

The **EtherCAT**-based embedded motion controller optimized for industrial robots.

DTP10-L Software User's Manual

DAINCUBE Corp.
ARM Cortex-A9 Linux system

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Preface

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Important information

This documentation is intended for qualified audience only. The product described herein is not an end user product. It was developed and manufactured for further processing by trained personnel.

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Product support

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Safety precautions

Be sure to observe all of the following safety precautions.

Strict observance of these warning and caution indications are a MUST for preventing accidents, which could result in bodily injury and substantial property damage. Make sure you fully understand all definitions of these terms and related symbols given below, before you proceed to the manual.

Safety precautions

The following symbols may be used in this specification:



Warning:

Warnings indicate conditions that, if not observed, can cause personal injury.



Caution :

Cautions warn the user about how to prevent damage to hardware or loss of data.



Note:

Notes call attention to important information that should be observed.

Revision history

[illegible]

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1. Introduction

Thank you very much for purchasing our product.

Improper usage or mishandling may result in a product not only being unable to deliver full functions but also produce unexpected troubles or shorten the product's life.

Please read this manual carefully, and operate the product properly by paying attention to its handling.

When operating the product, always keep this manual at hand and read the relevant items as required.

1.1. General precautions

- Be sure to read this Instruction Manual for proper use of this product.
- Part or all of this Instruction Manual may not be used or reproduced without permission.
- Please take note that we shall not be liable for any effects resulting from using this Instruction manual.
- This manual may be modified when necessary because of improvement of the product, modification or changes in specifications.
- Some drawings in this manual are shown as a typical example and may differ from the shipped product.

2. Safety information

- Before unpacking and installing the product or adding devices on it, carefully read all the manuals that came with the package.
- Avoid using product in extreme dust, humidity and temperature conditions. Do not place the product in wet area.
- Before carrying out assembly and adjustment work or maintenance and inspection work of the machine, be sure to disconnect the power cord. Otherwise, electric shock may result.
- After turning OFF power, wait at least five minutes before servicing the product. Otherwise, residual electric charges may result in electric shock.



Warning

- Be sure to check grounding before you use the unit. Danger of personal injury due to electric shock!
- Be sure to use the unit within the voltage range indicated.
- The operator must have a sufficient educational level and must know details of intended use described in the user's manual.
- Be sure to check the wiring to the main unit.
- When the user (customer) extends wiring, malfunction may occur due to faulty wiring. In this case, inspect wiring thoroughly and check it for properness before turning on the power.
- Before operating the unit, be sure to check that there is no danger in or around the operating range.
- Do not allow water or oil to get on the unit and the power cord.
- Install the unit in a place which can endure its weight and conditions while running.
- Take care not to squeeze and thus damage the cable with any object.

- Do not lay the cable over sharp edges to avoid damaging the cable sheath.
- Check the mounting screws regularly so that they are always firmly tightened.
- Never touch terminals directly or internal parts of controller.
- Do not disassemble or modify the product.
- Before carrying out assembly and adjustment work or maintenance and inspection work of the machine, be sure to disconnect the power cord.
- Connect the power supply after completing the adjustment of all the cables and switches.



Caution

- After the shutdown window, turn off the power supply. Otherwise the components could be destroyed or undefined signals could occur.
- To prevent the equipment from falling to the ground.
- Never lay the device onto unstable surfaces. It could fall to ground and thus be damaged.
- It is recommended to use the unit in an environment where no electrical noise is present. In noisy environments, use a filter fitted.
- Never lay the device close to heat sources or into direct sunlight.
- Avoid exposing the device to mechanical vibrations, excessive dust, and humidity or to strong magnetic fields.
- Make sure that no foreign objects or liquids can penetrate into the device.
- Wipe the power plug with a clean, dry cloth periodically to eliminate dust.
- Always pay special attention to the robot's movement in the Teach Mode.

3. Warranty and warranty coverage

The Teach Pendant you purchased has been delivered upon completion of our strict shipping test.

3.1. Warranty period

The warranty period is as follows:

- 12 months after our shipment.

3.2. Scope of the warranty

Where a defective condition occurs during proper use conditions and obviously under the responsibility of the manufacturer, within the term above, we shall repair the product without charge.

However, any items that apply to the following are excluded from the warranty coverage.

- The warranty is not valid if the defect is due to accidental damage, mishandling, misuse, voltage fluctuation, high/low voltage or natural disaster.
- If the product is repaired or tried to repair from unauthorized personal/Repair Shop.

- If the product serial number is tempered.
- The product is defective due to wear of parts, which can be considered as consumable parts by the nature. (such as a cable)
- Defects resulting from changes over time such as natural color fading of paint.
- Defects resulting from mishandling or improper use.
- Defects resulting from an inadequacy or error in maintenance and inspection.
- Defects resulting from the use of any part other than our genuine parts.
- Defects resulting from a modification not approved by us or our dealers.

Only a delivered product shall be singly warranted, and no damage induced by the defect of the delivery product can be warranted. For repair, transport the product to our factory.

3.3. Service coverage

The cost of a delivered product does not include expenses for program creation and engineer dispatching. Therefore, the following are charged separately even within the warranty term:

- Maintenance and inspection.
- Technical guidance and technical training in the operating instructions.
- Technical guidance and technical training on program-related matters such as program creation.

4. Features

DTP10-L is an embedded-based teach pendant with a high-performance Cortex-A9 (ARM 1GHz * 4 core) processor. It accommodates the needs of various industrial fields, supports various communication methods, and uses Linux OS without royalty. Most Linux development tools and Open sources known to engineers make it easier to develop applications. DTP10-L's device drivers and sample programs are all available through customer support.

4.1. Software specification

Name	Version
Linux Kernel	3.14.38
Real-time OS	2.6.4
EtherCAT	1.5.2
Qt	5.4.2
gcc	4.9.2

5. How to build a software development environment

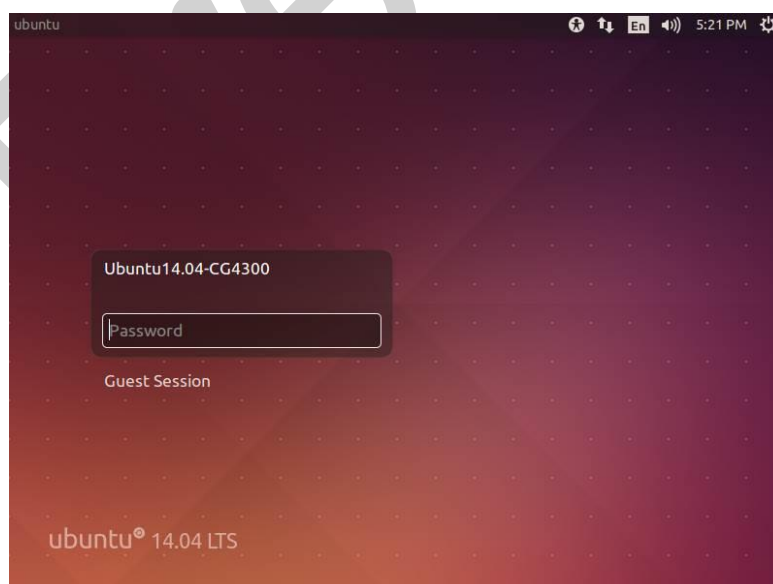
5.1. Host Requirements

5.1.1. Ubuntu 14.04

1. This document describes software development environment in Ubuntu 14.04.
2. In Ubuntu 14.04 later, development environment was not built. If you want to proceed to a version other than Ubuntu 14.04, you may encounter a lot of problems and many additional settings may be needed to fix it. There are many versions of the Linux distribution, and we can not support all of them, so any version not covered in this manual should be solved on your own.

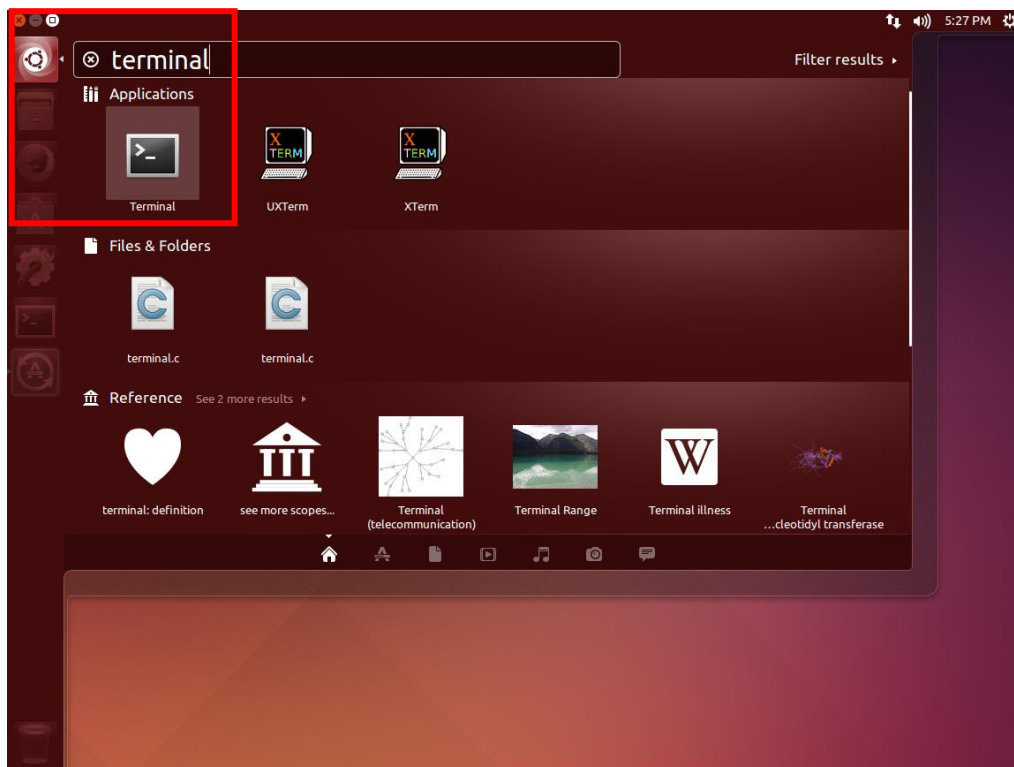
5.2. Ubuntu settings

5.2.1. Ubuntu login



You should login Ubuntu 14.04-CG4300 that we provided. Password is "daincube".

5.2.2. Ubuntu terminal



In order to enter the command line in Ubuntu, you need to run Terminal.

5.2.3. Host package installation

After installing Ubuntu, install the utilities and libraries by typing the following command at the console. These are the programs you need to develop.

You do not need to use Ubuntu 14.04-CG4300. It is already working.

```
$sudo apt-get install asciidoc autoconf automake bison build-essential  
$sudo apt-get install ccache chrpath coreutils curl cvs desktop-file-utils  
$sudo apt-get install diffstat docbook-utils dpkg g++ gawk gcc gcc-multilib  
$sudo apt-get install gettext git-core groff help2man ia32-libs intltool  
$sudo apt-get install lib32z1 libc6-dev-i386 libdbus-glib-1-dev libfreetype6-dev  
$sudo apt-get install libgl1-mesa-dev libglu1-mesa-dev libgtk2.0-dev liblz2-dev  
$sudo apt-get install liborbit2-dev libsdl1.2-dev libtool lzop  
$sudo apt-get install m4 make mercurial ncurses-dev python-pysqlite2  
$sudo apt-get install python-xcbgen rpm scrollkeeper sed socat subversion  
$sudo apt-get install tcl texi2html texinfo uboot-mkimage u-boot-tools  
$sudo apt-get install unzip uuid-dev wget xsltproc xterm zlib1g zlib1g-dev
```

5.2.4. Samba server setup (If necessary)

If Samba (file sharing utility) is installed, development becomes easier. If necessary, install and set up as below.

```
$sudo ufw disable
```

```
$sudo apt-get install samba
```

```
$sudo vi /etc/samba/smb.conf
```

```
[/etc/samba/smb.conf]
```

```
[global]
```

```
hosts allow = 192.168. 192.168. 127.
```

```
##### Authentication #####
```

```
guest ok = yes
```

```
guest account = root
```

```
[home]
```

```
path = /home
```

```
writeable = yes
```

```
guest ok = yes
```

```
$sudo service samba restart
```

```
$sudo shutdown -r now
```

5.2.5. ssh server setup (If necessary)

You can also connect to ssh client.

```
$sudo apt-get install openssh-server
```

```
$sudo gedit /etc/ssh/sshd_config
```

```
$sudo /etc/init.d/ssh restart
```

5.2.6. tftp server setup (If necessary)

Please install it if necessary.

```
$sudo apt-get install tftpd-hpa
```

```
$sudo vim /etc/default/tftpd-hpa
```

```
$sudo service tftpd-hpa restart
```

5.2.7. nfs server setup (If necessary)

```
$sudo apt-get install nfs-common nfs-kernel-server portmap
```

```
$sudo vi /etc/exports
```

```
$sudo /etc/init.d/nfs-kernel-server restart
```

```
$sudo /etc/init.d/portmap restart
```

5.3. Build tool setup

5.3.1. Toolchain setup

Install Toolchain that we provided.

```
$/poky-glibc-i686-meta-toolchain-qt5-cortexa9hf-vfp-neon-toolchain-1.8.sh
```

5.3.2. Xenomai setup

Unzip the Xenomai Real-time library under the /opt/ directory.

