https://www.halvorsen.blog

Modbus

With Practical LabVIEW Examples

Hans-Petter Halvorsen

Contents

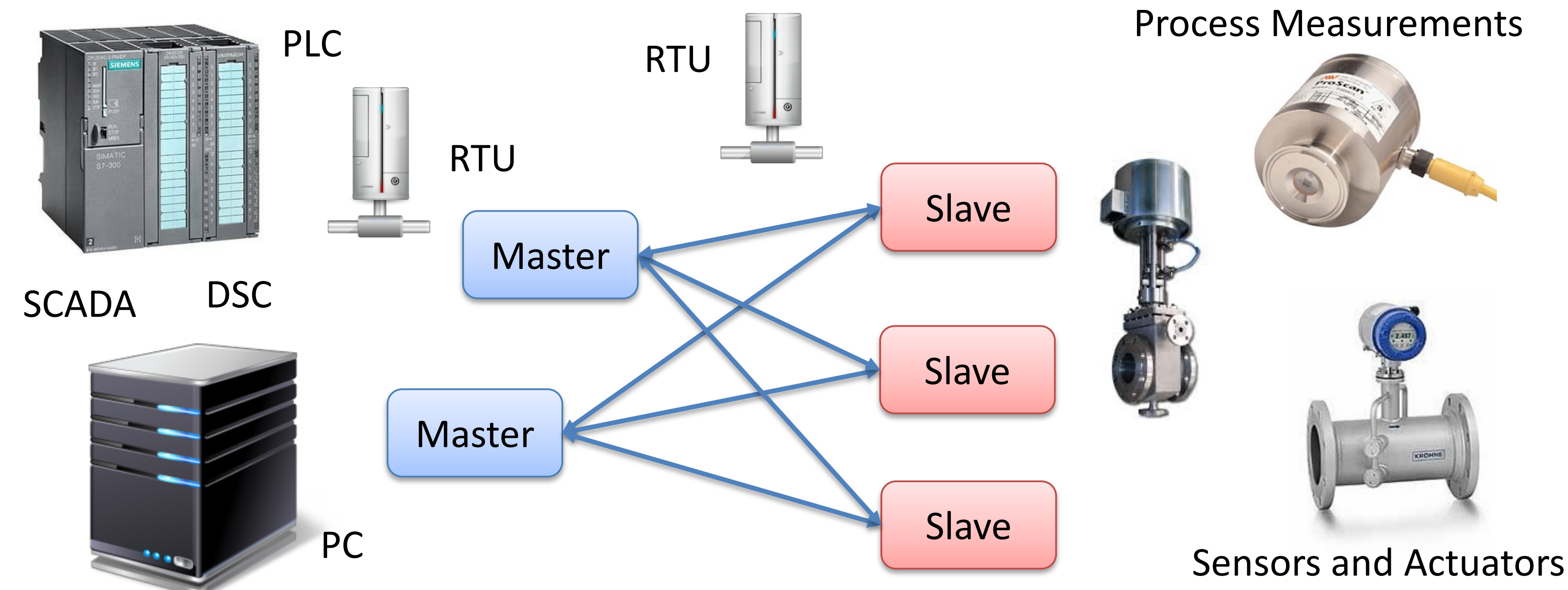
Modbus

What is Modbus?

- **Modbus is a serial communications protocol** originally published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs).
- **Simple and robust**, it has since become a de facto standard communication protocol, and it is now a commonly available means of connecting industrial electronic devices
- The development and update of Modbus protocols has been managed by the Modbus Organization since April 2004, when Schneider Electric transferred rights to that organization (https://modbus.org)
- Modbus became the first widely accepted fieldbus standard.

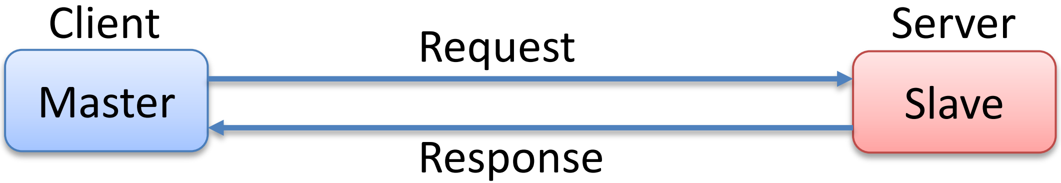
Modbus

The master typically is a PLC (Programmable Logic Controller), PC or DCS (Distributed Control System)



A remote terminal unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a DCS or SCADA System

Master/Slave



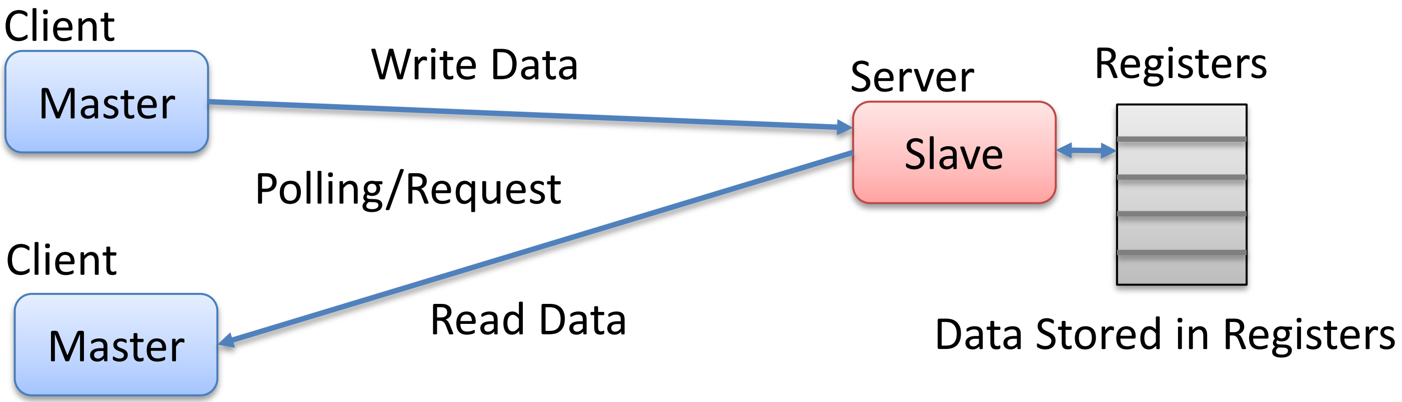
The Modbus protocol follows a Master/Slave (Client/Server) architecture where a Master (Client) transmits a request to a Slave (Server) and waits for the response.

Note! The terms “Master” and “Slave” used in Modbus has been replaced with the terms “Client” and “Server”. The LabVIEW Modbus package still use the old terms, so they will also be used in this Tutorial

Master/Slave

- Modbus protocol is defined as a master/slave protocol, meaning a device operating as a master will poll one or more devices operating as a slave.
- This means a slave device cannot volunteer information; it must wait to be asked for it.
- The master will write data to a slave device's registers and read data from a slave device's registers. A register address or register reference is always in the context of the slave's registers.

Master/Slave



Modbus protocol is defined as a master/slave protocol, meaning a device operating as a master will poll one or more devices operating as a slave. This means a slave device cannot volunteer information; it must wait to be asked for it. The master will write data to a slave device's registers and read data from a slave device's registers. A register address or register reference is always in the context of the slave's registers.

Modbus Register Types

- **Coil** (Discrete Output)
  - Coils are 1-bit registers, used to control discrete outputs, Read or Write
- **Discrete Input** (Read Only)
  - 1-bit registers
- **Input Register** (Read Only)
- **Holding Register** (Read/Write)

Access Levels

- In SCADA systems, it is common for embedded devices to have certain values defined as inputs, such as gains or proportional integral derivative (PID) settings, while other values are outputs, like the current temperature or valve position.
- To meet this need, Modbus data values are divided into four ranges
- In many cases, sensors and other devices generate data in types other than simply Booleans and unsigned integers.
- It is common for slave devices to convert these larger data types into registers. For example, a pressure sensor may **split a 32-bit floating point value across two 16-bit registers**.

Access Levels

Register Type	Data Type	Master Access	Slave Access
Coils	Bit (Boolean)	Read/Write	Read/Write
Discrete Input	Bit (Boolean)	Read-only	Read/Write
Input Register	Unsigned Word	Read-only	Read/Write
Holding Register	Unsigned Word	Read/Write	Read/Write

An **Unsigned Word** is a 16-bit nonnegative Integer Value between 0 – 65535 (2^16)

Register Addresses

- 0x = **Coil**, Address Range: **00001-09999**
- 1x = **Discrete Input**, Address Range: **10001-19999**
- 3x = **Input Register**, Address Range: **30001-39999**
- 4x = **Holding Register**, Address Range: **40001-49999**

When using the extended referencing, all *number* references must be exactly six digits. This avoids confusion between coils and other entities. For example, to know the difference between holding register #40001 and coil #40001, if coil #40001 is the target, it must appear as #040001.

Register Referencing

40001:7

- This is a commonly used notation for referencing individual bits in a register.
- This example references register 40001 (which is a Holding Register), bit 7.
- Bits are generally numbered starting at bit 0, which is the least significant or right most bit in the field of 16 bits found in a Modbus register.

