

### 1. Device installation

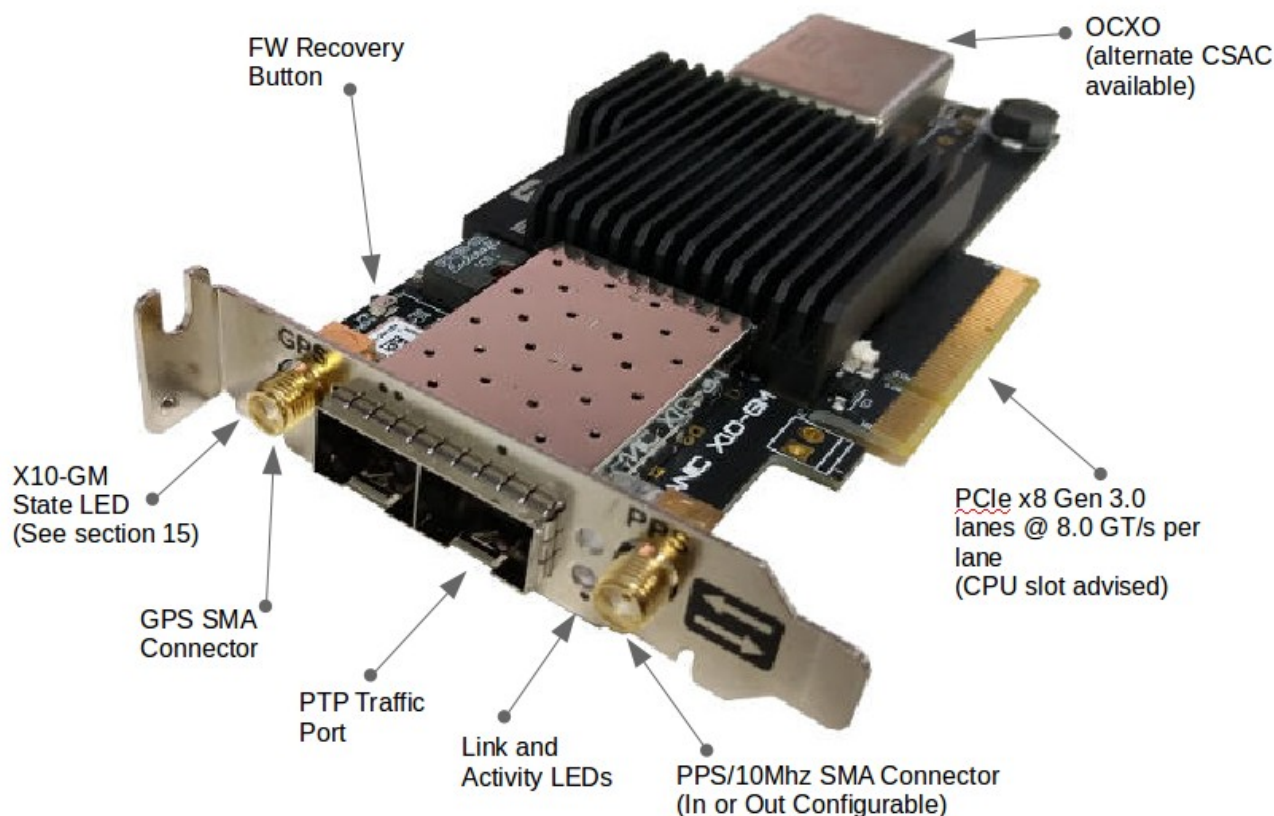
Installation of the ExaNIC X10-GM (X10-GM) is almost identical to other ExaNIC devices and this document be used in conjunction with the 'ExaNIC Configuration Guide'.

It is important to note when installing some motherboards have certain PCI Express slots connected directly to the processor and others connected to the chipset; for optimal low-latency performance, install the ExaNIC into a slot directly connected to the processor.

Install SFP+ modules into the ExaNIC as required. There are no limitations on the type or manufacturer of SFP+ modules that can be used, we supply and recommend Finisar modules. PTP traffic will be served out of the first port of the X10-GM card. (Refer to the below picture to identify the first port.)