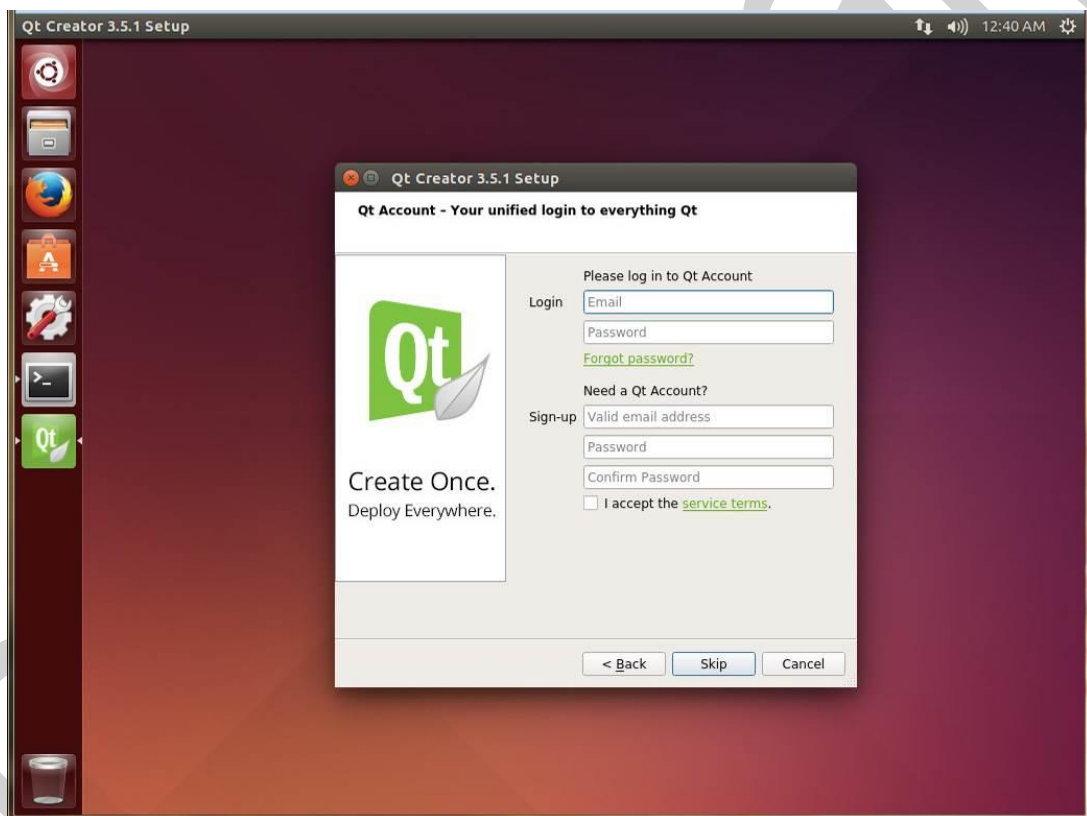
```
$tar xvfz xenomai-2.6.4.tar.gz /opt/
```

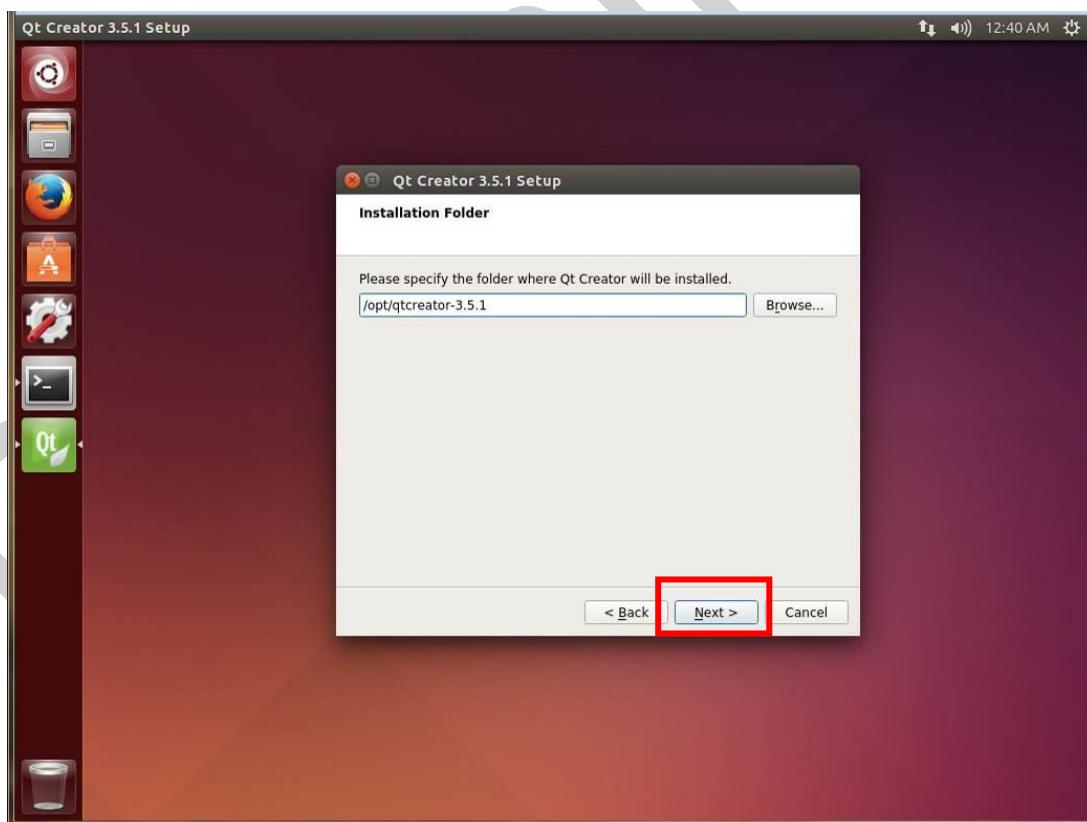
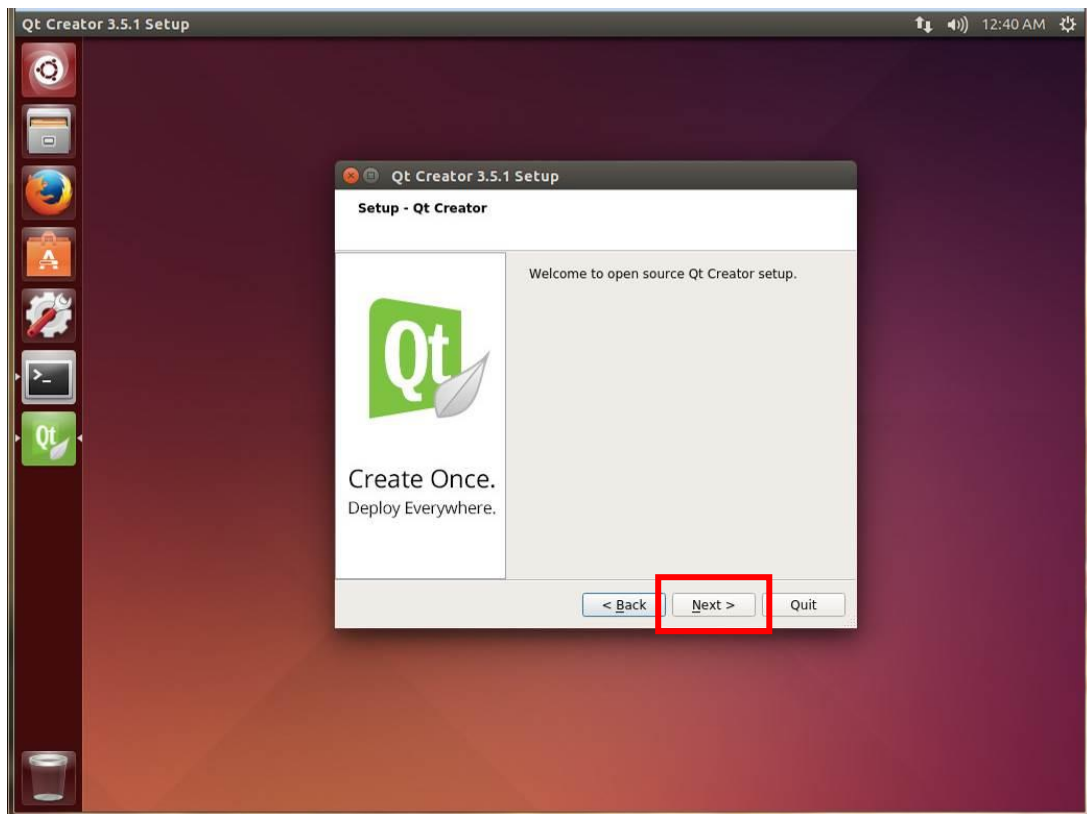
5.3.3. Qt creator setup

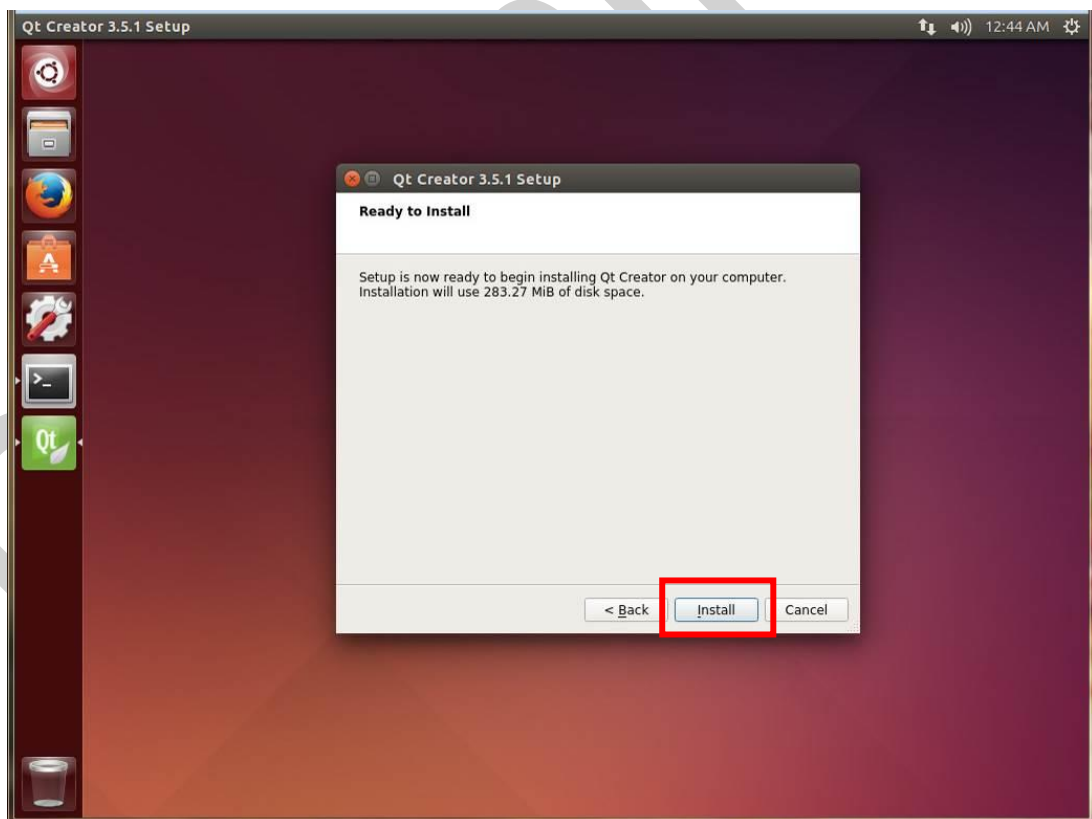
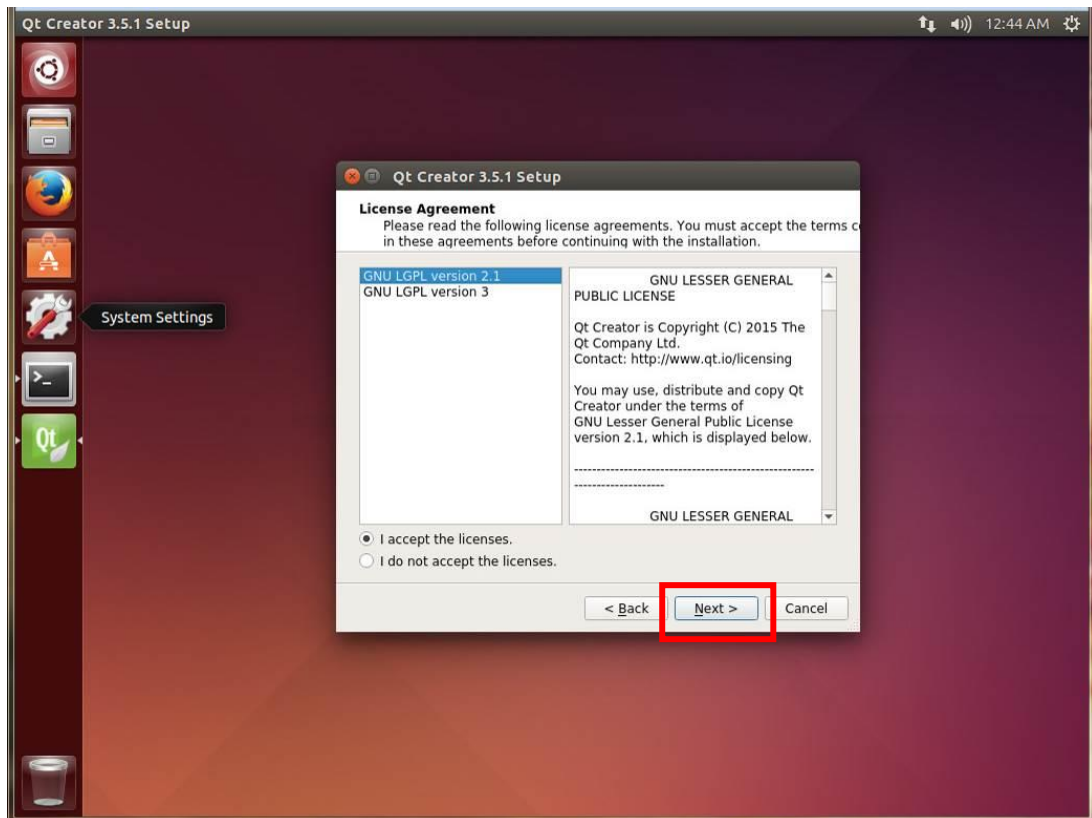
Install Qt Creator 3.5.1

