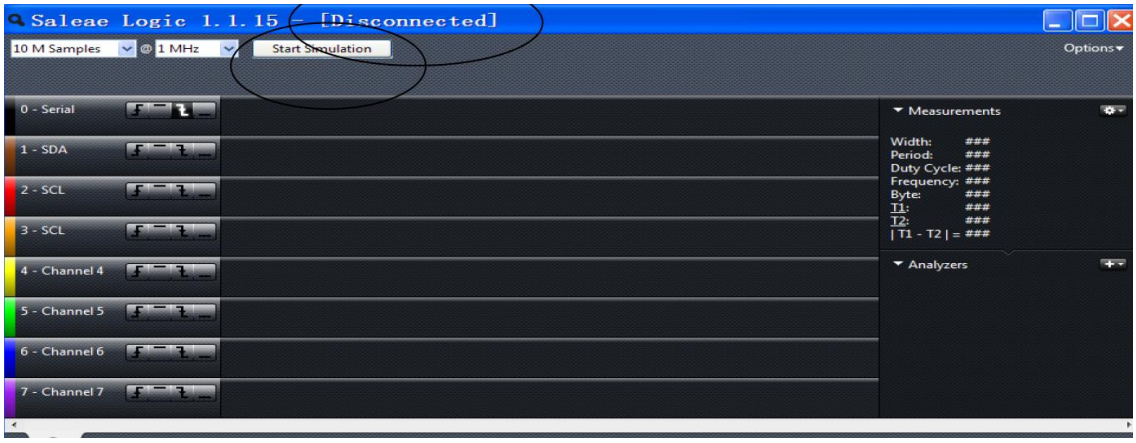
## 2. Software installation and software basic application

First, install the logic software, you can download it from the official website, the download address is http://www.saleae.com/downloads.

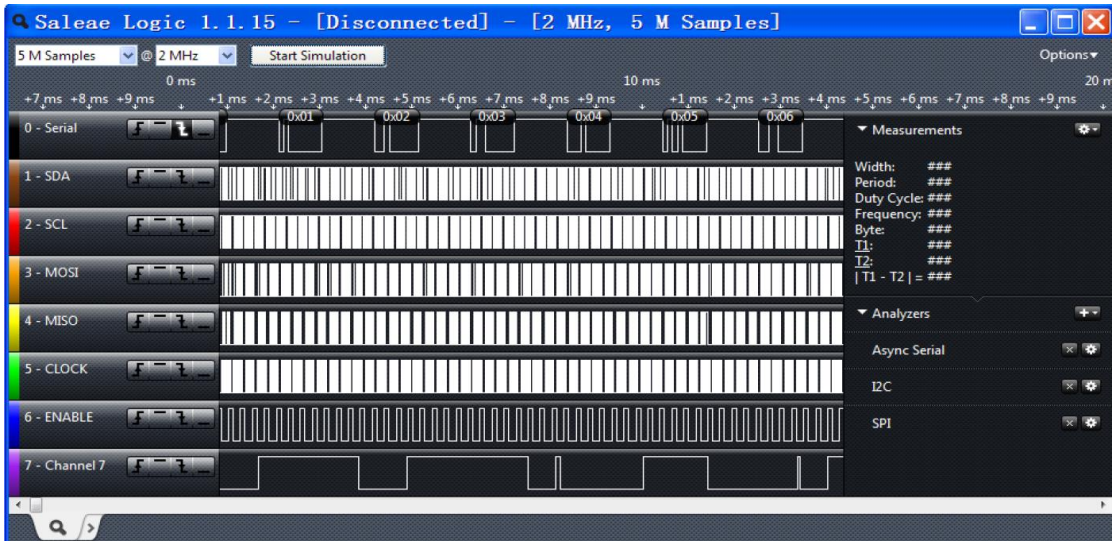
There is various system version support here, please download the system support version you need.

After downloading, double-click to install. After installation, a shortcut will appear on the desktop 


Double-click the shortcut to enter.