Modbus Protocols

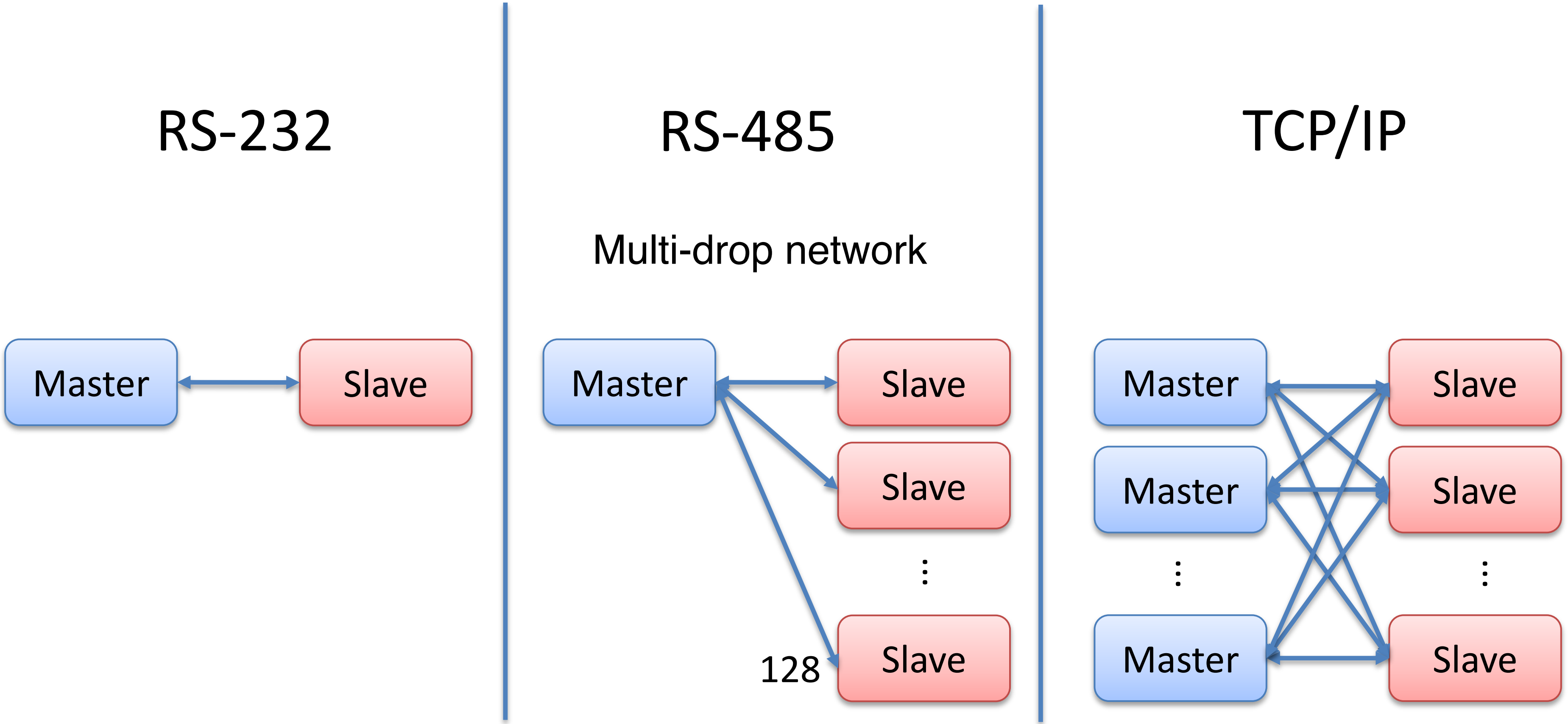
- Modbus ASCII
- Modbus RTU (Remote Terminal Unit)
  - Modbus RTU uses RS-485 or RS-232
- **Modbus TCP/IP**
  - Modbus TCP uses Ethernet

We will focus on Modbus TCP/IP in this Tutorial

Modbus ASCII and Modbus RTU are simple serial protocols that use RS-232 or RS-485 to transmit data packets.

Modbus TCP/IP follows the OSI Network Model and can be used in an ordinary Ethernet network

Modbus Communication



Modbus TCP/IP

- Modbus TCP/IP follows the OSI Network Model and can be used in an ordinary Ethernet network
- Modbus TCP requires that you know or define IP addresses on the network
- Modbus TCP/IP uses Port **502**

Modbus in LabVIEW

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Table of Contents

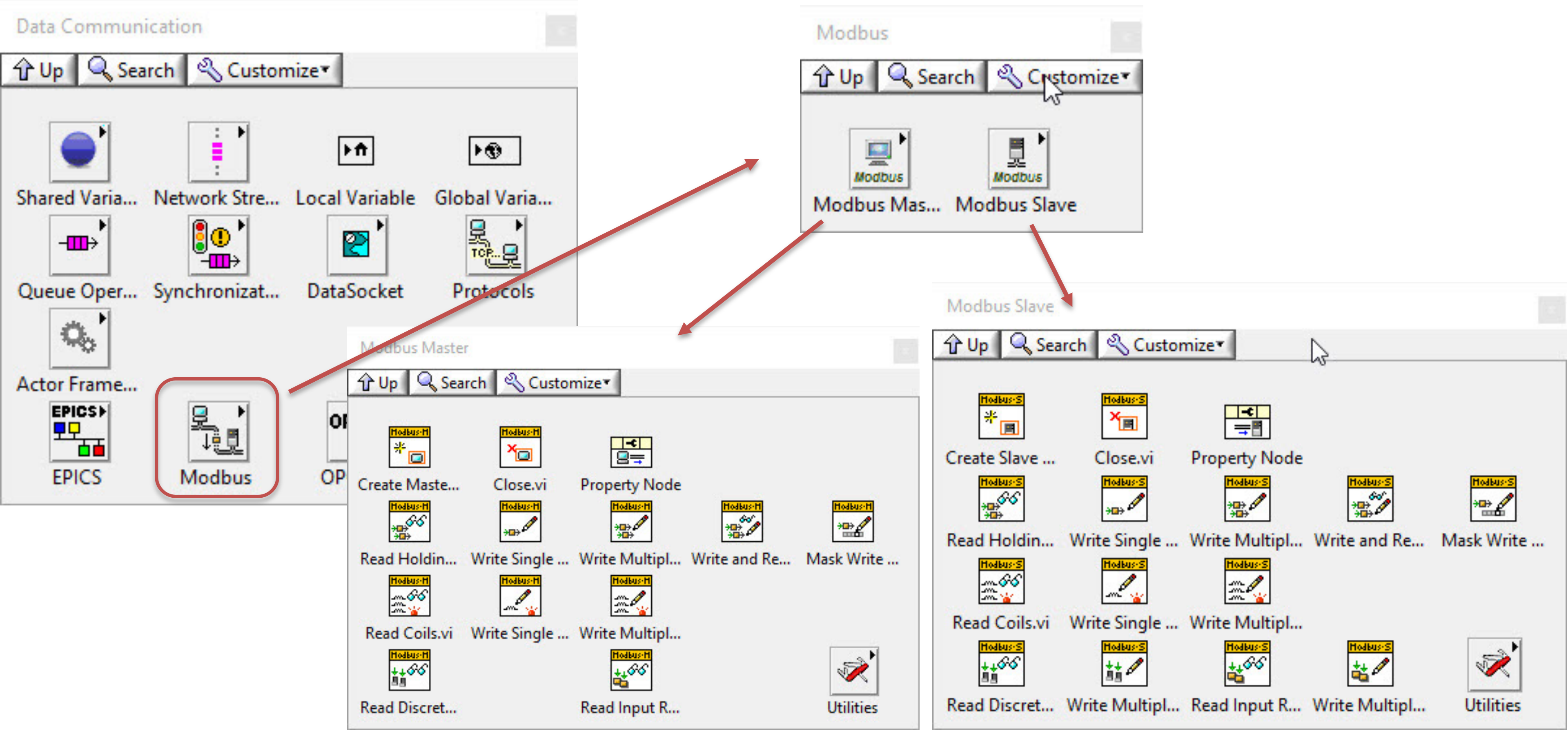
Modbus in LabVIEW

3 ways to use Modbus in LabVIEW:

- Use a high-level OPC Server
- Use Modbus I/O Server
- Use the LabVIEW Modbus API

“LabVIEW Real-Time Module” or “LabVIEW DSC Module” required

LabVIEW Modbus API



LabVIEW Examples

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Table of Contents

Modbus LabVIEW Examples

- LabVIEW Coils Examples
- LabVIEW Discrete Input Registers Examples
- LabVIEW Input Registers Examples
- LabVIEW Holding Registers Examples

Memory Type	Data Type	Master Access	Slave Access
Coils	Bit (Boolean)	Read/Write	Read/Write
Discrete Input	Bit (Boolean)	Read-only	Read/Write
Input Register	Unsigned Word	Read-only	Read/Write
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LabVIEW Coils Examples