Connect the GPS SMA to an externally mounted GPS antenna, one preferably with an unobstructed view of the sky. Proper cable, grounding techniques, and lightning arrests should be used. Do not mount the antenna near obstructions such as a wall or obstacles blocking part of the sky.

A second SMA marked PPS can be connected for 1PPS/10MHz connections to allow synchronization. The behavior of this connection is configurable and is covered in sections 13 and 14.



## 2. Software installation

Software installation of the X10-GM is identical to that of other ExaNIC devices. Please see the 'ExaNIC Configuration Guide' for details. Note that the first driver software to support the X10-GM is 1.8.0.

## 3. After installation

Assuming installation completed successfully, verify that the `exanic-config` utility works and reports the hardware type and function of the ExaNIC X10-GM PTP grandmaster:

```
$ sudo exanic-config
```

```
Device exanic0:
```

```
Hardware type: ExaNIC X10-GM
```

```
Board ID: 0x00
```

```
Temperature: 64.2 C   VCCint: 0.94 V   VCCaux: 1.85 V
```

```
Function: PTP grandmaster
```

```
Firmware date: 20160725 (Mon Jul 25 06:42:00 2016)
```

The `exanic-config` utility can be used to inspect diagnostic information about the card and SFP modules. Its general use is covered in more detail in the 'ExaNIC Configuration Guide'.

## 6. The `exanic-config` PTP status

The `exanic-config` utility can be used to inspect extended diagnostic information about the PTP configuration and status. For example:

```
$ sudo exanic-config exanic0 ptp status
```

```
Device exanic0:
```

```
PTP grandmaster: enabled
```

```
Synchronize to GPS time: enabled
```

```
Hardware time: 2016-08-07 23:51:38.225087568 TAI
```

```
                2016-08-07 23:51:02.225087568 UTC
```

```
TAI-UTC offset: 36s
```

```
MAC address: 64:3f:5f:01:2D:68
```

```
PTP configuration:
```

```
  Ethernet multicast: off
```

```
  IPv4 multicast: on
```

```
  IPv4 unicast negotiation: off
```

```
  IPv4 address: 192.168.1.11
```

```
  PTP domain: 0
```

```
  PTP priority 1: 128
```

```
  PTP priority 2: 128
```

```
  Multicast announce interval: 1 (2s)
```

```
  Multicast sync interval: 0 (1s)
```

```

GPS receiver status:
  Fix type: 3D fix
  Number of tracked satellites: 10
  Estimated clock accuracy: 12ns
PTP grandmaster status:
  Number of unicast clients: 0
  PTP packets sent: 248
  PTP packets received: 73

```

The `exanic-config` utility will either accept the Linux interface name (e.g. `eth7`) or the device name of the ExaNIC device (e.g. `exanic0` for the first ExaNIC in the system by PCI ID, and `exanic0:0` for the first port of that card).

The Hardware time is reported to the user in Co-ordinated Universal Time (UTC) and International Atomic Time (TAI), and all PTP network traffic is in TAI. The current offset between TAI and UTC is also displayed.

## 5. PTP Configuration

The `exanic-config` utility also provides methods for configuring the X10-GM as a PTP grandmaster. To access a list of the PTP configuration commands execute:

```
$ sudo exanic-config exanic0 ptp --help
```

```

Detailed PTP grandmaster configuration and status:
exanic-config <device> ptp status
exanic-config <device> ptp { enable | disable }
exanic-config <device> ptp ip-address <addr>
exanic-config <device> ptp show-profile
exanic-config <device> ptp profile { default | telecom | none }
exanic-config <device> ptp eth-multicast { on | off }
exanic-config <device> ptp ip-multicast { on | off }
exanic-config <device> ptp ip-unicast { on | off }
exanic-config <device> ptp gps-sync { on | off }
exanic-config <device> ptp domain <value>
exanic-config <device> ptp priority1 <value>
exanic-config <device> ptp priority2 <value>
exanic-config <device> ptp announce-interval <value>
exanic-config <device> ptp sync-interval <value>
exanic-config <device> ptp save

```

Note after configuring the desired PTP configuration for it to remain persistent over a power cycle it is required to save the setup to EEPROM using the PTP save call. For example:

```
$ sudo exanic-config exanic0 ptp save
```