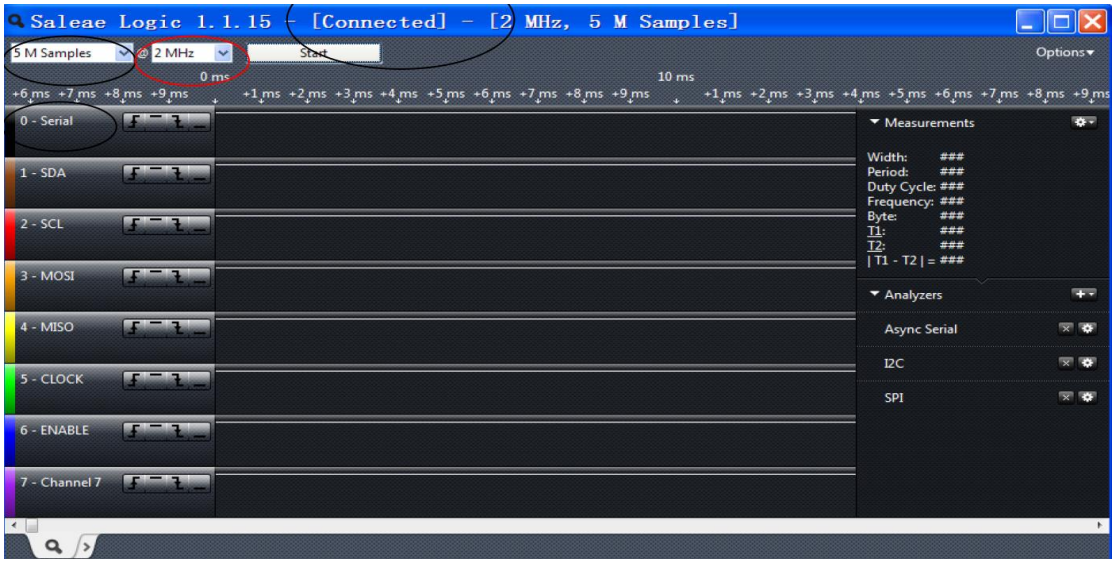



When the logic analyzer software is not plugged in, the top display is Disconnected, which can be used for start simulation. After clicking on the mouse, an analog waveform will appear. If you set the protocol in advance, it will produce a match. The waveform of your agreement ~! Of course, the non-true measured waveform allows you to experience it in advance. Click the left mouse button to zoom in on the waveform, the right button to zoom out, and the mouse wheel to zoom in and out. You can experience it in advance without using the hardware.



# 3. Hardware installation

After the software is installed, you can insert the hardware. After plugging in the hardware, it will automatically prompt to discover the new hardware. Then in the prompt dialog box, you can directly click “Install the software automatically (recommended)”. After the installation, the one just after the installation “Disconnected” will automatically change to “Connect”, and start simulation will automatically change to start, which is connected with the actual hardware. Below we can use to measure the actual waveform and can set the channel name, sampling depth, sampling frequency, and other parameters.




There are two very important parameters in the logic analyzer, namely the sampling depth and the sampling frequency. You can see that in this software, there are two places where you can choose the size of the number, the first is the sampling depth, and the second is the sampling frequency.


The 5M on the front means that we collect from the beginning, and when we collect 5Mbit data, it will stop automatically. The 2M on the back can collect 2M bit data in 1s. So we can set it up and collect the data of 2.5s.

The strength of the saleae logic analyzer is that it sends the collected data to the computer in real time via USB high-speed communication, so the sampling depth depends on the memory of our computer, which can be up to several G, that is, if We set the sampling depth of 1G, the sampling frequency is 1M, then we can collect nearly 17 minutes of data to save and analyze slowly, which is very useful for you to analyze the data information of some chips.

## 4. Trigger settings

The trigger setting is for the convenience of everyone to use when collecting from the useful signal, so you can avoid collecting a lot of useless signals at the beginning.


Here, set the channel which you use to trigger. You can set the rising edge to start collecting data, or the falling edge to start collecting data, or high and low level to start collecting data. The default is to not set the trigger. When the start is clicked, the data collection will start automatically, and the sampling depth will be automatically stopped after the set sampling depth is completed.

