Overview

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1 OVERVIEW

1.1 EtherSound technology overview

EtherSound enhances established technologies to provide easy-to-implement, high-quality audio networks.

The patent-pending EtherSound protocol provides fully deterministic, very low-latency transmission of synchronized audio channels over standard Ethernet.

EtherSound maintains a fully digital path between networked audio devices. Up to 64 channels of 24-bit digital audio, control data, and bi-directional status data may be transported among a virtually infinite number of connected devices.

The overall audio network may have one or more locations where audio is inserted. All devices “downstream” from the source may playback audio from that source.

Off-the-shelf Ethernet components (i.e. switches) can be used to extend the number of audio devices, as well as the distance between the devices on the network (i.e. using optical fiber). List of tested Ethernet components are available at Digigram.

Configuration and set-up are simpler than analog systems. EtherSound drastically reduces installation costs of systems for public address, installed sound, residential installations, etc…

The ESnet Reference Designs proposed by Digigram serve as the networking core for manufacturers to integrate EtherSound Technology within their own audio equipment, such as loudspeakers, amplifiers, and signal routers and processors.

1.2 How EtherSound works

EtherSound technology is a combination of a communication protocol based on true Ethernet frames and implementations of the use of this protocol in several ESnet Reference Designs.

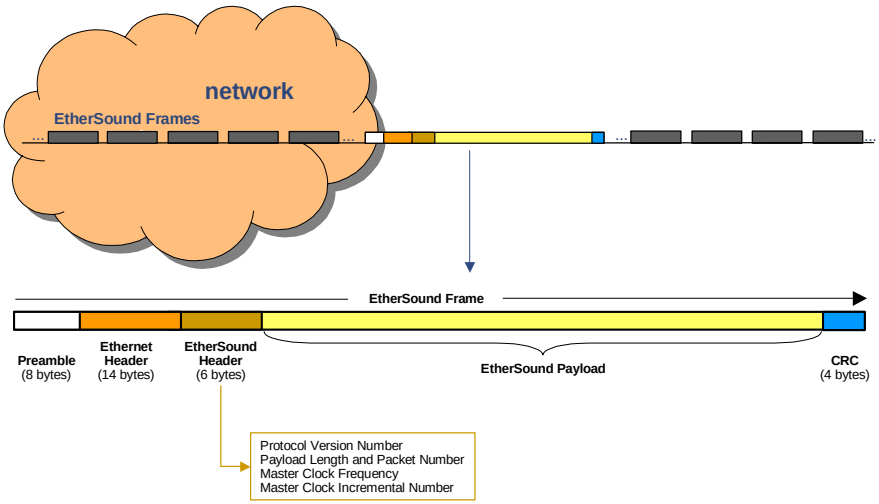
1.2.1 The EtherSound Protocol

The EtherSound protocol developed by Digigram is based on true Ethernet frames and provides a means of communication between EtherSound- capable devices.

1.2.1.1 EtherSound Frames

EtherSound frames are wrapped up in standard Ethernet frames and consist of two main parts:

- the **EtherSound Header**, that includes all important information relevant to the protocol,
- the **EtherSound Payload**, the actual data transmitted via the network.



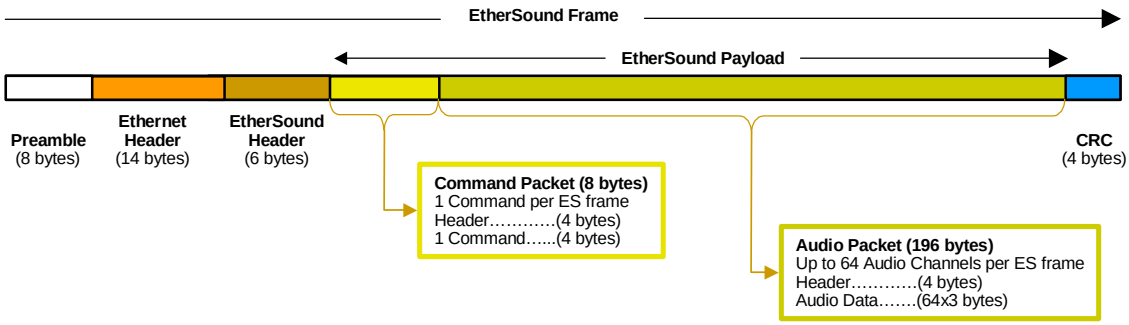
The EtherSound Payload, as with standard Ethernet frames, is divided in a set of packets. Each packet is made of:

- the **Packet Header**, where the packet type and structure description is defined,
- the **Packet Data**, the actual data.