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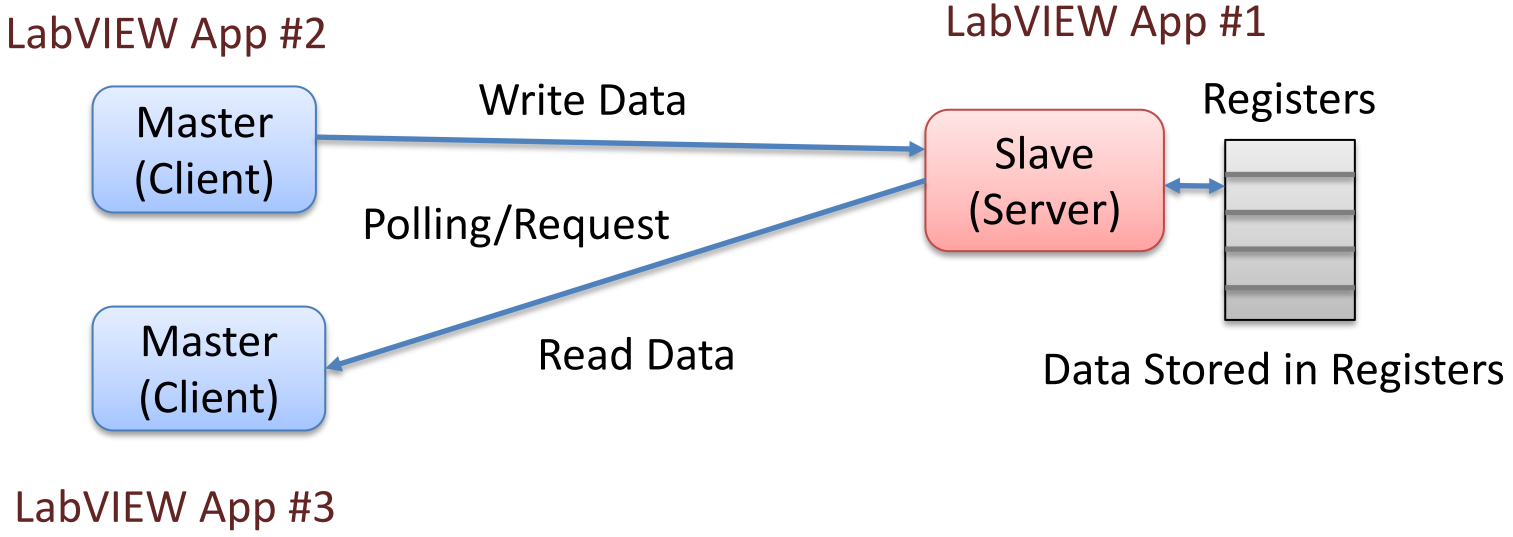
Table of Contents

LabVIEW Coils Example

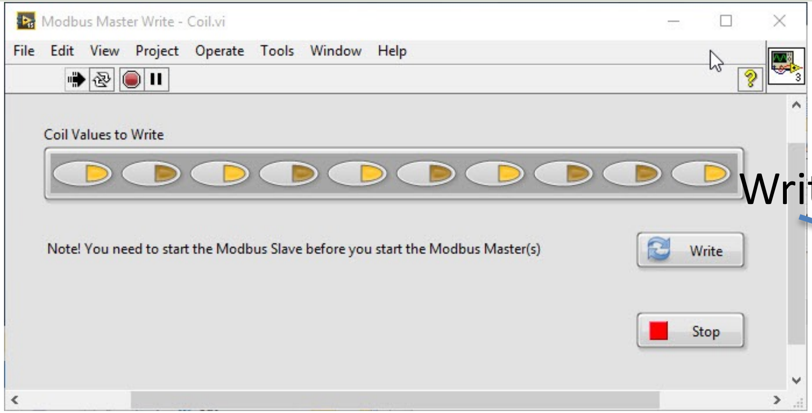
In this Example we Create 3 different LabVIEW Applications:



Memory Type	Data Type	Master Access	Slave Access
Coils	Bit (Boolean)	Read/Write	Read/Write

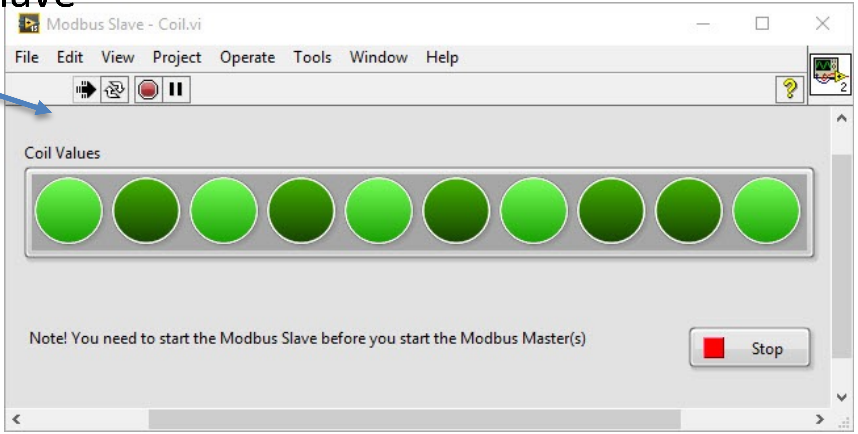
LabVIEW Coils Example

LabVIEW App #2 (Master)



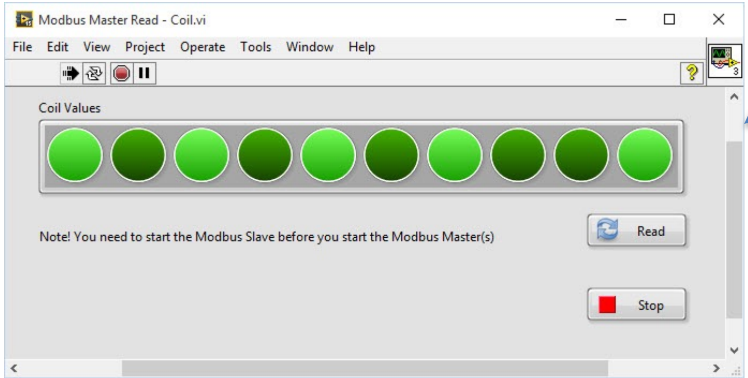
LabVIEW App #1 (Slave)

Write Data to Slave



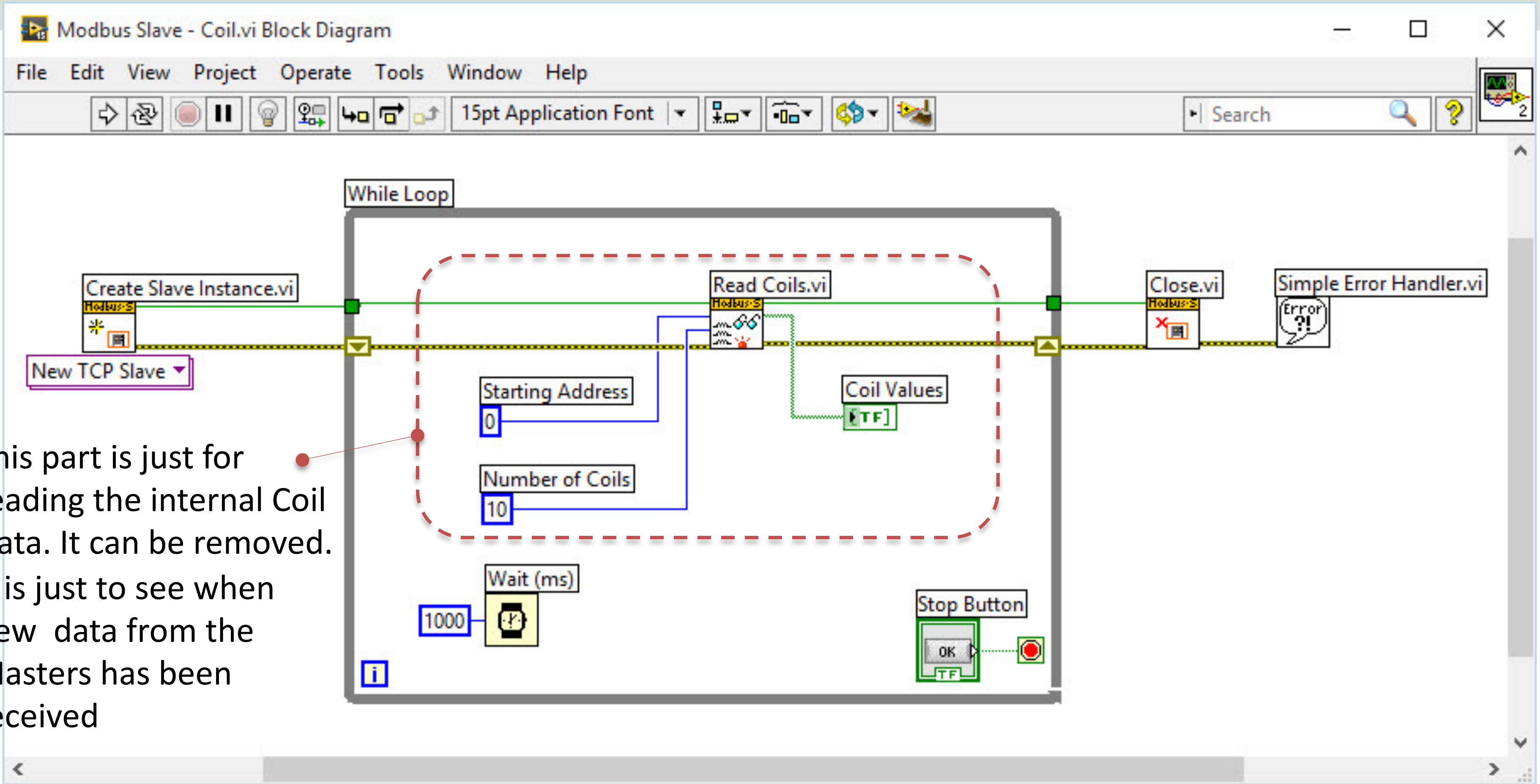
LabVIEW App #3 (Master)

