JTAG Debugging for ESP32

Version 1.0

About This Document

This document provides a guide to installing OpenOCD for ESP32 and debugging using gdb under Linux. The document is structured as follows:

Chapter	Title	Content
Chapter 1	Introduction	Introduction to the purpose of this document.
Chapter 2	JTAG Adapter Hardware	Introduction to JTAG adapters for ESP32-enabled variant of OpenOCD.
Chapter 3	Environment Setup for JTAG	Introduction to environment setup for JTAG debugging.
Chapter 4	Debugging Example	A guide to debugging using gdb with the example of ***esp-idf/ examples/02_blink***.
Chapter 5	Notes	Notes on OpenOCD's support for ESD-IDF FreeRTOS and ESP32 quirks.

Release Note

Date	Version	Release notes
2017.03	V1.0	Initial release.

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1. Introduction

The ESP32 have two powerful Xtensa cores, allowing for a great deal of variety of program architectures. The FreeRTOS OS that comes with ESP-IDF is capable of multi-core pre-emptive multithreading, allowing for an intuitive way of writing software.

The downside of the ease of programming is that debugging without the right tools is harder: figuring out a bug that is caused by two threads, running even simultaneously on two different CPU cores, can take a long time when all you have are printf statements. A better and in many cases quicker way to debug such problems is by using a debugger, connected to the processors over a debug port.

Espressif has ported OpenOCD to support the ESP32 processor and the multicore FreeRTOS, which will be the foundation of most ESP32 apps, and has written some tools to help with features OpenOCD does not support natively.

This document provides a guide to installing OpenOCD for ESP32 and debugging using gdb under Linux.

📖 ***Note:***

- *Please note that this document is meant as a workaround for lack of a Windows version of OpenOCD as yet. Users with access to a Linux or Mac system are recommended to OpenOCD directly without resorting to virtual machines. For updated information on JTAG debugging for ESP32, please refer to: https://github.com/espressif/esp-idf/blob/master/docs/openocd.rst.*
- *This document is written based on tests using ESP-WROVER-KIT.*

2. JTAG Adapter Hardware

Users will need a JTAG adapter that is compatible with both the voltage levels on the ESP32 and with the OpenOCD software. The JTAG port on the ESP32 is an industry-standard JTAG port which lacks (and does not need) the TRST pin. All JTAG I/O pins are powered from the VDD_3P3_RTC pin (which normally would be powered by a 3.3V rail), so the JTAG adapter needs to be able to work with JTAG pins in that voltage range.

On the software side, OpenOCD supports a fair amount of JTAG adapters. Please see *http://openocd.org/doc/html/Debug-Adapter-Hardware.html* for an (unfortunately slightly incomplete) list of the adapters OpenOCD works with. This page lists SWD-compatible adapters as well; note that the ESP32 does not support SWD.

At Espressif, we have tested the TIAO USB Multi-protocol Adapter board as well as the Flyswatter2, which are both USB2.0 high-speed devices and give a good throughput. We have also tested a J-Link-compatible and an EasyOpenJTAG adapter; both worked as well but are somewhat slower.

The minimal signaling to get a working JTAG connection are TDI, TDO, TCK, TMS and GND. Some JTAG debuggers also need a connection from the ESP32 power line to a line called Vtar to set the working voltage. SRST can optionally be connected to the CH_PD of the ESP32, although for now, support in OpenOCD for that line is pretty minimal.

3. Environment Setup for JTAG

3.1. Install ESP-IDF

Please install Git in your Linux virtual machine first.

```
sudo apt-get install git
```

📖 ***Note:***

- *The prerequisite for successful environment setup is that the virtual machine can access extranet.*
- *Please refer to ESP-IDF Getting Started Guide for compiling a sample code before installing OpenOCD. In* ***Chapter 4****,* ***esp-idf\examples\02_blink*** *is used as the sample code for ESP32 JTAG debugging guide.*

3.2. Install OpenOCD

1. The sources for the ESP32-enabled variant of OpenOCD are available from *Espressif Github*. To download the source, use the following commands:

```
git clone https://github.com/espressif/openocd-esp32.git

cd openocd-esp32

git submodule init

git submodule update
```

2. Execute the following command in the command terminal on Linux.

```
sudo apt-get install make

sudo apt-get install libtool

sudo apt-get install pkg-config

sudo apt-get install autoconf

sudo apt-get install automake

sudo apt-get install texinfo

sudo apt-get install libusb-1.0
```

📖 ***Note:***

- *Version of pkg-config should be 0.2.3 or above.*
- *Version of autoconf should be 2.6.4 or above.*
- *Version of automake should be 1.9 or above.*
- *When using USB-Blaster, ASIX Presto, OpenJTAG and FT2232 as adapters, drivers libFTDI and FTD2XX need to be downloaded and installed.*
- *When using CMSIS-DAP, HIDAPI is needed.*

3. Input the following commands on the Linux virtual machine.

```
./bootstrap
```

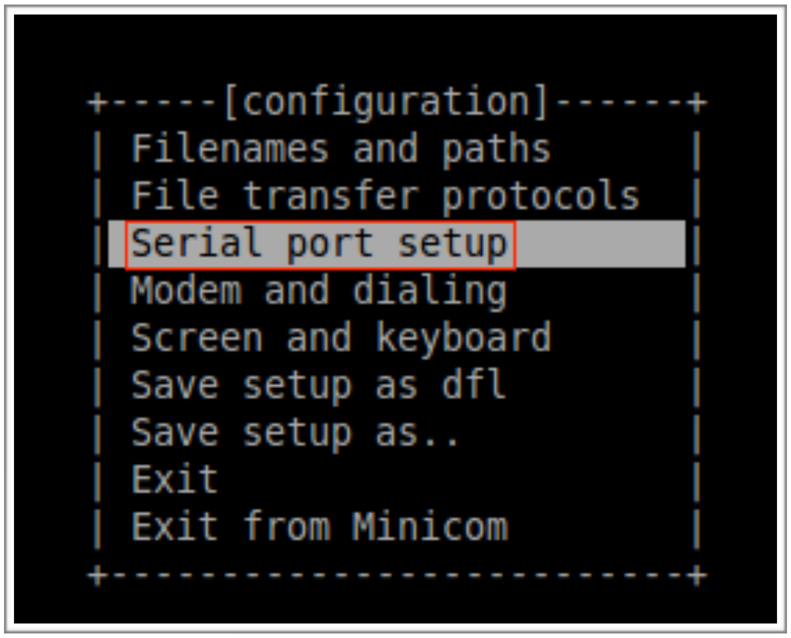
```
./configure

make
```

⚠ ***Notice:***

- *Should errors occur, please try again until the command `make` works. If there is a submodule problem from OpenOCD, please `cd` to the directory **openocd-esp3** and input `git submodule update --init`.*
- *If the commands are successfully run, information of the enabled JTAG will be printed. If the information of your device is not shown in the log, please use **./configure** to enable your device with reference to **../openocd-esp32/doc/INSTALL.txt**.*
- *For details concerning compiling OpenOCD, please refer to **openocd-esp32/README**.*

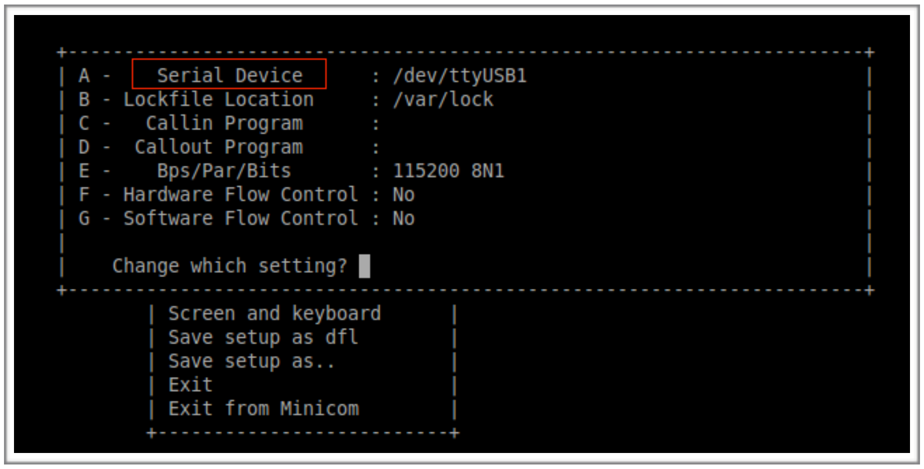
3.3. Set up Environment for gdb

1. Connect JTAG to ESP32 and to the PC. Wait for the installation of the driver. When the driver is successfully installed, select your device on Linux and click on it to connect it to the Linux machine.
2. Open another command prompt window on Linux. Connect Minicom to the serial port and wait for printing.
   - Install Minicom;
   - Input the command `sudo apt-get install minicom`;
   - Configure Minicom with the command `sudo minicom -s` and you will see the following prompt:



```
+-----[configuration]------+
| Filenames and paths      |
| File transfer protocols  |
| Serial port setup        |
| Modem and dialing        |
| Screen and keyboard      |
| Save setup as dfl        |
| Save setup as..          |
| Exit                     |
| Exit from Minicom        |
+--------------------------+
```

