基于 Linux 的 EtherCAT 开发例程使用手册

Revision History

Draft Date	Revision No.	Description
2018/06/17	V1.0	1. 初始版本。

目　　录

1 实验说明

本文介绍使用广州创龙 AM437x 开发板、Linux-3.14.43 内核，提供基于 EtherCAT 协议控制伺服驱动器，驱动伺服电机运转的方法。

表 1

开发板型号	是否支持本实验
TL437x-EVM	支持
TL437x-EasyEVM	支持
TL437x-IDK	支持
TL437xF-EVM	支持

本实验开发环境：

硬件：伺服驱动器——SANYO RS2A03A0KA4W00

伺服电机——SANYO R2AA08075FXH00W

软件：EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval.tar.gz （例程源码压缩包）

EC-Engineer （版本不定，会定期持续更新，路径为：光盘资料\Tools\Windows）

内核版本：Linux-3.14.43

2 Linux 内核编译

由于 EtherCAT 主站不能使用普通网口的驱动，所以需要重新配置 Linux 内核，把普通网口驱动（即 TI CPSW 驱动）从内核删除。为便于测试，我司提供经验证的内核镜像文件位于光盘“Demo\EtherCAT\Linux-EtherCAT”目录，将其复制开发板文件系统 rootfs 分区 boot 目录下，并按照《Linux 内核编译方法》文档步骤，重新编译驱动模块并安装到开发板文件系统。以下提供修改内核 CPSW 驱动的具体方法。

打开 Ubuntu，进入 Linux-3.14.43 内核源码顶层目录。按照《Linux 内核编译方法》文档依次执行清理内核、配置内核步骤，直到执行如下命令，进入内核图形配置界面：

```
Host#    make ARCH=arm CROSS_COMPILE=arm-linux-gnueabihf- menuconfig
```

```
tronlong@tronlong-virtual-machine:~/AM437x/kernel/Linux-3.14.43$ pwd
/home/tronlong/AM437x/kernel/Linux-3.14.43
tronlong@tronlong-virtual-machine:~/AM437x/kernel/Linux-3.14.43$ make ARCH=arm C
ROSS_COMPILE=arm-linux-gnueabihf- menuconfig
scripts/kconfig/mconf Kconfig
```

图 1

进入“Device Drivers > Network device support > Ethernet driver support”路径，将“TI CPSW Switch Support”选项修改为 M，即 TI CPSW 驱动编译成模块；或者把选项改成空，即 TI CPSW 驱动从内核删除。

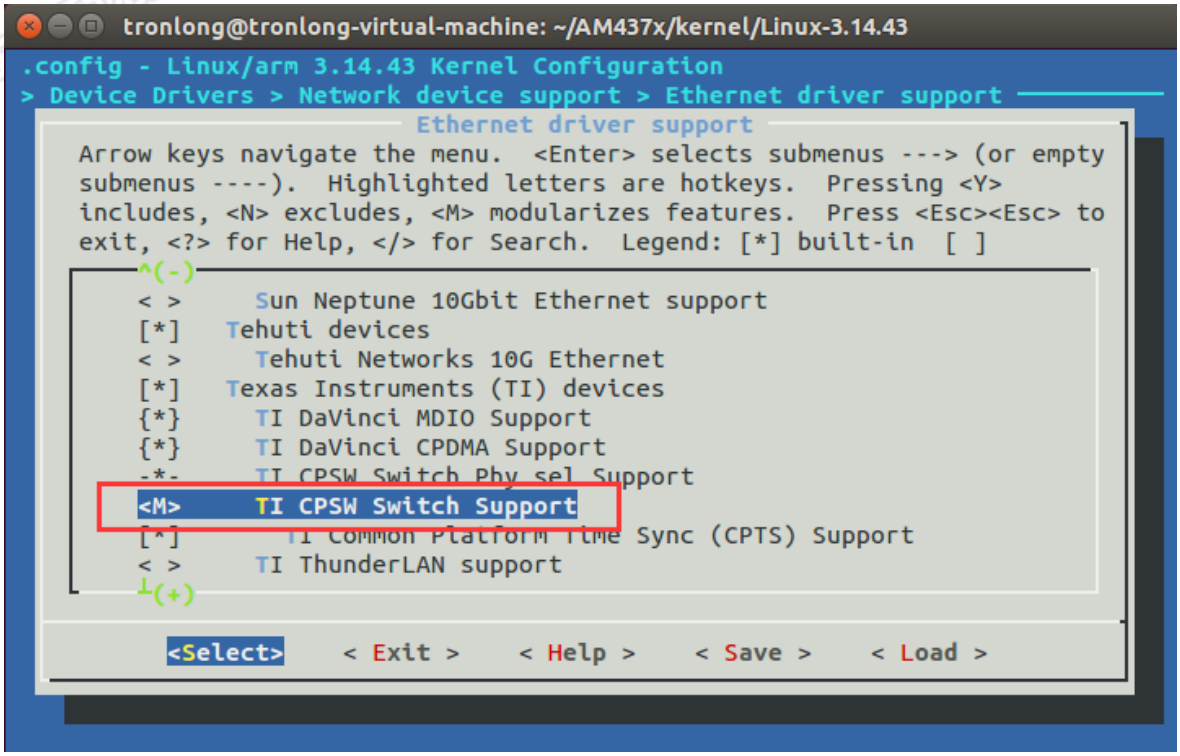

图 2

按照《Linux 内核编译方法》文档，重新编译修改后的 Linux 内核。将在“arch/arm/boot”路径下编译生成的 zImage 内核镜像文件替换到 SD 系统卡 rootfs 分区的 boot 目录下，重新编译驱动模块，并将其安装到 SD 卡文件系统目录下。

3 编译 EtherCAT 主站驱动和应用程序

3.1 编译 EtherCAT 主站驱动

在 Ubuntu 上新建 EtherCAT 例程工作目录“Linux_EtherCAT”，将光盘资料“Demo\EtherCAT\Linux-EtherCAT”目录下的 EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval.tar.gz 源码压缩文件拷贝到该目录。进入该目录，执行如下指令解压源码到当前路径：

Host# tar zxvf EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval.tar.gz -C .