Read Data from Slave



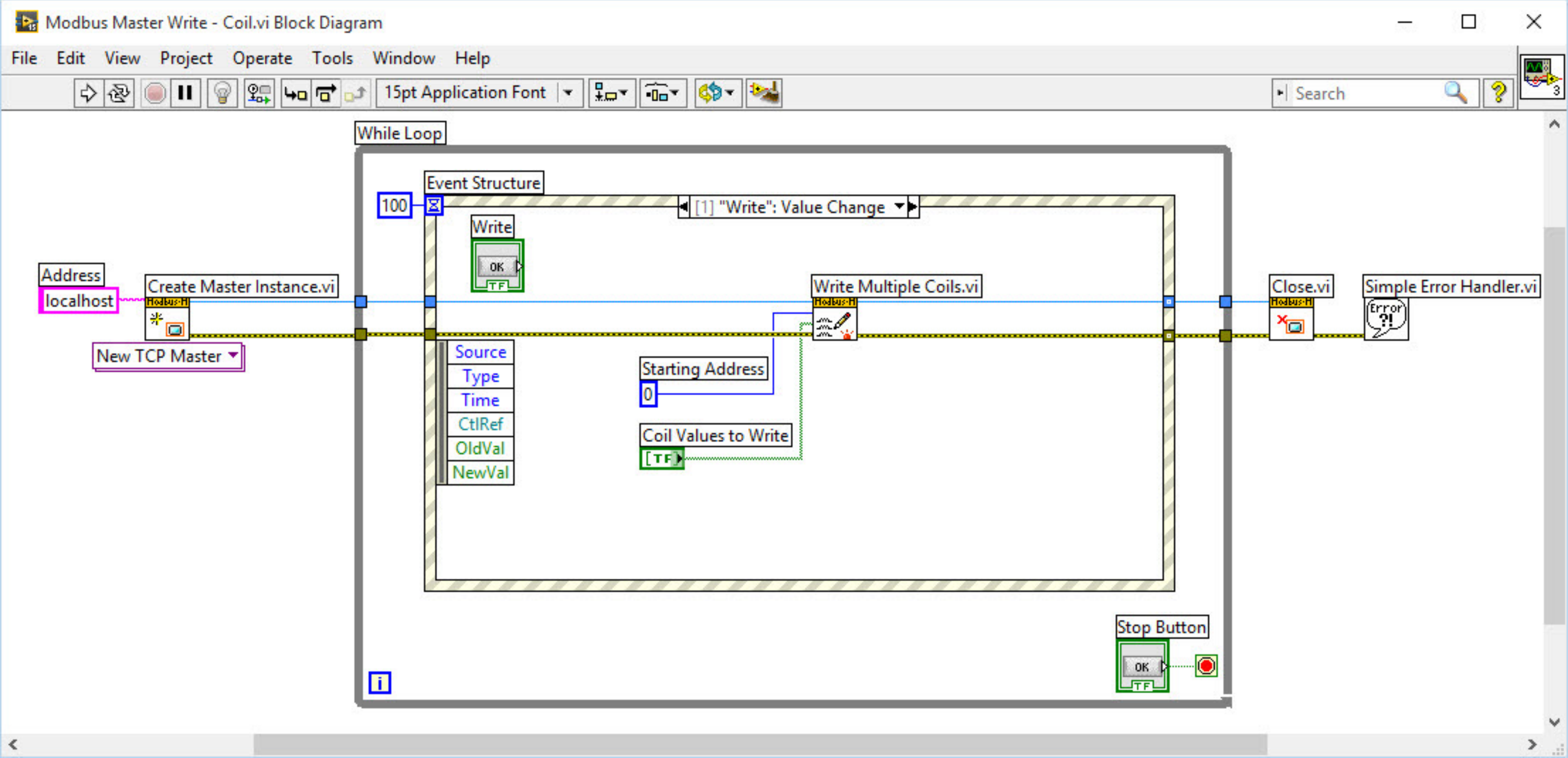
Note! You need to start/run the Modbus Slave App before you start the Modbus Master Apps

Modbus Slave

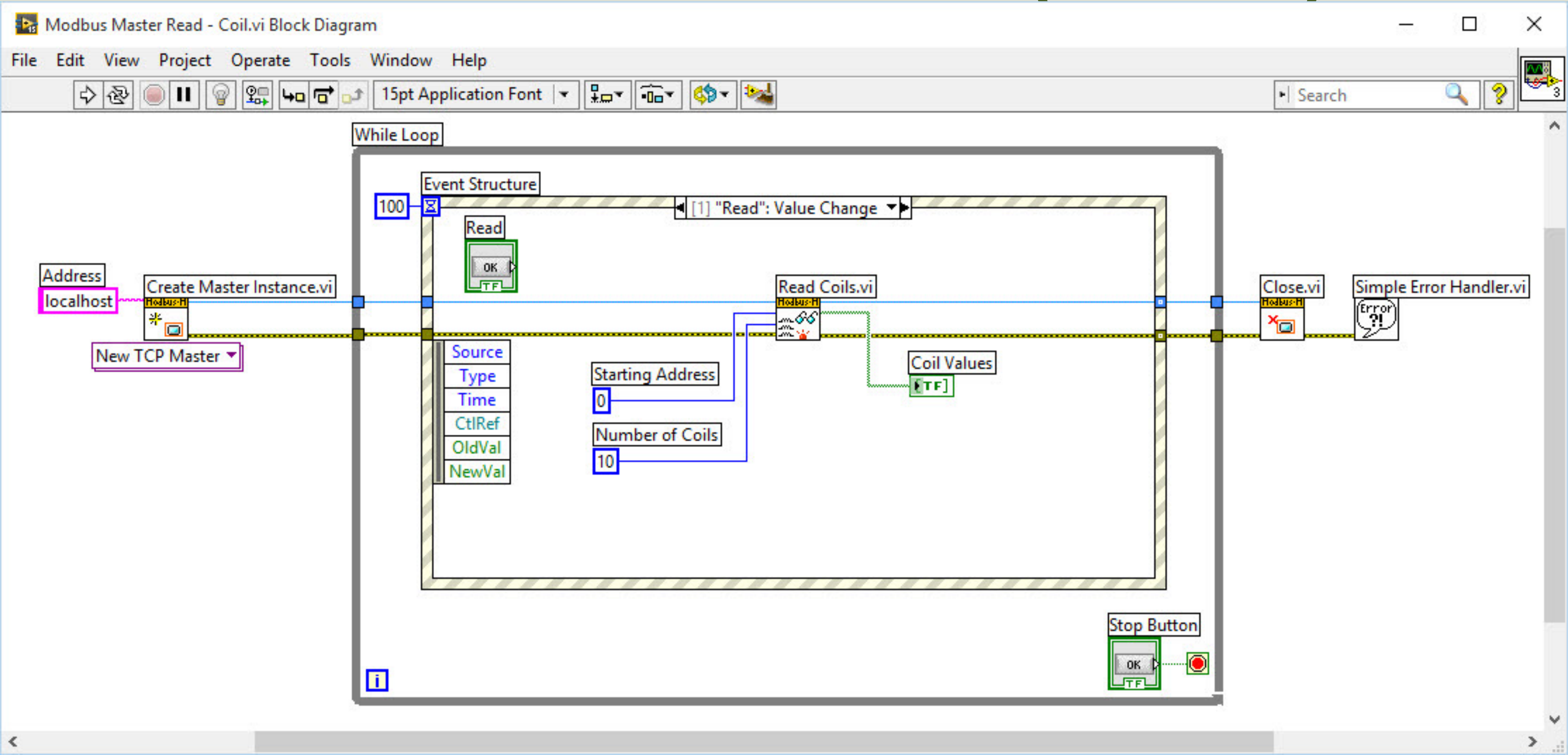


This part is just for reading the internal Coil Data. It can be removed. It is just to see when new data from the Masters has been received