Then we can formally collect a set of data for observation!

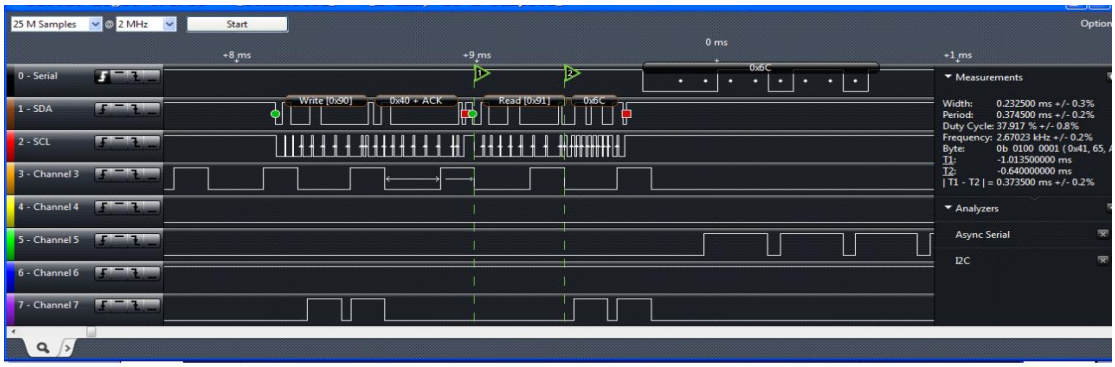
## 5. Signal collect

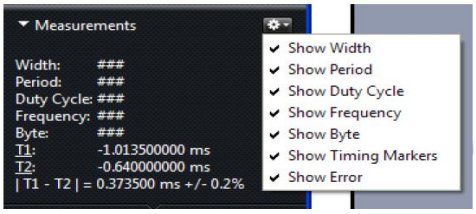
**It is important to note that the internal buffer used in the analyzer is 74HC244, so the normal working voltage of our equipment is below 5.5V, and below 1.5V will be considered as low level. 1.5V to 5.5V will be considered high level. The maximum withstand voltage is 7.5V, so please pay attention to the test voltage.**

Connect the GND channels to the GND pin of your board.

Choose any of the 8 data channels you need to connect to your device. And select the appropriate sampling depth and sampling frequency, as well as trigger conditions, then the following point can be directly started to start the acquisition.

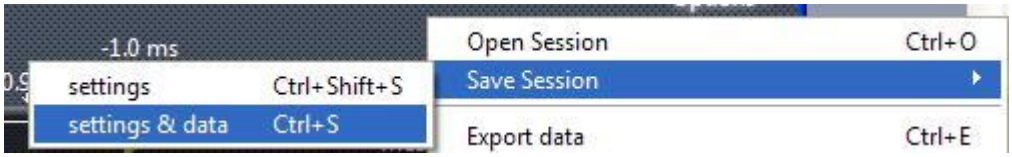
The acquired waveform is shown in the figure below:



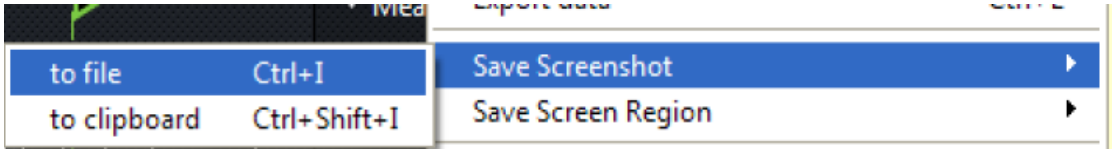




The user puts the mouse on the waveform and automatically displays some necessary information on the right side, including pulse width length, period, frequency and so on. Everyone can click on the pinnacle on their own, and they can choose the information they want to show.