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT$ pwd
/home/tronlong/AM437x/Linux_EtherCAT
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT$ ls
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval.tar.gz
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT$ tar zxvf EC-Master-V2
.9-Linux_armv6-vfp-eabihf-Eval.tar.gz -C .
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/License.txt
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Bin/
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Bin/Linux/
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Bin/Linux/armv6-vfp-eabihf/
```

图 3

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT$ ls
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval
EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval.tar.gz
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT$
```

解压出来的源码

图 4

进入源码“EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys”路径，打开 Makefile 文件：

Host# cd EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys

Host# gedit Makefile

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT$ cd EC-Master-V2.9-Lin
ux_armv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys$ ls
atemsys.c  atemsys.h  Makefile
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys$ gedit Makefile
```

图 5

按照如下要求修改 Makefile 文件对应参数：

KERNELDIR=用户 Linux 内核源码路径实际路径

CROSS_COMPILE=用户交叉编译工具实际路径

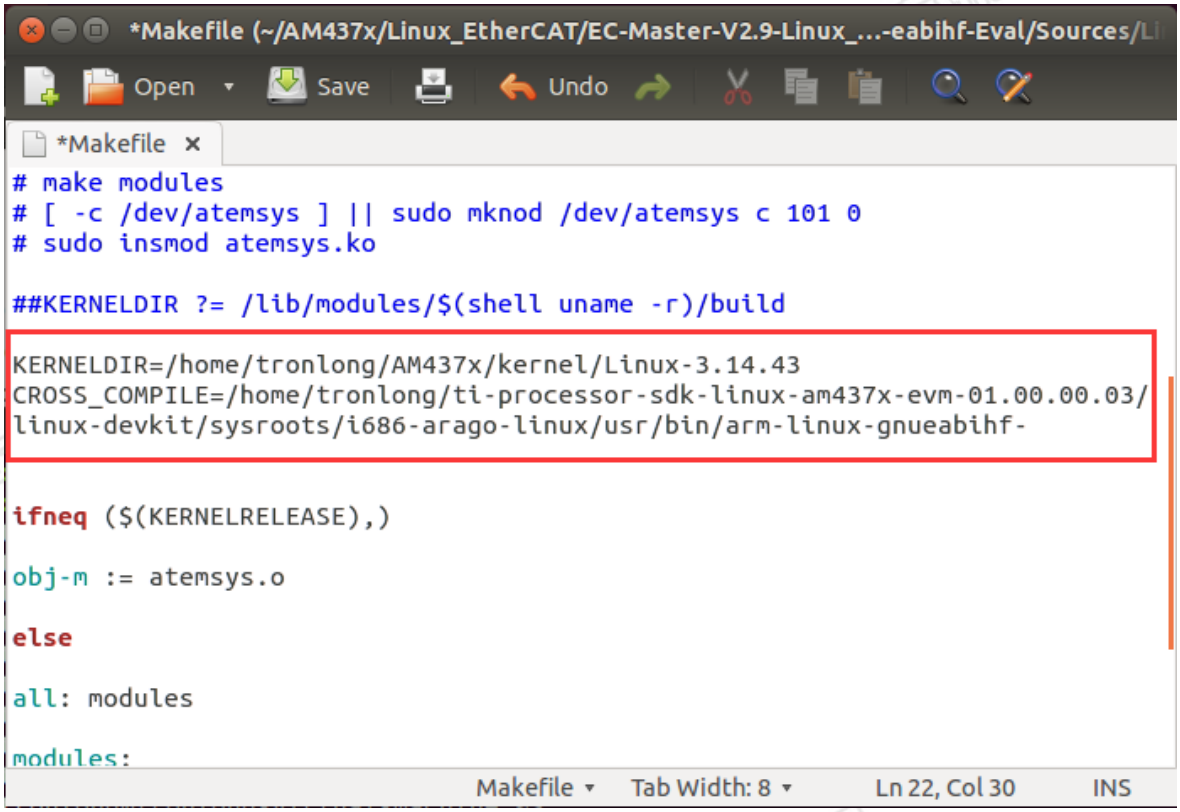

图 6

修改完保存退出，在当前目录下执行 make 指令，编译生成 atemsys.ko 驱动模块，将其拷贝到 SD 卡文件系统“/home/root”目录下。为便于测试，我司提供经验证 atemsys.ko 文件位于光盘“Demo\EtherCAT\Linux-EtherCAT”目录下。

Host# make

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys$ pwd
/home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/
Sources/LinkOsLayer/Linux/atemsys
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys$ make
make -C /home/tronlong/AM437x/kernel/Linux-3.14.43 M=/home/tronlong/AM437x/Linux
_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/a
temsys modules ARCH=arm CROSS_COMPILE=/home/tronlong/ti-processor-sdk-linux-am43
7x-evm-01.00.00.03/linux-devkit/sysroots/i686-arago-linux/usr/bin/arm-linux-gnue
abihf-
make[1]: Entering directory `/home/tronlong/AM437x/kernel/Linux-3.14.43'
  CC [M]  /home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-ea
bihf-Eval/Sources/LinkOsLayer/Linux/atemsys/atemsys.o
  Building modules, stage 2.
  MODPOST 1 modules
  CC      /home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-ea
bihf-Eval/Sources/LinkOsLayer/Linux/atemsys/atemsys.mod.o
  LD [M]  /home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-ea
bihf-Eval/Sources/LinkOsLayer/Linux/atemsys/atemsys.ko
make[1]: Leaving directory `/home/tronlong/AM437x/kernel/Linux-3.14.43'
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys$ ls
atemsys.c  atemsys.ko     atemsys.mod.o  Makefile    modules.order
atemsys.h  atemsys.mod.c  atemsys.o      Makefile~   Module.symvers
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Sources/LinkOsLayer/Linux/atemsys$
```

图 7

同时将“EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Bin/Linux/armv6-vfp-eabihf/”目录下的 libemllCPSW.so 文件拷贝到 SD 卡文件系统“/home/root”目录下。

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Bin/Linux/armv6-vfp-eabihf$ pwd
/home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/
Bin/Linux/armv6-vfp-eabihf
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Bin/Linux/armv6-vfp-eabihf$ ls
EcMasterDemo2Eval  EcMasterDemoSyncSmEval  libemllSockRaw.so
EcMasterDemoEval   libemllCPSW.so
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Bin/Linux/armv6-vfp-eabihf$
```

图 8

3.2 编译 EcMasterDemoDC_motor

进入“EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor”目录，打开并修改 Makefile 环境变量：

Host# gedit Makefile

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor$ pwd
/home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/
Examples/EcMasterDemoDC_motor
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor$ gedit Makefile
```