   - Select “Serial port setup” and the following prompt will show up:



```
+-----------------------------------------------------------------------+
| A -    Serial Device      : /dev/ttyUSB1                              |
| B - Lockfile Location     : /var/lock                                 |
| C -   Callin Program      :                                           |
| D -  Callout Program      :                                           |
| E -    Bps/Par/Bits       : 115200 8N1                                |
| F - Hardware Flow Control : No                                        |
| G - Software Flow Control : No                                        |
|                                                                       |
|    Change which setting?                                              |
+-----------------------------------------------------------------------+
        | Screen and keyboard      |
        | Save setup as dfl        |
        | Save setup as..          |
        | Exit                     |
        | Exit from Minicom        |
        +--------------------------+
```

- Reconfigure Serial Device, connects Minicom to the device UART, and disable the hardware flow control; save the configuration as default and as DFL.
- Input the command `minicom`. If Minicom is correctly configured, output log on the terminal will show that the ESP32 device is running. (Please make sure there are programs running in the flash of ESP32.)

3. Invoke OpenOCD:
   - Copy *esp32.cfg* in *esp-idf/docs* to the *openocd-esp32* directory;
   - Edit the copied *esp32.cfg* file. Most importantly, change the `source [find interface/ftdi/tumpa.cfg]` line to reflect the physical JTAG adapter connected. (Note that this step is not needed when using the ESP-WROVER-KIT.)
   - Open a terminal and `cd` to the ***openocd-esp32*** directory;
   - Run ***./src/openocd -s ./tcl -f ./esp32.cfg*** to start OpenOCD.
   - If OpenOCD is successfully invoked, you should see the following output:

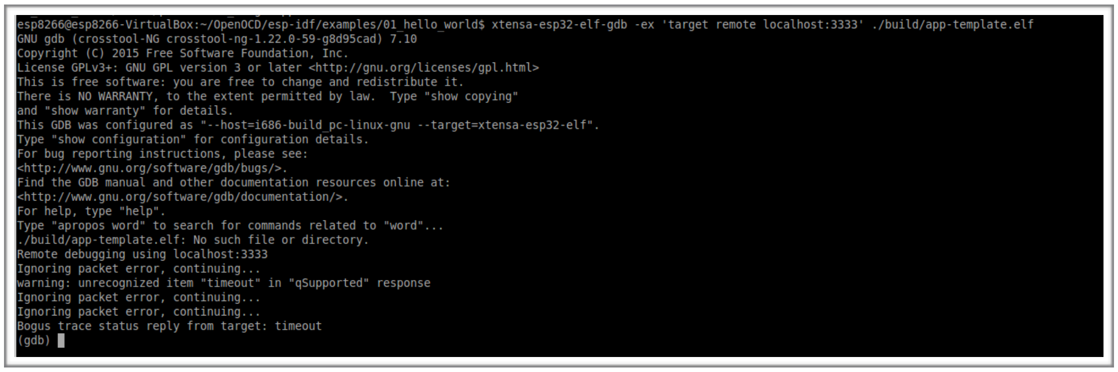
```
Open On-Chip Debugger 0.10.0-dev-00446-g6e13a97-dirty (2016-08-23-16:36)

    Licensed under GNU GPL v2

    For bug reports, read

    http://openocd.org/doc/doxygen/bugs.html

    none separate

    adapter speed: 200 kHz

    Info : clock speed 200 kHz

    Info : JTAG tap: esp32.cpu0 tap/device found: 0x120034e5 (mfg: 0x272
(Tensilica), part: 0x2003, ver: 0x1)

    Info : JTAG tap: esp32.cpu1 tap/device found: 0x120034e5 (mfg: 0x272
(Tensilica), part: 0x2003, ver: 0x1)

    Info : esp32.cpu0: Debug controller was reset (pwrstat=0x5F, after clear
0x0F).

    Info : esp32.cpu0: Core was reset (pwrstat=0x5F, after clear 0x0F).
```

- If you see an error indicating permission problems, please see the “Permissions delegation” part in the ***OpenOCD README***.
- If you see JTAG errors (...all ones/...all zeroes), please check your connections and see if everything is powered on.

4. Invoke gdb.
   - Run the following command:

```
xtensa-esp32-elf-gdb -ex 'target remote localhost:3333' ./build/app-template.elf
```

   - If the command works, the following printed log will be shown:



```
esp8266@esp8266-VirtualBox:~/OpenOCD/esp-idf/examples/01_hello_world$ xtensa-esp32-elf-gdb -ex 'target remote localhost:3333' ./build/app-template.elf
GNU gdb (crosstool-NG crosstool-ng-1.22.0-59-g8d95cad) 7.10
Copyright (C) 2015 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "--host=i686-build_pc-linux-gnu --target=xtensa-esp32-elf".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
./build/app-template.elf: No such file or directory.
Remote debugging using localhost:3333
Ignoring packet error, continuing...
warning: unrecognized item "timeout" in "qSupported" response
Ignoring packet error, continuing...
Ignoring packet error, continuing...
Bogus trace status reply from target: timeout
(gdb) 
```

The environment for JTAG is now set up in the Linux machine.

📖 ***Note:***

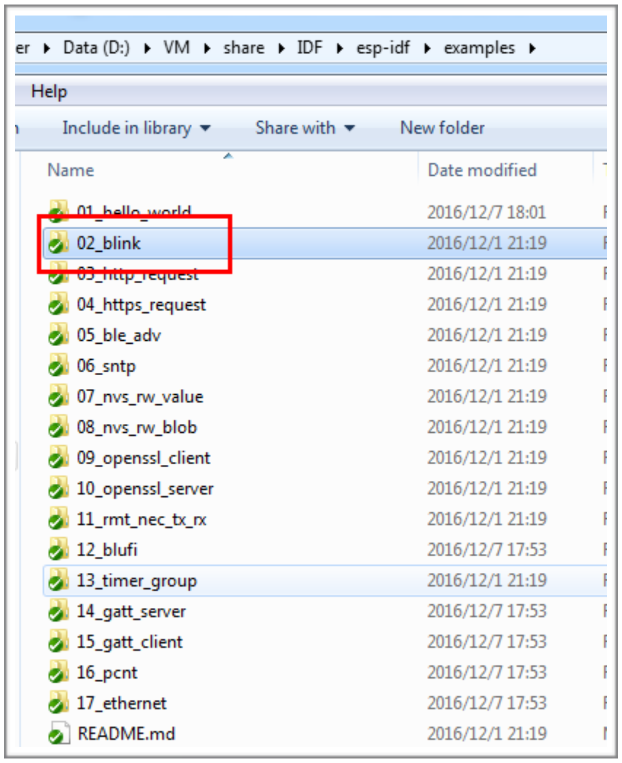
If you have compiled the ESP32 toolchain using Crosstool-NG, or if you have downloaded a precompiled toolchain from the Espressif website, you should already have xtensa-esp32-elf-gdb, a version of gdb that can be used for this.

Connecting gdb to the APP or PRO CPU happens by changing the port gdb connects to. `target remote localhost:3333` *connects to the PRO CPU, and* `target remote localhost:3334` *to the APP CPU.*

Hardware-wise, when one CPU is halted because of debugging reasons, the other one will be halted as well; resuming also happens simultaneously.