In addition, if we want to collect multiple information, we can save the information, click on Option in the upper right corner, there is a

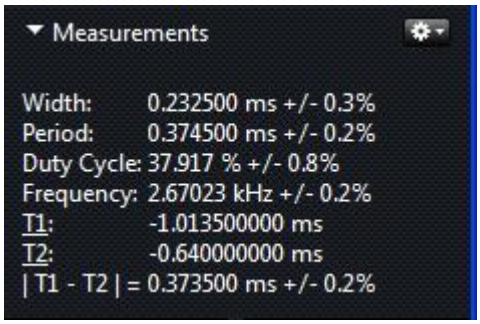



You can save the current information, then grab the next screen, and finally compare each screen, you can also save the graphics as a picture format, etc., you can try to find out for yourself.




## 6. Data analysis

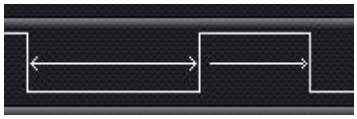
First, let's take a look at the information displayed in the Measurements column on the left.



When we put the mouse into a pulse, it will display a piece of data information on the left side. 

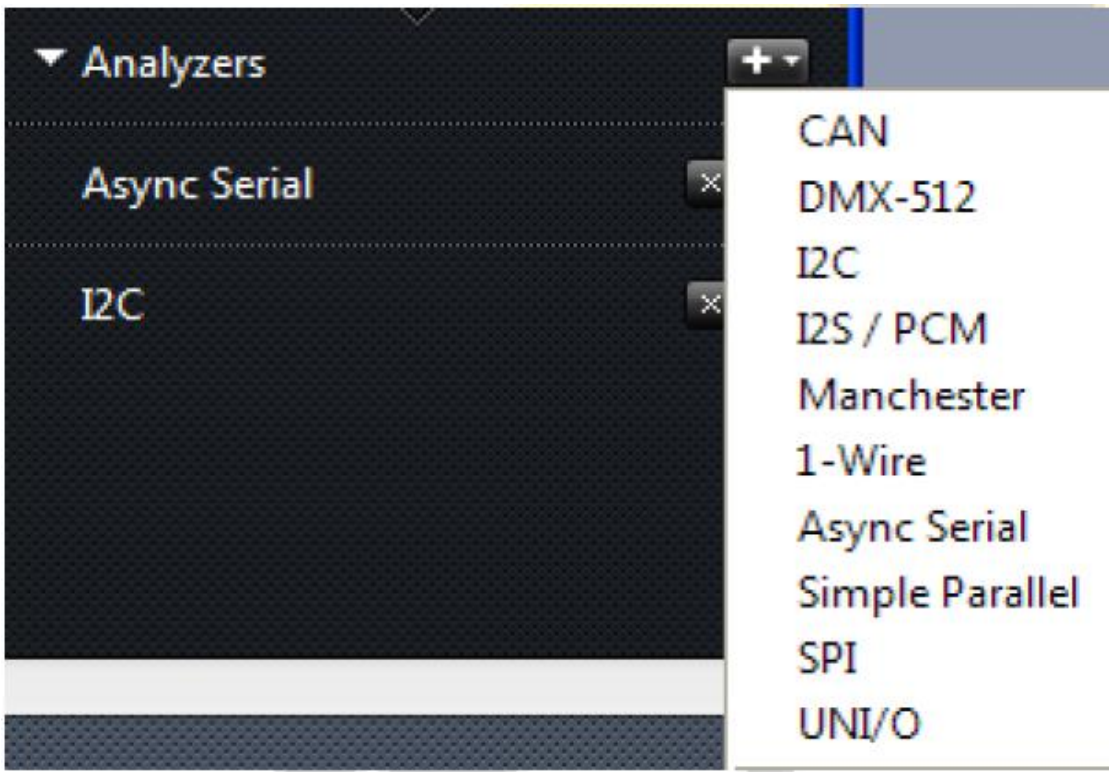
Then we will analyze the information on the right side by the pair.

First, the first parameter Width is for this graphic  this part, It is expressed that the length of this part is 0.232500ms.