图 9

CROSS_COMPILE=用户具体的交叉编译工具路径

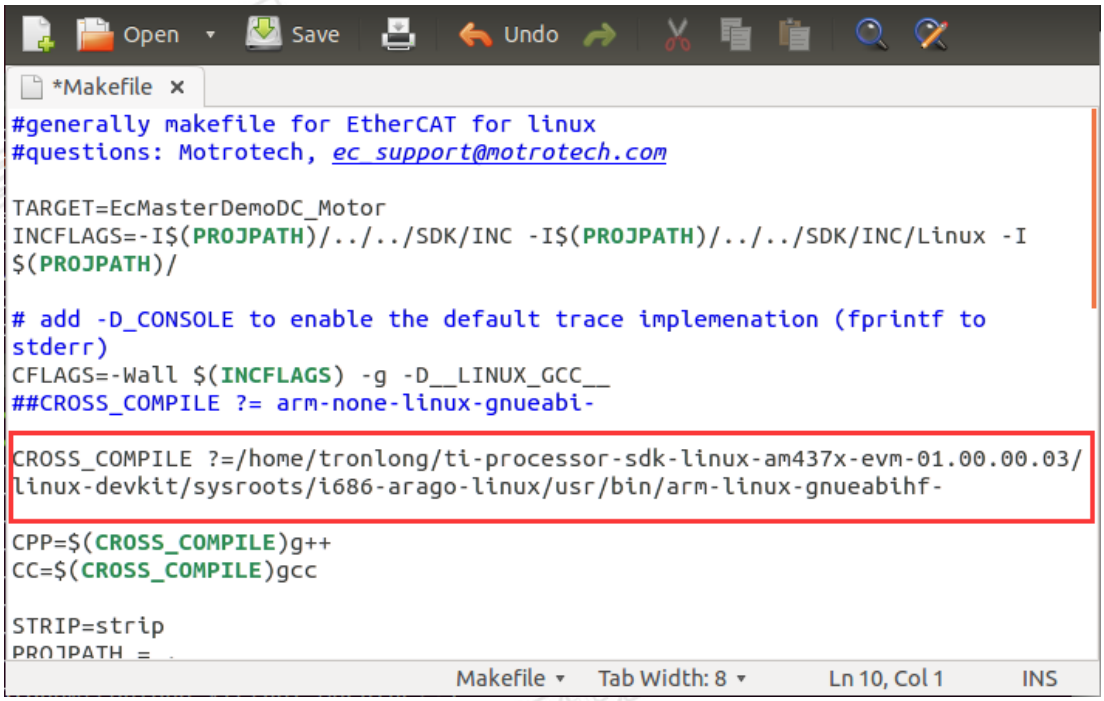

图 10

修改完保存退出，执行 make 指令，编译后生成 EcMasterDemoDC_Motor 文件，将其拷贝到 SD 卡文件系统“/home/root”目录下。为便于测试，我司提供经验证 EcMasterDemoDC_Motor 文件位于光盘“Demo\EtherCAT\Linux-EtherCAT”目录下。

Host# make

```
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor$ pwd
/home/tronlong/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_armv6-vfp-eabihf-Eval/
Examples/EcMasterDemoDC_motor
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor$ make
/home/tronlong/ti-processor-sdk-linux-am437x-evm-01.00.00.03/linux-devkit/sysroo
ts/i686-arago-linux/usr/bin/arm-linux-gnueabihf-g++ -L. -o EcMasterDemoDC_Motor
DCDemoMain.o DCDemo.o ecatDemoCommon.o ecatNotification.o Logging.o selectLinkLa
yer.o motrotech.o -Wall -I./../../SDK/INC -I./../../SDK/INC/Linux -I./  -g -D__L
INUX_GCC__  -L./../../SDK/LIB/Linux/armv6-vfp-eabihf -lAtemRasSrv -lEcMaster -lp
thread -lm -ldl -lrt
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor$ ls
DCDemoConfig.h      ecatDemoCommon.h      Logging.h      selectLinkLayer.cpp
DCDemo.cpp          ecatDemoCommon.o      Logging.o      selectLinkLayer.h
DCDemo.h            ecatNotification.cpp  Makefile       selectLinkLayer.o
DCDemoMain.cpp      ecatNotification.h    Makefile~      SlaveInfo.h
DCDemoMain.o        ecatNotification.o    motrotech.cpp
DCDemo.o            EcMasterDemoDC_Motor  motrotech.h
ecatDemoCommon.cpp  Logging.cpp           motrotech.o
tronlong@tronlong-virtual-machine:~/AM437x/Linux_EtherCAT/EC-Master-V2.9-Linux_a
rmv6-vfp-eabihf-Eval/Examples/EcMasterDemoDC_motor$
```

图 11

4 生成 MasterMotor 的 ENI 配置文件

将光盘“Tools\Windows”目录下的 EC-Engineer 压缩文件（版本不定，会定期持续更新）解压并安装，将电机驱动器通过网线与电脑连接，同时需要确保电脑能够正常接入互联网。打开 EC-Engineer，点击“Online configuration”选择 Class A 工程：