## 6. Enabling or Disabling the PTP stack

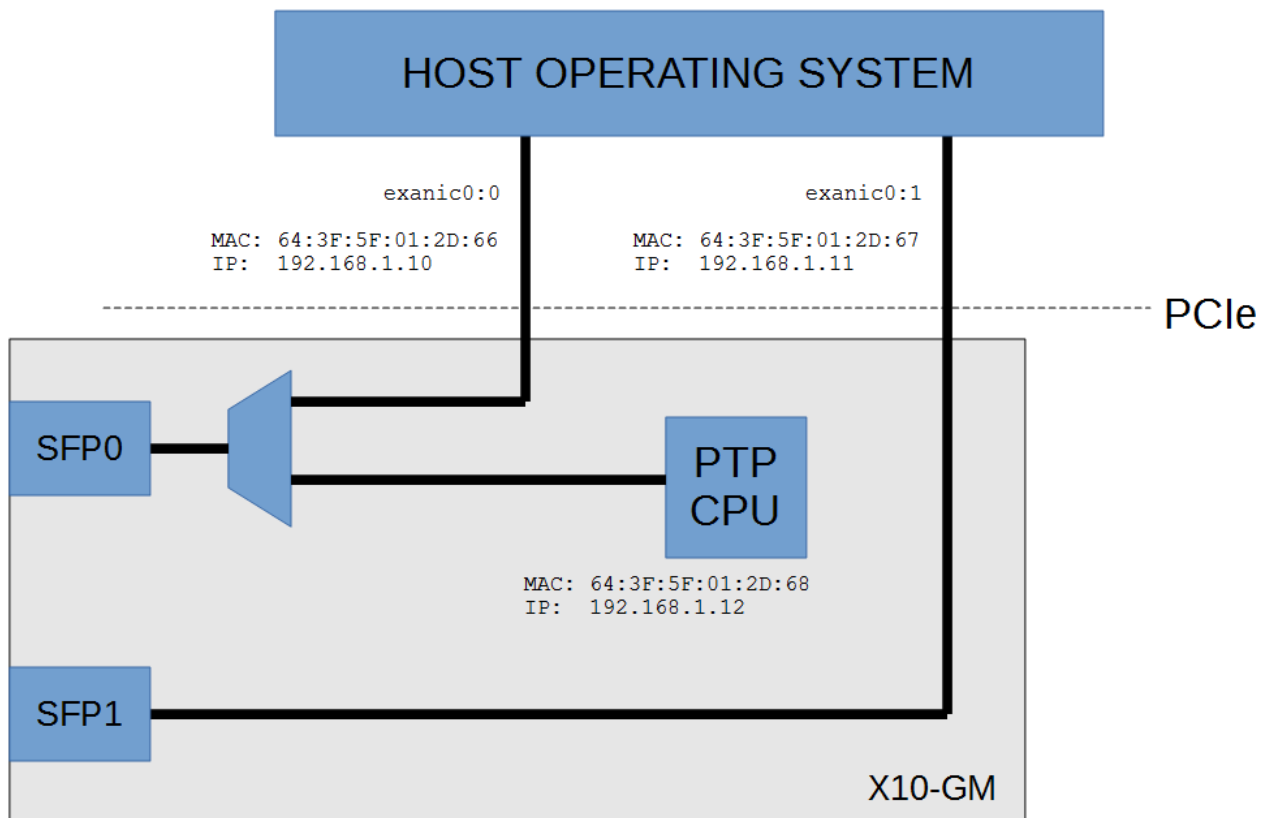
Normally the X10-GM operates as a PTP grandmaster serving out the PTP protocol, however it can be configured to suppress the PTP behaviour to allow operation as a normal NIC or to allow a different grandmaster to control the network. To disable the PTP stack on the X10-GM execute:

```
$ sudo exanic-config exanic0 ptp disable
```

Supported values are *enable* or *disable*.

## 7. MAC and IP addresses

The X10-GM provides 2 interfaces for the host, each of which has a MAC assigned at the factory, and can have an IP address set by the host. The CPU within the X10-GM that handles the PTP stack also has a MAC assigned at the factory, and needs to be assigned an IP address by the user for use on IP networks.