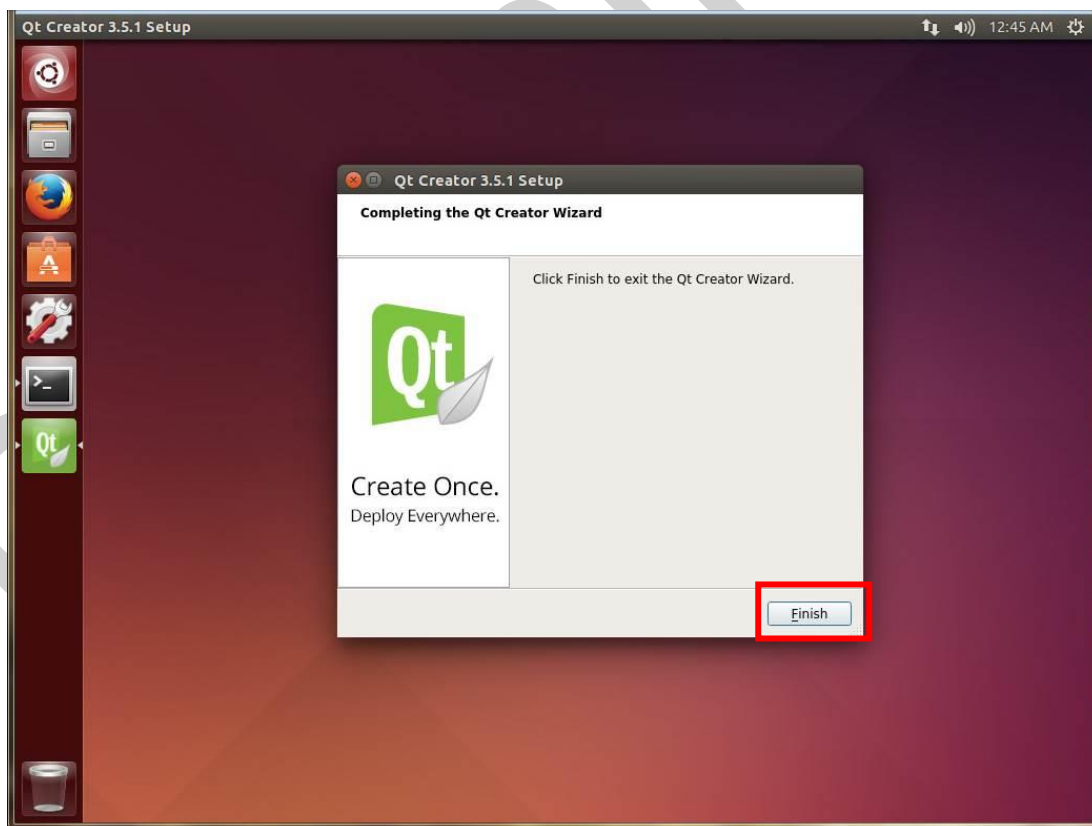
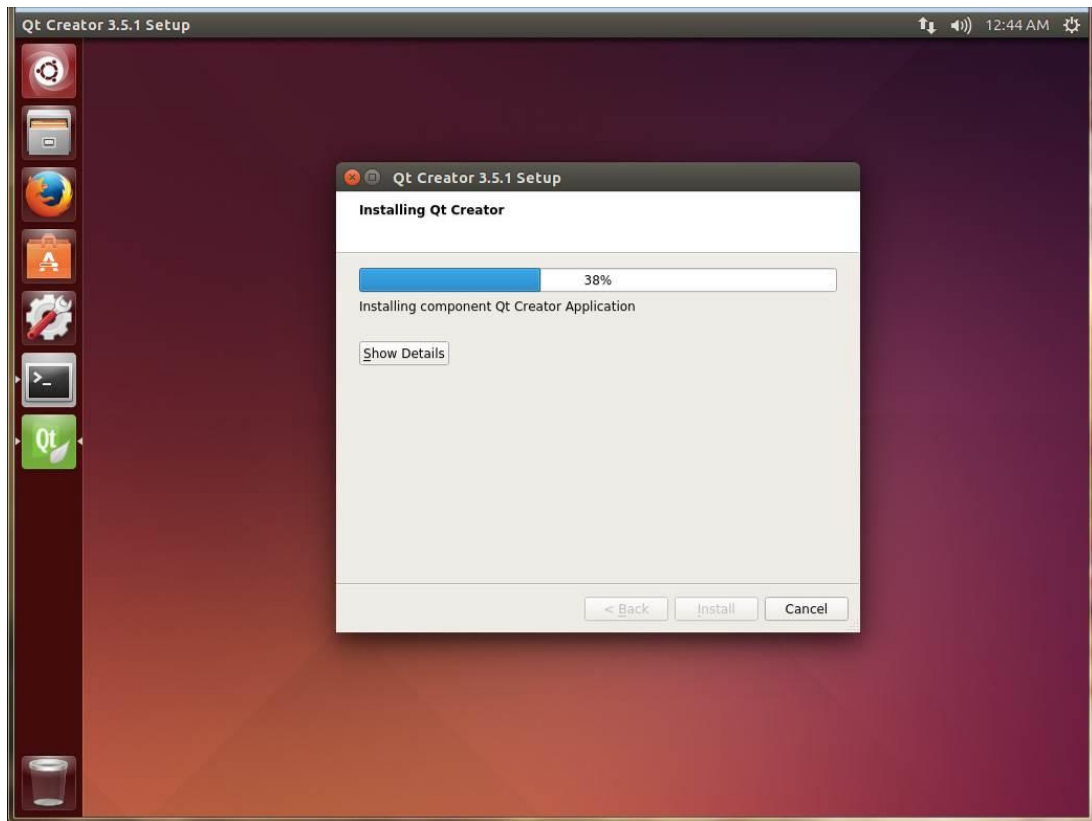
Execute the Qt Creator installation file with the following.

```
$/qt-creator-opensource-linux-x86-3.5.1.run
```









To cross-compile with QT Creator, you must specify the cross-compiler in qtcreator.sh.

`$vi /opt/qtcreator-3.5.1/bin/qtcreator.sh`

```
[/opt/qtcreator-3.5.1/bin/qtcreator.sh]
source /opt/poky/1.8/environment-setup-cortexa9hf-vfp-neon-poky-linux-gnueabi
#! /bin/sh
```

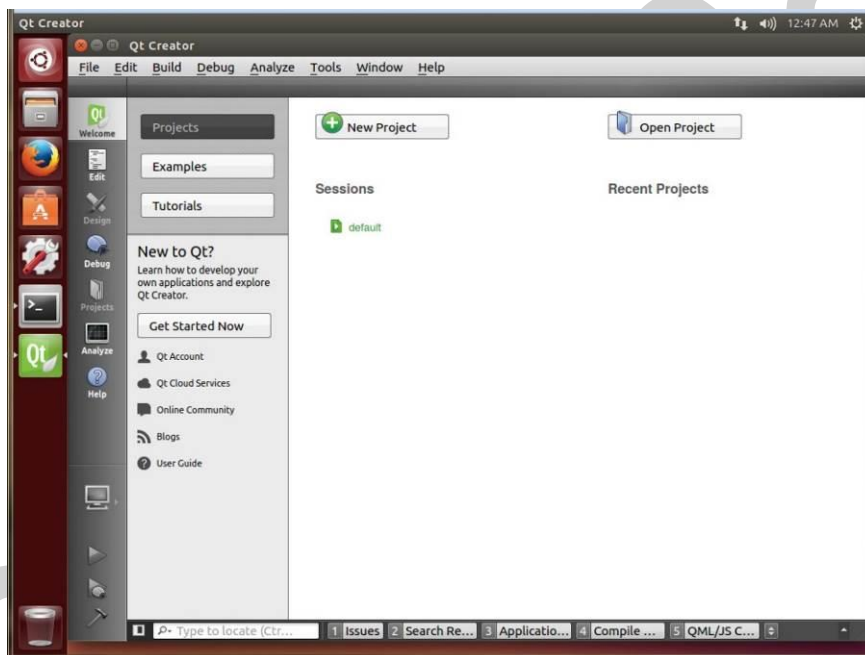
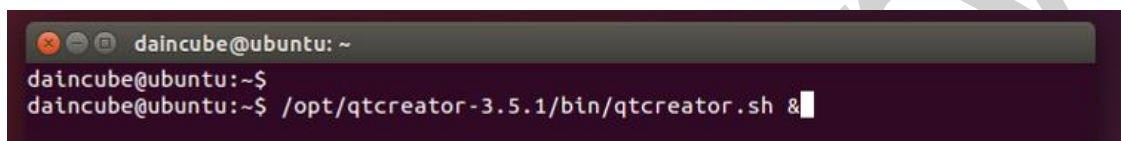
Add the following string to `/opt/qtcreator-3.5.1/bin/qtcreator.sh`.

Be sure to use before the "`#! /bin/sh`".

`source /opt/poky/1.8/environment-setup-cortexa9hf-vfp-neon-poky-linux-gnueabi`

When the modification is complete, run Qt Creator with the command below.

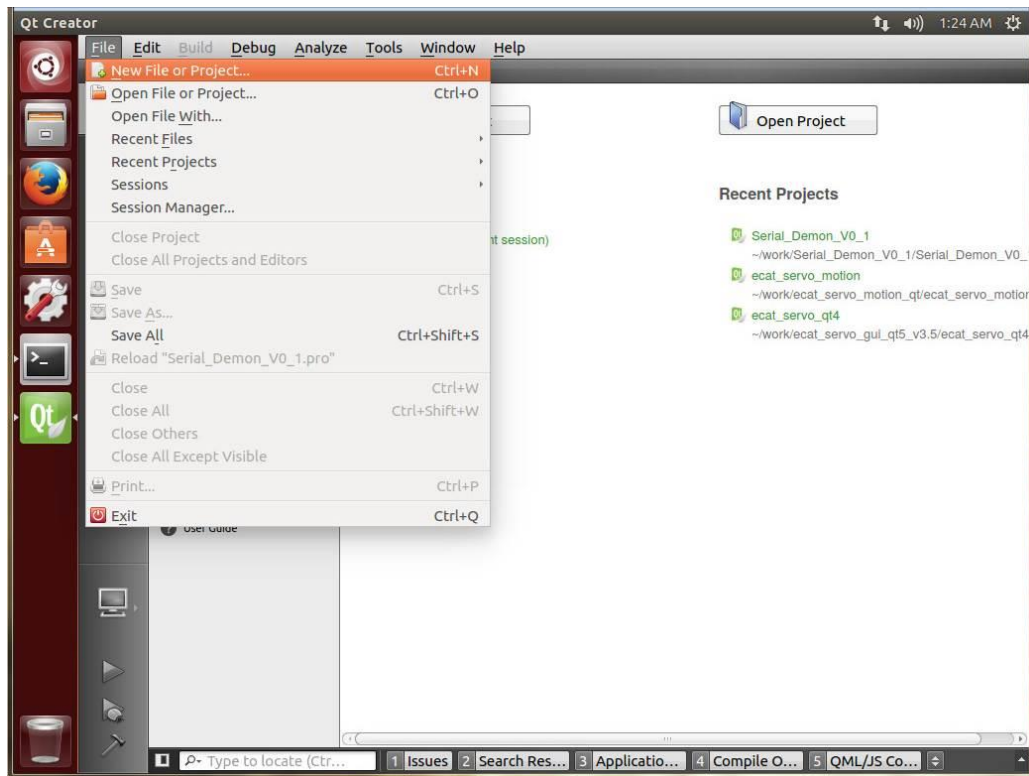
`$/opt/qtcreator-3.5.1/bin/qtcreator.sh &`