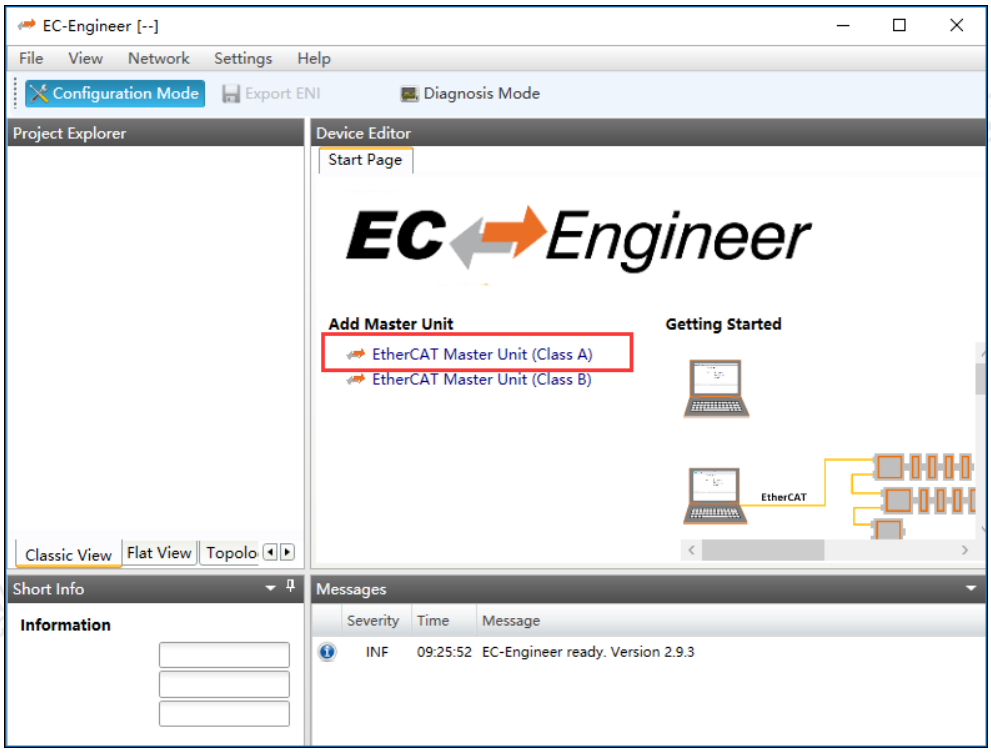

图 12

选择 File > ESI Manager，将电机驱动器的 RS2-ECT_P0002813E01_20130601.xml 文件添加进去。

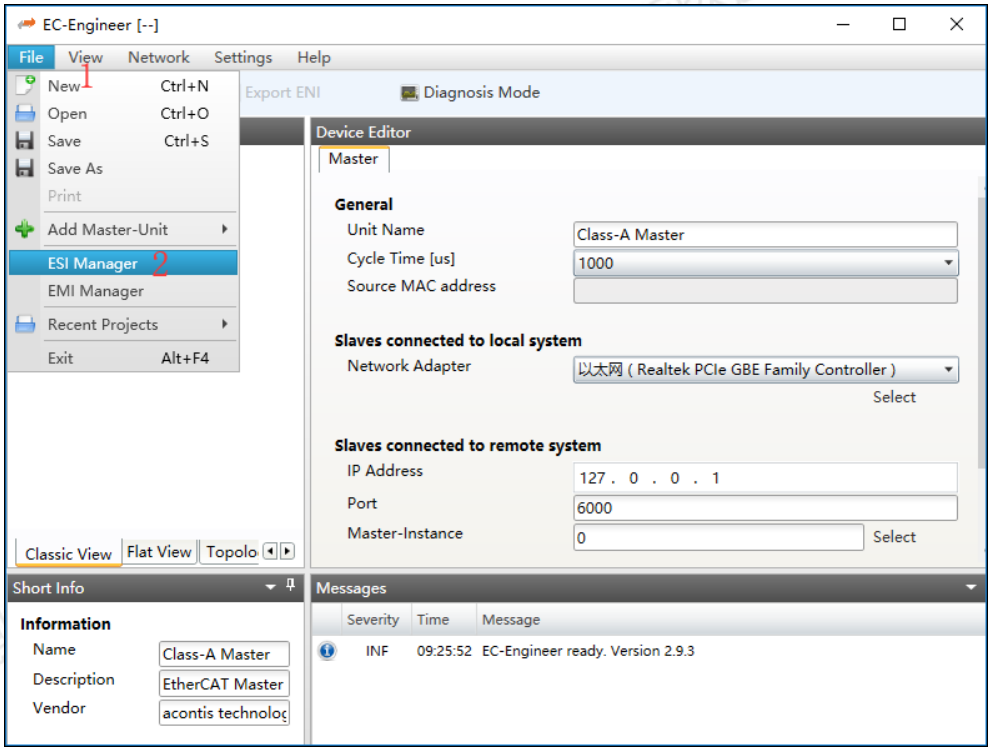

图 13

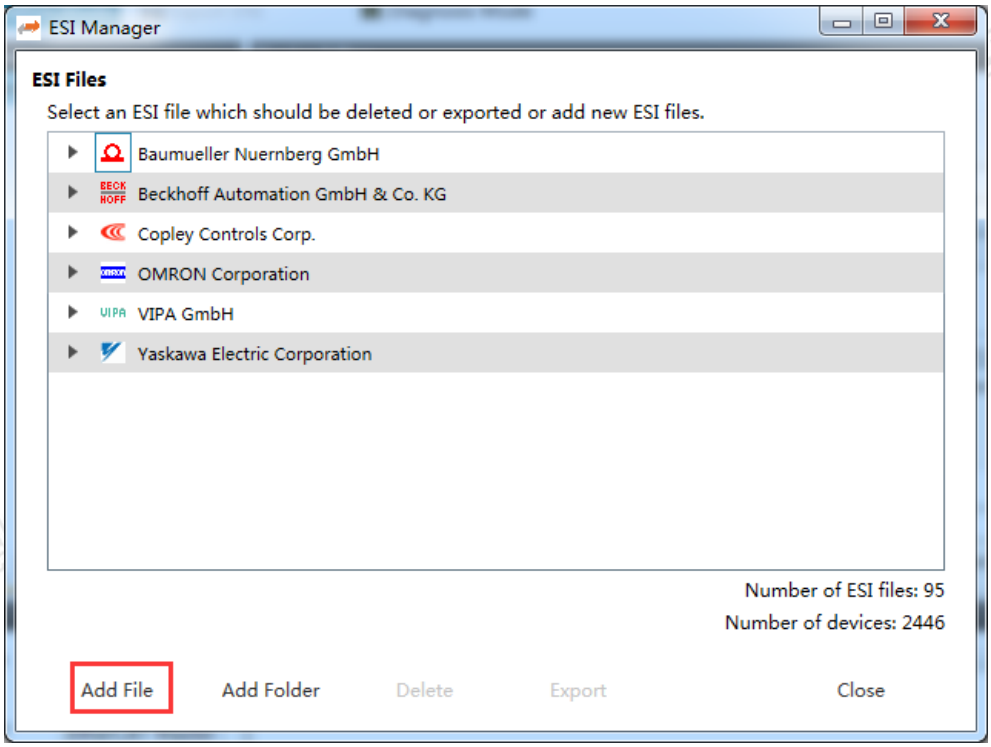

图 14

选择对应厂家提供的.xml 文件：

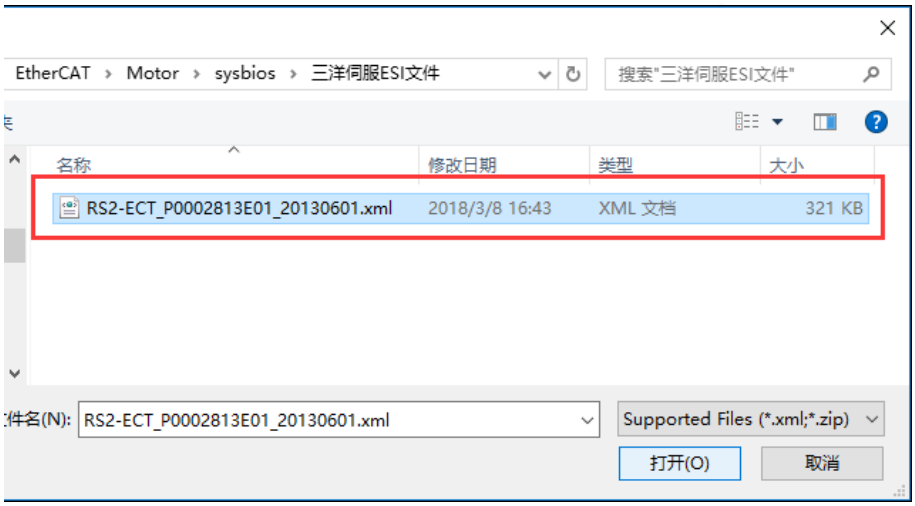

图 15

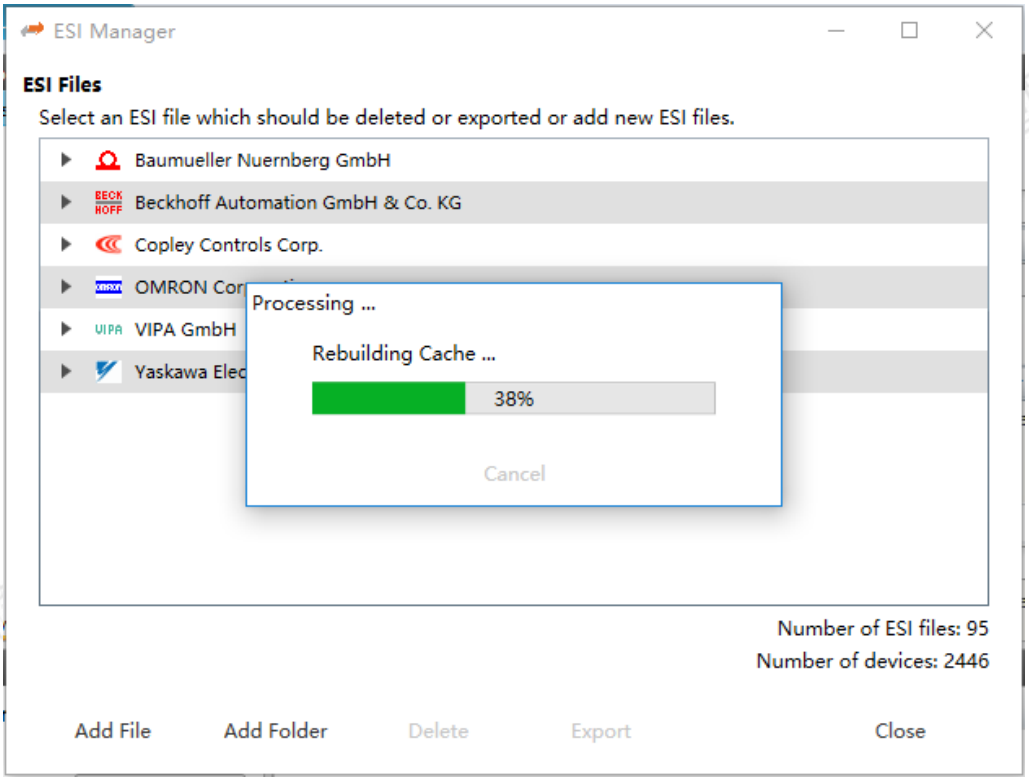
ESI Manager
ESI Files
Select an ESI file which should be deleted or exported or add new ESI files.
Baumueller Nuernberg GmbH
Beckhoff Automation GmbH & Co. KG
Copley Controls Corp.
OMRON Cor
VIPA GmbH
Yaskawa Elec
Processing ...
Rebuilding Cache ...
38%
Cancel
Number of ESI files: 95
Number of devices: 2446
Add File
Add Folder
Delete
Export
Close

