# Development of an EtherCAT solution

## Remote Lab Demonstration Tutorial 4

***November 2010***

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# Revision History

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# 1 Introduction

## 1.1 Goals

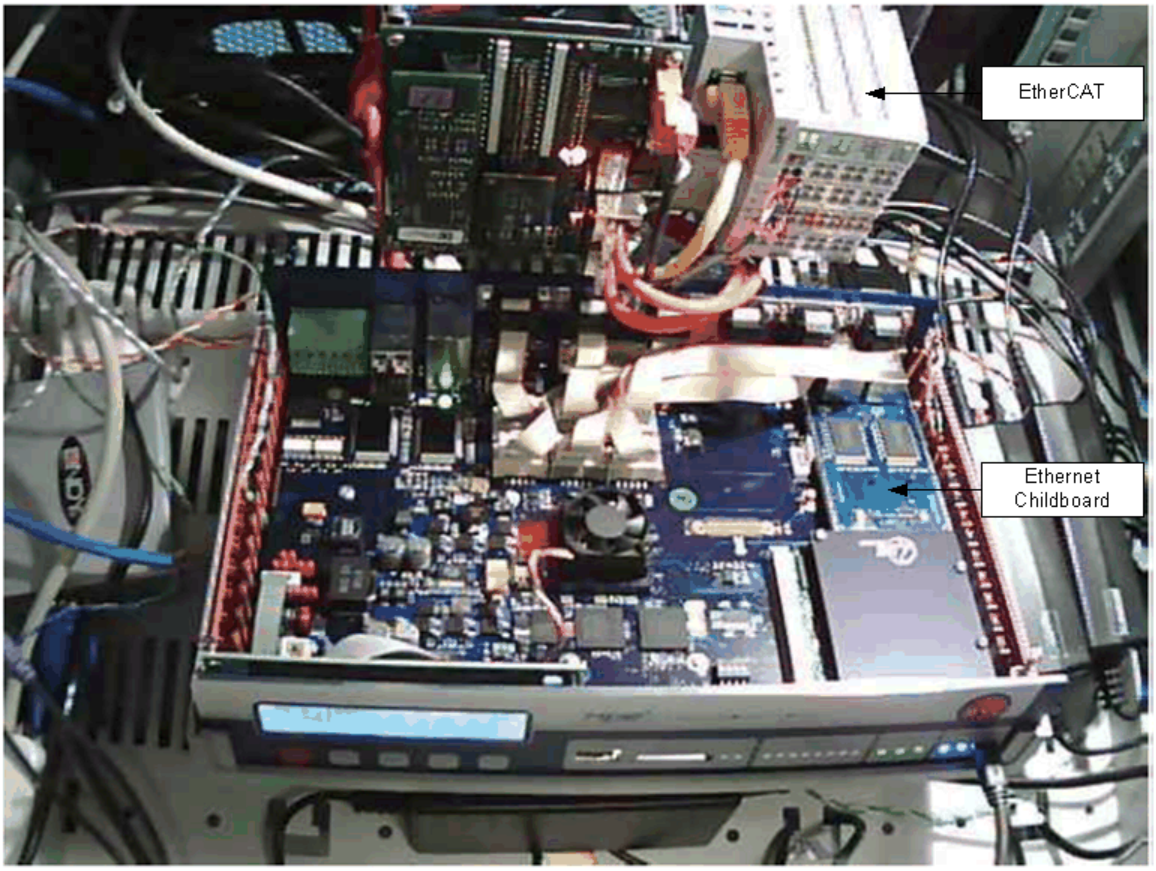
This tutorial shows how to implement an EtherCAT master on the Hpe_IRP. More specifically it shows:

- How to create an FPGA design which provides an additional Ethernet port
- How to start with the EtherCAT master stack from acontis technologies GmbH*.
- How to start with the EtherCAT master stack from König Prozessautomatisierungs GmbH*.

The Remote Lab (Figure 1) provides some EtherCAT slaves. You can try out the EtherCAT master demos there.

This document assumes familiarity with the environment of the Hpe_IRP which is described in [4].