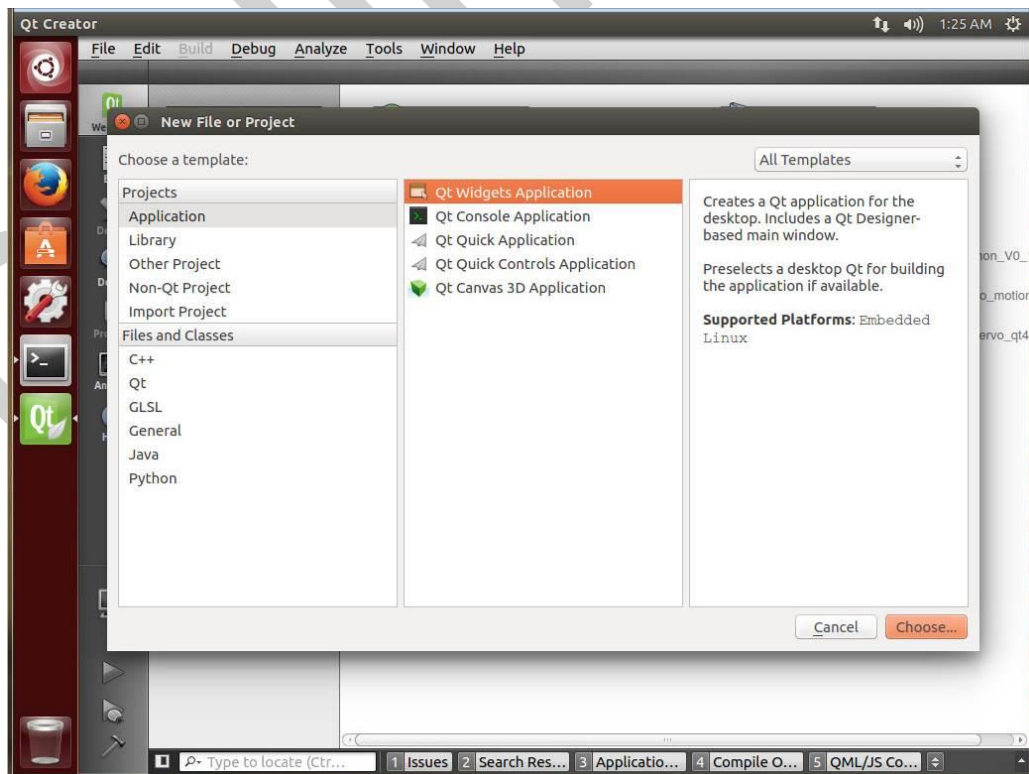
5.4. Qt GUI application project

5.4.1. Create a Qt GUI application (Helloworld)

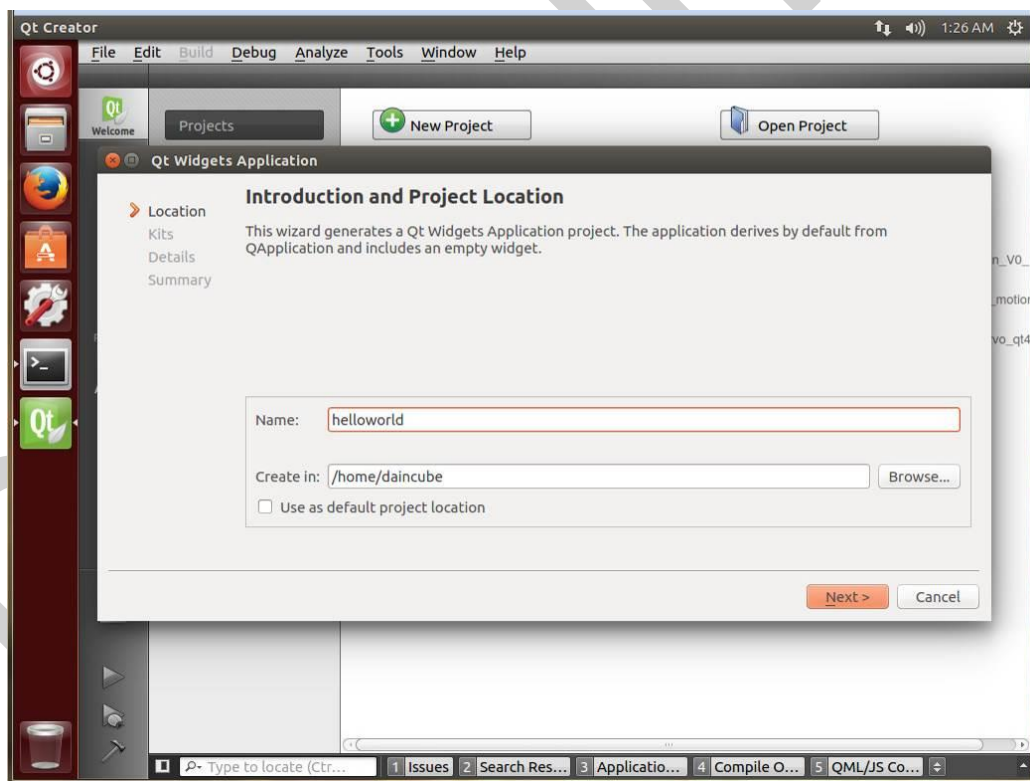
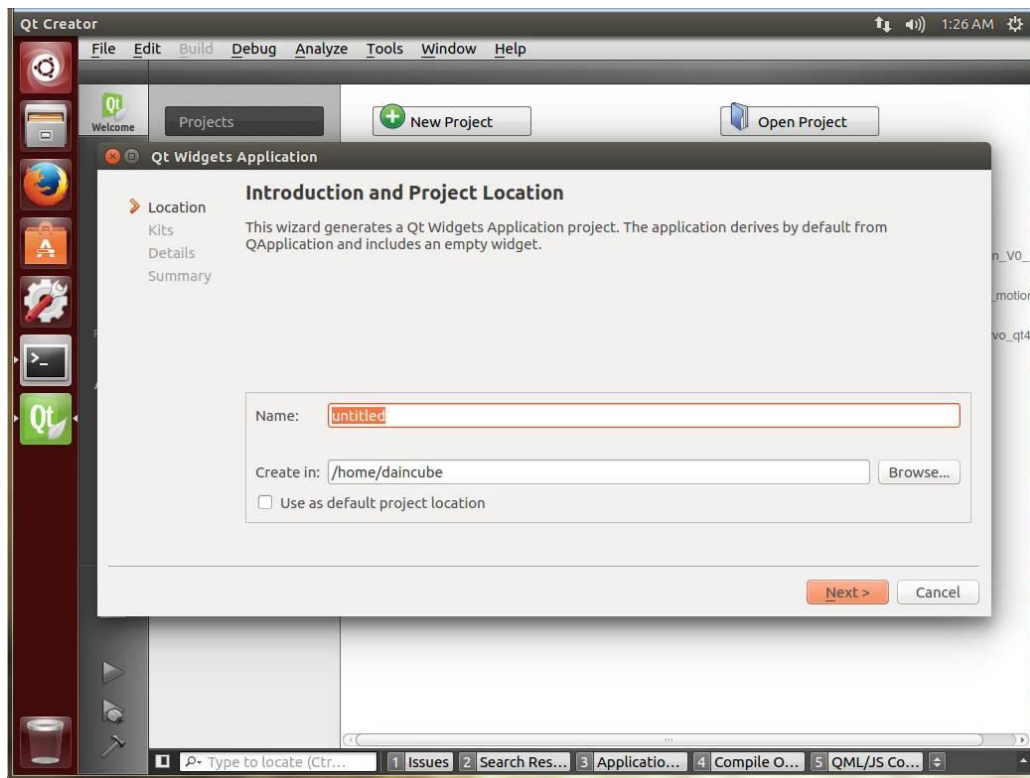
File > New Project... Select to create the project.



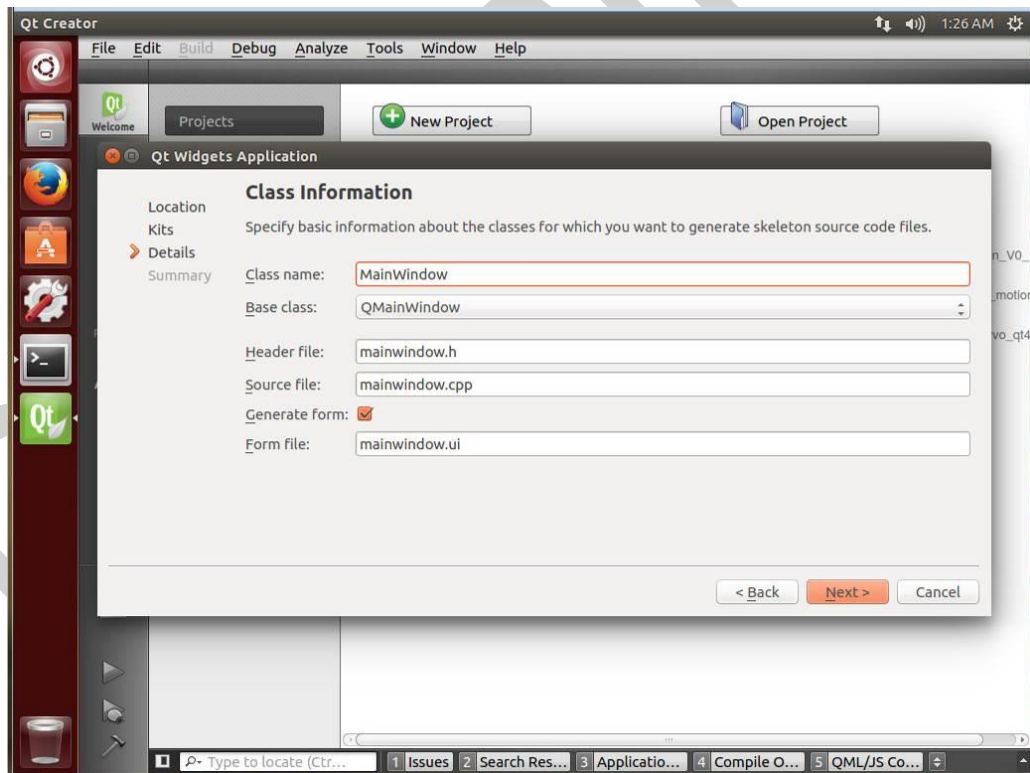
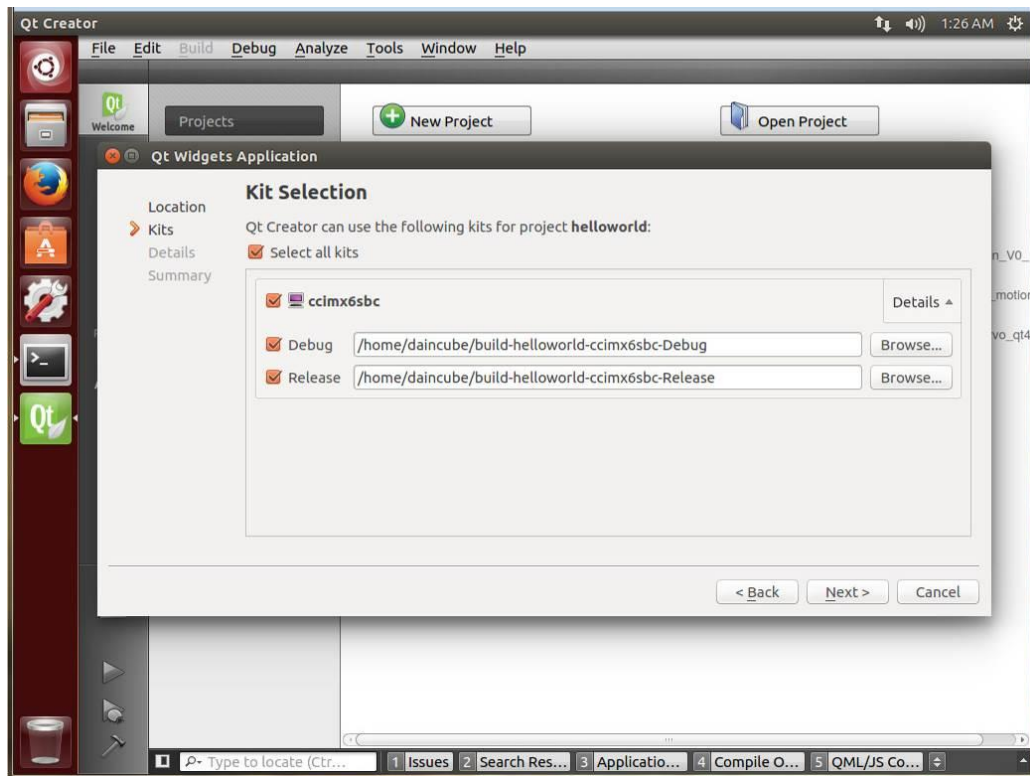
Select Projects > Application > Qt widgets Application and Choose... button.



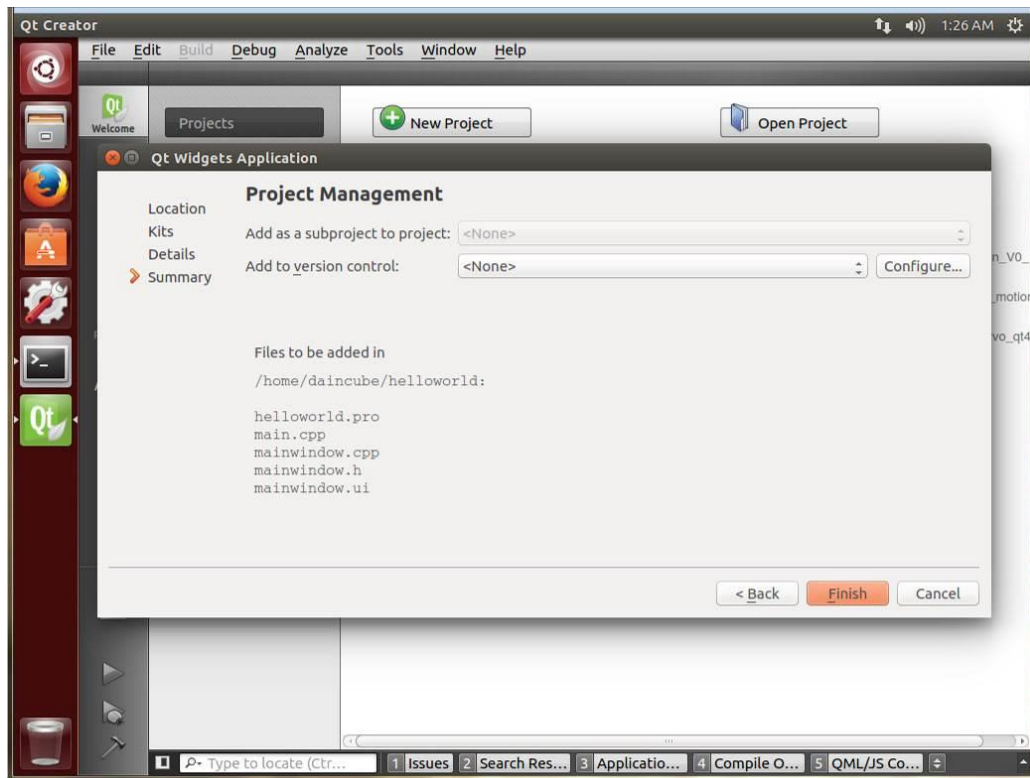
Enter the Project name and path and click Next >.