4. Debugging Example

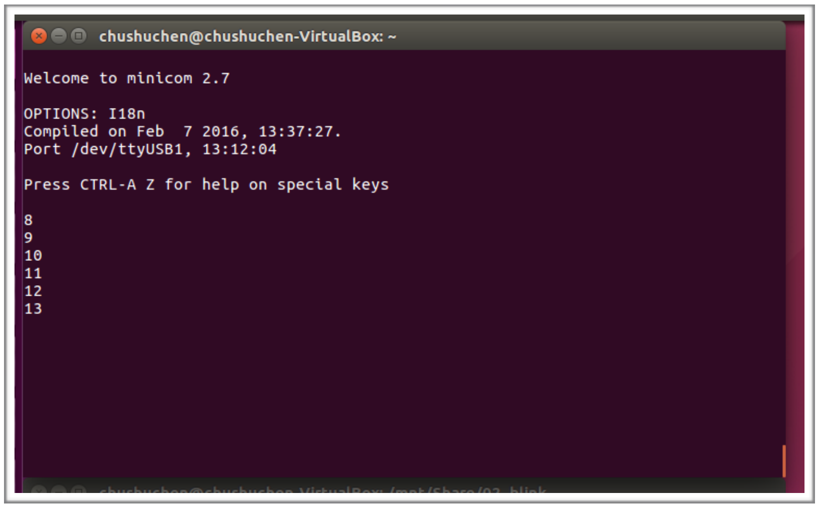
This chapter provides a guide to debugging using gdb with the example of ***esp-idf/ examples/02_blink***.



Name	Date modified
01_hello_world	2016/12/7 18:01
02_blink	2016/12/1 21:19
03_http_request	2016/12/1 21:19
04_https_request	2016/12/1 21:19
05_ble_adv	2016/12/1 21:19
06_sntp	2016/12/1 21:19
07_nvs_rw_value	2016/12/1 21:19
08_nvs_rw_blob	2016/12/1 21:19
09_openssl_client	2016/12/1 21:19
10_openssl_server	2016/12/1 21:19
11_rmt_nec_tx_rx	2016/12/1 21:19
12_blufi	2016/12/7 17:53
13_timer_group	2016/12/1 21:19
14_gatt_server	2016/12/7 17:53
15_gatt_client	2016/12/7 17:53
16_pcnt	2016/12/7 17:53
17_ethernet	2016/12/7 17:53
README.md	2016/12/1 21:19

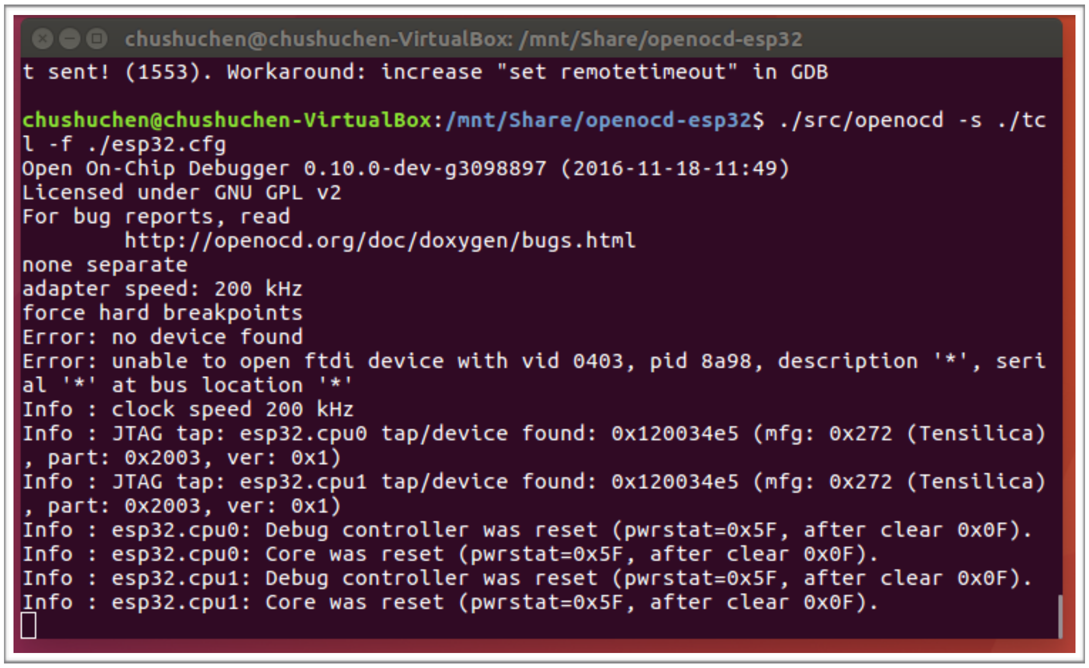
Figure 4-1. *esp-idf/examples/02_blink*

1. Input `minicom` on terminal. The following output log will show. (Print is added in the program of ***02_blink.***)



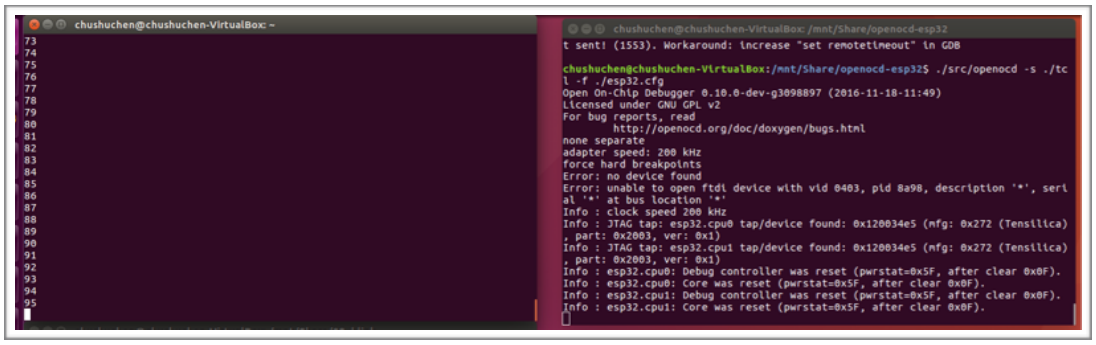
```
Welcome to minicom 2.7

OPTIONS: I18n
Compiled on Feb  7 2016, 13:37:27.
Port /dev/ttyUSB1, 13:12:04

Press CTRL-A Z for help on special keys

8
9
10
11
12
13
```

2. Run the OpenOCD command `./src/openocd -s ./tcl -f ./esp32.cfg`. The following printed log will show up:



```
t sent! (1553). Workaround: increase "set remotetimeout" in GDB

chushuchen@chushuchen-VirtualBox:/mnt/Share/openocd-esp32$ ./src/openocd -s ./tc
l -f ./esp32.cfg
Open On-Chip Debugger 0.10.0-dev-g3098897 (2016-11-18-11:49)
Licensed under GNU GPL v2
For bug reports, read
        http://openocd.org/doc/doxygen/bugs.html
none separate
adapter speed: 200 kHz
force hard breakpoints
Error: no device found
Error: unable to open ftdi device with vid 0403, pid 8a98, description '*', seri
al '*' at bus location '*'
Info : clock speed 200 kHz
Info : JTAG tap: esp32.cpu0 tap/device found: 0x120034e5 (mfg: 0x272 (Tensilica)
, part: 0x2003, ver: 0x1)
Info : JTAG tap: esp32.cpu1 tap/device found: 0x120034e5 (mfg: 0x272 (Tensilica)
, part: 0x2003, ver: 0x1)
Info : esp32.cpu0: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu0: Core was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu1: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu1: Core was reset (pwrstat=0x5F, after clear 0x0F).
```

3. If the printing continues, please try pressing the reset button on the ESP32 board.


chushuchen@chushuchen-VirtualBox: ~
chushuchen@chushuchen-VirtualBox: /mnt/Share/openocd-esp32

```
73
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88
89
90
91
92
93
94
95
```
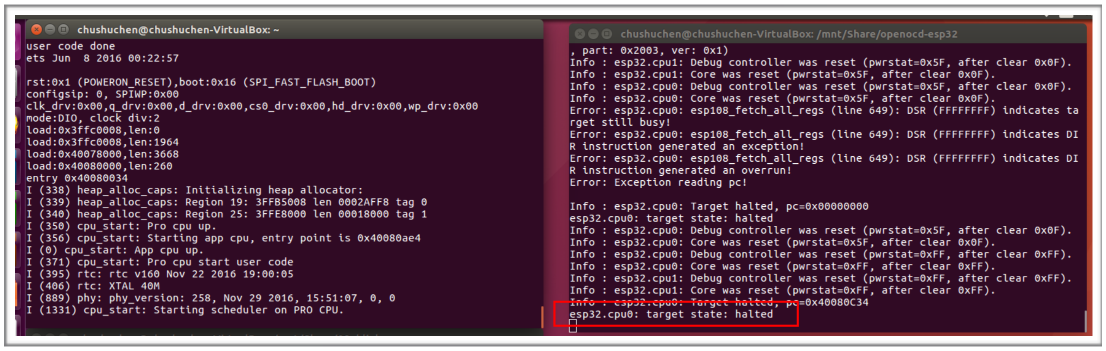

```
t sent! (1553). Workaround: increase "set remotetimeout" in GDB

chushuchen@chushuchen-VirtualBox:/mnt/Share/openocd-esp32$ ./src/openocd -s ./tc
l -f ./esp32.cfg
Open On-Chip Debugger 0.10.0-dev-g3098897 (2016-11-18-11:49)
Licensed under GNU GPL v2
For bug reports, read
        http://openocd.org/doc/doxygen/bugs.html
none separate
adapter speed: 200 kHz
force hard breakpoints
Error: no device found
Error: unable to open ftdi device with vid 0403, pid 8a98, description '*', seri
al '*' at bus location '*'
Info : clock speed 200 kHz
Info : JTAG tap: esp32.cpu0 tap/device found: 0x120034e5 (mfg: 0x272 (Tensilica)
, part: 0x2003, ver: 0x1)
Info : JTAG tap: esp32.cpu1 tap/device found: 0x120034e5 (mfg: 0x272 (Tensilica)
, part: 0x2003, ver: 0x1)
Info : esp32.cpu0: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu0: Core was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu1: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu1: Core was reset (pwrstat=0x5F, after clear 0x0F).
```