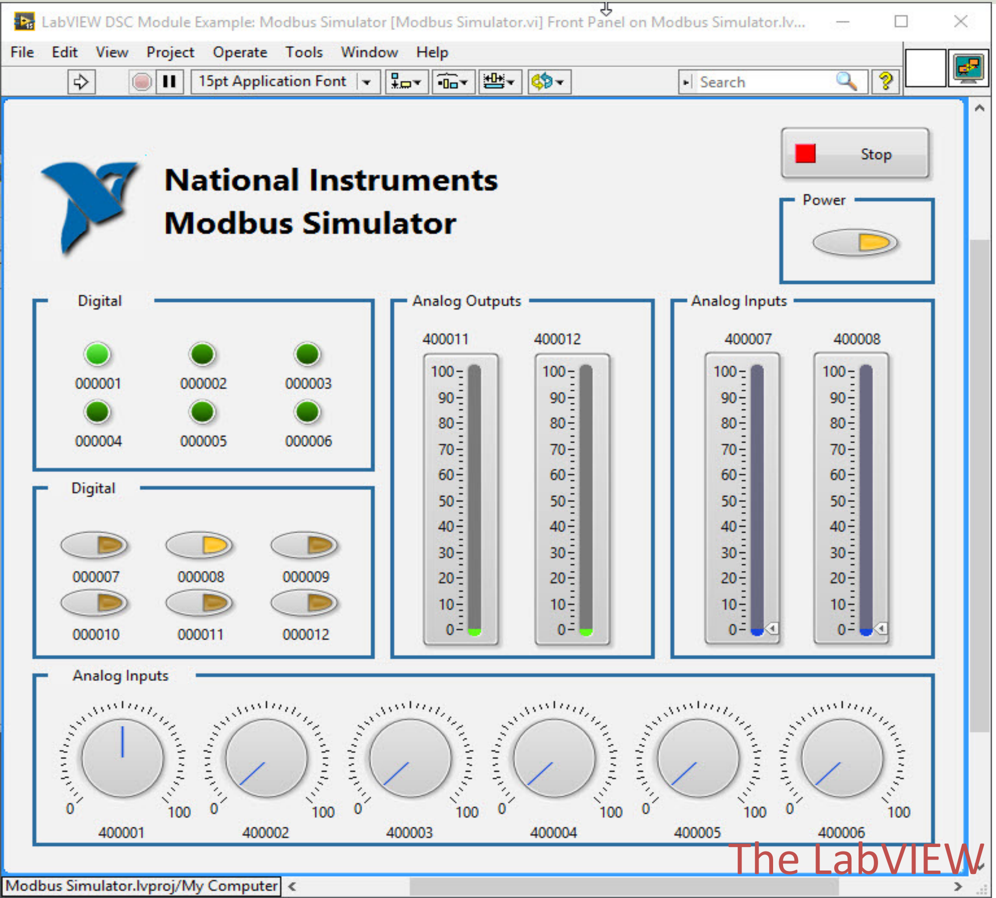
Modbus Master (Write)



Modbus Master (Read)



LabVIEW Modbus Simulator

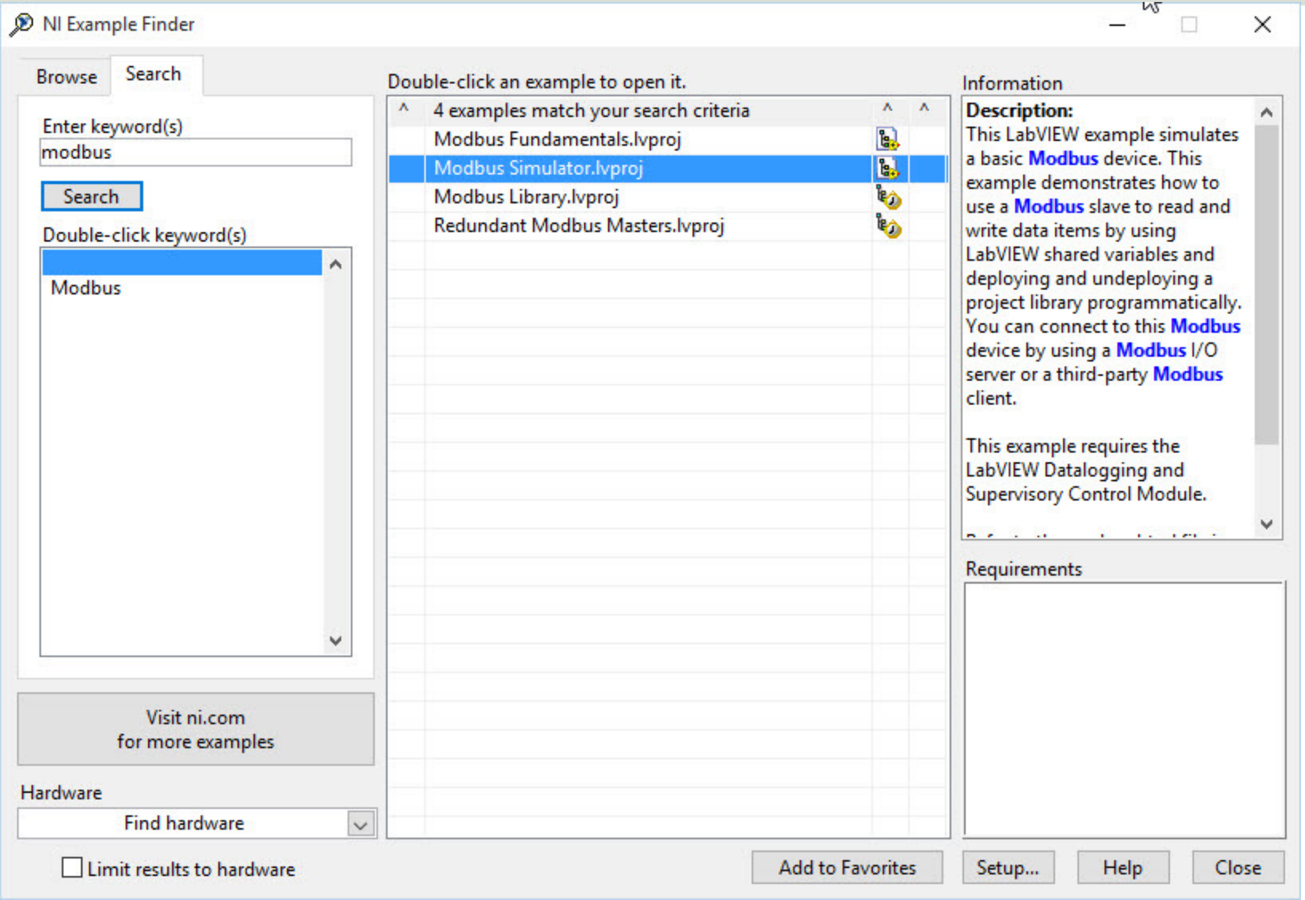


The LabVIEW Modbus Simulator is integrated with "LabVIEW Real-Time Module" or "LabVIEW DSC Module"

It can be used for test purpose, etc.

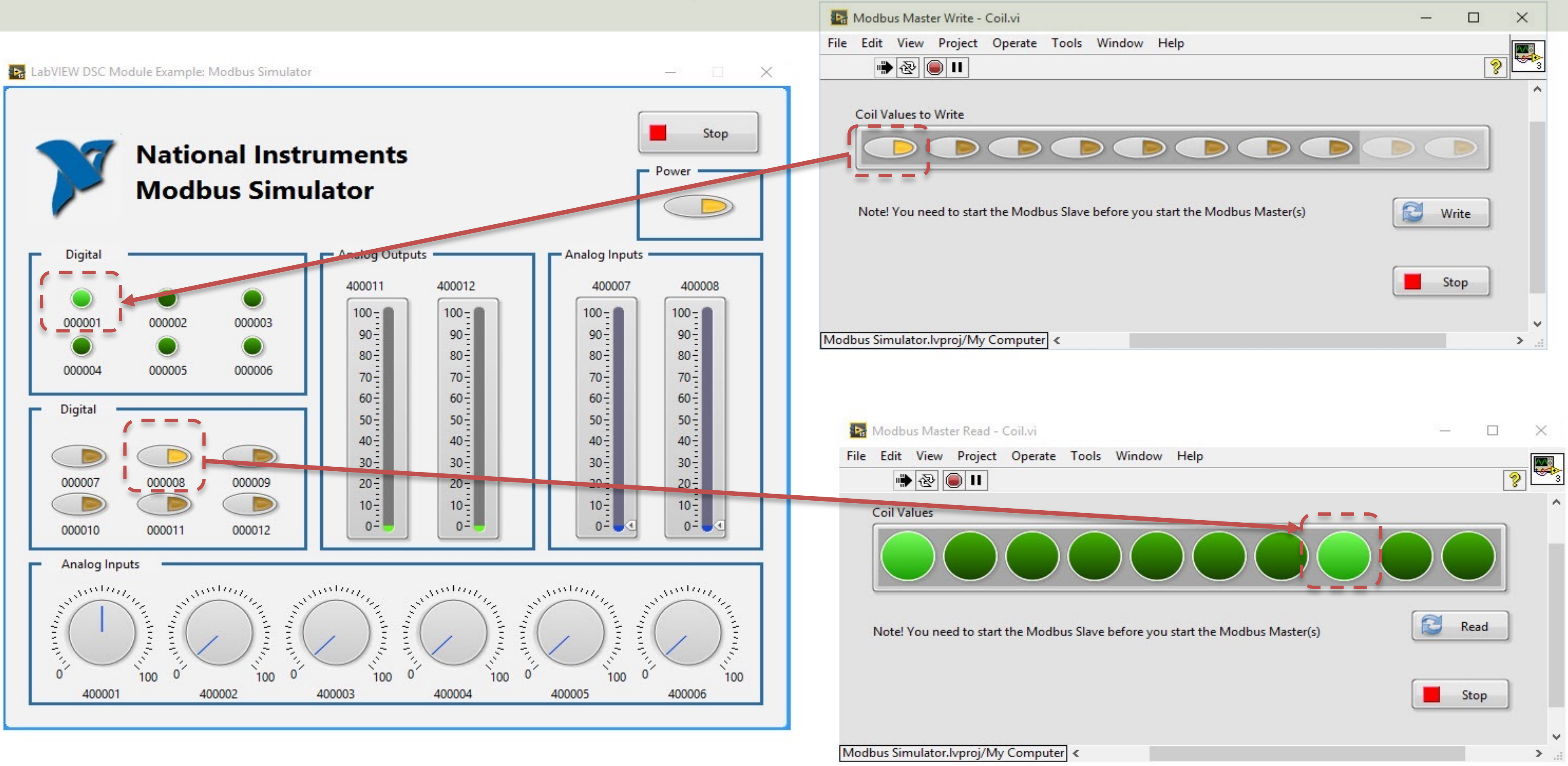
The LabVIEW Modbus Simulator is a **Modbus Slave** (Server)