图 16

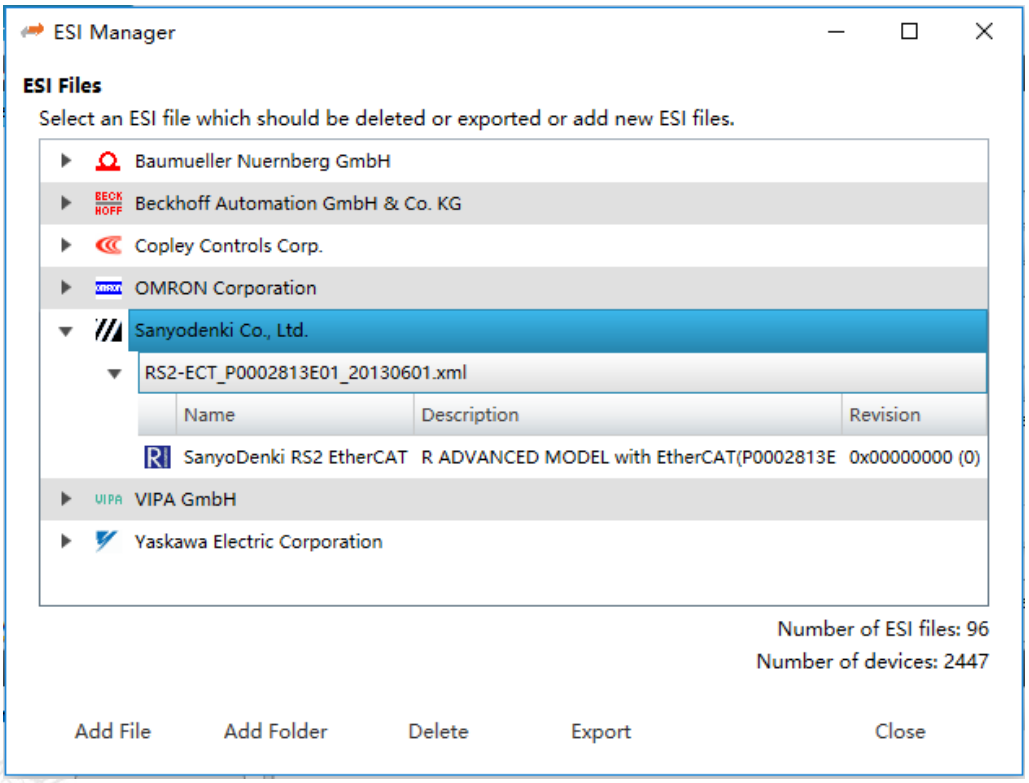
ESI Manager
ESI Files
Select an ESI file which should be deleted or exported or add new ESI files.
Baumueller Nuernberg GmbH
Beckhoff Automation GmbH & Co. KG
Copley Controls Corp.
OMRON Corporation
Sanyodenki Co., Ltd.
RS2-ECT_P0002813E01_20130601.xml
Name
Description
Revision
SanyoDenki RS2 EtherCAT
R ADVANCED MODEL with EtherCAT(P0002813E
0x00000000 (0)
VIPA GmbH
Yaskawa Electric Corporation
Number of ESI files: 96
Number of devices: 2447
Add File
Add Folder
Delete
Export
Close

图 17

Cycle Time 选择 1000us，在 Network Adapter 选项栏里选择从站连接的网卡，按 Select 进行连接，连接后按钮变为 Deselect 。（Cycle Time 的大小可能会影响电机的抖动，具体根据实际的电机设置，此处使用 1000us。）