The second parameter Period is the period 

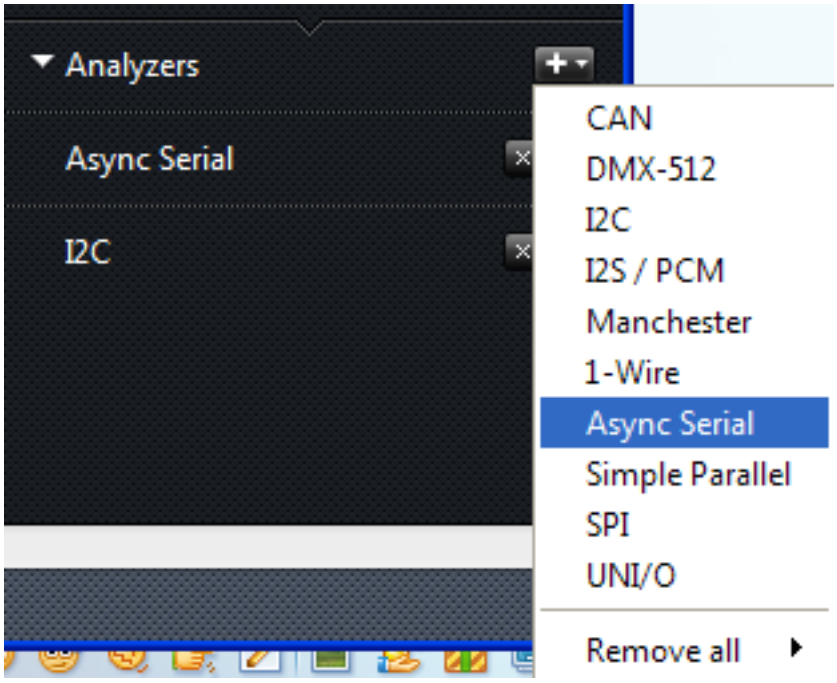
The third parameter Duty Cycle is the duty cycle of the current cycle, and the fourth parameter Frequency is the frequency of the current signal, which is the reciprocal of the cycle. T1 and T2 are the two-time labels in the analyzer. We can get the information we need by placing the label. We can click the  and  , then can get two green lines in the waveform, which can be obtained by placing the green line. The scale label shows the position of T1 and T2 and the value of |T1-T2| on the right side.

A more powerful feature of the Saleae logic analyzer is the ability to automatically analyze protocols, including the following protocol types.