1.2.1.2 EtherSound Protocol V1

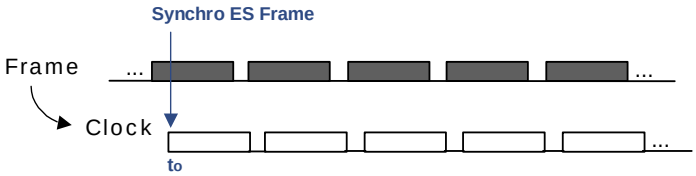
The current version of the EtherSound protocol (V1) has a payload of two packets:

- a **Command Packet** that transmits 1 command. This command can be a control command or a status request command.
- an **Audio Packet** for transmitting up to 64 audio channels at 44.1 KHz or 48 KHz



1.2.1.3 Audio Channel Synchronization

For the audio channel synchronization EtherSound uses the arrival of a EtherSound frame as a master clock pulse:

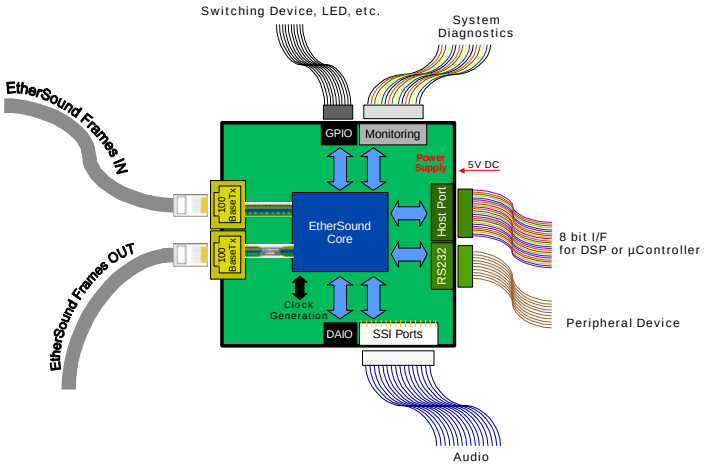


Each frame (that may contain up to 64 Audio Channels) is transmitted at the sampling frequency: 44100 Hz or 48000 Hz.

1.2.2 The EtherSound hardware

Each ESnet Reference Design developed by Digigram, like the MSx 88 Eeprom 200K or the S2 Prom 100K, provides the electronics schema and the binary code of the FPGA that allow manufacturers to integrate EtherSound within their own design. In this document we will use the MSx 88 Eeprom 200K for our examples.

Here is an overview of the ESnet Reference Design MSx 88 Eeprom 200K .



1.2.2.1 ESnet Reference Design MSx 88 Eeprom 200K

ESnet Reference Design MSx 88 Eeprom 200K provides either 8 audio inputs or 8 audio outputs.

Each module has a set of two RJ45 and six HE10 connector ports:

- **Ethernet Out Port:** RJ45 port used to send EtherSound frames in an EtherSound network.
- **Ethernet In Port:** RJ45 port used:
  - To receive EtherSound frames from an EtherSound network
  - For software control and management from a computer (Primary Master only)
- **SSI Port:** Standard serial interface for connecting serial audio interfaces.
- **GPIO Port:** General Purpose Inputs and Outputs port typically used for controlling switching devices, LEDs, etc.
- **DAIO Port:** Port reserved by Digigram and not available in this reference design.
- **Monitoring Port:** Used for the Reset, Power-Down, Audio Channel Selection and Hardware/Software Audio Configuration signals.
- **RS232 Port:** Serial port used to connect peripheral devices to an EtherSound device. It also includes a pin for master/slave selection.
- **Host Port:** 8-bit interface port used to control the EtherSound device from a DSP or µController.

1.2.2.2 ESnet Reference Design S2 Prom 100K

ESnet Reference Design S2 Prom 100K provides 2 audio outputs.

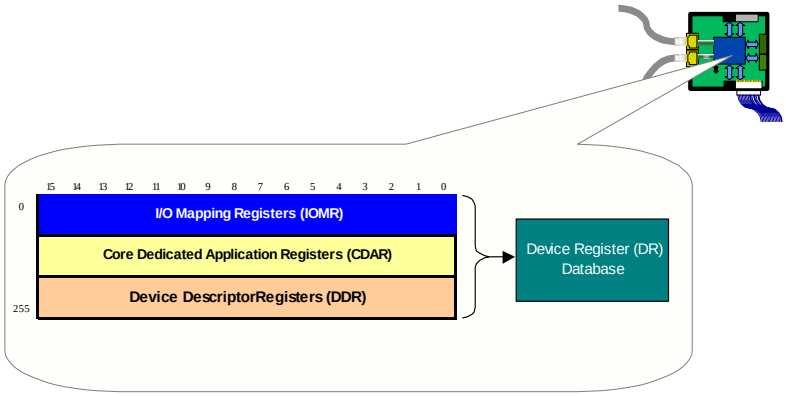
Each module has a set of two RJ45 and six HE10 connector ports:

- **Ethernet Out Port:** RJ45 port used to send EtherSound frames in an EtherSound network.
- **Ethernet In Port:** RJ45 port used:
  - To receive EtherSound frames from an EtherSound network
- **SSI Port:** Standard serial interface for connecting serial audio interfaces.
- **GPIO Port:** General Purpose Inputs and Outputs port typically used for controlling switching devices, LEDs, etc.
- **DAIO Port:** Not available in this reference design.
- **Monitoring Port:** Used for the Reset, Power-Down, Audio Channel Selection and Hardware/Software Audio Configuration signals.
- **RS232 Port**: Not available in this reference design.
- **Host Port**: Not available in this reference design.

1.2.2.3 EtherSound registers

Each EtherSound FPGA firmware has an internal database of 256 16-bit-Device Registers (DR). These Device Registers, also called the DR database, provide configuration information status or manage the behavior of the EtherSound device. These Device Registers are grouped in three separate categories:

- **DDR: Device Descriptor Registers (48 registers)** describe the status and the configuration of the EtherSound Kernel of the device. All the EtherSound devices include these registers.
- **IOMR: I/O Mapping Registers (128 registers)** describe the behavior of the EtherSound device audio I/Os (i.e. the EtherSound channel assignments to audio I/Os). The number of IOMR depends of the audio capacity of the EtherSound device.
- **CDAR: Core Dedicated Application Parameters (80 registers)** The Core Dedicated Application Registers (CDAR) are reserved for specific optional functions not included by default in every EtherSound device, such as RS232, GPIOs, analog gains, parameters for µcontroller or DSP software.