When the program is halted in the OpenOCD window, as the screenshot below shows, and the terminal stops printing, it means that the OpenOCD is invoked.


chushuchen@chushuchen-VirtualBox: ~
chushuchen@chushuchen-VirtualBox: /mnt/Share/openocd-esp32

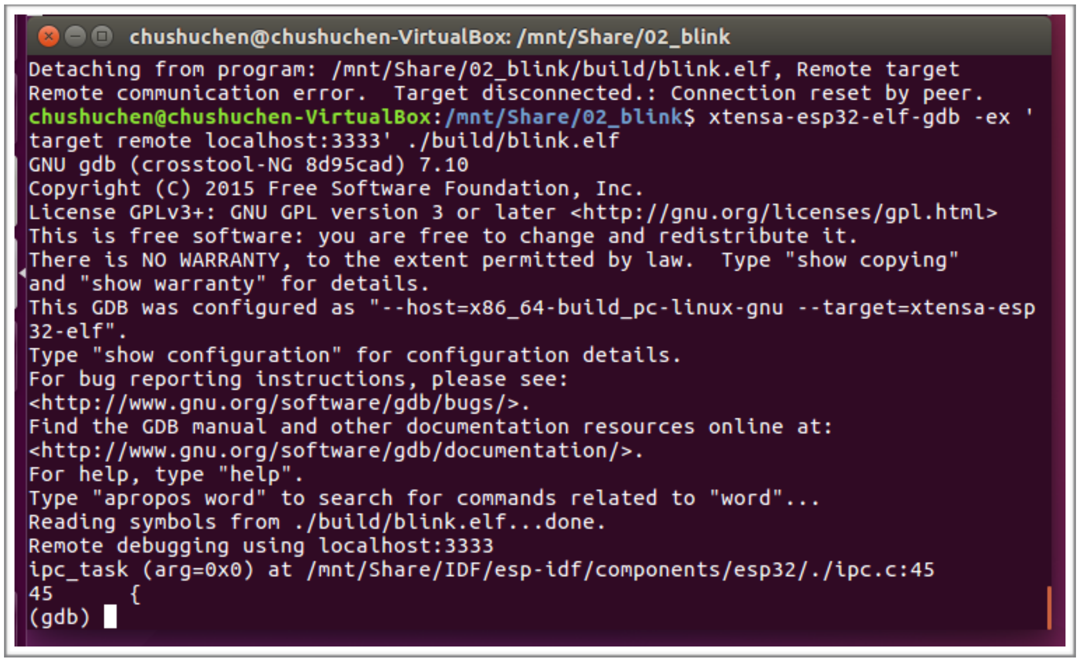
```
user code done
ets Jun  8 2016 00:22:57

rst:0x1 (POWERON_RESET),boot:0x16 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0x00
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:2
load:0x3ffc0008,len:0
load:0x3ffc0008,len:1964
load:0x40078000,len:3668
load:0x40080000,len:260
entry 0x40080034
I (338) heap_alloc_caps: Initializing heap allocator:
I (339) heap_alloc_caps: Region 19: 3FFB5008 len 0002AFF8 tag 0
I (340) heap_alloc_caps: Region 25: 3FFE8000 len 00018000 tag 1
I (350) cpu_start: Pro cpu up.
I (356) cpu_start: Starting app cpu, entry point is 0x40080ae4
I (0) cpu_start: App cpu up.
I (371) cpu_start: Pro cpu start user code
I (395) rtc: rtc v160 Nov 22 2016 19:00:05
I (406) rtc: XTAL 40M
I (889) phy: phy_version: 258, Nov 29 2016, 15:51:07, 0, 0
I (1331) cpu_start: Starting scheduler on PRO CPU.
```

```
, part: 0x2003, ver: 0x1)
Info : esp32.cpu1: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu1: Core was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu0: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu0: Core was reset (pwrstat=0x5F, after clear 0x0F).
Error: esp32.cpu0: esp108_fetch_all_regs (line 649): DSR (FFFFFFFF) indicates ta
rget still busy!
Error: esp32.cpu0: esp108_fetch_all_regs (line 649): DSR (FFFFFFFF) indicates DI
R instruction generated an exception!
Error: esp32.cpu0: esp108_fetch_all_regs (line 649): DSR (FFFFFFFF) indicates DI
R instruction generated an overrun!
Error: Exception reading pc!

Info : esp32.cpu0: Target halted, pc=0x00000000
esp32.cpu0: target state: halted
Info : esp32.cpu0: Debug controller was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu0: Core was reset (pwrstat=0x5F, after clear 0x0F).
Info : esp32.cpu0: Debug controller was reset (pwrstat=0xFF, after clear 0xFF).
Info : esp32.cpu0: Core was reset (pwrstat=0xFF, after clear 0xFF).
Info : esp32.cpu1: Debug controller was reset (pwrstat=0xFF, after clear 0xFF).
Info : esp32.cpu1: Core was reset (pwrstat=0xFF, after clear 0xFF).
Info : esp32.cpu0: Target halted, pc=0x40080C34
esp32.cpu0: target state: halted
```

4. Run the command below in the ***02_blink*** window.

```
xtensa-esp32-elf-gdb -ex 'target remote localhost:3333' ./build/blink.elf
```

The following log will show up:



```
chushuchen@chushuchen-VirtualBox: /mnt/Share/02_blink
Detaching from program: /mnt/Share/02_blink/build/blink.elf, Remote target
Remote communication error.  Target disconnected.: Connection reset by peer.
chushuchen@chushuchen-VirtualBox:/mnt/Share/02_blink$ xtensa-esp32-elf-gdb -ex '
target remote localhost:3333' ./build/blink.elf
GNU gdb (crosstool-NG 8d95cad) 7.10
Copyright (C) 2015 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "--host=x86_64-build_pc-linux-gnu --target=xtensa-esp
32-elf".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./build/blink.elf...done.
Remote debugging using localhost:3333
ipc_task (arg=0x0) at /mnt/Share/IDF/esp-idf/components/esp32/./ipc.c:45
45      {
(gdb) 
```

As the screenshot above shows, the program is halted at line 45 of `ipc_task`.

5. Set a breakpoint to halt the program before `blink_task`.

   Input the following command to set breakpoints in gdb window.

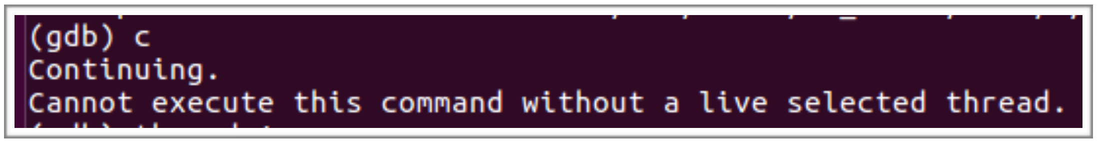
```
(gdb) break blink_task
```

The following log will output:

```
Breakpoint 1 at 0x400d8888: file/mnt/Share/02_blink/main/./
blink.c, line 23.
```

It means that breakpoint 1 is set in the 23rd line in the function `blink.c`.