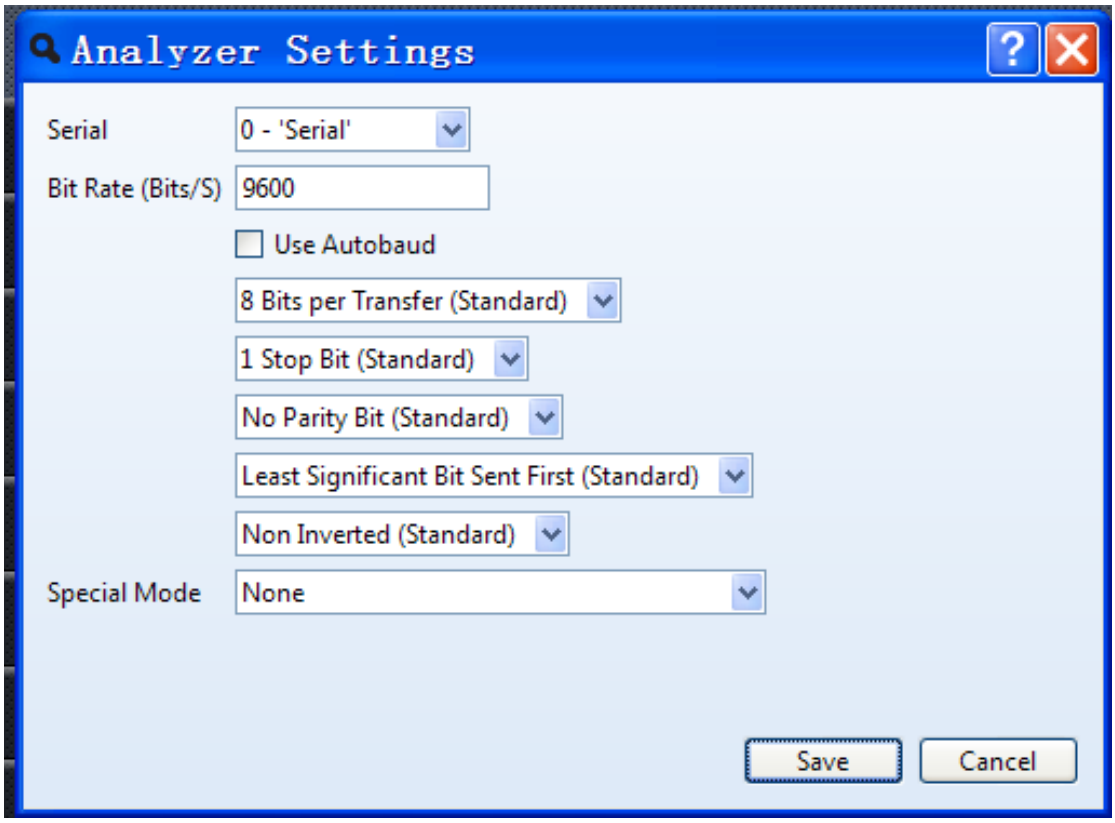



For these types of waveforms, not only the waveform can be displayed, but also

the protocol value can be directly displayed. The display mode can be binary, decimal, hexadecimal, ASCII, and so on. We can see in the above picture, channel 0 is a line of UART, channel 1 is the SDA pin of I2C, and channel 2 is the SCL pin of I2C. Then we can clearly see that the data is analyzed. The specific operation method is: Click on the Analyzers on the right and select Async Serial.

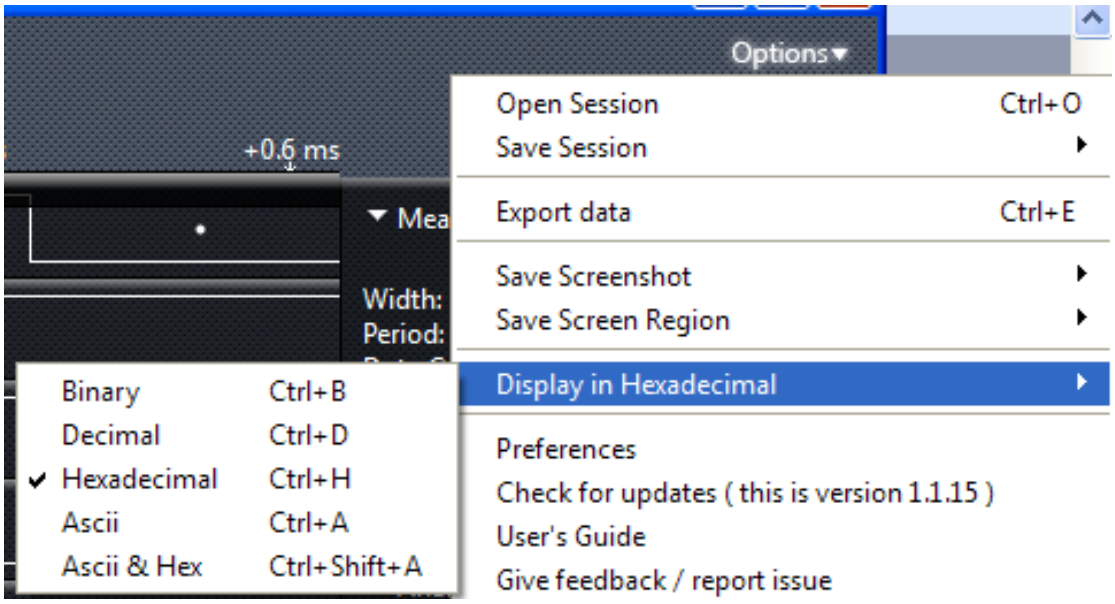



The following page will appear. In this interface, we need to select the parameters of the UART communication, including channel selection, baud rate selection, data bit, stop bit check digit, etc., which can be selected according to the actual situation. Once you have made your selection, you can click Save.