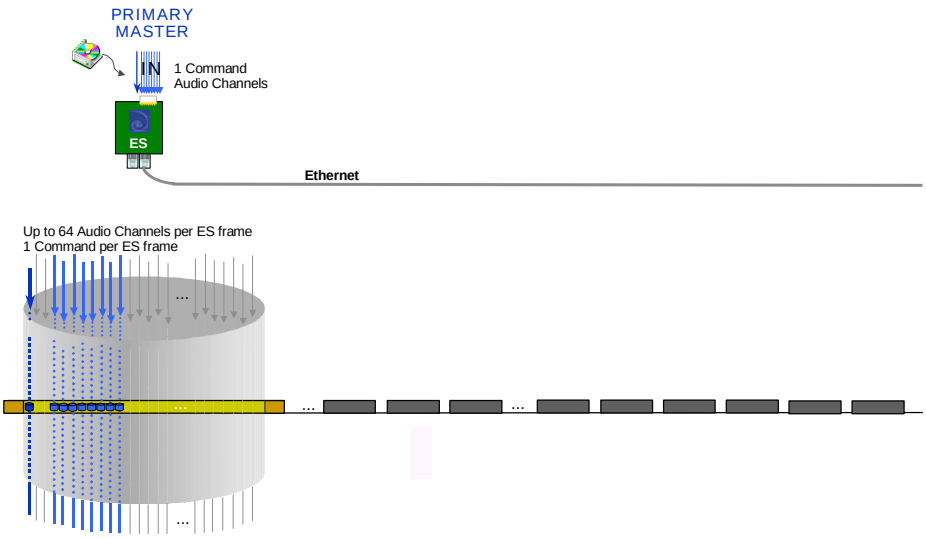


1.2.2.4 Primary Master

The first EtherSound device in the network is called the **Primary Master**. As well as being a source of audio for the network, the Primary Master provides the commands and clock for audio channel synchronization.

In other words, it is the Primary Master that initializes and builds the EtherSound frames and the first to fuel these frames with audio channels. By connecting its "Ethernet IN" Port to a Host Computer (PC) you can remotely control and manage the entire EtherSound network via software.

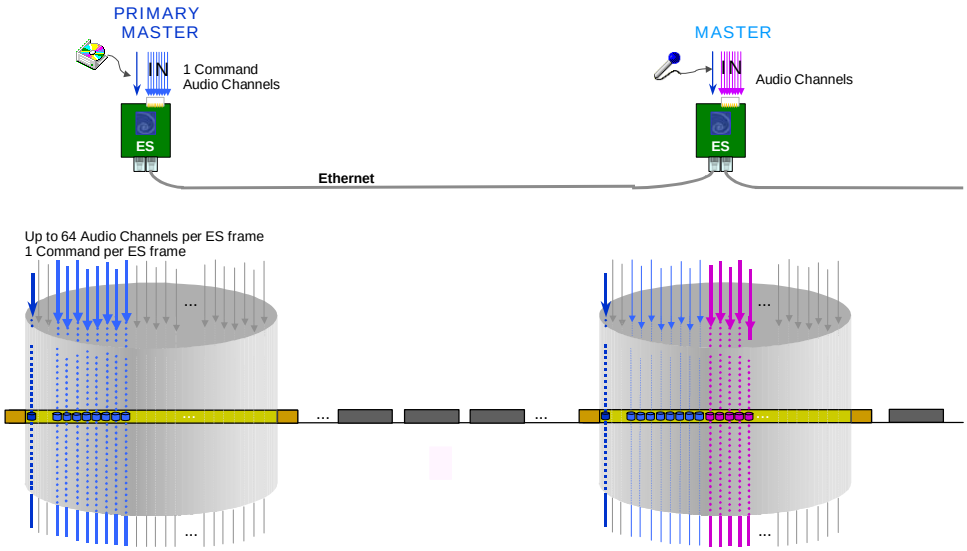
If the Primary Master is out of order, the next master device in the network automatically becomes a Primary Master. If the problem disappears, the system automatically returns to its initial state.



1.2.2.5 Master

A device in the network located downstream from the Primary Master and contributing additional audio channels into the EtherSound stream is called **Master.**

A Master answers to the status requests and commands of the Primary Master.