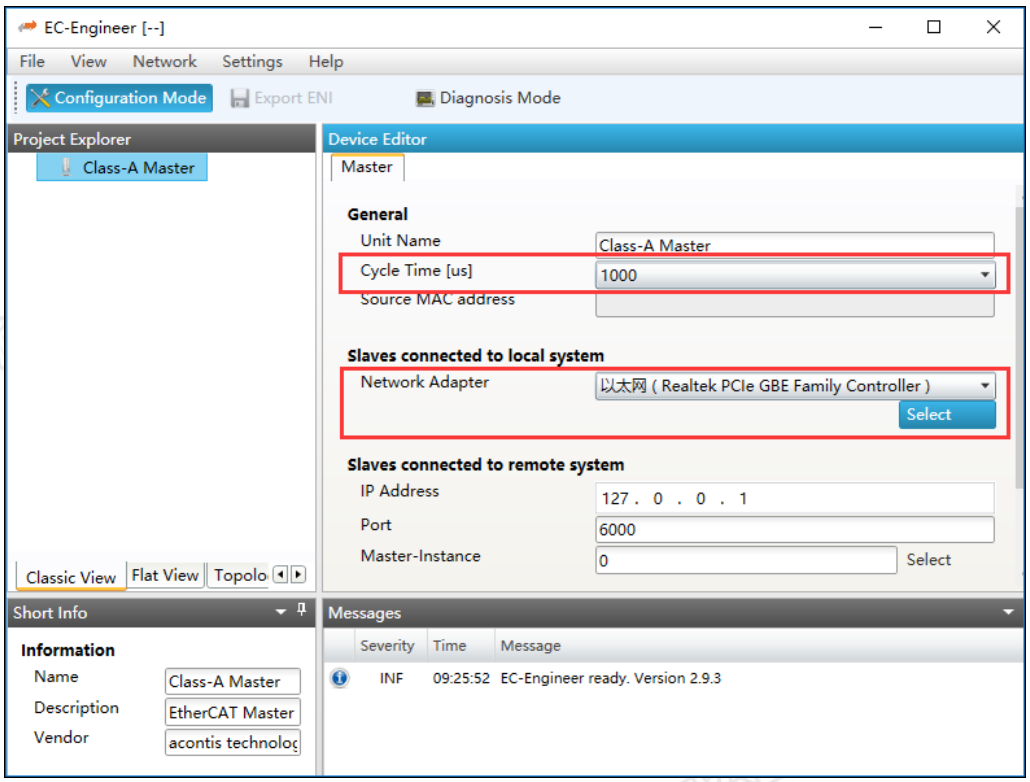

图 18

点击 Network 扫描从站设备：

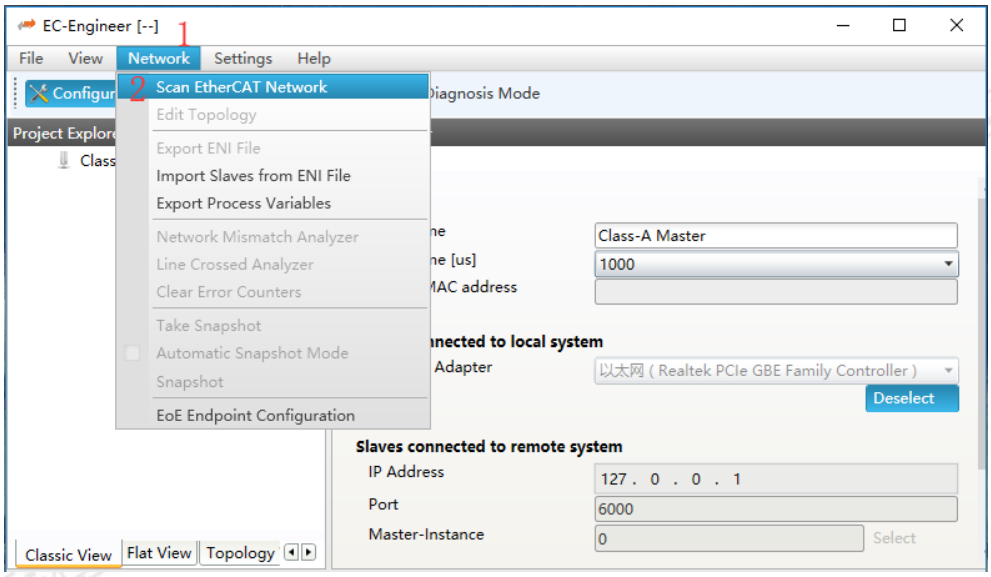

图 19

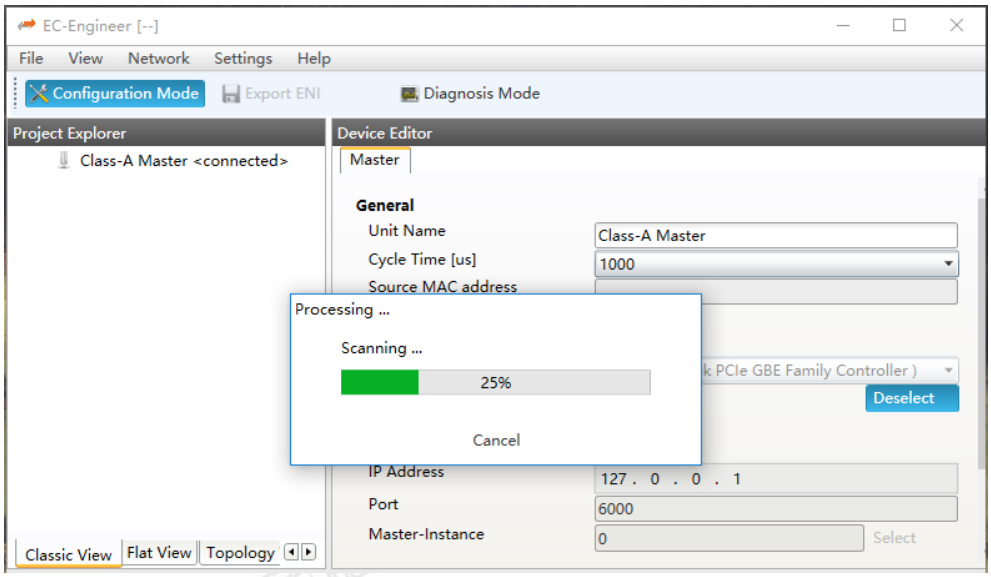

图 20

成功扫描出从站之后，选中从站设备，点击 Exports ENI 按钮生成从站的 eni 文件。文件名可自拟，这里文件名设定为 eni_SANYO_motor，按 Diagnosis Mode 按钮可以观察从站信息。