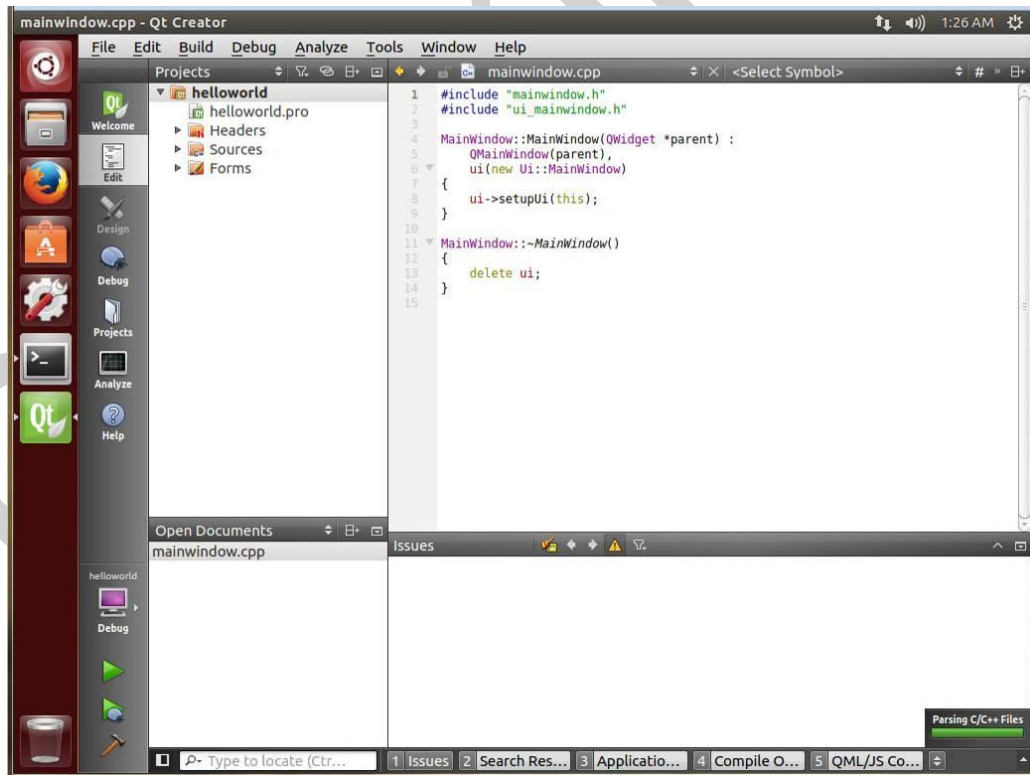
If the "Kits Selection" setting is already set, you can select it and you can select it later.



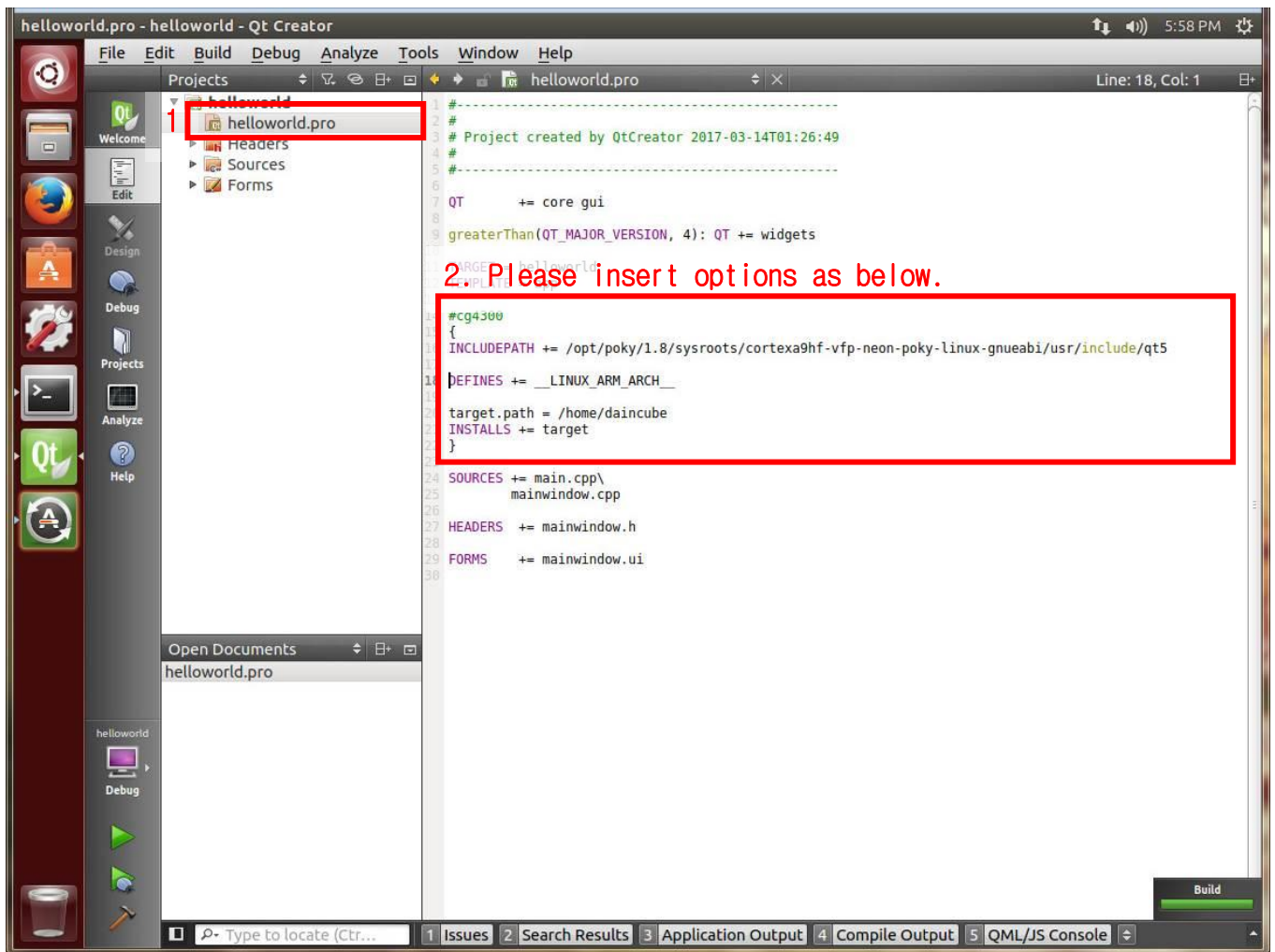
Version Control Tool(SVN, GIT...) can be set. Click Finish.



Projects created.



To make Cross-Compile, type the following.
target.path is the internal path of the board(CG4300).



\$vi helloworld.pro

[helloworld.pro]

```
#cg4300
```

```
{
```

```
INCLUDEPATH += /opt/poky/1.8/sysroots/cortexa9hf-vfp-neon-poky-linux-gnueabi/usr/i  
nclude/qt5
```

```
DEFINES += __LINUX_ARM_ARCH__
```

```
target.path = /home/daincube
```

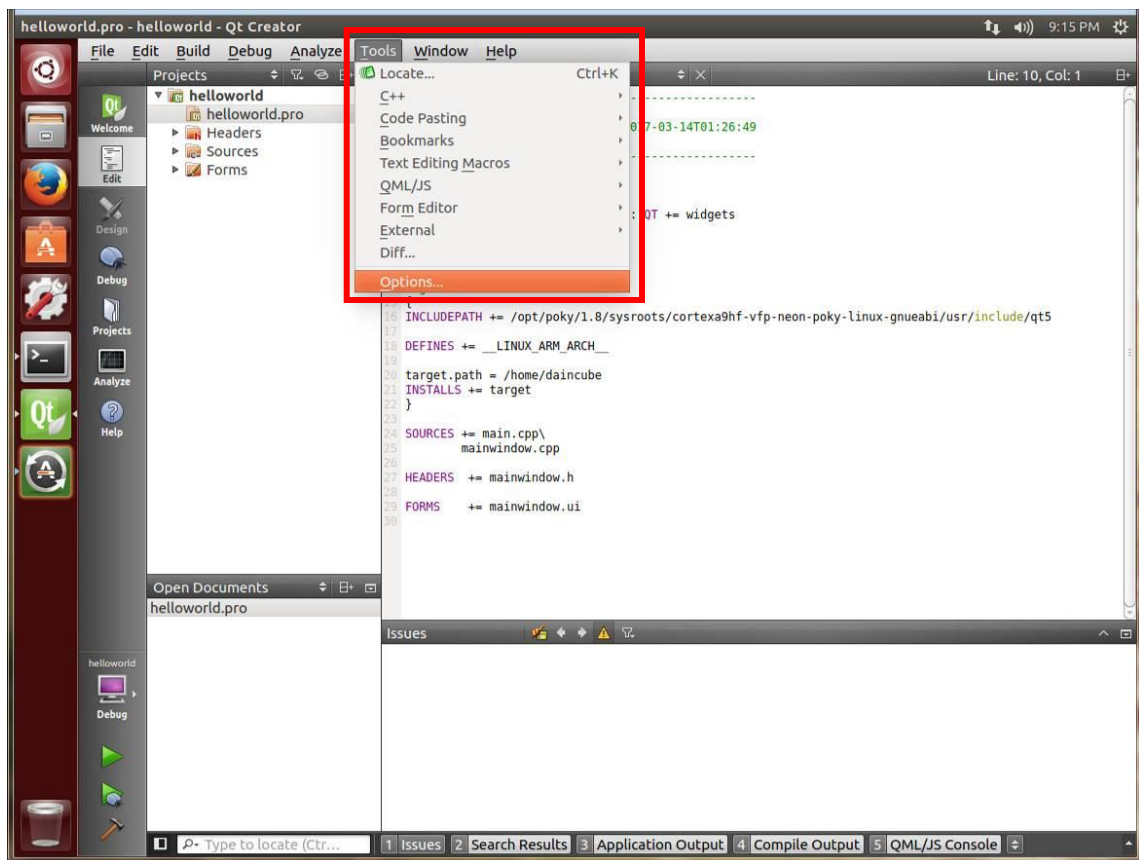
```
INSTALLS += target
```

```
}
```

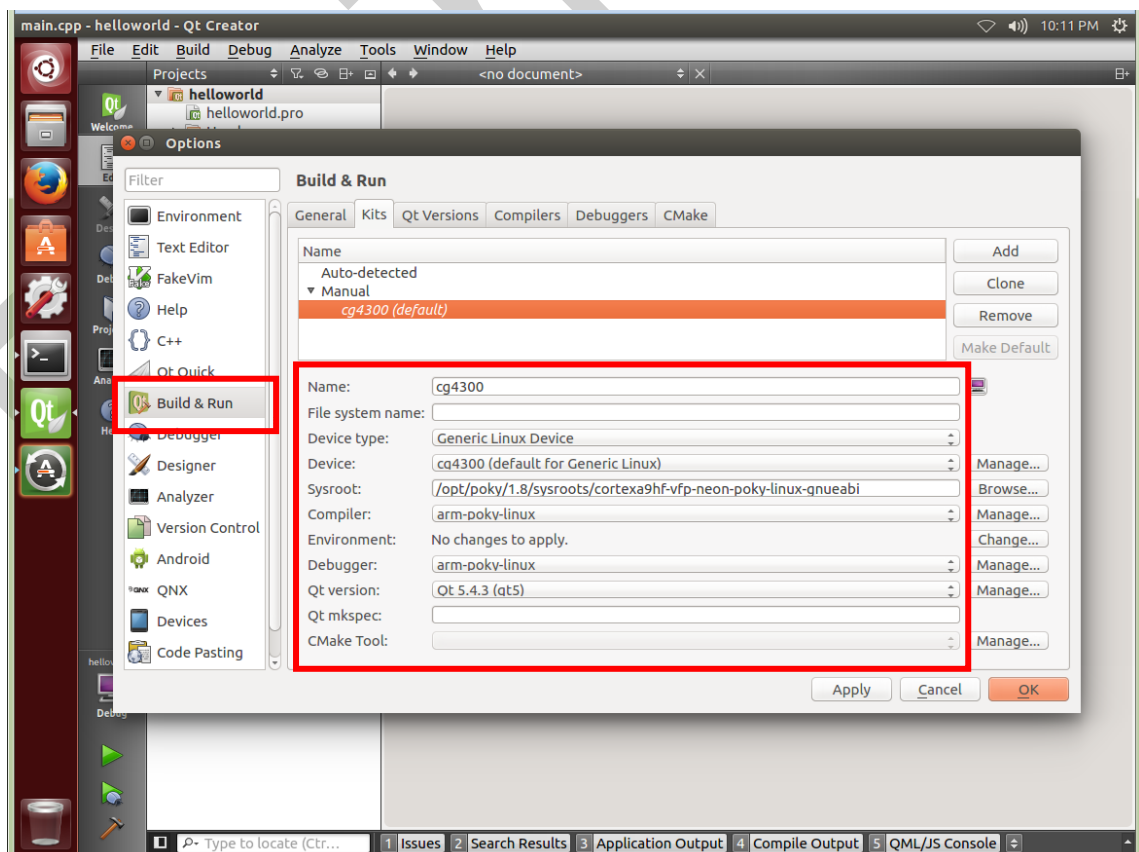
Add the following string to helloworld.pro.