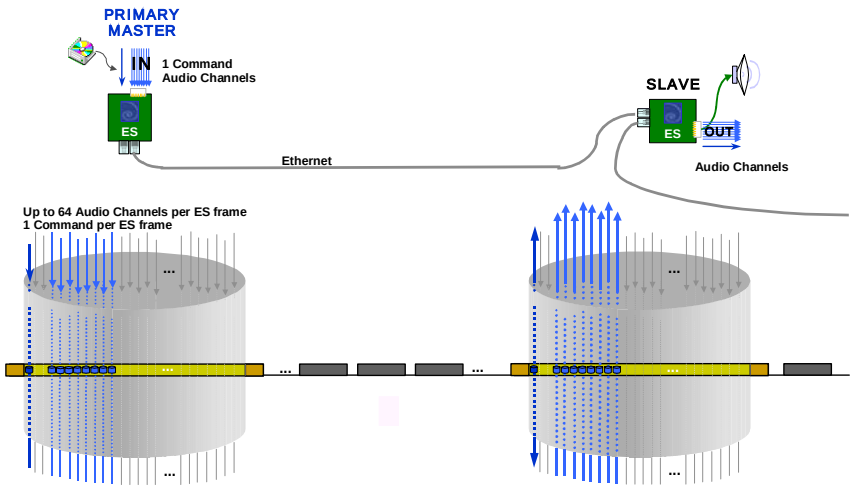


Notes: *A Master device is always located downstream of a Primary Master device.*

1.2.2.6 Slave

An EtherSound device that receives the EtherSound stream and restores standard audio is called a **Slave**.

A slave answers to the status requests and commands of the Primary Master.



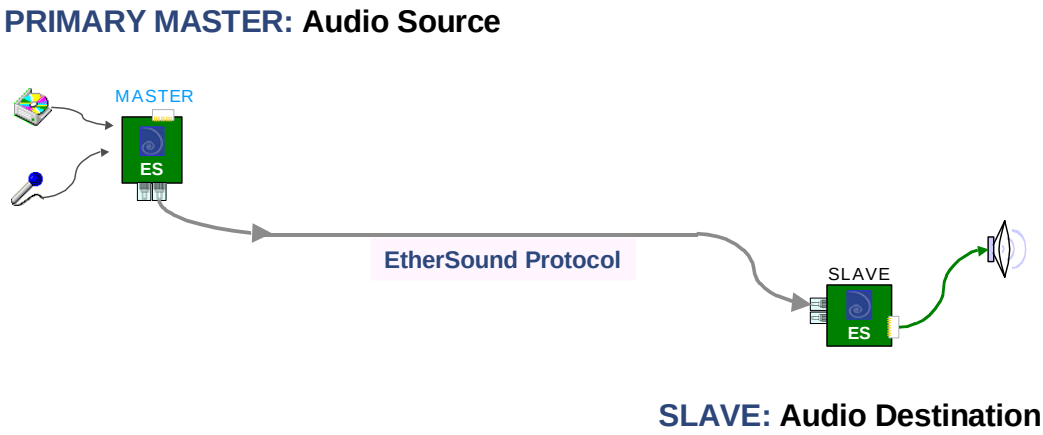
1.2.3 The EtherSound network

1.2.3.1 Ethernet / IEEE 802.3 compatibility

EtherSound technology is compatible with IEEE 802.3x standards and operates on full duplex switched, Fast Ethernet networks. Data is typically transported via dedicated Local Area Networks (LANs) with a minimum bandwidth of 100Mbps (100BaseTx) full duplex.

1.2.3.2 The simplest configuration

The simplest EtherSound configuration consists of one Primary Master and one Slave device:



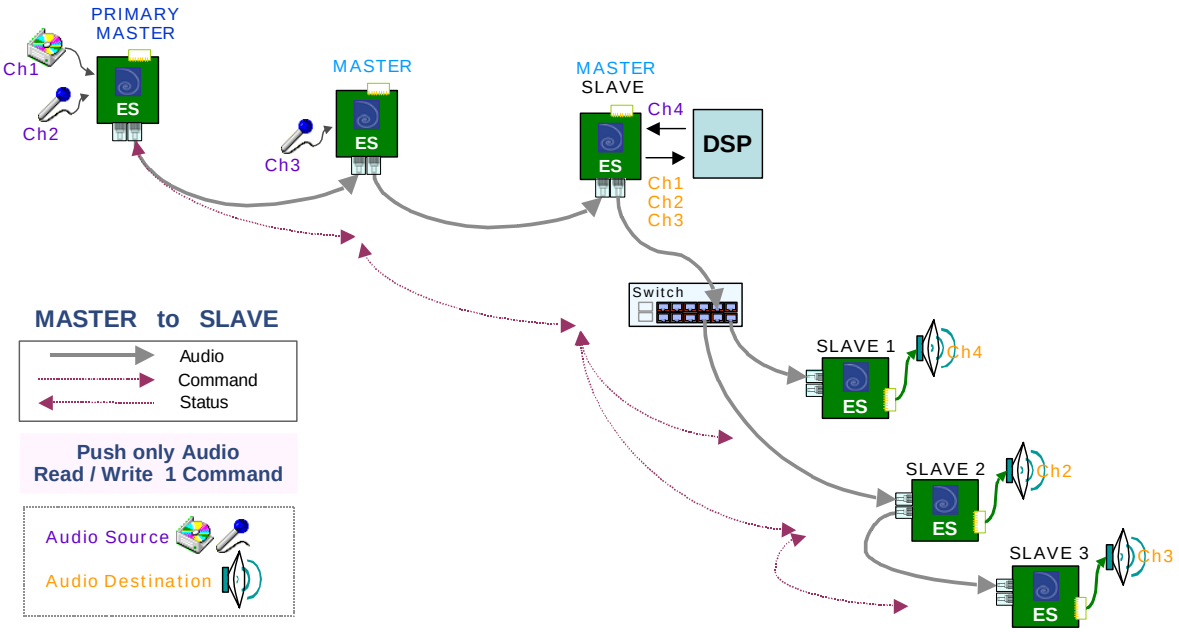
1.2.3.3 Connecting EtherSound devices

The following system architecture illustrates all types of EtherSound devices available.