To configure the IP address for the PTP stack:

```
$ sudo exanic-config exanic0 ptp ip-address 192.168.1.12
```

The IP address for the host interface is set using standard methods:

```
$ sudo ifconfig eth1 192.168.1.10
```

Don't forget to save to EEPROM with `exanic-config exanic0 ptp save`

## 8. PTP Profiles

To simplify the configuration of a PTP network standard profiles were defined. These profiles include default values and acceptable ranges. To select and configure the X10-GM to one of the standard PTP profiles use the command:

```
$ sudo exanic-config exanic0 ptp profile default
```

The acceptable values are *default*, *telecom* and *none*. 'none' allows the operator to enter any values without restriction. To show the current selected profile and ranges execute the command:

```
$ sudo exanic-config exanic0 ptp show-profile
```

## 9. Setting the PTP communication method

The PTP protocol can be configured to use several communication methods and management techniques. The multicast methods (IP and Ethernet) will configure the X10-GM to broadcast out PTP messages, whereas IP unicast will require the PTP clients to initiate connections.

```
$ sudo exanic-config exanic0 ptp ip-multicast on
```

```
$ sudo exanic-config exanic0 ptp eth-multicast off
```

```
$ sudo exanic-config exanic0 ptp ip-unicast off
```

It is suggested that ip-multicast be used to validate the network configuration before deciding on alternate communication methods.

## 10. Enabling or Disabling GPS synchronization

By default the X10-GM utilizes an on-board GNSS receiver (GPS) to tightly synchronize the X10-GM oscillator to GPS time from anywhere on the globe. An operator can however disable the X10-GM synchronization, this allows the X10-GM to be synchronized from alternate sources such as the Host PC.

To disable the GPS to oscillator synchronization execute:

```
$ sudo exanic-config exanic0 ptp gps-sync off
```

The acceptable values are *on* or *off*.

For best operation the X10-GM should be attached to an antenna installed with an unobstructed view of the sky. This will result in a high quality positional and time sync lock, and can be confirmed by verifying "Fix Type" is reported as "3D fix" when running `exanic-config exanic0 ptp status`.

## 11. Configuring PTP best master priority values

A number of configuration fields are used by the X10-GM in the execution best master clock algorithm (BMCA). These are used in conjunction with quality and performance metrics of the X10-GM to determine which device should operate as a grandmaster on a particular network. The exanic-config application can be used to set the priority1 and priority2 fields to modify the priority of the X10-GM in best master clock identification decisions. For example:

```
$ sudo exanic-config exanic0 ptp priority1 127
$ sudo exanic-config exanic0 ptp priority2 1
```

The acceptable values are between 0 and 255, where a lower value is chosen over a higher value in the BMCA.

## 12. Configuring PTP grandmaster broadcast intervals

A number of configuration fields are used by the X10-GM to control timing of PTP protocol messages. These are used to manage announce messages as part of the best master clock identification and sync messages as part of time synchronization. The exanic-config program can be used to set these values to adjust the timing and traffic on the network. For example:

```
$ sudo exanic-config exanic0 ptp announce-interval 3
$ sudo exanic-config exanic0 ptp sync-interval -1
```

The supplied interval values are used to calculate the interval in seconds, using the formula  $2^x$  seconds, where X is the supplied value. For example an announce-interval of 3 equals  $2^3$  or 8 seconds and a sync-interval of -1 equals  $2^{-1}$  or half a second.

The acceptable values are between -127 and 127, however PTP profiles set a minimum and maximum and these are respected.

## 13. Configuring PPS Output

The X10-GM includes a PPS connector that can be used as either an input or output. When operating in output mode a 10MHz or 1PPS signal can be generated, which can be used to synchronize the time of other devices that can accept the PPS input.

*As this is available for other ExaNIC devices it is configurable through the exanic-config level commands, not the ptp commands.*

Usage:

```
$ sudo exanic-config <device> pps-out { on | off }
$ sudo exanic-config <device> 10m-out { on | off }
```

For example:

```
$ sudo exanic-config exanic0 pps-out on
```

#### 14. Configuring PPS Input

There is no specific configuration value for setting the X10 GM for PPS input, instead the input is setup and utilised by the `exanic-clock-sync` utility that manages the ExaNIC's clock synchronization.