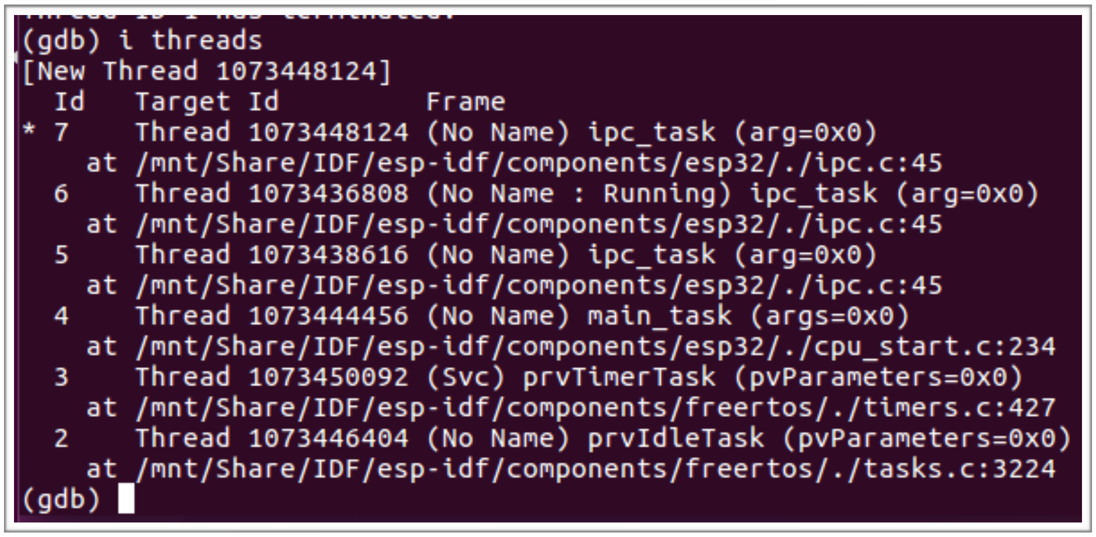
6. Run the command `continue` or `c` in gdb window, and the program will stop at breakpoint 1.



```
(gdb) c
Continuing.
Cannot execute this command without a live selected thread.
```

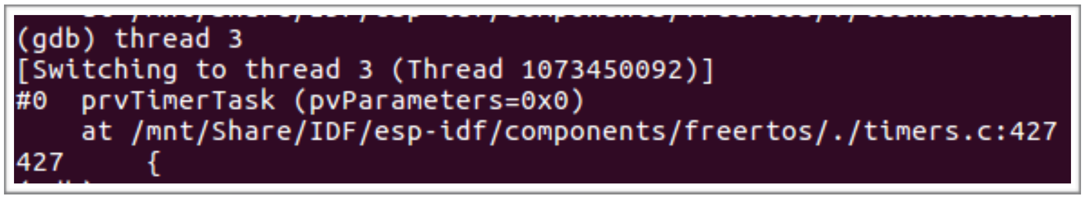
If the information in the above screenshot shows, choose one thread to run.

- Use the gdb command `i threads` to check information about threads:



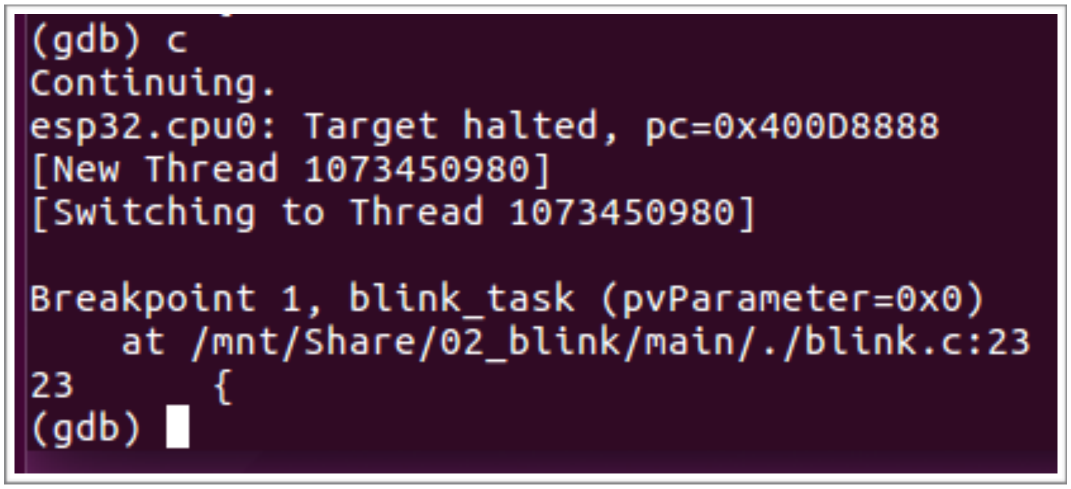
```
(gdb) i threads
[New Thread 1073448124]
  Id   Target Id         Frame
* 7    Thread 1073448124 (No Name) ipc_task (arg=0x0)
    at /mnt/Share/IDF/esp-idf/components/esp32/./ipc.c:45
  6    Thread 1073436808 (No Name : Running) ipc_task (arg=0x0)
    at /mnt/Share/IDF/esp-idf/components/esp32/./ipc.c:45
  5    Thread 1073438616 (No Name) ipc_task (arg=0x0)
    at /mnt/Share/IDF/esp-idf/components/esp32/./ipc.c:45
  4    Thread 1073444456 (No Name) main_task (args=0x0)
    at /mnt/Share/IDF/esp-idf/components/esp32/./cpu_start.c:234
  3    Thread 1073450092 (Svc) prvTimerTask (pvParameters=0x0)
    at /mnt/Share/IDF/esp-idf/components/freertos/./timers.c:427
  2    Thread 1073446404 (No Name) prvIdleTask (pvParameters=0x0)
    at /mnt/Share/IDF/esp-idf/components/freertos/./tasks.c:3224
(gdb) 
```

- Input a gdb command to choose the thread to run. For example, input `thread 3` to run thread 3, as the following screenshot shows:



```
(gdb) thread 3
[Switching to thread 3 (Thread 1073450092)]
#0  prvTimerTask (pvParameters=0x0)
    at /mnt/Share/IDF/esp-idf/components/freertos/./timers.c:427
427     {
```

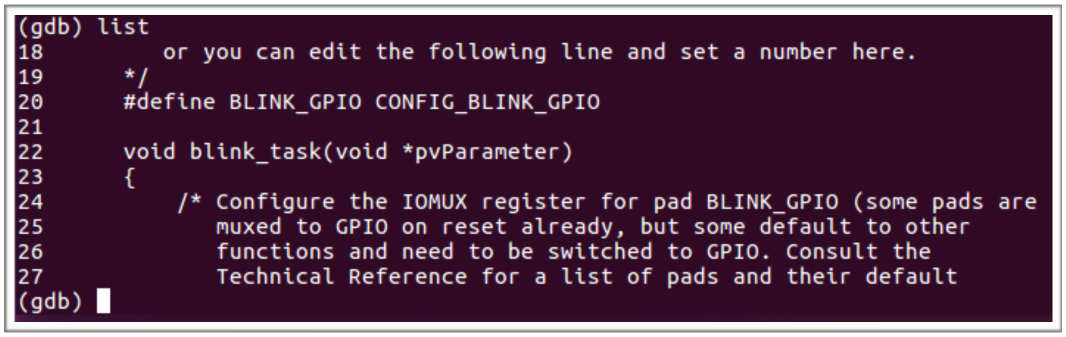
- Input command `c` to continue running the program:



```
(gdb) c
Continuing.
esp32.cpu0: Target halted, pc=0x400D8888
[New Thread 1073450980]
[Switching to Thread 1073450980]

Breakpoint 1, blink_task (pvParameter=0x0)
    at /mnt/Share/02_blink/main/./blink.c:23
23      {
(gdb) 
```