Audio transmission is in only one direction. When an audio channel is "*extracted*" by a device from the EtherSound stream, that channel continues to remain available for all downstream slave devices, until a master device inserts audio in this channel.

In this example, the Master/Slave device extracts the audio channels from the network, and is configured so that it applies some DSP processing and audio mixing before contributing the result down to the network as a new audio channel.

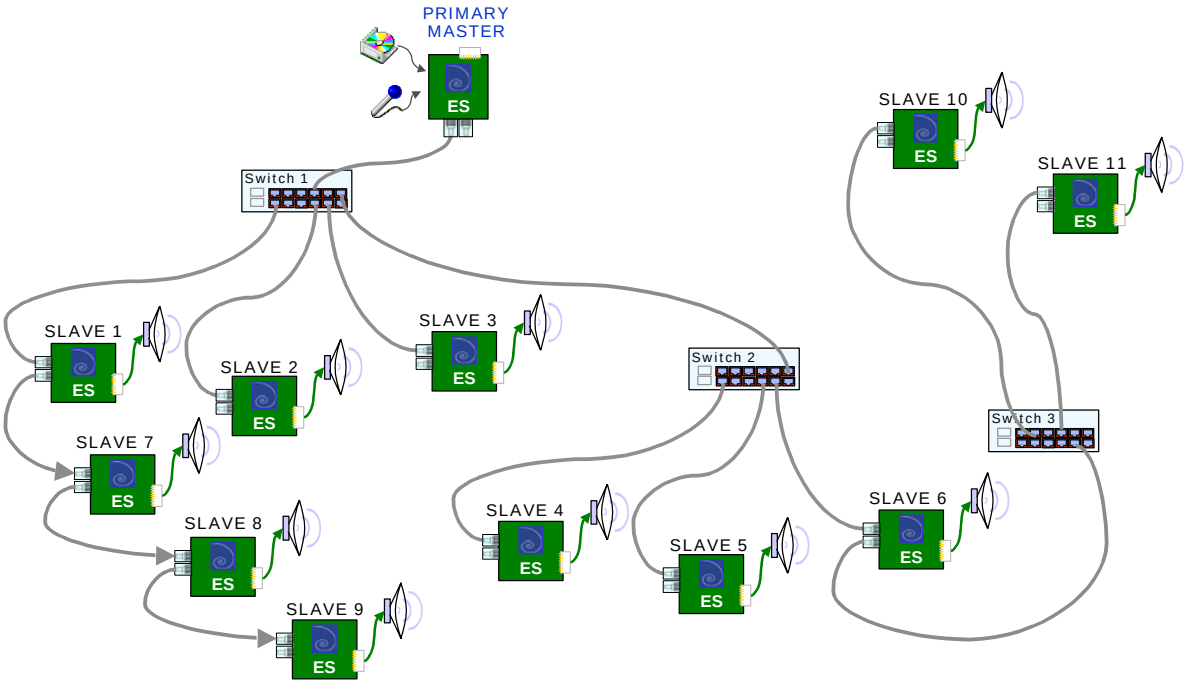
Status information is bi-directional so that it may be provided by any device on the network and read via the Primary Master.



1.2.3.4 Network Architectures

Network architectures may be Daisy Chain, Star or a combination of both. A virtually unlimited number of devices may be daisy-chained, with no additional hardware, using the Ethernet-standard Unshielded Twisted Pair (UTP) Category 5 cabling. Devices may be up to 100 meters apart with no limitation on the distance between the first and last devices in the chain.

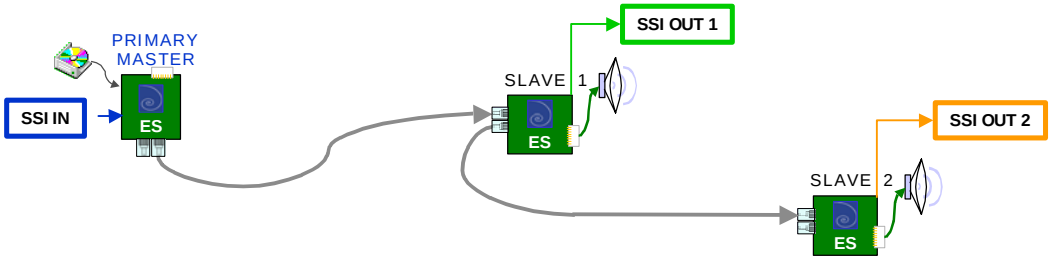
Common Ethernet switches may also be used to distribute EtherSound transmissions to networked audio devices, facilitating more complex network architectures and extending the distance between devices. A list of tested components is available at Digigram.