**Figure 1. Remote lab setup**



## 1.2 Referenced Documents

| Ref | Document | Document Number/Location |
|---|---|---|
| 1 | Intel Remote Lab Access Guide | Contact your Intel representative |
| 2 | Hpe® Industrial Reference Platform (IRP) User Manual | http://www.ge-research.com/attach/UserManual-Hpe_IRP.pdf |
| 3 | Hpe® desk Basic Manual | http://www.ge-research.com/attach/UserManual_HpeDesk_basic.pdf |
| 4 | Remote Lab Demonstration | 324614 |

# 2 Creating an EtherCAT master

An EtherCAT master requires a 100 MBit/s Ethernet port and a protocol stack. The former can be realized with a standard Ethernet MAC. The latter can be realized in software.

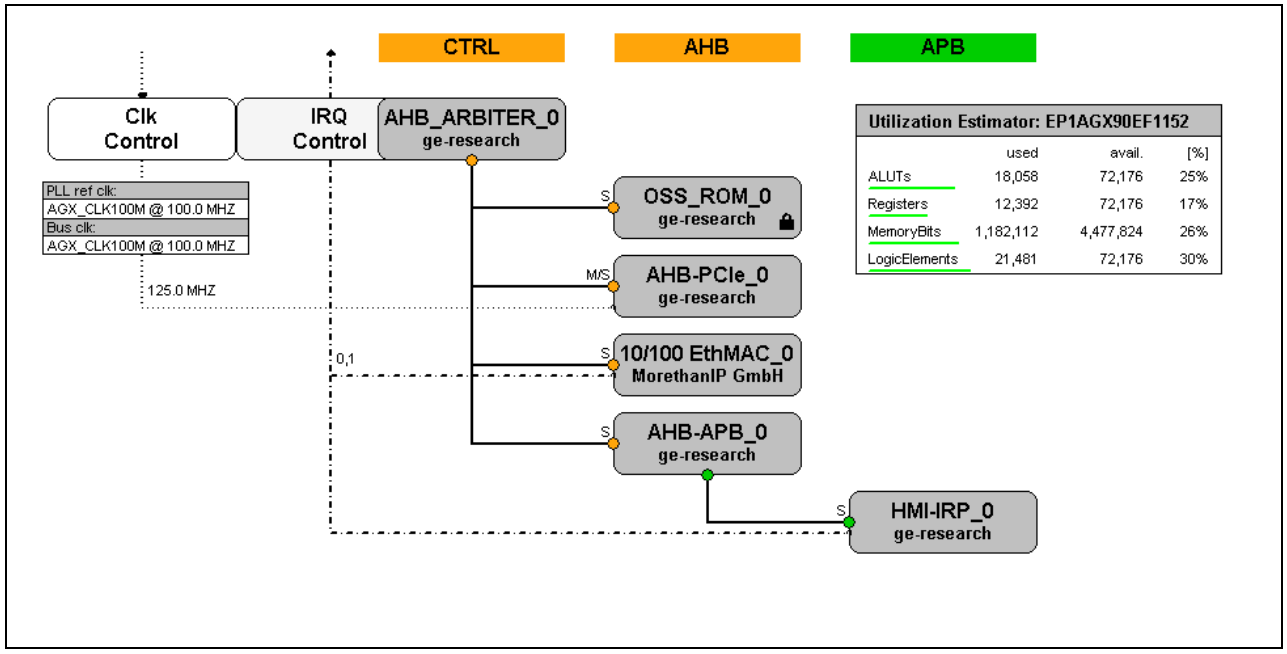
The Hpe_IRP offers three Ethernet interfaces and can be extended with two additional Ethernet interfaces. For details refer to [2]. In the setup shown in Figure 1 the Ethernet port which is directly provided by the Qseven module (ETH2) is already connected to the local network. Hence the system needs to be extended with the FPGA.

## 2.1 Creating an FPGA design

First we create an FPGA design with a 100 MBit/s Ethernet MAC to provide a second Ethernet interface. We will use this second Ethernet interface for the EtherCAT.