5.4.2. Debugging a Qt GUI application (Helloworld)

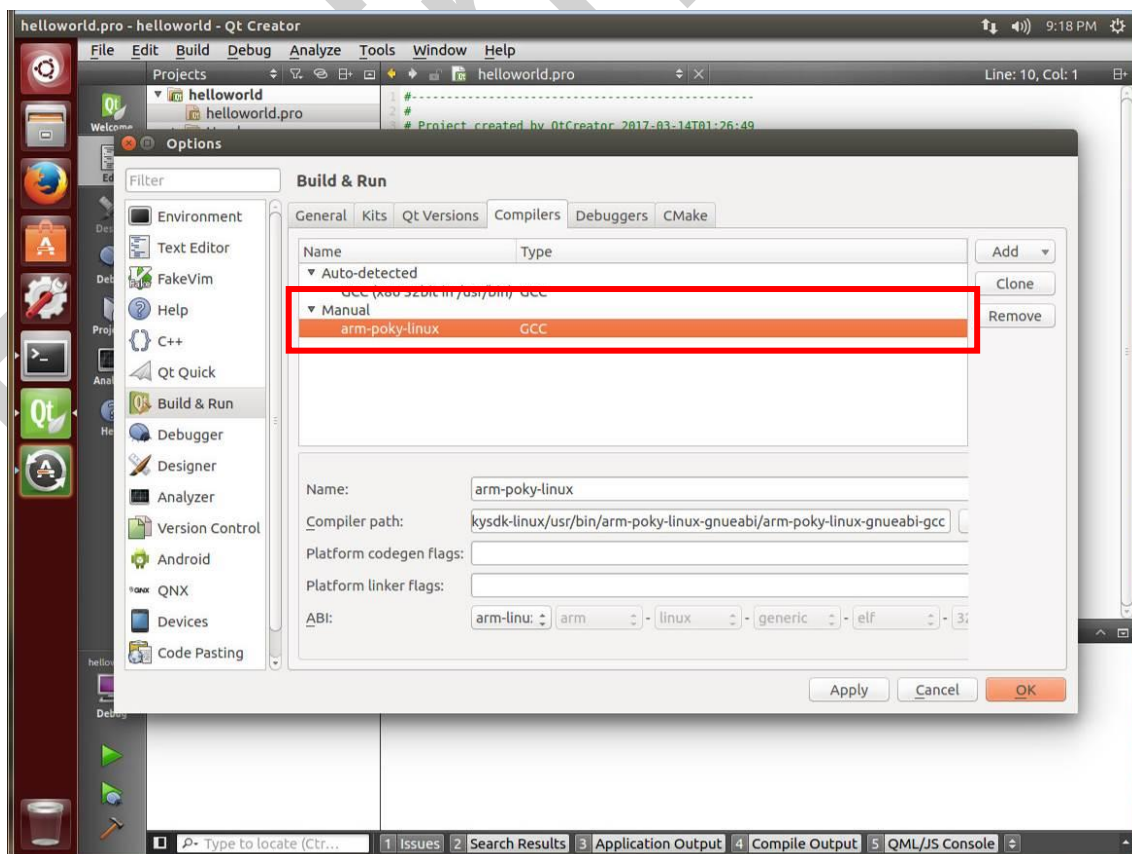
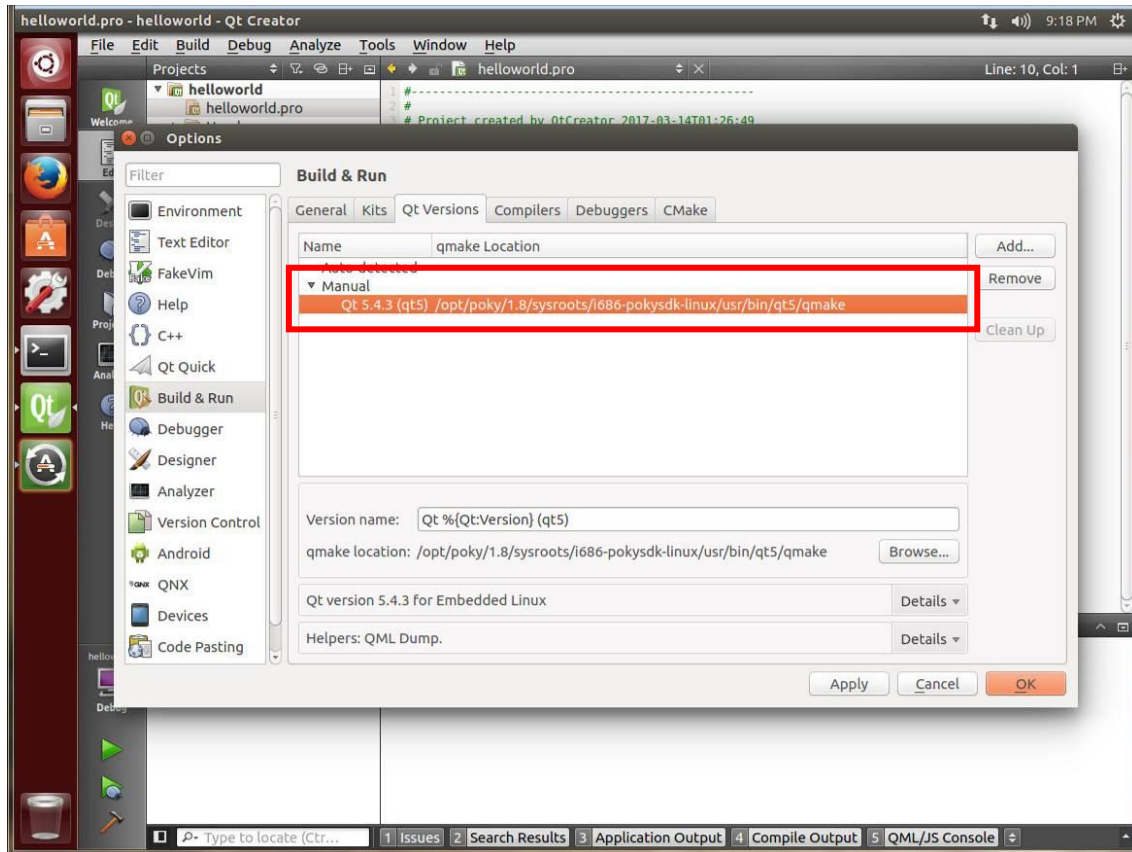
Some settings are required for debugging as shown below.



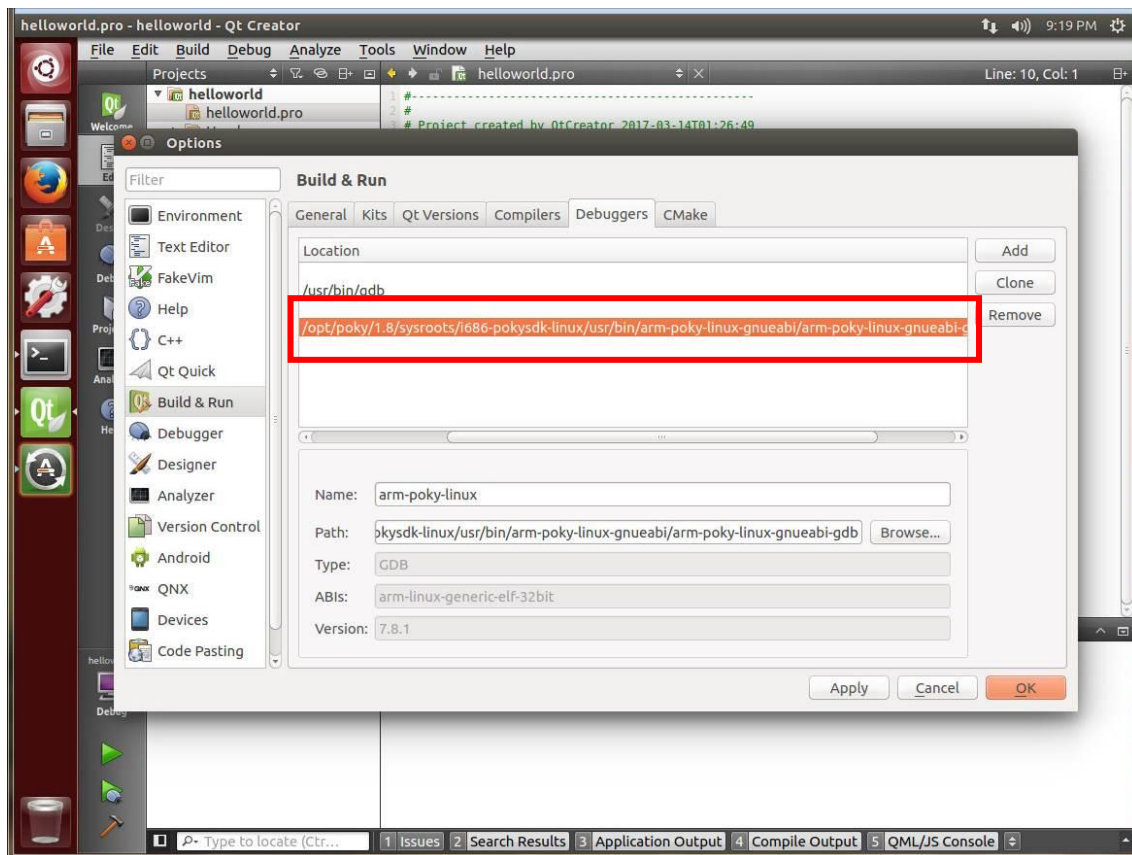
Set the cross-compiler in Options > Build & Run > Kits.



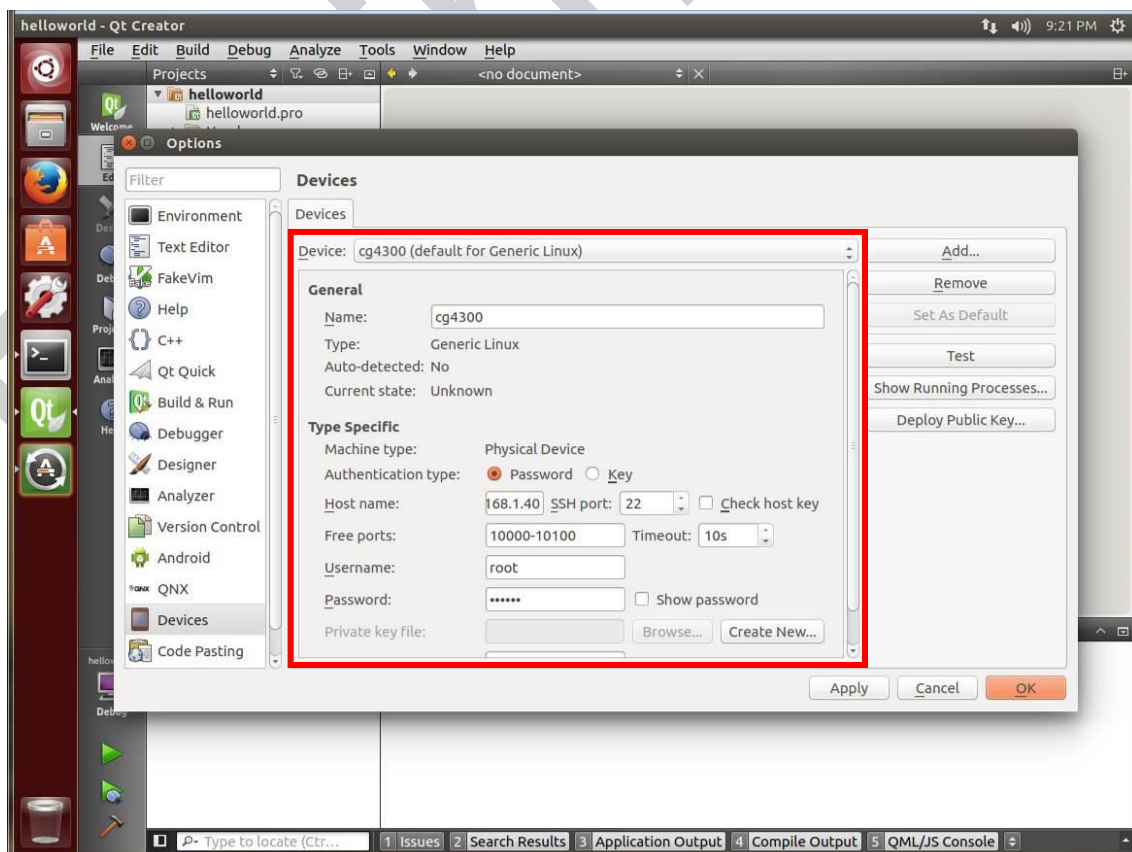
If you specify qmake location in Options > Build & Run > Qt Versions, the version is checked automatically.