NI Example Finder



Find Modbus Examples with NI Example Finder

LabVIEW Modbus Simulator Example



LabVIEW Discrete Input Registers Examples

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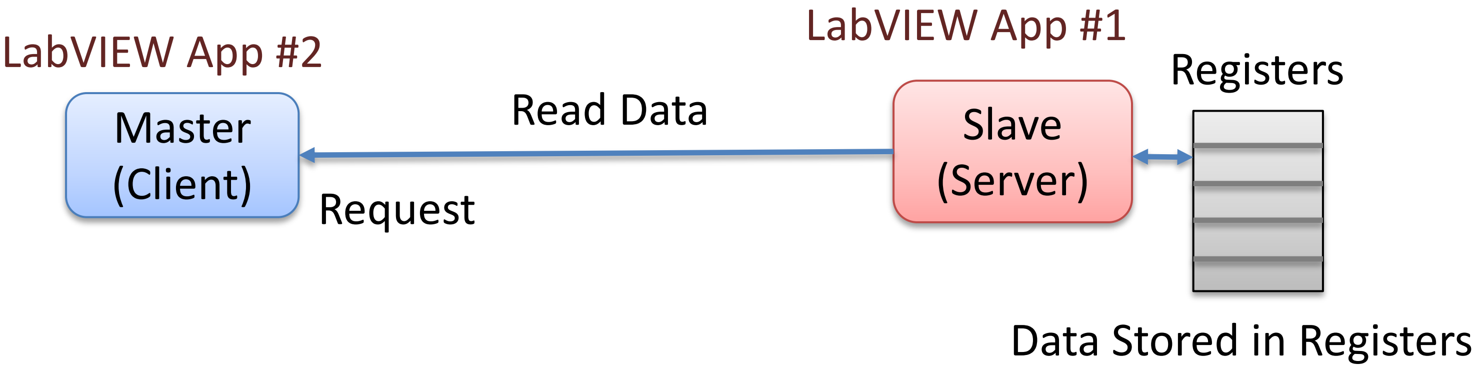
Table of Contents

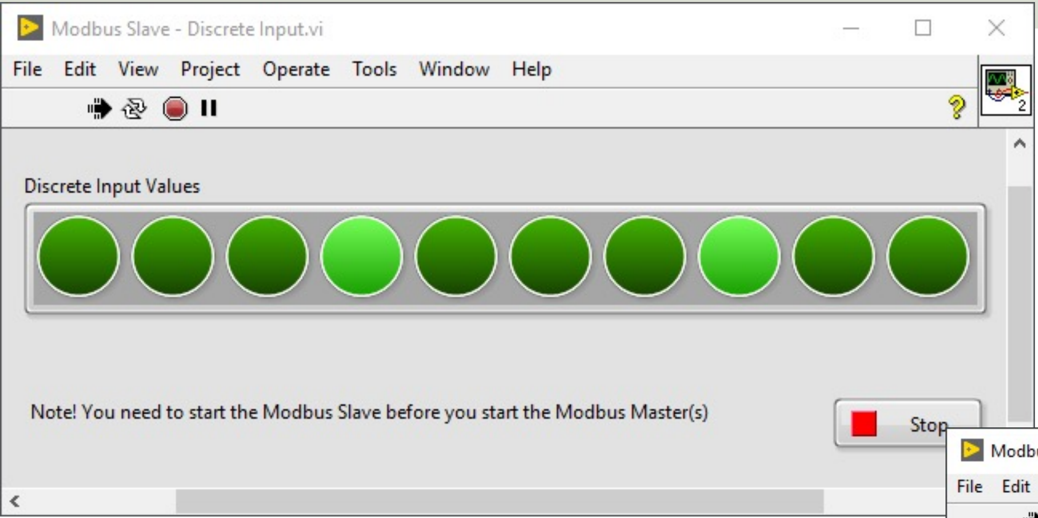
LabVIEW Discrete Input Registers Examples

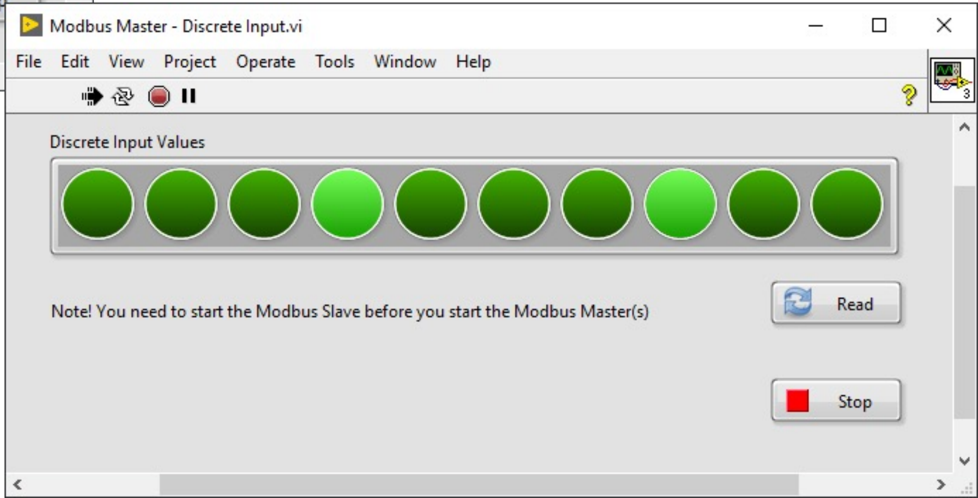
In this Example we Create 2 different LabVIEW Applications:



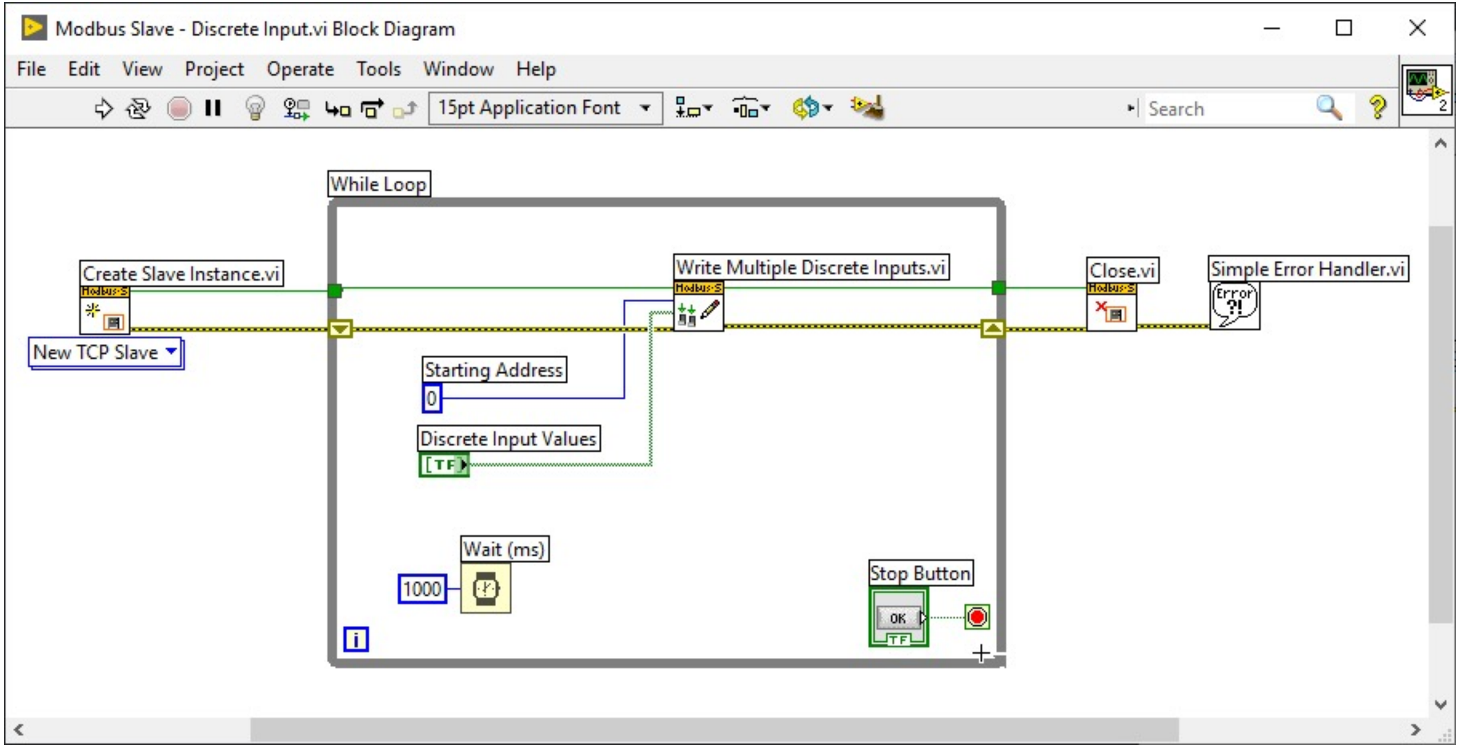
Memory Type	Data Type	Master Access	Slave Access
Discrete Input	Bit (Boolean)	Read-only	Read/Write