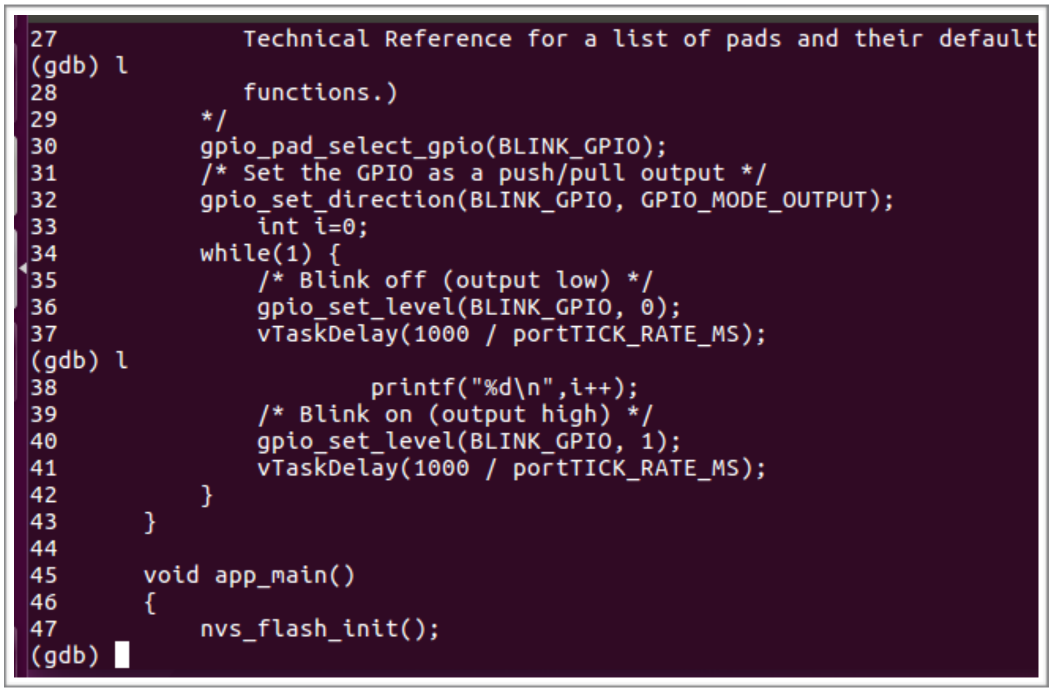
As the screenshot above shows, the program stops at breakpoint 1, in the 23rd line of ***blink.c***.

7. Input command `list` or `l` to see the code.



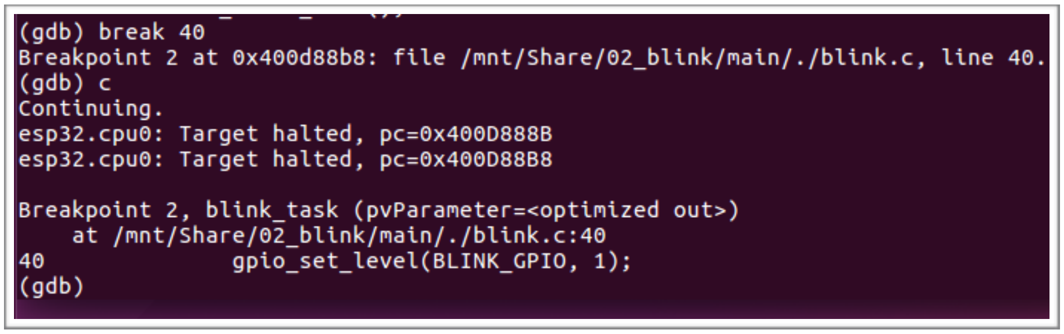
```
(gdb) list
18          or you can edit the following line and set a number here.
19       */
20      #define BLINK_GPIO CONFIG_BLINK_GPIO
21
22      void blink_task(void *pvParameter)
23      {
24          /* Configure the IOMUX register for pad BLINK_GPIO (some pads are
25             muxed to GPIO on reset already, but some default to other
26             functions and need to be switched to GPIO. Consult the
27             Technical Reference for a list of pads and their default
(gdb) 
```

Continue inputing command `l` to see the rest of the code.



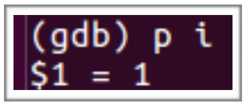
```
27             Technical Reference for a list of pads and their default
(gdb) l
28             functions.)
29          */
30          gpio_pad_select_gpio(BLINK_GPIO);
31          /* Set the GPIO as a push/pull output */
32          gpio_set_direction(BLINK_GPIO, GPIO_MODE_OUTPUT);
33              int i=0;
34          while(1) {
35              /* Blink off (output low) */
36              gpio_set_level(BLINK_GPIO, 0);
37              vTaskDelay(1000 / portTICK_RATE_MS);
(gdb) l
38                      printf("%d\n",i++);
39              /* Blink on (output high) */
40              gpio_set_level(BLINK_GPIO, 1);
41              vTaskDelay(1000 / portTICK_RATE_MS);
42          }
43      }
44
45      void app_main()
46      {
47          nvs_flash_init();
(gdb) 
```

8. To set a new breakpoint in line 40, input the command `break 40.` Run the command `continue` or `c`, and the program will stops at line 40.



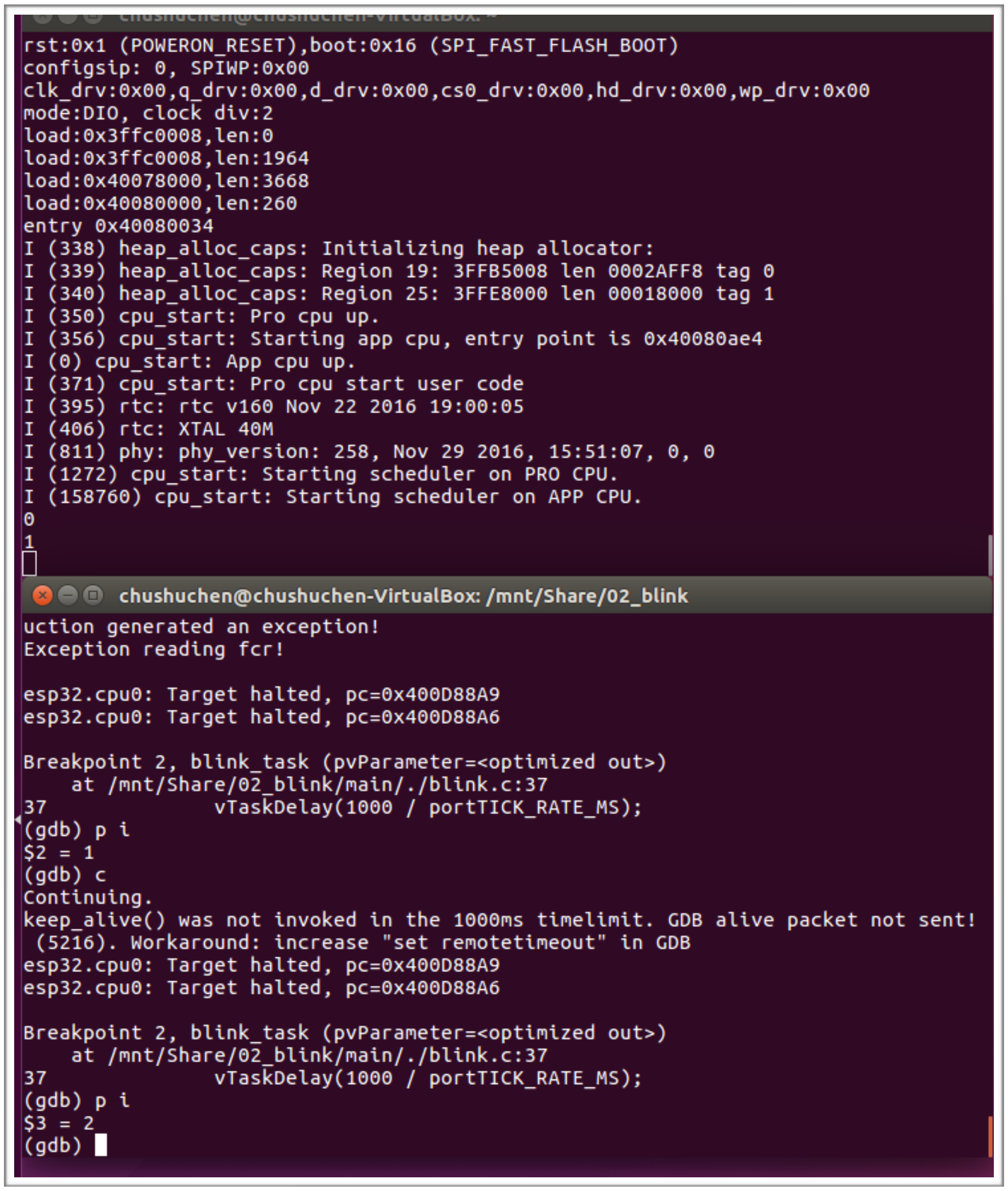
```
(gdb) break 40
Breakpoint 2 at 0x400d88b8: file /mnt/Share/02_blink/main/./blink.c, line 40.
(gdb) c
Continuing.
esp32.cpu0: Target halted, pc=0x400D888B
esp32.cpu0: Target halted, pc=0x400D88B8

Breakpoint 2, blink_task (pvParameter=<optimized out>)
    at /mnt/Share/02_blink/main/./blink.c:40
40                  gpio_set_level(BLINK_GPIO, 1);
(gdb)
```