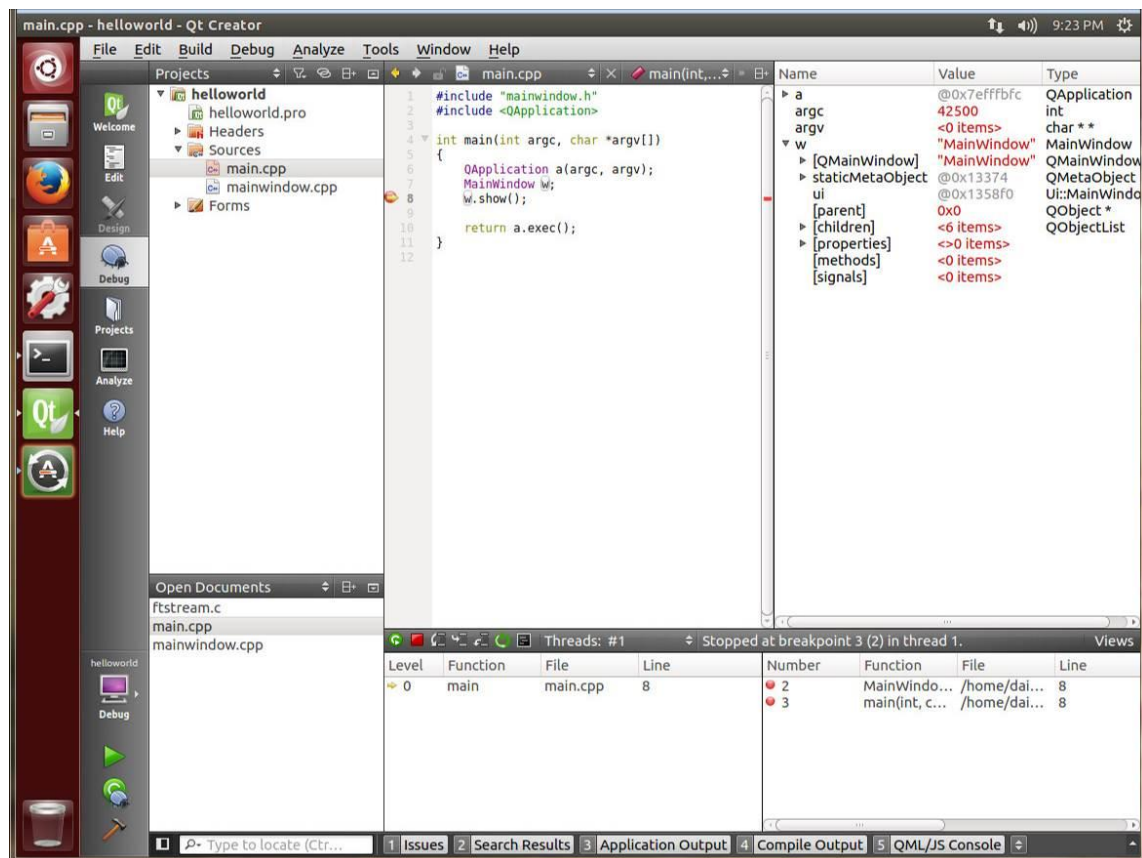
Options > Build & Run > Debuggers must be set to arm-poky-linux-gnueabi-gdb to enable remote debugging of the CG4300.



Options > Devices information is the network information of the CG4300 product.



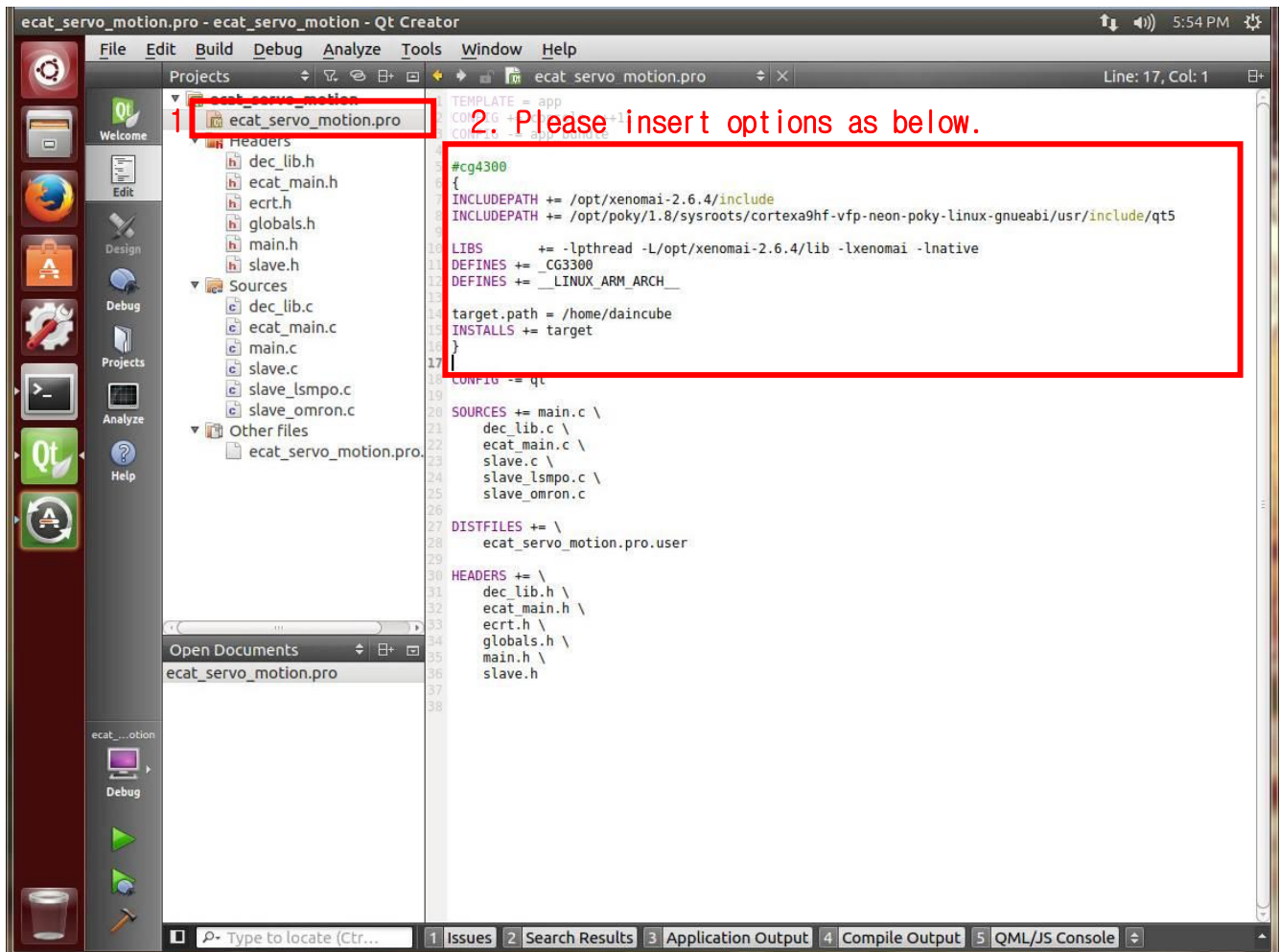
Debugging CG4300 remotely.



[helloworld application executed on CG4300]

5.4.3. Xenomai real-time project

To use the Xenomai real-time api, you need to specify the path to the Xenomai library and include file in the project. This example program (ecat_servo_motion) is not a Qt application. However you can create it as a plain C project and manage it with Qt Creator.



Add the following string to the Qt project file (ecat_servo_motion.pro) using the Xenomai api.

```
[ecat_servo_motion.pro]
#cg4300
{
    INCLUDEPATH += /opt/xenomai-2.6.4/include
    INCLUDEPATH += /opt/poky/1.8/sysroots/cortexa9hf-vfp-neon-poky-linux-gnueabi/usr/include/qt5

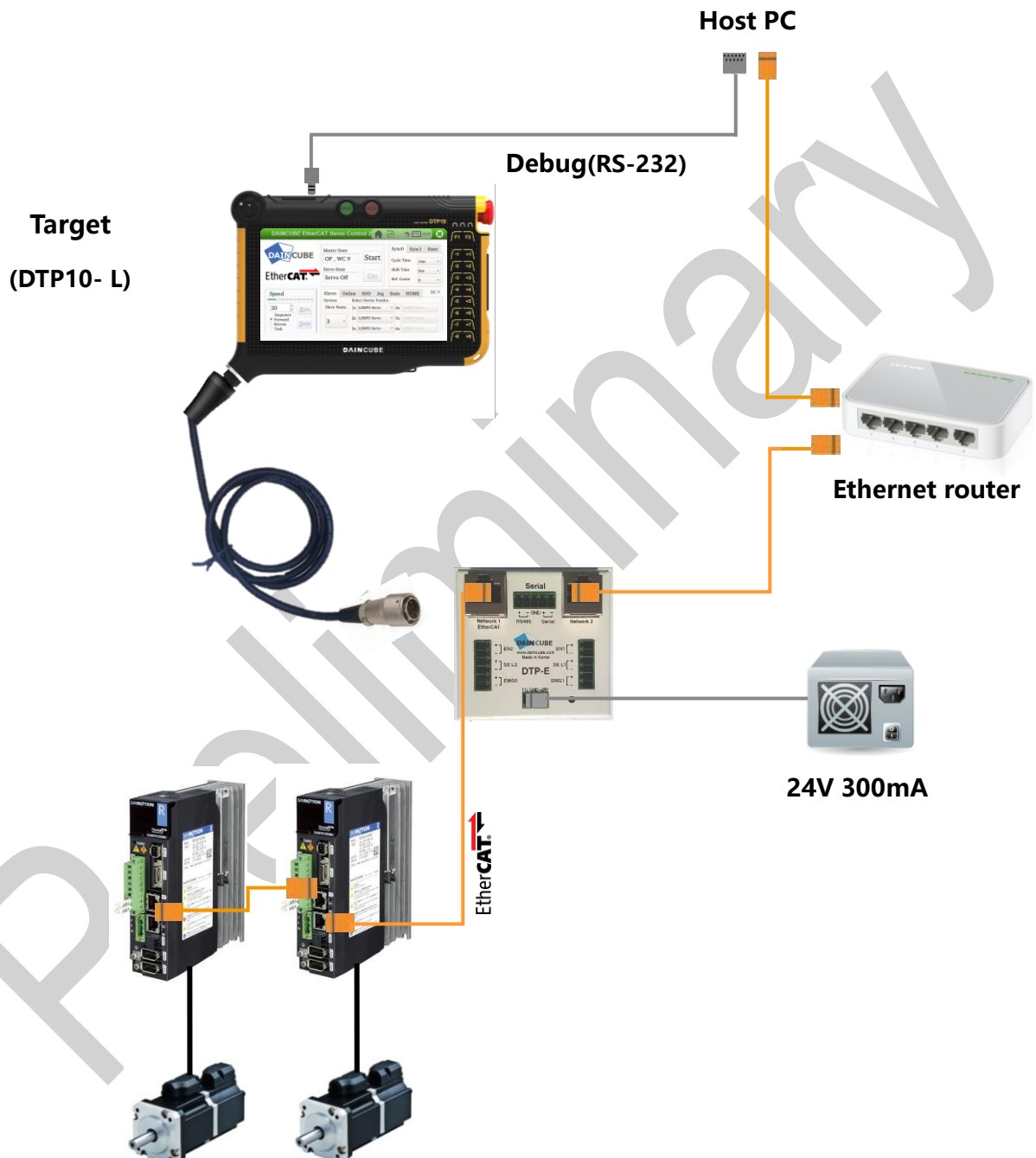
    LIBS += -lpthread -L/opt/xenomai-2.6.4/lib -lxenomai -lnative
    DEFINES += __LINUX_ARM_ARCH__

    target.path = /home/daincube
    INSTALLS += target
}
```

6. EtherCAT Example

This section describes how to use the example program to control the servo drive and motor and how to build it.

6.1. DTP10-L and Servo Driver Connection



6.2. EtherCAT Sample application description and usage

6.2.1. EtherCAT Master & sample application execution

After booting by connecting to DTP10-L as in above 6., power on DTP10-L and boot up. Then check the following files in "start.master" and "stop.master".

[Check to start.master script]

```
[root@CG4300-Q7 /]# vi /home/daincube/start.master

/etc/init.d/ethercat start          -> EtherCAT Master Start
insmod /lib/modules/3.14.38/ethercat/ec_ddcxen.ko
                                -> Add to EtherCAT Master Module
export LD_LIBRARY_PATH=/usr/xenomai/lib
export DISPLAY=:0

/home/daincube/ecat_servo_motion -c 1000 -v l -s 30 -t f -a 3 &

/home/daincube/ecat_servo_gui_qt5 &      -> Execute Qt application
```

[Check to stop.master script]

```
[root@CG4300-Q7 /]# vi /home/daincube/stop.master

/etc/init.d/ethercat stop          -> EtherCAT Master Start
rmmod ec_ddcxen                   -> Remove to EtherCAT Master Module
rmmod ec_fec                      -> Remove to Ethernet Module
```

From the DTP10-L Console terminal, enter the following commands to run the EtherCAT Master and Qt sample application.

```
[root@CG3300 /]#
[root@CG3300 /]# /home/daincube/start.master
Shutting down EtherCAT master 1.5.2 EtherCAT: Master module cleaned up.
done
Starting EtherCAT master 1.5.2 EtherCAT: Master driver 1.5.2 2eff7c993a63
EtherCAT 0: Registering RTDM device EtherCAT.
EtherCAT: 1 master waiting for devices.
IPv6: ADDRCONF(NETDEV_UP): sit0: link is not ready
ec_fec 2188000.ethernet: Unbalanced pm_runtime_enable!
... Syncopation ...
```

```

EtherCAT WARNING 0-2: Slave did not sync after 5000 ms.
EtherCAT 0: Slave states on main device: OP.
ec-app: Slave[0] Set SERVO_ON
ec-app: Slave[1] Set SERVO_ON
ec-app: Slave[2] Set SERVO_ON
ec-app: [slv_inx:0] = target_val:1886989899
ec-app: [slv_inx:1] = target_val:-990230200
ec-app: [slv_inx:2] = target_val:1053377192
ec-app: ServoRun ..

```

Command :

When this is done, the motor is running and the servo driver can be controlled by entering command at the DTP10-L console terminal.