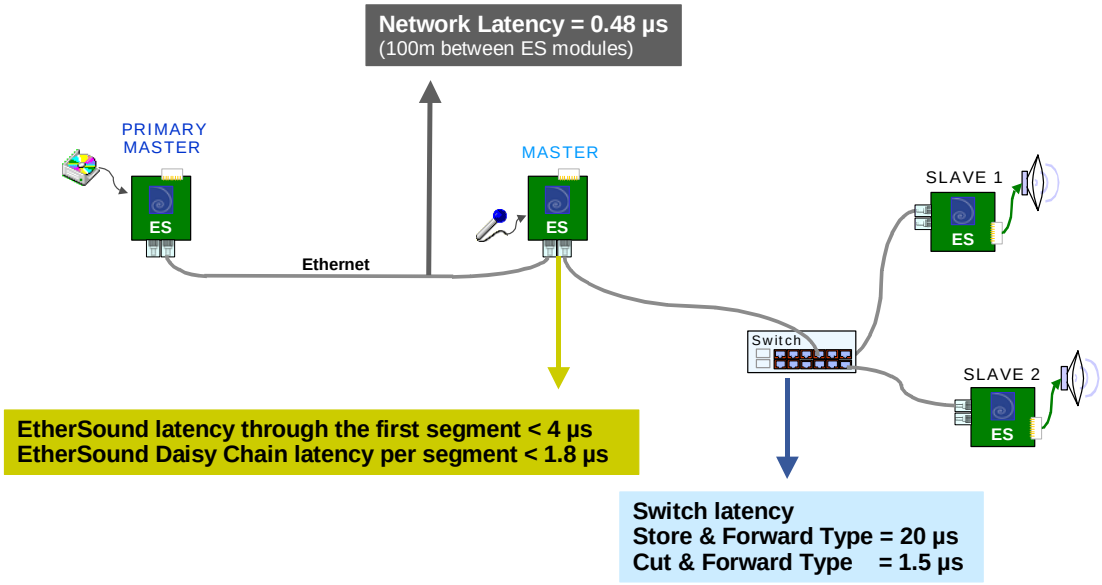
1.2.3.5 Timing and Latency of the Digigram Reference Designs

Typical end-to-end, network transmission time (SSI In to SSI Out) is 6 samples.

Less than 1.8 µs of latency is added per EtherSound device passing audio downstream (that is daisy chained).



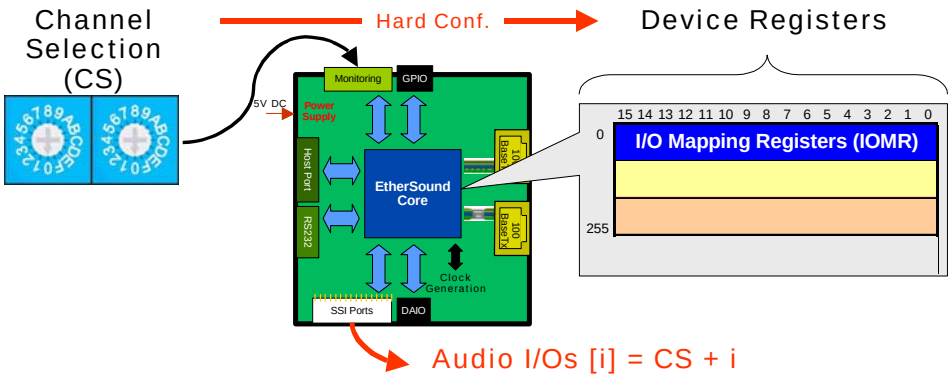
Examples of typical latencies introduced when using switches or long enough CAT5 cables are also shown.



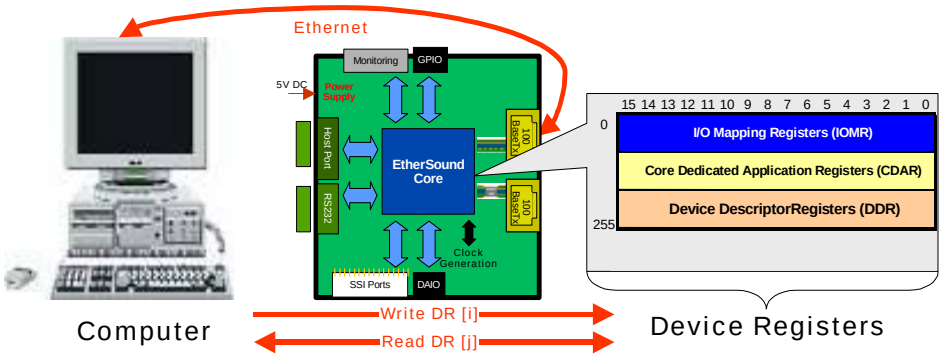
1.2.4 EtherSound programming of ESnet Reference Design MSx 88 Eeprom 200K based devices

EtherSound technology provides several ways to program the Device Registers of an EtherSound module. Here is an overview relating to the ESnet Reference Design MSx 88 Eeprom 200K:

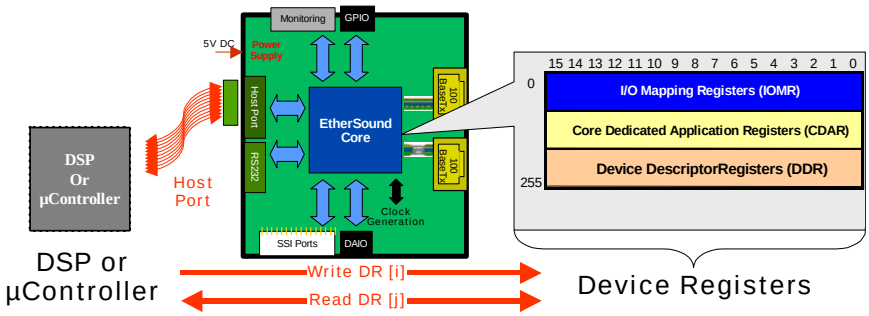
- **By Hardware using Wheel, Dip Switches, or external logic** directly connected to the specific monitoring port signals. This solution allows to control directly the I/O Mapping Registers (IOMR) (i.e. the local EtherSound channel assignments to audio I/Os) without any software. It is available with Master and Slave devices.