Use Hpe_Desk to generate a design as shown in Figure 2. For details on the Hpe_Desk usage, refer to [4].

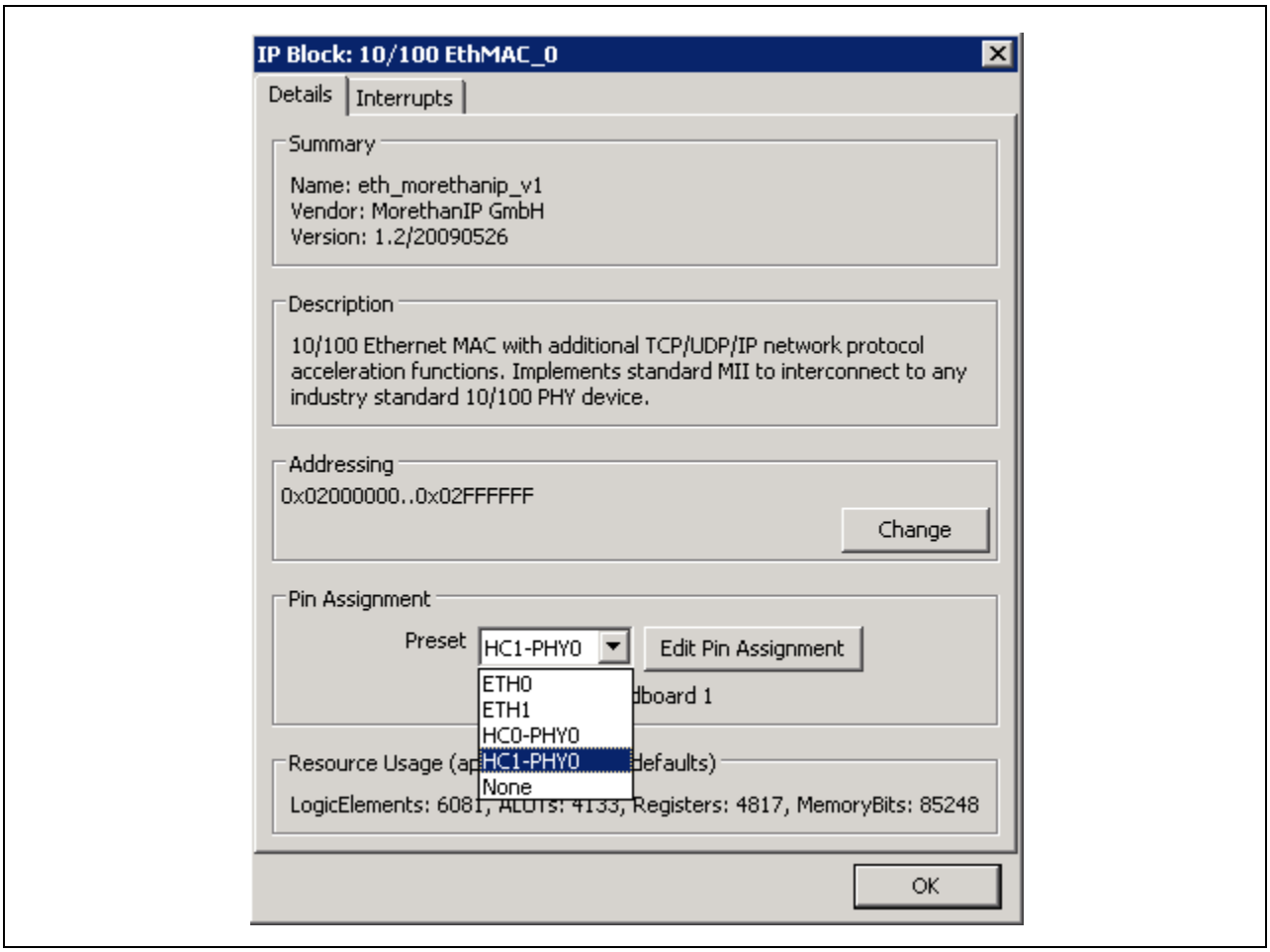
**Figure 2. FPGA design**




Double click on the 10/100 EthMAC IP core and set the Pin Assignment to `HC1-PHY0` (see Figure 3). This connects the IP core to the first Ethernet PHY (PHY0) on the second childboard (HC-1). In Figure 1 you can see the childboard mounted on the second (rightmost) childboard connector.