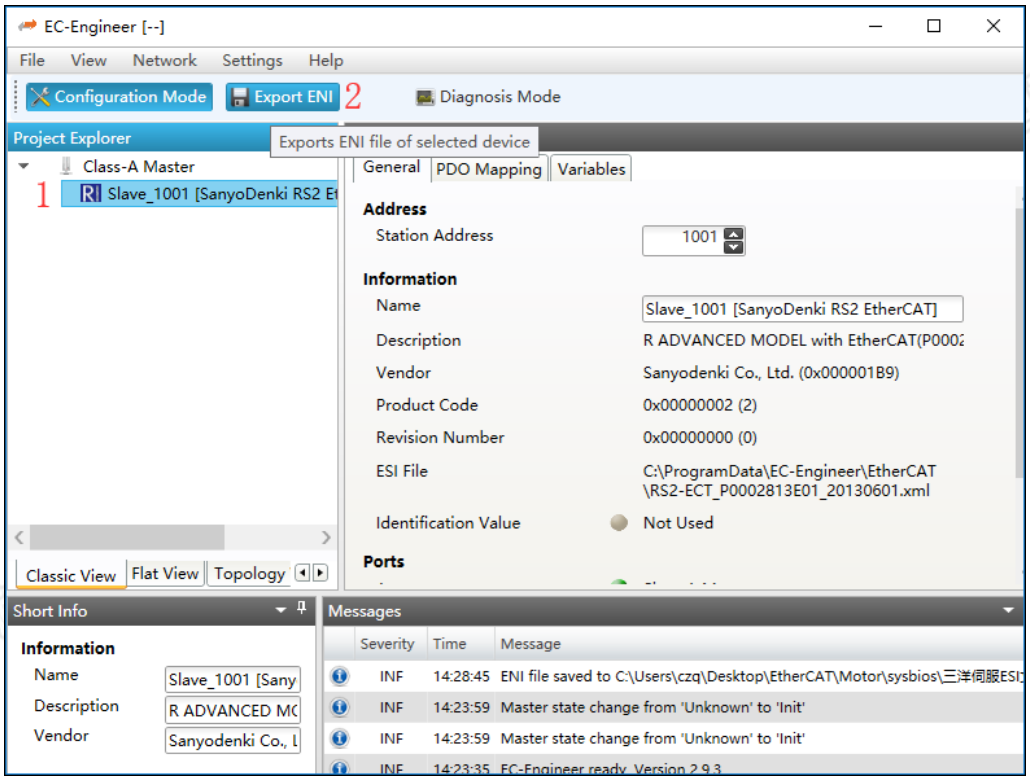

图 21

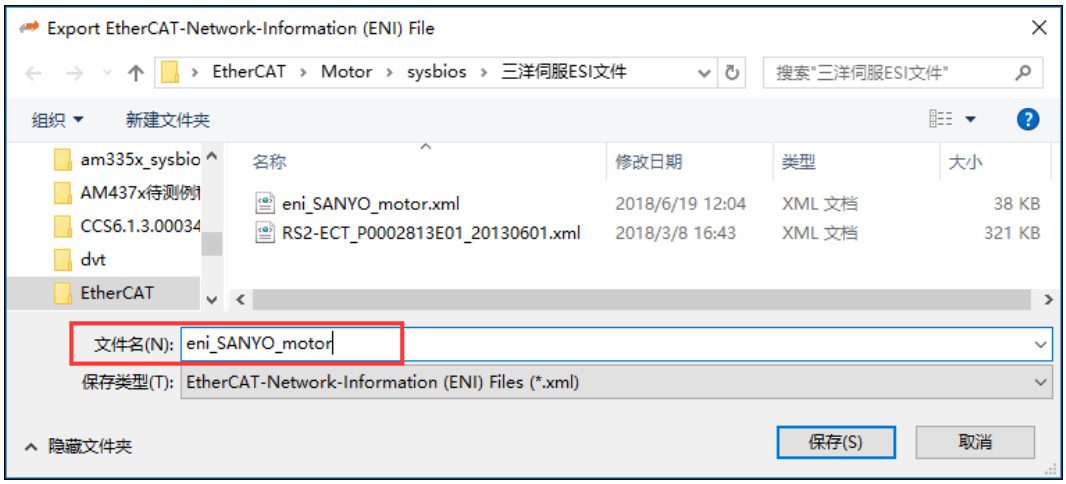

图 22

此时会在当前路径生成 eni_SANYO_motor.xml 配置文件，该文件记录了从站的配置信息，文件配置的 cycle time 为 1000us，不同型号伺服驱动器生成的.xml 文件不同。将配置生成的 eni_SANYO_motor.xml 文件拷贝到开发板文件系统“/home/root”目录下。

5 运行程序

开发板上电启动进入文件系统，可以看到当前目录下应包含如下四个文件：

```
root@AM437x-Tronlong:~# pwd
/home/root
root@AM437x-Tronlong:~# ls
EcMasterDemoDC_Motor   eni_SANYO_motor.xml
atemsys.ko             libemllCPSW.so
root@AM437x-Tronlong:~#
```

图 23

将网线连接开发板千兆网口到伺服驱动器的以太网口 CN0，开发板文件系统执行如下指令卸载 ti_cpsw 驱动（普通网口驱动），卸载过程中的报错信息可忽略。卸载前确认已将 CPSW 驱动编译成模块，或者已从内核直接删除 CPSW 驱动。

Target# rmmod ti_cpsw

```
root@AM437x-Tronlong:~# rmmod ti_cpsw
[   41.014993] Unable to handle kernel NULL pointer dereference at virtual address 00000
00d
[   41.023237] pgd = dc6f8000
[   41.025969] [0000000d] *pgd=9d50c831, *pte=00000000, *ppte=00000000
[   41.032316] Internal error: Oops: 17 [#1] ARM
[   41.036701] Modules linked in: xhci_plat_hcd xhci_hcd dwc3 btwilink bluetooth ti_vpfe
 videobuf2_dma_contig videobuf2_memops ov2659 v4l2_common videobuf2_core 6lowpan_iphc vi
deodev c_can_platform ti_am335x_adc at24 ads7846 snd_soc_tlv320aic3x kfifo_buf industria
lio ti_cpsw(-) c_can dwc3_omap media can_dev
[   41.064047] CPU: 0 PID: 1738 Comm: rmmod Not tainted 3.14.43 #3
[   41.070008] task: dd5a8400 ti: dc6e2000 task.ti: dc6e2000
[   41.075457] PC is at omap_device_idle+0x18/0x80
[   41.080022] LR is at _od_runtime_suspend+0x24/0x2c
[   41.084849] pc : [<c0025f28>]    lr : [<c0025fb4>]    psr: a00f0013
[   41.084849] sp : dc6e3cc0  ip : dc6e3cd8  fp : dc6e3cd4
[   41.096390] r10: dd677210  r9 : c08969f0  r8 : c08969f0
[   41.101648] r7 : 00000008  r6 : 00000000  r5 : 00000000  r4 : 00000000
[   41.108214] r3 : 00000000  r2 : c0025f90  r1 : dd677210  r0 : dd677200
[   41.114784] Flags: NzCv  IRQs on  FIQs on  Mode SVC_32  ISA ARM  Segment user
[   41.121963] Control: 10c5387d  Table: 9c6f8059  DAC: 00000015
[   41.127743] Process rmmod (pid: 1738, stack limit = 0xdc6e2238)
[   41.133699] Stack: (0xdc6e3cc0 to 0xdc6e4000)
[   41.138097] 3cc0: 00000000 dd677210 dc6e3cec dc6e3cd8 c0025fb4 c0025f1c dd677210 0000
```

图 24

卸载 CPSW 驱动后，用 ifconfig 命令查看，没有 eth0 和 eth1 网卡设备表示正常。

```
root@AM437x-Tronlong:~# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:124 errors:0 dropped:0 overruns:0 frame:0
          TX packets:124 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:188753 (184.3 KiB)  TX bytes:188753 (184.3 KiB)

root@AM437x-Tronlong:~#
```

图 25

执行如下指令，加载 EtherCAT 主站驱动：

Target# insmod atemsys.ko

```
root@AM437x-Tronlong:~# insmod atemsys.ko
[  213.443421] atemsys: atemsys v1.2.15 loaded
root@AM437x-Tronlong:~#
```

图 26

执行如下指令运行主站程序 EcMasterDemoDC_Motor，可以看到电机正反转一次然后停止，串口打印信息如下：

Target# ./EcMasterDemoDC_Motor -f eni_SANYO_motor.xml -auxclk 1000 -v 2 -t 50000 -perf -cpsw 1 1 1 m custom am437X 4 1 0

指令注释：

- -f eni_SANYO_motor.xml：加载网络配置 eni.xml 文件；
- -auxclk 1000：cycle time 1000us
- -v 2：信息打印级别为 2
- -t 10000：持续时间，Time in msec, 0 = forever (default = 120000)
- -perf：打印性能参数；
- -cpsw 1 1 1 m custom am437X-idk：网口类型为 ti 的 CPSW，port 1，Polling 模式，high priority，Master，RefBoard
- 4 1 0 分别是 PHY address，PHY connection mode， Not use DMA buffers

```
root@AM437x-Tronlong:~# ./EcMasterDemoDC_Motor -f eni_SANYO_motor.xml -auxclk 1000 -v 2 -t
 -perf -cpsw 1 1 1 m custom am437X 4 1 0
Full command line: -f "eni_SANYO_motor.xml"-auxclk 1000 -v 2 -t 10000 -perf -cpsw 1 1 1 m
custom am437X 4 1 0
```