- **By software, using the "Ethernet IN" interface connected to an external computer and thanks to a specific Ethernet protocol.** This solution allows reading and writing in any local Device Register. It is only available on a Primary Master, but allows addressing any register of any device.
  Digigram provides a PC/Windows Application Programming Interface for Windows to control any register on any EtherSound equipment of an EtherSound network through the connected Primary Master. No knowledge of the Ethernet protocol is needed.



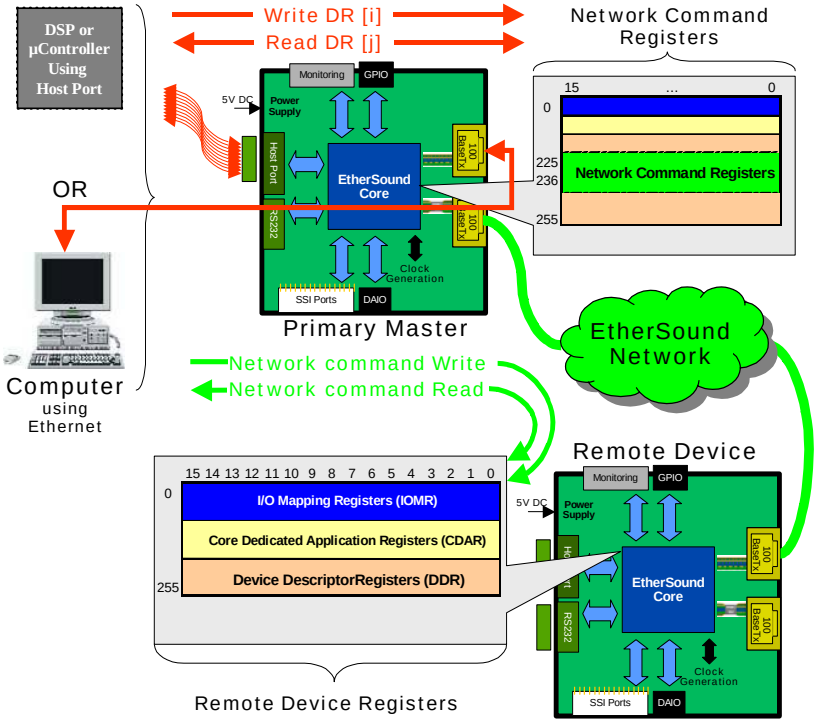
- **By software, using the Host Port from an external µController or a DSP.** This solution allows reading and writing in any local Device Register. Furthermore, the Host port of the Primary master allows to access any register of any device.



Primary Master specific feature:

Among its Device Registers, the **Primary Master** contains "**Network Command Registers**". These registers are dedicated to the sending of **Read** and **Write EtherSound commands** toward the **remote EtherSound devices** on the network. They are accessed via the Ethernet IN interface or the Host Port of the Primary Master as all the other Device Registers.

This specific feature, available only on the Primary Master, allows to read and write any Device Register of any EtherSound device on the network.
Digigram provides a PC/Windows application-programming interface for Windows to help the programming of any remote Device Register from the EtherNet interface, without any knowledge of the Ethernet protocols.



2 APPENDIX A: GLOSSARY

AUDIO CHANNEL

An **Audio Channel** is a single mono audio signal. By extension, an audio channel is one of the 64 slots of an EtherSound Frame, i.e. a signal sampled at 48 or 44.1 kHz with a 24-bit resolution.

BROADCAST

A configuration where an equipment transmits simultaneously towards all the other equipments.

CDAR

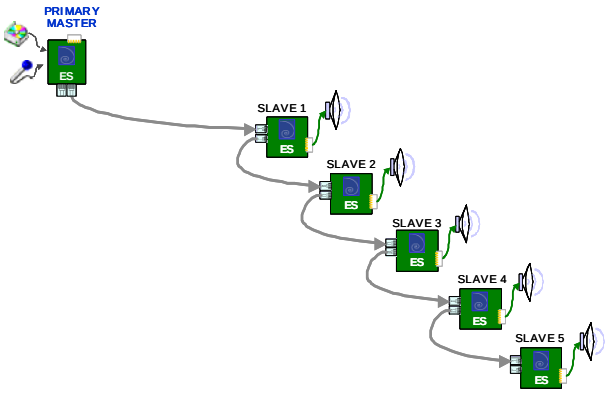
CDAR are the **C**ore **D**edicated **A**pplication **R**egisters. These EtherSound registers are reserved for Digigram or client-specific peripheral functions, such as RS232, GPIO, analog gain….

DAIO

DAIO stands for **D**edicated **A**pplication **I**nputs **O**utputs. It is a set of 10 pins available in the Digigram Reference Designs. They require a specific logic programming of the FPGA.

DAISY CHAIN

The **Daisy Chain** is a network topology where all devices are "serially" linked one to the other.



DDR

DDR are the **D**evice **D**escriptor **R**egisters. They describe the status and the configuration of the EtherSound Kernel of the device.