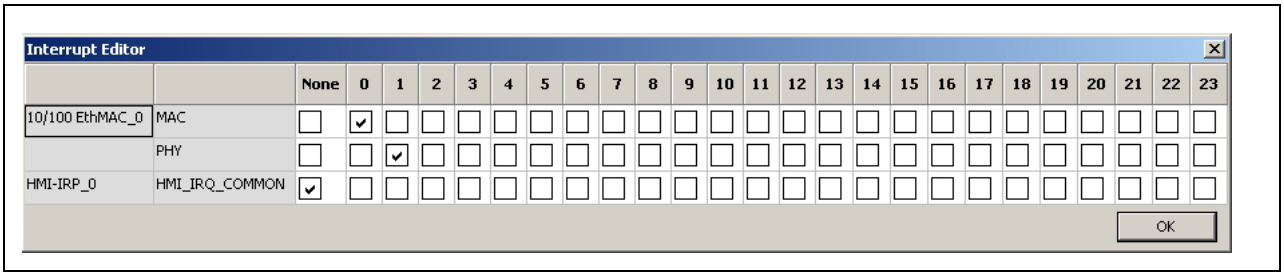
**Important**: Check that your setup is the same as the one in Figure 1. If not, you need to set the pinning according to your particular setup. Otherwise the EthMAC IP core (Figure 2) will be connected to the wrong, or even no PHY.

**Figure 3. Pin Assignment for the setup shown in Figure 1**




Double click on IRQ Control and connect the interrupts as shown in Figure 4.

**Figure 4. Interrupt configuration**




Synthesize the design and load it into the FPGA. If you do not want to wait until the synthesis has finished you can open a prebuilt Hpe_Desk project in the Remote Lab and click on the download design icon. Restart the Hpe_IRP after downloading the design.

## 2.2 Check the running configuration

After restarting the Hpe_IRP, check that the FPGA contains the correct design. The command lsfpga should produce the following output:

```
irp@hpe_irp ~ $ /usr/sbin/lsfpga
OSS_ROM version: 4
ROM size       : 912 bytes
Number of IPs  : 6
Timestamp      : 2010-09-07, 16:30:09 (0x4c864c71)
AIM info size  : 0 bytes
CRC            : 0xce57a01f [OK]

00 AHB Arbiter: Gleichmann Electronis Research (rev:1)
01 OSS ROM: Gleichmann Electronis Research (rev:1)
02 AHB<->PCIe Bridge: Gleichmann Electronis Research (rev:1)
03 Ethernet 10/100: MorethanIP (rev:12)
04 AHB<->APB Bridge: Gleichmann Electronis Research (rev:1)
05 HMI: Gleichmann Electronis Research (rev:1)
```

Check if the driver `mtip100` is loaded:

```
irp@hpe_irp ~ $ lsmod
Module                  Size  Used by
mtip100                 9888  0
hpe_irp_hmi             6788  0
sdhci_pci               7548  0
sdhci                  18592  1 sdhci_pci
pcspkr                  2524  0
e1000e                110060  0
hpe_irp_bridge          9980  1 mtip100
hpe_irp_bus             4508  3 mtip100,hpe_irp_hmi,hpe_irp_bridge
```

The driver `mtip100` makes the EthMAC IP core (Figure 2) appear as additional Ethernet interface. This can be checked with the command `ifconfig`. In the following output `eth4` is the new Ethernet interface.

```
irp@hpe_irp ~ $ /sbin/ifconfig
eth2      Link encap:Ethernet  HWaddr 00:30:D6:06:09:43
          inet addr:192.168.100.3  Bcast:192.168.100.255
…

eth4      Link encap:Ethernet  HWaddr 00:30:D6:01:63:E5
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 b)  TX bytes:0 (0.0 b)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
…
```