9. Input `print i` or `p i` to check the value of variable i in the codes.



```
(gdb) p i
$1 = 1
```

10.Run the command `c` and the program will stop at breakpoint 2 while looping. The printed log of the serial port will show the value of variable i, which is the same as the value returned by the command `p i`.



```
rst:0x1 (POWERON_RESET),boot:0x16 (SPI_FAST_FLASH_BOOT)
configsip: 0, SPIWP:0x00
clk_drv:0x00,q_drv:0x00,d_drv:0x00,cs0_drv:0x00,hd_drv:0x00,wp_drv:0x00
mode:DIO, clock div:2
load:0x3ffc0008,len:0
load:0x3ffc0008,len:1964
load:0x40078000,len:3668
load:0x40080000,len:260
entry 0x40080034
I (338) heap_alloc_caps: Initializing heap allocator:
I (339) heap_alloc_caps: Region 19: 3FFB5008 len 0002AFF8 tag 0
I (340) heap_alloc_caps: Region 25: 3FFE8000 len 00018000 tag 1
I (350) cpu_start: Pro cpu up.
I (356) cpu_start: Starting app cpu, entry point is 0x40080ae4
I (0) cpu_start: App cpu up.
I (371) cpu_start: Pro cpu start user code
I (395) rtc: rtc v160 Nov 22 2016 19:00:05
I (406) rtc: XTAL 40M
I (811) phy: phy_version: 258, Nov 29 2016, 15:51:07, 0, 0
I (1272) cpu_start: Starting scheduler on PRO CPU.
I (158760) cpu_start: Starting scheduler on APP CPU.
0
1
```

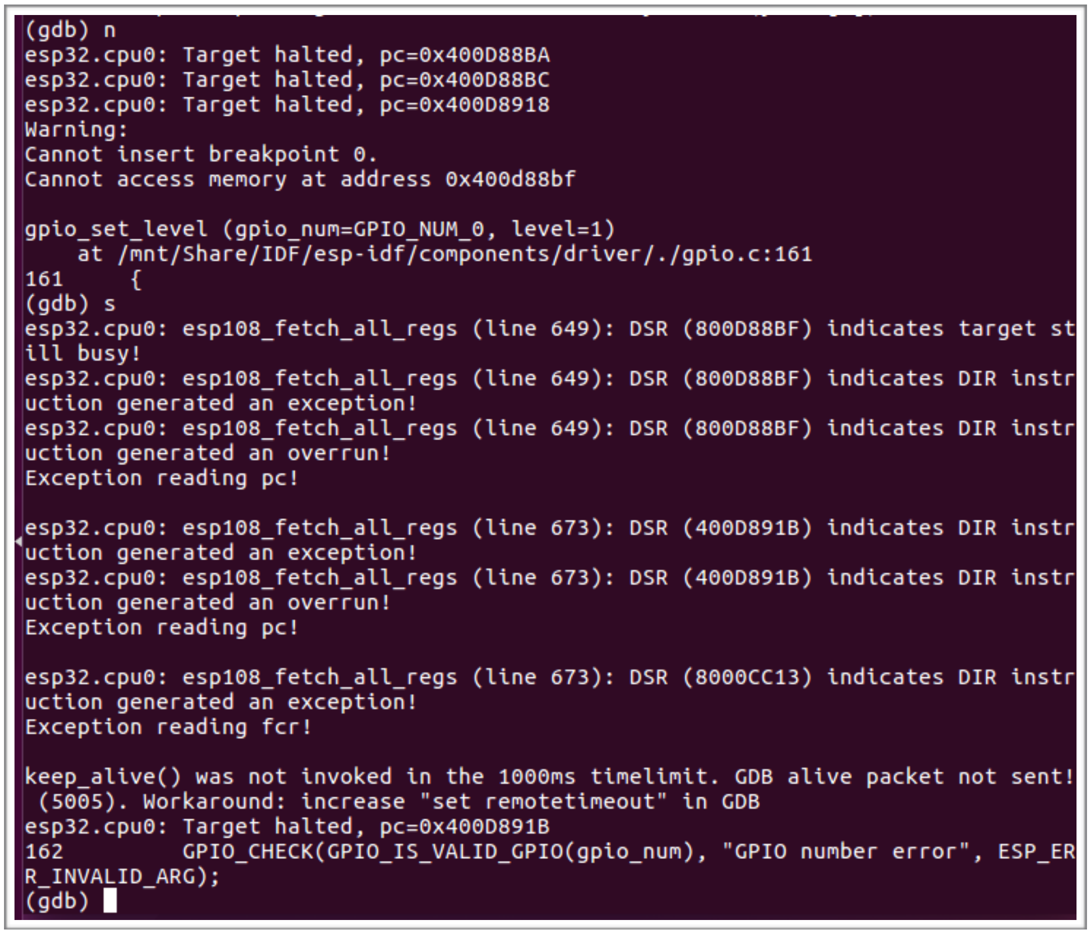
chushuchen@chushuchen-VirtualBox: /mnt/Share/02_blink

```
uction generated an exception!
Exception reading fcr!

esp32.cpu0: Target halted, pc=0x400D88A9
esp32.cpu0: Target halted, pc=0x400D88A6

Breakpoint 2, blink_task (pvParameter=<optimized out>)
    at /mnt/Share/02_blink/main/./blink.c:37
37              vTaskDelay(1000 / portTICK_RATE_MS);
(gdb) p i
$2 = 1
(gdb) c
Continuing.
keep_alive() was not invoked in the 1000ms timelimit. GDB alive packet not sent!
 (5216). Workaround: increase "set remotetimeout" in GDB
esp32.cpu0: Target halted, pc=0x400D88A9
esp32.cpu0: Target halted, pc=0x400D88A6

Breakpoint 2, blink_task (pvParameter=<optimized out>)
    at /mnt/Share/02_blink/main/./blink.c:37
37              vTaskDelay(1000 / portTICK_RATE_MS);
(gdb) p i
$3 = 2
(gdb)
```

📖 ***Note:***

Please restart OpenOCD and gdb when having problems executing the program.

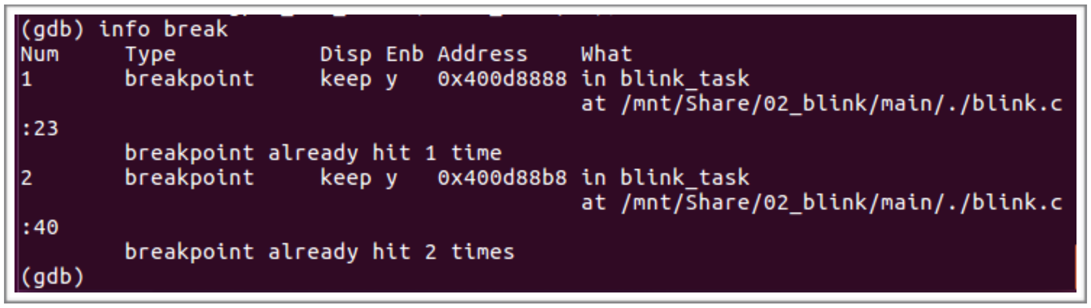
11.Use the command `n` to step execution, or command `s` to step into a function.



```
(gdb) n
esp32.cpu0: Target halted, pc=0x400D88BA
esp32.cpu0: Target halted, pc=0x400D88BC
esp32.cpu0: Target halted, pc=0x400D8918
Warning:
Cannot insert breakpoint 0.
Cannot access memory at address 0x400d88bf

gpio_set_level (gpio_num=GPIO_NUM_0, level=1)
    at /mnt/Share/IDF/esp-idf/components/driver/./gpio.c:161
161     {
(gdb) s
esp32.cpu0: esp108_fetch_all_regs (line 649): DSR (800D88BF) indicates target st
ill busy!
esp32.cpu0: esp108_fetch_all_regs (line 649): DSR (800D88BF) indicates DIR instr
uction generated an exception!
esp32.cpu0: esp108_fetch_all_regs (line 649): DSR (800D88BF) indicates DIR instr
uction generated an overrun!
Exception reading pc!

esp32.cpu0: esp108_fetch_all_regs (line 673): DSR (400D891B) indicates DIR instr
uction generated an exception!
esp32.cpu0: esp108_fetch_all_regs (line 673): DSR (400D891B) indicates DIR instr
uction generated an overrun!
Exception reading pc!

esp32.cpu0: esp108_fetch_all_regs (line 673): DSR (8000CC13) indicates DIR instr
uction generated an exception!
Exception reading fcr!

keep_alive() was not invoked in the 1000ms timelimit. GDB alive packet not sent!
 (5005). Workaround: increase "set remotetimeout" in GDB
esp32.cpu0: Target halted, pc=0x400D891B
162             GPIO_CHECK(GPIO_IS_VALID_GPIO(gpio_num), "GPIO number error", ESP_ER
R_INVALID_ARG);
(gdb)
```