ETHERNET

Most used Local Area Network (LAN), originally developed by Digital Equipment Corporation, Intel Corporation and Xerox Corporation (DIX), standardised by the IEEE Committee, ISO normalized. Standard off-the-shelf components widely available at reasonable cost.

FRAME

A **Frame** is a set of characters that are transmitted as an entity according to a defined format. The frame follows a coding procedure at the physical level before emission. The EtherSound Frame is fully compliant to Ethernet 802.3 standard.

FULL DUPLEX

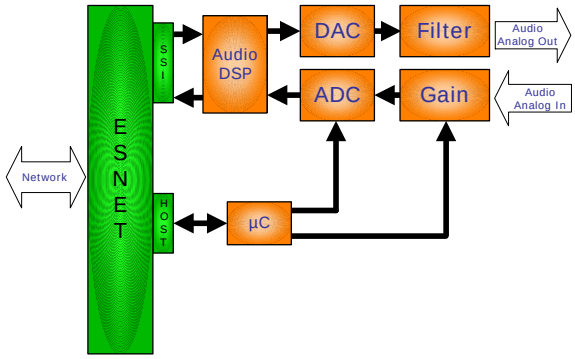
A transmission is said to be **Full Duplex** when data can be transmitted and received simultaneously.

GPIO

GPIO stands for **G**eneral **P**urpose **I**nputs **O**utputs. The ESnet MSx 88 Eeprom 200K Reference Design has 8 GPIO pins that can be fully configured to either retrieve or output an LVDS level to remotely control external devices such as relays and switches. GPIOs can be used for example with a microphone equipped with a two-position switch that will be connected in that case to the GPIO inputs.

HOST PORT

The Host Port is an interface provided on the ESnet MSx 88 Eeprom 200K Reference Design for communication with a µController or a DSP on an Application Board.



The communication will be performed via the EtherSound Device Registers.

IEEE 802

Committee created in 1980 that has established standards for informatics equipment connection. IEEE 802.3-4-5 describes the Physical and Link Layers (MAC) from the ISO OSI reference model. Those different physical layers can interface with the IEEE 802.2 norm that describes the upper part of the Link Layer (LLC).

IOMR

IOMR are the ESnet **I/O M**apping **R**egisters that describe for each Audio I/O what needs to be associated in the frame. Each one of these sixty four 16-bit registers store the bundle number to put in or get from the frame, the packet type the device must select in the frame.

LATENCY

The latency of a device measures the insertion delay it will add in a system.

MASTER

A device in the network that is downstream from the Primary Master that contributes additional audio channels into the EtherSound stream is called **Master.**

A Master answers to the status requests and commands of the Primary Master. Also see *Master/Slave* and *Primary Master*.

MASTER/SLAVE

A device may be configured to both contribute and extract audio channels. This device is called **Master/Slave**.

A Master/Slave answers to the status requests and commands of the Primary Master.

MULTICAST

A configuration where an equipment transmits simultaneously towards a group or list of other equipment.

PRIMARY MASTER

The first EtherSound device in the network is called the **Primary Master**. As well as being a source of audio for the network, the Primary Master provides the commands and clock for audio channel synchronization.

SLAVE

An EtherSound device that receives the EtherSound stream and restores standard audio is called a **Slave**.

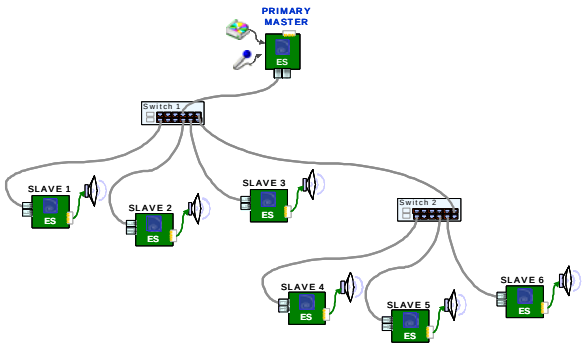
A slave answers to the status requests and commands of the Primary Master.

SSI

The **S**ynchronous **S**erial **I**nterface is the most common way to send/receive data to/from a Standard Audio DAC or ADC. This interface is provided on the ESnet MSx 88 Eeprom 200K Reference Design in form of 8 data wires (4 IN allowing 8 Channel Upload, 4 OUT allowing 8 Channel Download) and Clock control.

STAR

Star is a network topology where all devices are connected to a same unit (a switch in the following picture) that is handling all the communications.



UNICAST

A configuration where one equipment transmits towards a single equipment.

3 APPENDIX B: ORDERING INFORMATION

The table below includes all ordering details concerning the EtherSound product family:

Ordering Information

Ordering Code	Product Name	Product Description
	EtherSound OEM License Agreement MOIP option	Manufacture Only Intellectual Property OEM License Agreement (*includes ESnet MSx 88 Eeprom 200k and ESnet S2 Prom 100k Reference Designs*)
	EtherSound OEM License Agreement DMIP option	Design and Manufacture Intellectual Property OEM License Agreement
	ESnet Evaluation Kit	ESnet evaluation kit consisting of two ESnet evaluation boards and documentation
	ESnet Module MSx 88 Eeprom 200k	8 channel exclusive Master/Slave ESnet Module using a 200 kgate Xilinx associated to an Eeprom
	ESnet Module S2 Prom 100k	2 channel ESnet Slave Module, using a 100 kgate Xilinx associated to a Prom

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