The `exanic-clock-sync` program takes arguments in the form of one or more `<device>:<synchronization-source>` pairs. The synchronization source being one of either the host (host clock), pps (pulse-per-second input) or `exanicX` (another ExaNIC device). For example:

```
$ sudo exanic-clock-sync exanic0:pps exanic1:exanic0
```

If desired this can be placed in system startup scripts. A sample `init.d` script is provided in `configs/exanic-clock-sync`.

#### 15. X10-GM LED States

LED State	X10-GM State
Solid Green	All OK (GPS Fix)
Green Flashing	Adjust (GPS Fix) or Warmup (GPS Fix)
Orange (R+G) Flashing	Holdover (No GPS fix)
Red Flashing	Re-sync in progress (GPS could be any state)
Solid Orange (R+G)	GPS sync disabled (GPS could be any state)
LED Off	GM Disabled

## 16. Packet counters

There is several packet counters used on the X10-GM. The first are those packets sent by the onboard CPU handling the PTP stack. These are shown in the *ptp status* command:

```
PTP grandmaster status:
  Number of unicast clients: 0
  PTP packets sent: 248
  PTP packets received: 73
```

The host driver will also report packets sent/received by the card related to host activity. For example, *exanic-config* reports the following:

```
$ exanic-config exanic0:0
Device exanic0:
  Hardware type: ExaNIC X10-GM
  Board ID: 0x00
  Temperature: 58.6 C   VCCint: 0.94 V   VCCAux: 1.83 V
  Function: PTP grandmaster
  Firmware date: 20160805 (Fri Aug 5 07:08:15 2016)
  Port 0:
    Interface: enp1s0
    Port speed: 10000 Mbps
    Port status: enabled, no SFP, no signal, no link
    Bypass-only mode: off
    MAC address: 64:3f:5f:01:2D:66
    RX packets: 1254   ignored: 0   error: 0   dropped: 0
    TX packets: 914
```

This says that the host system has transmitted 914 packets and has received 1254 packets , and the CPU handling the PTP stack has transmitted 248 and received 73. Note that some packets such as broadcast packets would be received by both the host and PTP CPU.

## 17. Troubleshooting Link

*Note all interface numbers, IP addresses and device names below are for example only. These may differ on your system.*

1. Make sure the X10-GM port is configured to the correct speed e.g.  
\$ sudo exanic-config exanic0:0 speed 10000



2. Make sure the X10-GM has been assigned an IP address at the device level e.g.

```
$ sudo exanic-config exanic0 ptp ip-address 192.168.1.12
```

3. Make sure the X10-GM port is configured to the correct auto negotiation e.g.

```
$ sudo ethtool -s eth1 autoneg on
```

4. Is GPS connected? At boot time, the hardware clock on the X10-GM is at epoch time zero, or 1<sup>st</sup> Jan 1970. The X10-GM will serve time onto the network unless GPS has been detected and a lock established, at which point the correct time is known. From then on, GPS can be removed and the X10-GM will fallback to it's onboard oscillator.

In the case below, even though PTP is enabled, as the system has never had the time set via GPS (as can be seen with the year as 1970), it will be blocked from serving time.

```
$ exanic-config exanic0 ptp status
Device exanic0:
  PTP grandmaster: enabled
  Synchronize to GPS time: enabled
  Hardware time: 1970-01-01 00:01:00.769655540 TAI
                  1970-01-01 00:00:24.769655540 UTC
  TAI-UTC offset: 36s
  MAC address: 64:3f:5f:01:2d:68
```

5. Look to see that exanic-config ptp status is reporting an increase in the number of 'PTP packets sent' e.g.

```
$ sudo exanic-config exanic0 ptp status
```

```
Device exanic0:
  PTP grandmaster: enabled
  Synchronize to GPS time: enabled
  Hardware time: 2016-08-07 23:51:38.225087568 TAI
                  2016-08-07 23:51:02.225087568 UTC
  ...
  PTP grandmaster status:
    PTP packets sent: 39267
```

6. Look to see that the PTP slave system is receiving PTP traffic e.g.

```
$ sudo tcpdump -i eth1 port 319
```