The interface name, e.g. eth4, under which the EthMAC IP core appears, as well as IP and MAC address are determined by the standard network settings, .i.e. `/etc/conf.d/net`. An excerpt of this file is shown in the following listing. Note, the IP is set to "`null`", because for EtherCAT the interface does not need an IP address. It is sufficient that the interface is up.

```
# Association of the "Pin Assignment" in Hpe_AIM to the Linux network
# interface name. The "Pin Assignment" in Hpe_AIM determines to which PHY
# the MAC within the FPGA is connected and hence which connector it uses.
pinning_to_netif=(
```

```
        ETH0=eth0
        ETH1=eth9
        HC0-PHY0=eth3
        HC0-PHY1=eth5
        HC1-PHY0=eth4
        HC1-PHY1=eth6
        CAN-1=can-1
        CAN-2=can-2
)

mac_eth4="00:30:D6:01:63:E5"
config_eth4=( "null" )
```

## 2.3 acontis technologies GmbH's AT-EM EtherCAT master stack

The Hpe_IRP contains a demo version of acontis' EtherCAT master stack. It is located under:

```
/home/irp/Hpe_IRP_support/Demo_designs/3d_Party/acontis
```

If it is not there, or only an outdated version, it can be installed and/or updated through the Gentoo Software Management Tool emerge. To download and install the demo program use the following command:

```
sudo emerge app-examples/atem-demo
```

Change to the irp user's home directory and unpack the demo:

```
cd
tar xfj Hpe_IRP_support/Demo_designs/3d_Party/acontis/atem-demo-1.2.tar.bz2
```

Change to the new directory, compile and run the program:

```
cd atem-demo-1.2
./makeall
sudo ./runrel
```

The EtherCAT master should come up and some activity can be seen on the EtherCAT slaves. For more details refer to the provided readme.txt.

## 2.4 König Prozessautomatisierungs GmbH's KPA EtherCAT master stack

The Hpe_IRP contains a demo version of König's EtherCAT master stack. It is located under:

```
/home/irp/Hpe_IRP_support/Demo_designs/3d_Party/koenig
```

If it is not there, or only an outdated version, it can be installed and/or updated through the Gentoo Software Management Tool emerge. To download and install the demo program use the following command:

```
sudo emerge app-examples/kpa-master-demo
```

Change to the irp user's home directory and unpack the demo:

```
cd
tar xfj Hpe_IRP_support/Demo_designs/3d_Party/koenig/kpa.master*.tar.bz2
```

Change to the new directory, compile and run the program:

```
cd kpa.master*/samples/posix
make
cd test_app
sudo ./emaster-testapp.sh
```

The EtherCAT master comes up and shows an interactive menu:

```
set_driver_handlers(): 0x80498d4  0x80496d4  0x8049ac4  0x8049a94  0x8049844
0x8049bd4  0x8049894

0004: UDP channel opened :34980: Success
Slave count of currently loaded master configuration is 4.
Process image size is 0 inputs and 3 outputs.
Press:
 '1'-'5': to transit to specific state (1=I, 2=P, 3=B, 4=S, 5=O)
 'k': to transit single slave to specific state
 '0': to display current state
 'o': to display outputs
 'i': to display inputs
 'f': to set output
 'g': to get input
 's': to start cyclic update
 't': to stop cyclic update
 'a': to start auto communication
 'h': to display this help
 'q': to exit
 'e': to display statistics
 'r': to reset statistics
 'n': to get slaves quantity
 'j': to get slaves states
 'm': to get slaves ID data
 'l': to get slaves ID data
 'b': to get slaves DL Status
 'v': to get last error
 'w': to get snapshot
 'u': to get object dictionary(mailbox CoE)
 'p': to upload/download object data (mailbox CoE SDO upload/download)
 'x': to load xml
 'z': to set/reset external control task
 'c': FoE read/write
 'd': VoE read/write
 Enter: to one cyclic update

 '.': Enter to Extended menu
Extended menu:
        'a': AoE communication
        's': SoE communication
```

Type `z` to start the process task. You see activity on the EtherCAT slaves. Refer to the provided `readme` for details.