6.2.2. Terminating the EtherCAT Master & sample application

When running EtherCAT sample application, enter the following command at the DTP10-L console terminal to terminate the sample application and then enter the command again to terminate the EtherCAT Master.

```

Command:
Command: exit
EtherCAT Stop
ec-app: dec_close_domain_data (0)

```

6.2.3. EtherCAT sample application argument

When you run EtherCAT sample application, you need to input and execute arguments for the servo driver.

Ex) ./ecat_servo_motion -c 1000 -a 2 -v l -s 25 -t f

Option	Argument	Range	Unit	Default
Cycle Time	-c	1000 ~ 16000	us	1000
Servo Axis	-a	1 ~ 6	Axis	2
Servo Vendor	-v	s: sanyo o: omron l: ls mecapion e: elmo	-	l: ls mecapion
Run Speed	-s	1 ~ 100	-	25
Run Type	-t	f: forward r: reverse	-	f: foward

		t: task		
--	--	---------	--	--

6.2.4. EtherCAT sample application command

You can control the servo driver by entering additional commands while running the EtherCAT sample application.

Option	Command	Operation
Servo ON	on	Servo driver status is Servo On status.
Servo OFF	off	Servo driver status becomes Servo OFF status.
Servo Run	run	Servo driver status becomes Servo Run status and motor starts.
Servo Stop	stop	Servo driver status becomes Servo Stop status and motor starts.
Exit	exit	Exit application

6.2.5. EtherCAT sample application build

Extract the file "DTP10-L_SDK >> Example >> EtherCAT_Example >> "ecat_servo_motion_qt_20170322.tar.gz" to the desired location on the host PC.

[How to unzip]

```
HOST_PC # mkdir /Example
HOST_PC # tar xvzf /home/daincube/ecat_servo_motion_qt_20170322.tar.gz
```

Refer to 5.4.3 and build from Qt.

6.3. Qt EtherCAT GUI example

This section explains how to use the Qt example program and how to build a motor by controlling the servo driver with the EtherCAT master of DTP10-L.

6.3.1. DTP10-L and servo driver connection

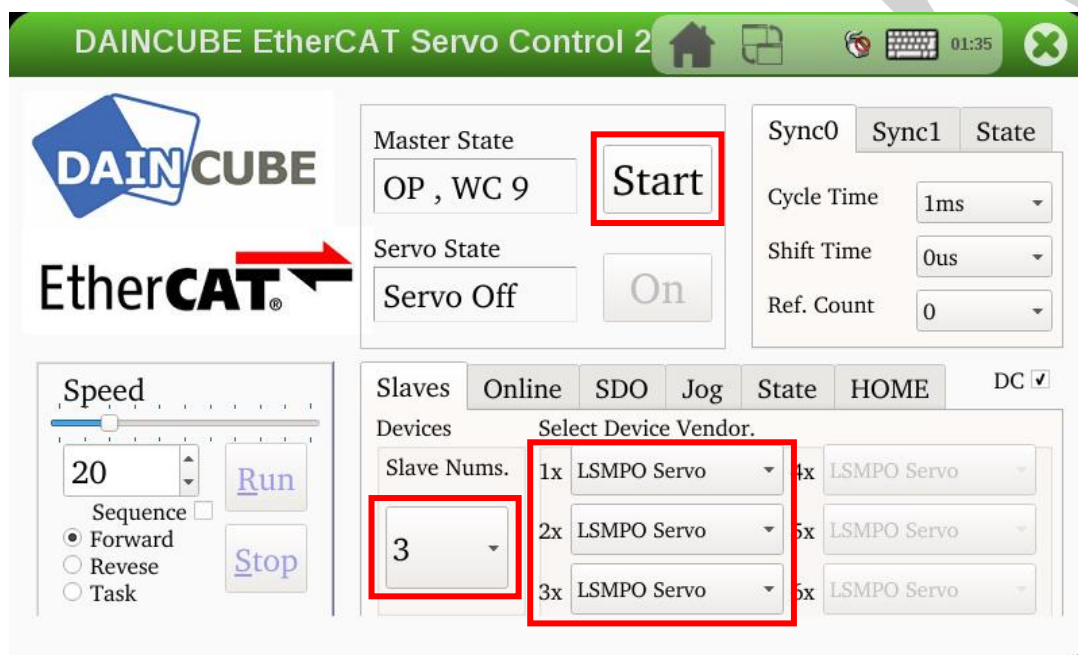
Refer to 6.1 and connect DTP10-L to servo driver.

6.3.2. Running the EtherCAT Master & Qt GUI sample application

When Qt application is executed, the following screen appears on the DTP10-L screen.

Set Cycle Timer, Slave Nums, Device vendor, Speed to slave device,

When you are finished, click "Start" button to start EtherCAT.

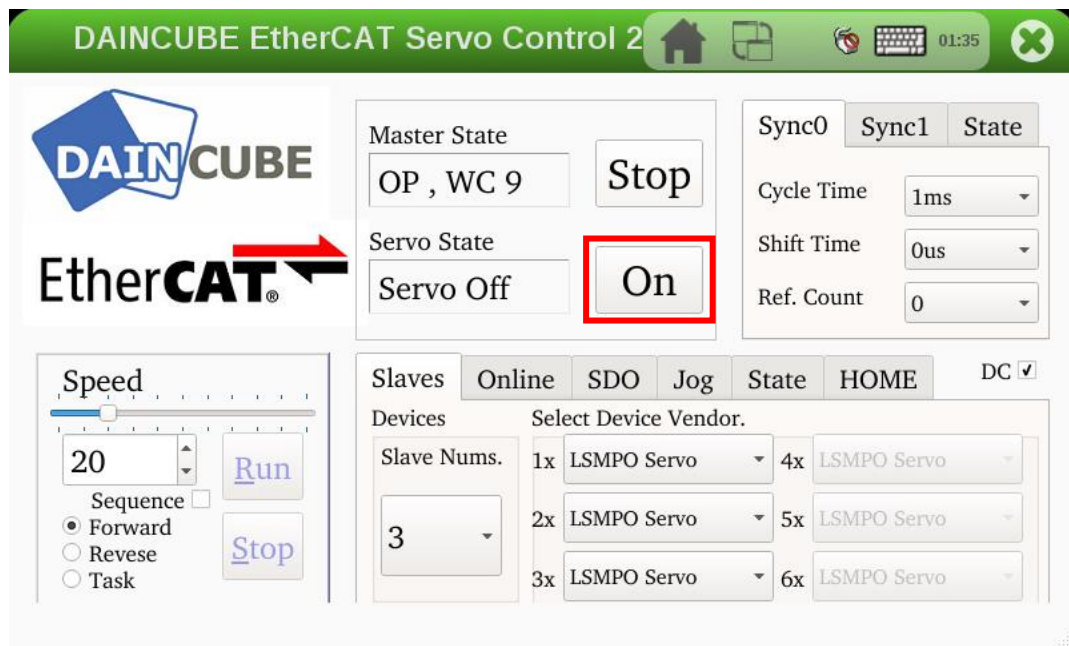


The slave device status is displayed in the EtherCAT state and you can see the state change.

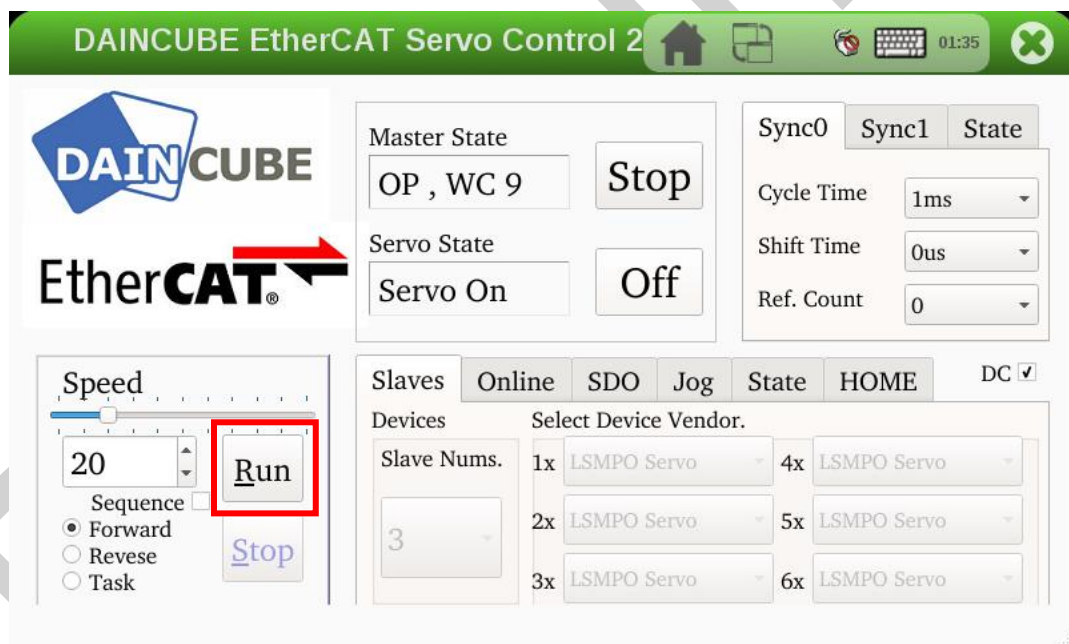
EtherCAT state changes to Pre-Op mode. Wait until OP mode changes.

If the slave state is changed to "OP" mode, the slave device is ready. Click the "On" button to activate the servo driver.

When Master state is "OP", press the "On" button to turn "Servo On".



Press the "Run" button to turn the motor.



7. FAQ

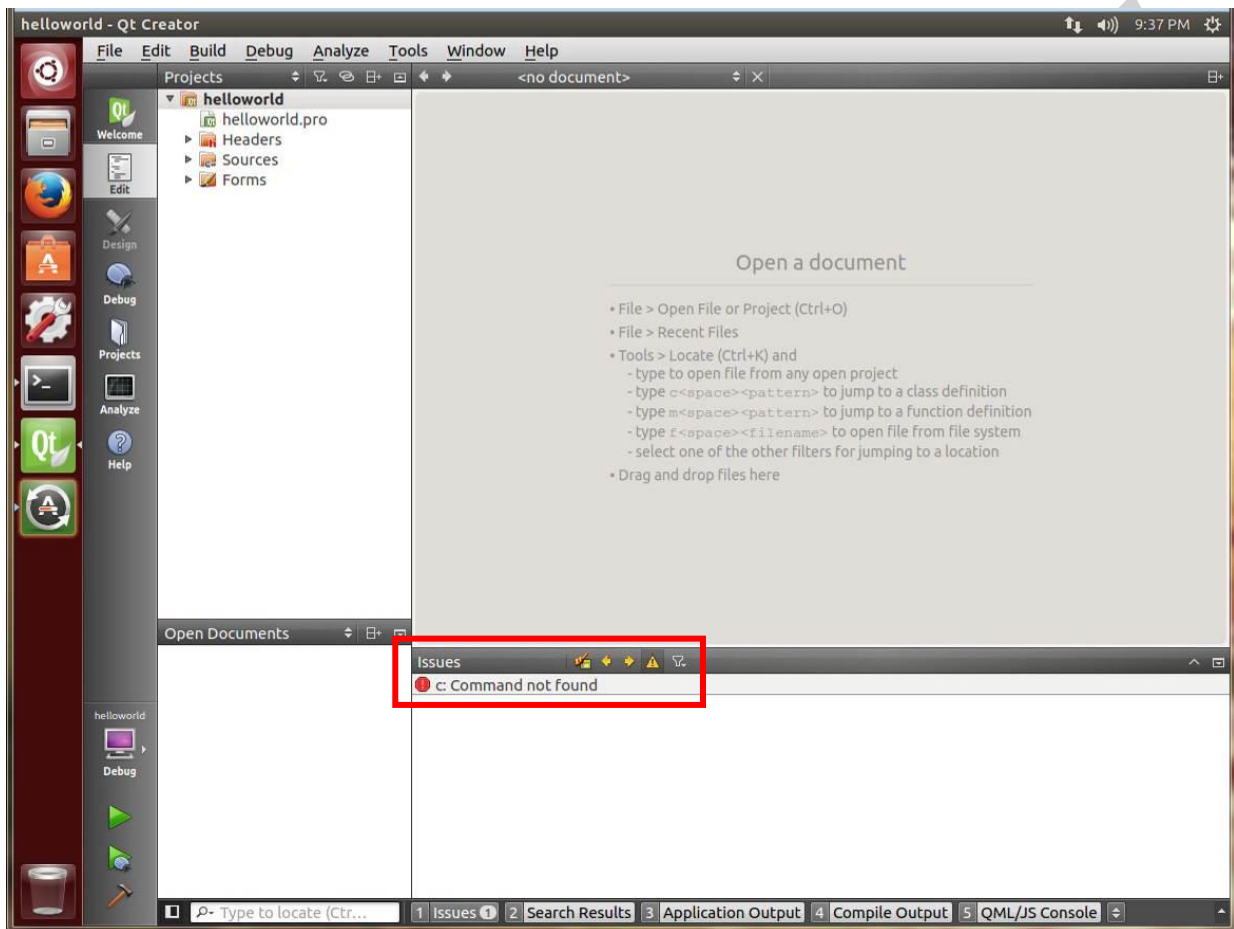
7.1. Default password

Target board (CG4300)

ID : root

PW : daincube

7.2. C: Command not found



Symptom : When running Qt Creator, c: Command not found

Cause : The path where the cross-compiler is installed should be recognized.

Solution : Execute `$ /opt/qtcreator-3.5.1/bin/qtcreator.sh &`

At this time, the path-related settings must be applied in qtcreator.sh.