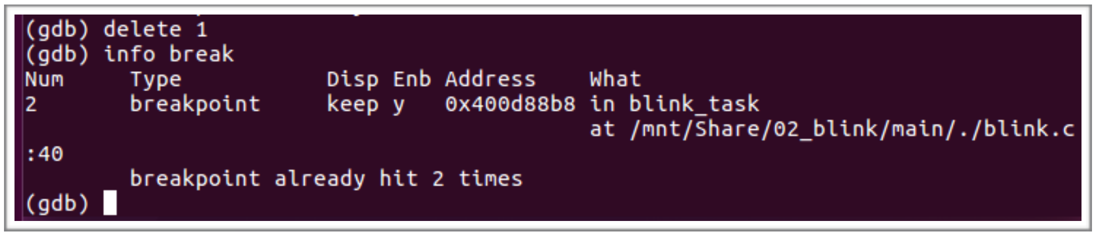
12.Since no more than two breakpoints can be set in an ESP32 device, please delete breakpoints already set in order to set new breakpoints.

- Use the command `info break` to check the breakpoints that have been set.



```
(gdb) info break
Num     Type           Disp Enb Address    What
1       breakpoint     keep y   0x400d8888 in blink_task
                                           at /mnt/Share/02_blink/main/./blink.c
:23
        breakpoint already hit 1 time
2       breakpoint     keep y   0x400d88b8 in blink_task
                                           at /mnt/Share/02_blink/main/./blink.c
:40
        breakpoint already hit 2 times
(gdb)
```

- Use the command `delete 1` to delete breakpoint 1.



```
(gdb) delete 1
(gdb) info break
Num     Type           Disp Enb Address    What
2       breakpoint     keep y   0x400d88b8 in blink_task
                                           at /mnt/Share/02_blink/main/./blink.c
:40
        breakpoint already hit 2 times
(gdb)
```

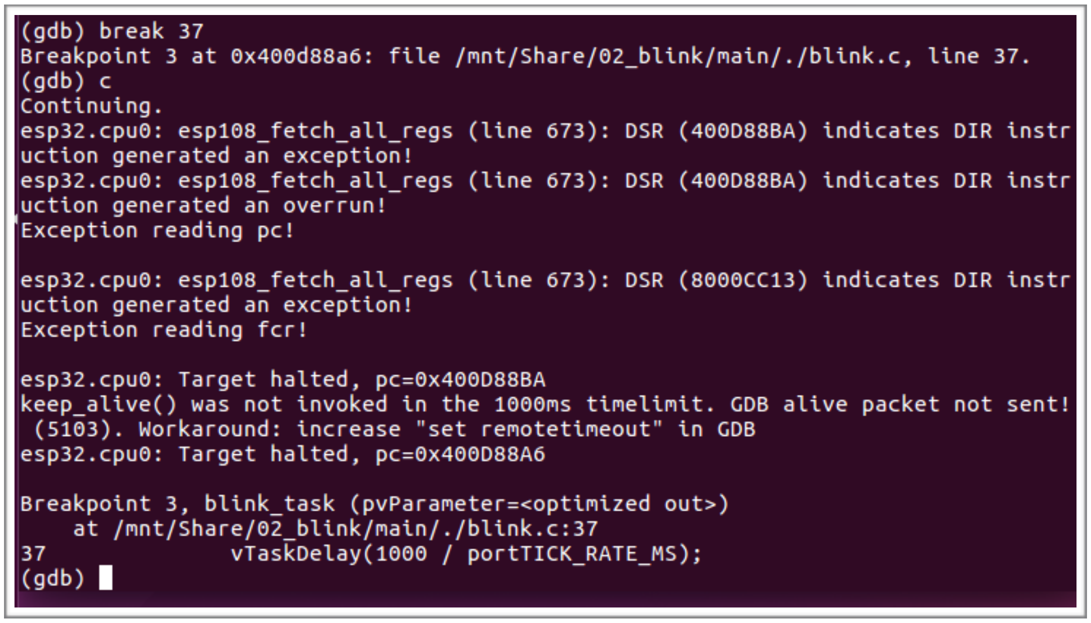
Table 4-1. Commands to Delete Breakpoints

Command	Description	Example

`delete`	Function:
	`delete [breakpoints num] [range...]`
	`delete`: deletes a breakpoint or a set of breakpoints.
		`delete 5`
		`delete 1-10`

`clear`	Function:
	• `clear`
	deletes multiple breakpoints in the current line.
	• `clear location`
	`clear`: deletes all breakpoints at a designated location.
	`location`: the location of the breakpoints to delete.
		`clear list_insert //Delete all the breakpoints in the function list_insert.`
		`clear list.c:list_delet //Delete all the breakpoints in the function list_delet in list.c.`
		`clear 12 //Delete all breakpoints in line 12.`
		`clear list.c:12 //Delete all breakpoints in line 12 in list.c.`

- Set new breakpoints.



```
(gdb) break 37
Breakpoint 3 at 0x400d88a6: file /mnt/Share/02_blink/main/./blink.c, line 37.
(gdb) c
Continuing.
esp32.cpu0: esp108_fetch_all_regs (line 673): DSR (400D88BA) indicates DIR instr
uction generated an exception!
esp32.cpu0: esp108_fetch_all_regs (line 673): DSR (400D88BA) indicates DIR instr
uction generated an overrun!
Exception reading pc!

esp32.cpu0: esp108_fetch_all_regs (line 673): DSR (8000CC13) indicates DIR instr
uction generated an exception!
Exception reading fcr!

esp32.cpu0: Target halted, pc=0x400D88BA
keep_alive() was not invoked in the 1000ms timelimit. GDB alive packet not sent!
 (5103). Workaround: increase "set remotetimeout" in GDB
esp32.cpu0: Target halted, pc=0x400D88A6

Breakpoint 3, blink_task (pvParameter=<optimized out>)
    at /mnt/Share/02_blink/main/./blink.c:37
37              vTaskDelay(1000 / portTICK_RATE_MS);
(gdb) 
```

📖 ***Note:***

The above-mentioned commands will meet basic debugging needs. For more gdb commands, please consult online resources.

5. Notes

5.1. FreeRTOS Support

OpenOCD has explicit support for the ESP-IDF FreeRTOS; FreeRTOS detection can be disabled in ***esp32.conf***. When enabled, gdb can see FreeRTOS tasks as threads. Viewing them all can be done using the gdb `i threads` command; changing to a certain task is done with `thread x`, with `x` being the number of the thread. All threads can be switched to except for a thread actually running on the other CPU; please see the following section ***ESP32 Quirks*** for more information.

5.2. ESP32 Quirks

- Normal gdb breakpoints (`b myFunction`) can only be set in IRAM, because that memory is writable. Setting these types of breakpoints in code will not work in flash. Instead, use a hardware breakpoint (`hb myFunction`). The ESP32 supports 2 hardware breakpoints. It also supports two watchpoints, so two variables can be watched for change or read by the gdb command `watch myVariable`.
- Because gdb only sees the system from the point of view of the selected CPU, only the FreeRTOS tasks that are suspended and the task running on the CPU, to which gdb is connected, will be shown correctly. The task that was active on the other CPU can be inspected, but its state may be wildly inconsistent.
- The ESP-IDF code can compile in various support options for OpenOCD: it can stop execution when the first thread is started, and break the system if a panic or unhandled exception is thrown. Both options are enabled by default but can be disabled using the ***esp-idf*** configuration menu. Please see the ***make menuconfig*** menu for more details.
- Normally, under OpenOCD, a board can be reset by entering `mon reset` or `mon reset halt` into gdb. For the ESP32, these commands work more or less, but they also have side effects. First of all, an OpenOCD reset only resets the CPU cores, not the peripherals, which may lead to undefined behaviour if software assumes the after-reset state of peripherals. Secondly, `mon reset halt` stops before FreeRTOS is initialized. OpenOCD assumes a running FreeRTOS (in the default configuration, you can change this by editing ***esp32.cfg***), and may get confused.

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