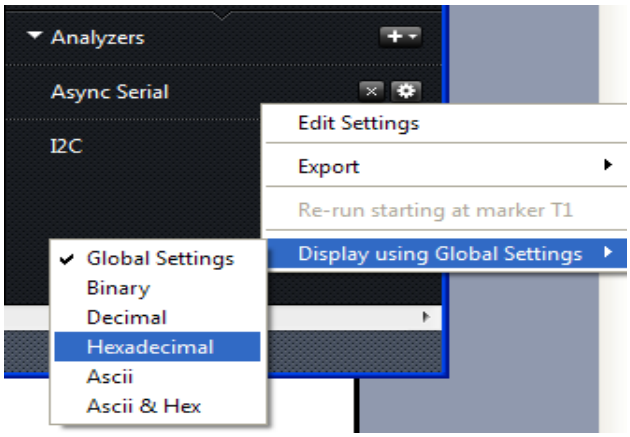



Then you will be prompted to modify the channel name, you can choose to change or not according to your needs, point Rename or Don't Rename.

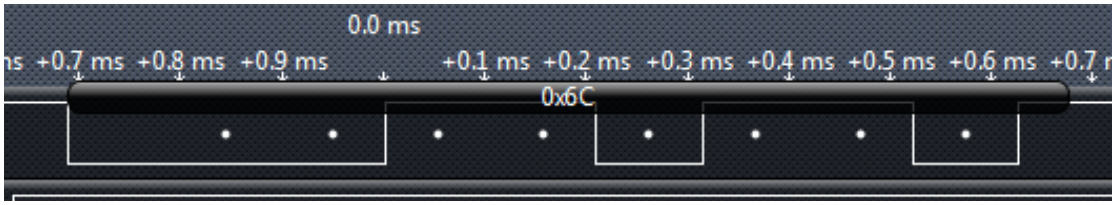

Then set the display format again. There are two places to choose the display format. You can choose one of them in the Options, as shown below.




Another click on the corresponding protocol, such as the pinion on the left side of the Async Serial, can also choose the display mode. I am used to choosing hexadecimal. After selecting, set the rising edge trigger, click Start, the sent data can be captured.

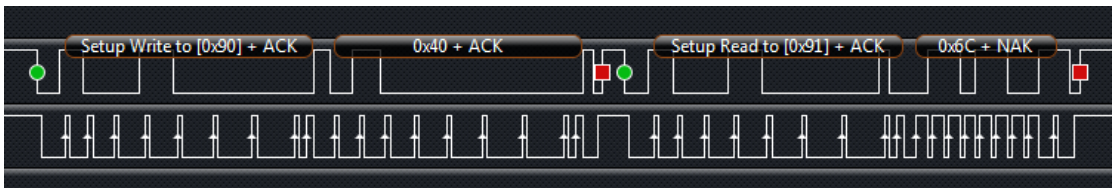



After capturing the data, the following will occur.




As you can see, the low bit is in the front and the high bit is in the back. The data is 0x6C, and you can see that there are 8 small white points on the top. Each white point indicates a data bit. The initial start bit is not available. Little white spots. We can automatically display our data.

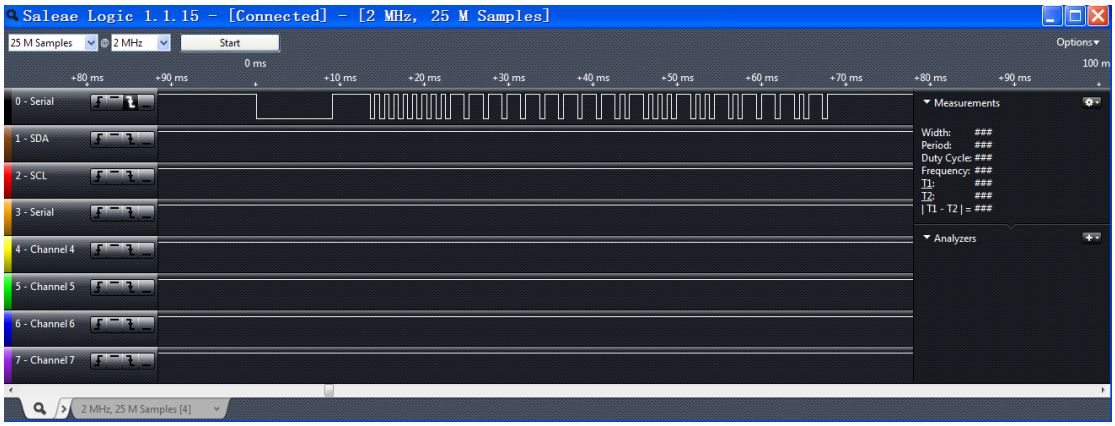
In the same way, we set up another IIC data to observe.