图 27

```
000007 : Run demo now with cycle time 1000 usec
000007 : Using AuxClock
[  140.151415] atemsys: device_open(0xdb833a40)
[  140.156037] atemsys: mmap: mapped IO memory, Phys:0x44df9000 UVirt:0xb6eb2000 Size:4096
[  140.755479] atemsys: mmap: mapped IO memory, Phys:0x44e10000 UVirt:0xb6eb1000 Size:8192
[  140.763733] atemsys: mmap: mapped IO memory, Phys:0x4a100000 UVirt:0xb6eab000 Size:3276
8
[  140.776438] atemsys: mmap: mapped DMA memory, Phys:0x9e500000 KVirt:0xde500000 UVirt:0x
b6dea000 Size:790528
000007 : Calibrate tsc measurement... done: 1000 MHz
003009 : ========================
003009 : Initialize EtherCAT Master
003009 : ========================
003009 : EC-Master V2.9.1.06 (Protected) for Linux_armv6-vfp-eabihf Copyright acontis tech
nologies GmbH @ 2016
003012 : OsGetLinkLayerRegFunc: try to load '/home/root/libemllCPSW.so'
003626 : CPSW INF: Port 1, Prio 1, Flags [Polling] [Master], Phy 4, PhyInterface 32,  MAC
60:64:05:67:f2:aa

003676 : CPSW INF: CPSW3G found. CPSW INF: HW-Id: 0x0019, RTL: 0, Major: 1, Minor: 0xf
003677 : CPSW INF: PHY found. Id=0x00221622
003678 : CPSW INF: Restart PHY auto negotiation
005386 : CPSW INF: PHY auto negotiation completed
005439 : Unlicensed version, stop sending ethernet frames after 60 minutes!
005477 : Bus scan successful - 1 slaves found
005497 : 1 identical messages skipped
005497 : ********************************************************************************
```

图 28

```
011783 : ============================================================
011783 : PerfMsmt 'JOB_ProcessAllRxFrames' (avg/max) [usec]:   60.4/119.6
011783 : PerfMsmt 'JOB_SendAllCycFrames  ' (avg/max) [usec]:   32.3/ 85.0
011783 : PerfMsmt 'JOB_MasterTimer       ' (avg/max) [usec]:   16.0/ 48.2
011783 : PerfMsmt 'JOB_SendAcycFrames    ' (avg/max) [usec]:   35.3/ 70.7
011783 : PerfMsmt 'Cycle Time            ' (avg/max) [usec]:  997.7/1053.5
011783 : PerfMsmt 'myAppWorkPd           ' (avg/max) [usec]:    4.0/ 12.5
011783 : PerfMsmt 'Write DCM logfile     ' (avg/max) [usec]:    2.1/  4.5
013787 : ============================================================
013787 : PerfMsmt 'JOB_ProcessAllRxFrames' (avg/max) [usec]:   54.1/119.6
013787 : PerfMsmt 'JOB_SendAllCycFrames  ' (avg/max) [usec]:   28.3/ 86.4
013787 : PerfMsmt 'JOB_MasterTimer       ' (avg/max) [usec]:   12.9/ 48.2
013787 : PerfMsmt 'JOB_SendAcycFrames    ' (avg/max) [usec]:   30.7/ 70.7
013787 : PerfMsmt 'Cycle Time            ' (avg/max) [usec]:  998.0/1053.5
013787 : PerfMsmt 'myAppWorkPd           ' (avg/max) [usec]:    3.0/ 12.5
013787 : PerfMsmt 'Write DCM logfile     ' (avg/max) [usec]:    1.7/  4.5
015787 : ============================================================
015787 : PerfMsmt 'JOB_ProcessAllRxFrames' (avg/max) [usec]:   56.9/119.6
015787 : PerfMsmt 'JOB_SendAllCycFrames  ' (avg/max) [usec]:   29.9/ 86.4
015787 : PerfMsmt 'JOB_MasterTimer       ' (avg/max) [usec]:   14.3/ 71.8
015787 : PerfMsmt 'JOB_SendAcycFrames    ' (avg/max) [usec]:   32.7/ 71.9
015787 : PerfMsmt 'Cycle Time            ' (avg/max) [usec]:  997.8/1053.5
015787 : PerfMsmt 'myAppWorkPd           ' (avg/max) [usec]:    3.3/ 12.5
015787 : PerfMsmt 'Write DCM logfile     ' (avg/max) [usec]:    1.8/  4.5
017789 : ============================================================
017789 : PerfMsmt 'JOB_ProcessAllRxFrames' (avg/max) [usec]:   69.5/119.6
017789 : PerfMsmt 'JOB_SendAllCycFrames  ' (avg/max) [usec]:   38.1/ 86.4
017789 : PerfMsmt 'JOB_MasterTimer       ' (avg/max) [usec]:   20.3/ 71.8
017789 : PerfMsmt 'JOB_SendAcycFrames    ' (avg/max) [usec]:   42.5/ 72.9
017789 : PerfMsmt 'Cycle Time            ' (avg/max) [usec]:  996.9/1053.5
017789 : PerfMsmt 'myAppWorkPd           ' (avg/max) [usec]:    4.8/ 12.5
017789 : PerfMsmt 'Write DCM logfile     ' (avg/max) [usec]:    2.6/  4.5
019786 :
019786 : Job times before shutdown
019786 : ========================
019786 : Shutdown EtherCAT Master
019786 : ========================
019787 : Slave[0] To Switch On Disabled 1237

019797 : Master state changed from <OP> to <INIT>
019799 : ============================================================
019799 : PerfMsmt 'JOB_ProcessAllRxFrames' (avg/max) [usec]:   59.4/119.6
019799 : PerfMsmt 'JOB_SendAllCycFrames  ' (avg/max) [usec]:   32.1/ 86.4
019799 : PerfMsmt 'JOB_MasterTimer       ' (avg/max) [usec]:   16.8/ 71.8
019799 : PerfMsmt 'JOB_SendAcycFrames    ' (avg/max) [usec]:   33.3/ 72.9
019799 : PerfMsmt 'Cycle Time            ' (avg/max) [usec]:  997.5/1053.5
019799 : PerfMsmt 'myAppWorkPd           ' (avg/max) [usec]:    3.8/ 12.5
019799 : PerfMsmt 'Write DCM logfile     ' (avg/max) [usec]:    2.1/ 19.7
[  157.197609] atemsys: dev_munmap: 0xde500000 -> 0x9e500000 (790528)
[  157.204156] atemsys: device_release, pDevDesc = 0xdd6f6700
020059 : CPSW INF: Disable running RX-DMA
020059 : CPSW INF: RX+TX DMA disabled. Delay 500
020072 : EcMasterDemoDc stop.
root@AM437x-Tronlong:~#
```

图 29

更多帮助

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