Let's see if it is very clear, green indicates the start bit, red indicates the stop bit, the first byte is the device address 0x90 and is the write operation, the second command writes the address 0x40. Then the third instruction is a read operation that contains the device address. The fourth byte is that the read data is 0x6C, and the acknowledge bit or the non-acknowledge bit is clear at a glance. Let's take a look at other protocols.

## 7. Using the Analyzer to Analyze TV Remote Control Protocols

Use the probe clip to connect GND to the GND pin of the board and channel 1 to the receive pin of the IR receiver tube HS0038. Set the falling edge trigger, then click Start, then press a button on the remote control to capture a waveform as follows:




The protocol of the infrared remote controller is not a standard protocol, and the remote controller of a manufacturer may have different protocols. Therefore, this protocol needs to be analyzed by ourselves. For the NEC protocol, it is the most used in the remote control protocol. The specific protocol rule is: firstly, the low-level duration (ie 38K carrier time) of about 9000us and the high-level duration of about 4500us are used as the boot code. The digital information of the key code is represented by the duration of a high and low level. The approximate value is 1680us. High level +560us Low level indicates 1,560us high-level +560us low level means 0. The rest of us can be read from that picture. You can use the two rulers T1 and T2 to read the final result. I write the binary, the low bit is in front and the high bit is in the back: 000000000 11111111 10100010 01011101 We put them into hexadecimal numbers are 0x00, 0xff, 0x45, 0xBA, then the infrared decoding is completed, the meaning of these 4 bytes, the first two bytes are the device code, that is, this model The home appliance remote control is all this code, the third byte 0x45 is the key code, that is, different keys have different key codes, the

fourth byte is the inverse of the key code, Everyone can see it right or not.

# 8. Logic Analyzer Usage Questions and Considerations

### About the sampling frequency of 24M maximum

In most cases, as long as your computer is fast enough and there is no interference from other USB devices, there is no problem with the logic analyzer reaching the 24M sampling frequency. However, if the current USB device is being used by other devices, the maximum sampling frequency may be one or two lower, such as 16M, 12M, etc.

1> The logic analyzer uses the USB2.0 standard. Under this standard, the theoretical maximum average bandwidth is 24M, but the logic analyzer has a lower priority, which means it is possible to “crash” to other Communication with USB devices.

2> The logic analyzer has four 512-byte buffers. Before the four buffers are filled, the USB must read some data. That is, the four buffers cannot be filled at the same time. Otherwise, The data cannot be entered, and the logic analyzer will report the error directly.

This means that if you are working at 24M, the USB device must not only give a 24M communication rate but must also ensure that other devices use USB resources before the four buffers are filled. For these reasons, logic analyzers can't work at 24M sampling frequency for long periods of time, depending on computer performance, availability and latency of USB bandwidth, and other devices that are taking up USB drives.

In order for your computer to maximize the sample rate, the following conditions are guaranteed:

1> Make sure that no other large programs take up longer CPU time

2> Make sure there is enough memory space, otherwise, the computer will not have enough RAM to get the data of the logic analyzer.

3> Connect the USB port of your computer as directly as possible, not through a USB hub

4> Try to make other USB-enabled devices use less USB resources

5> For the logic analyzer to have enough power to increase the sampling frequency, use a few other USB devices as possible.