LabVIEW Discrete Input Registers Examples

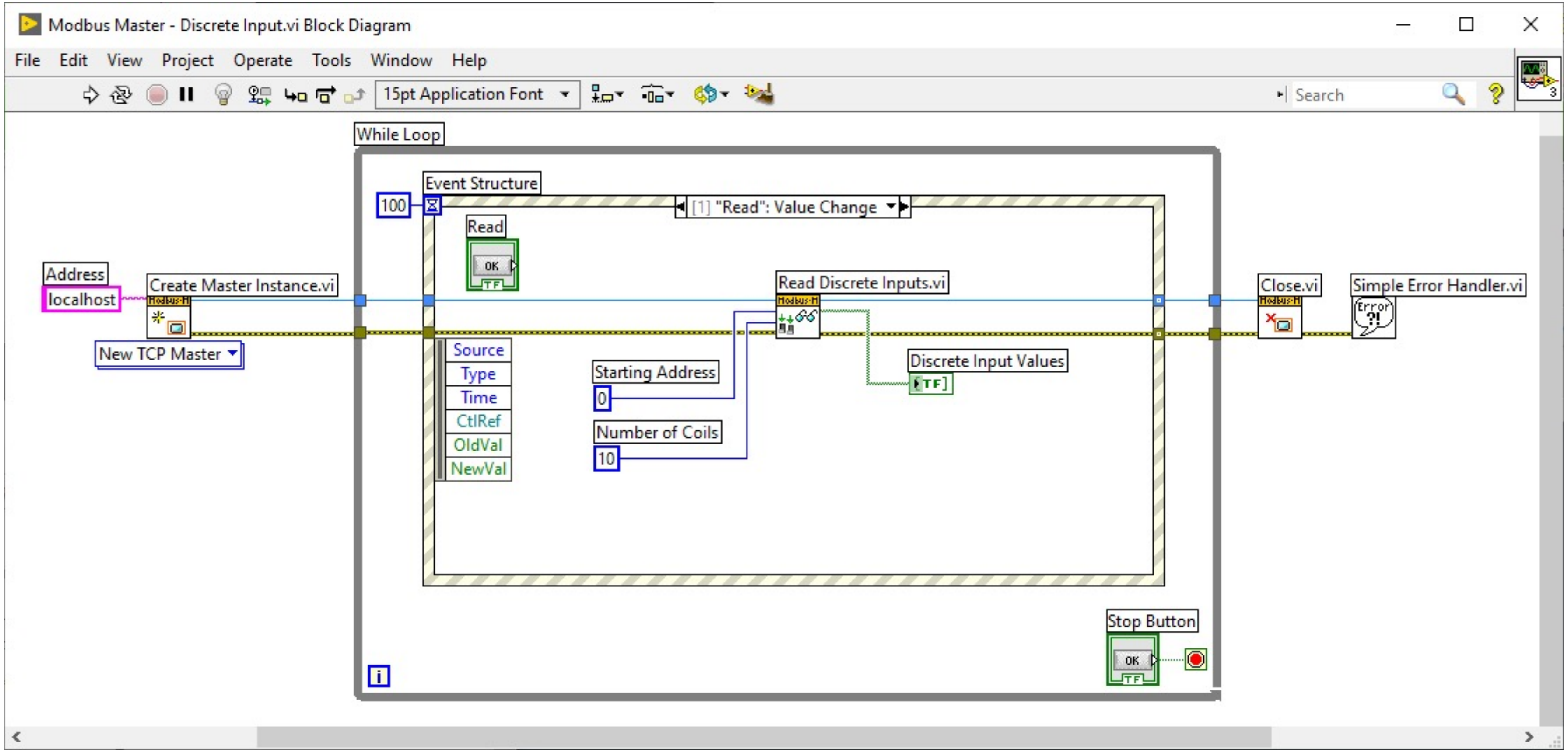




Modbus Slave



Modbus Master



LabVIEW Input Registers Examples

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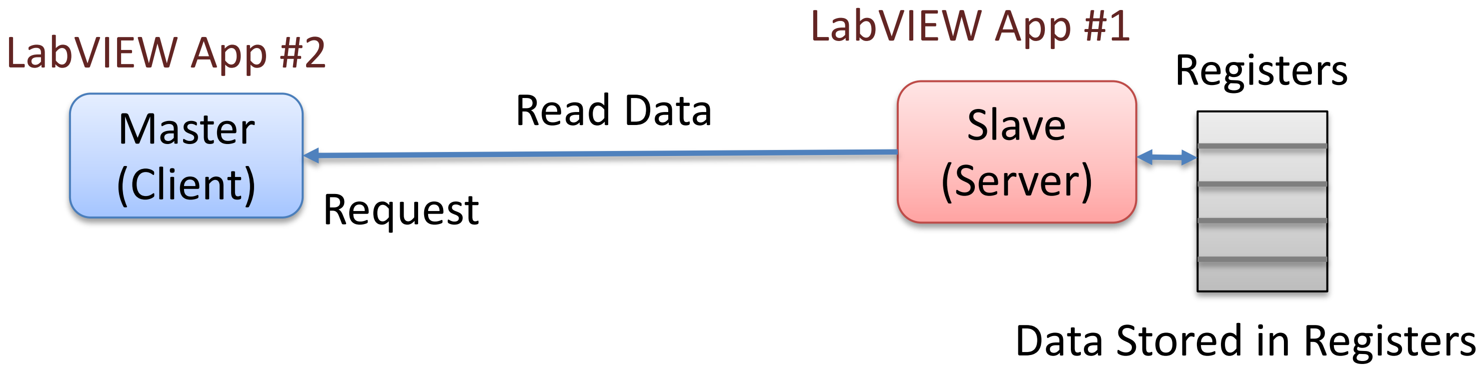
Table of Contents

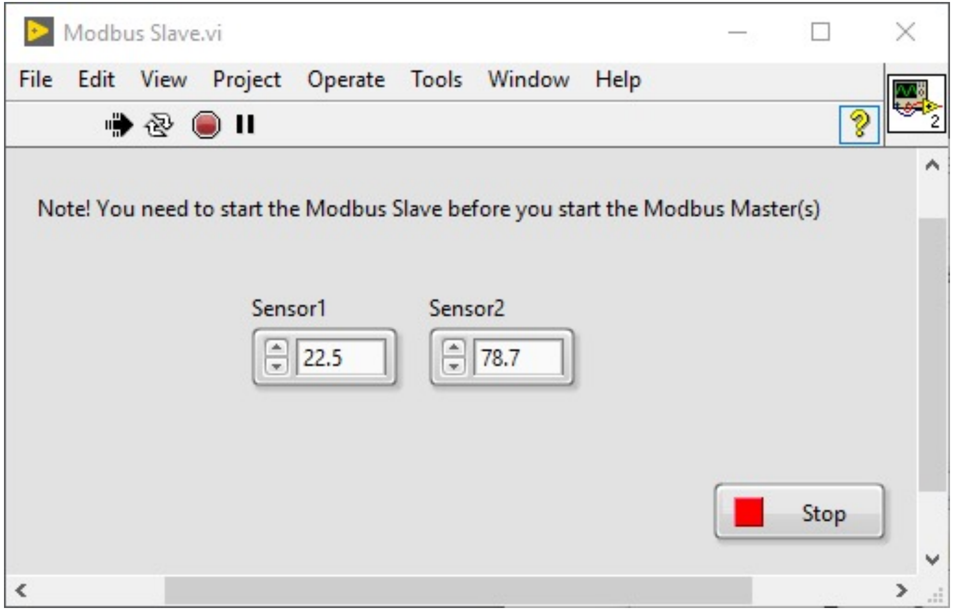
LabVIEW Input Registers Examples

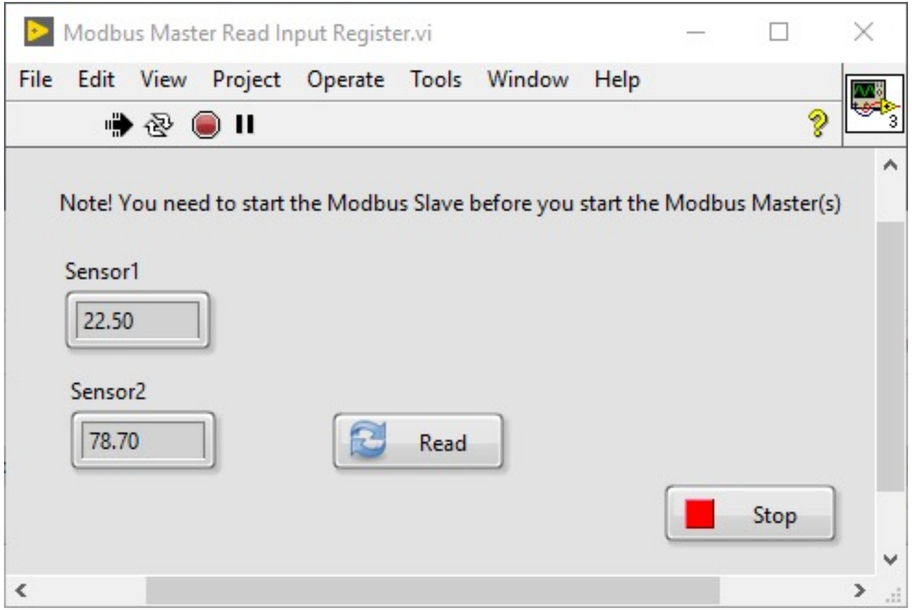
In this Example we Create 2 different LabVIEW Applications:



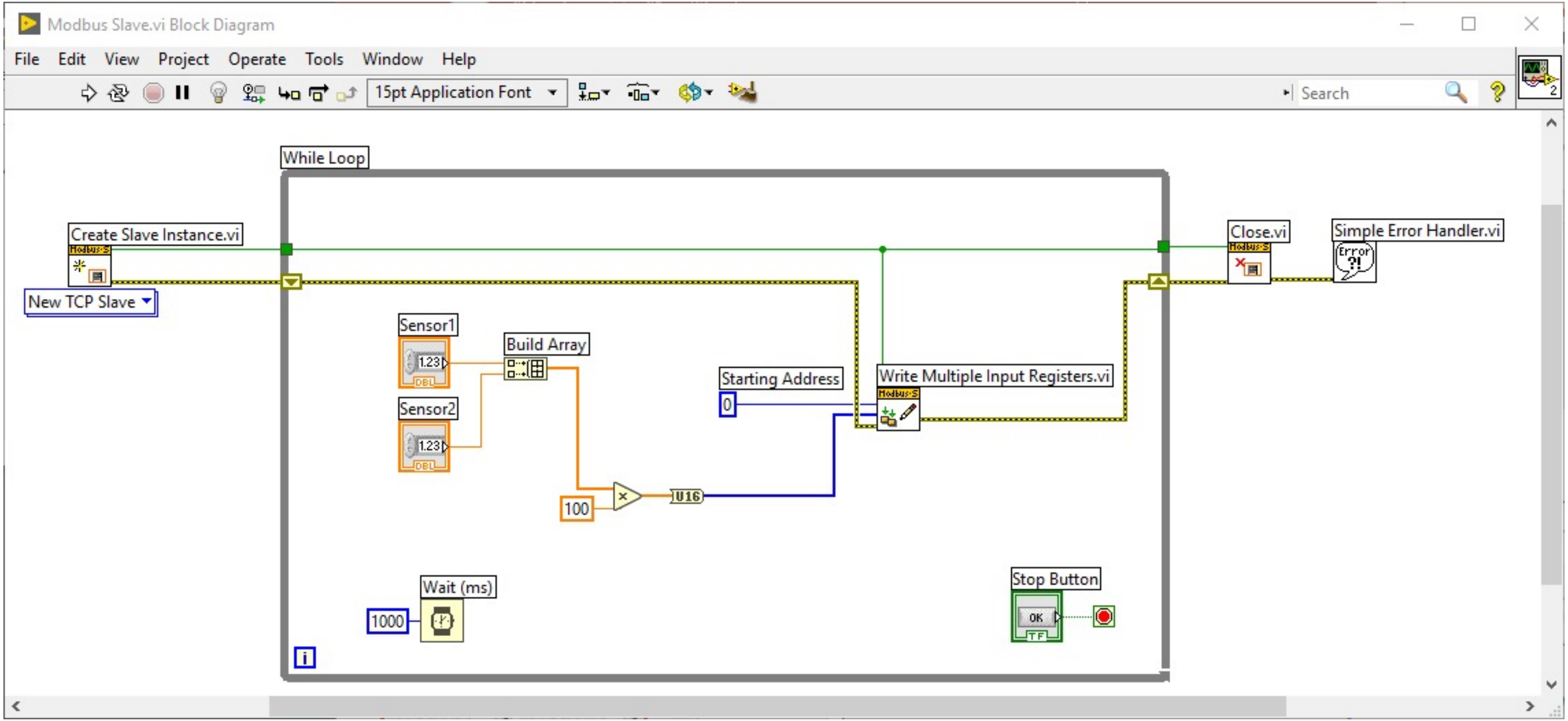
Memory Type	Data Type	Master Access	Slave Access
Input Register	Unsigned Word	Read-only	Read/Write

LabVIEW Input Registers Examples

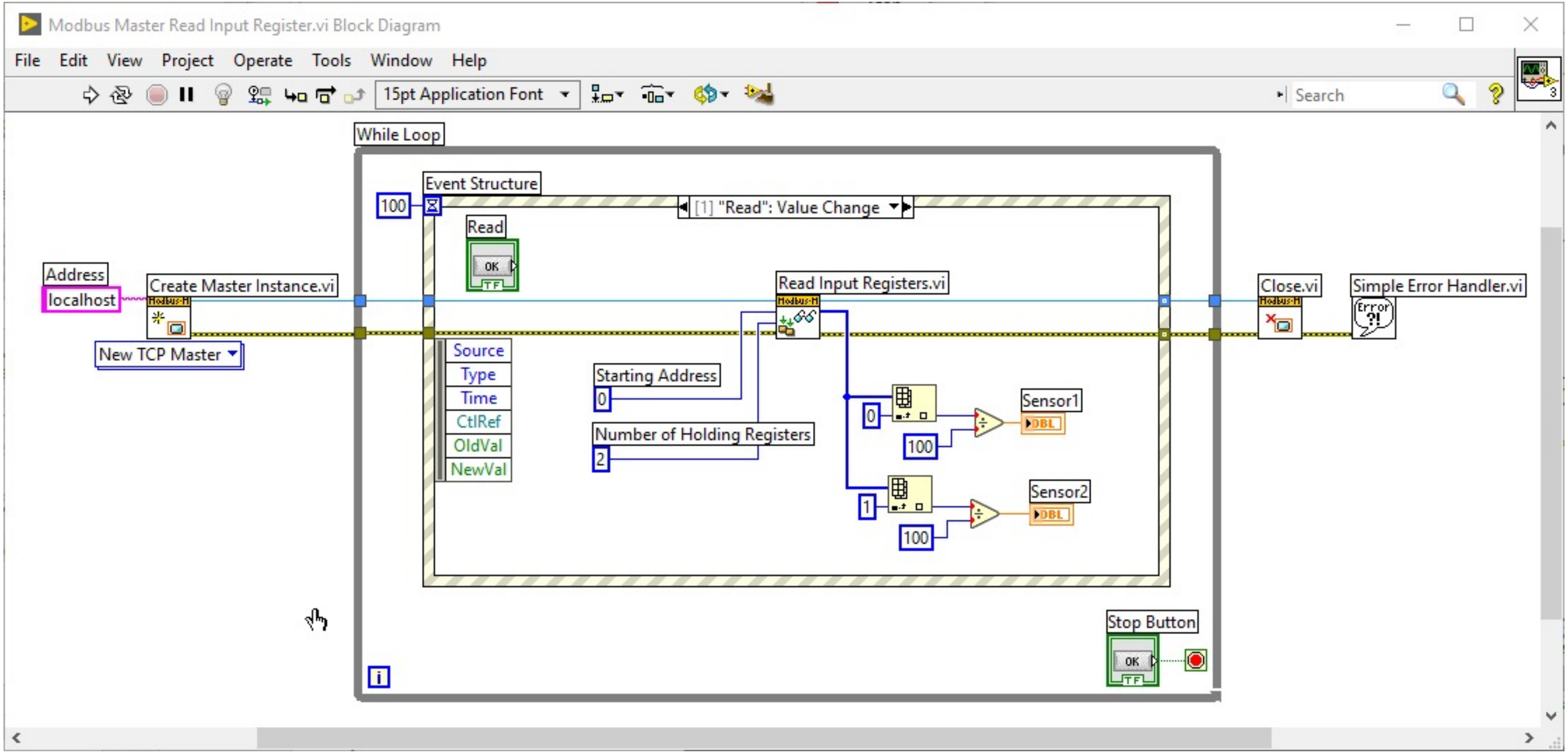




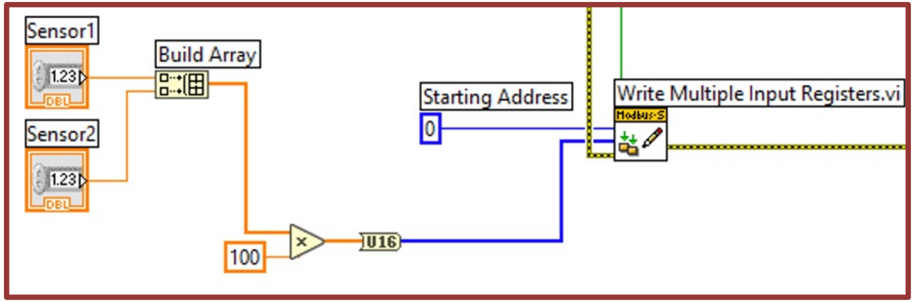
Modbus Slave

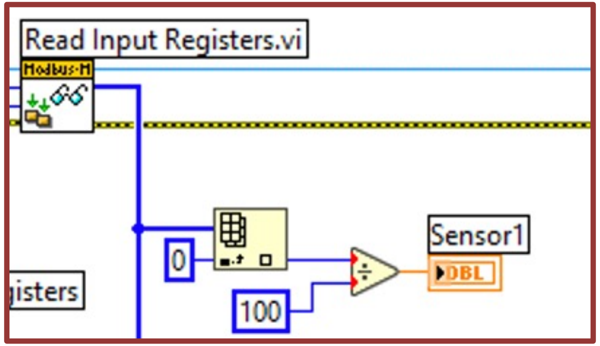


Modbus Master Read Input



Decimal/Floating-point Numbers





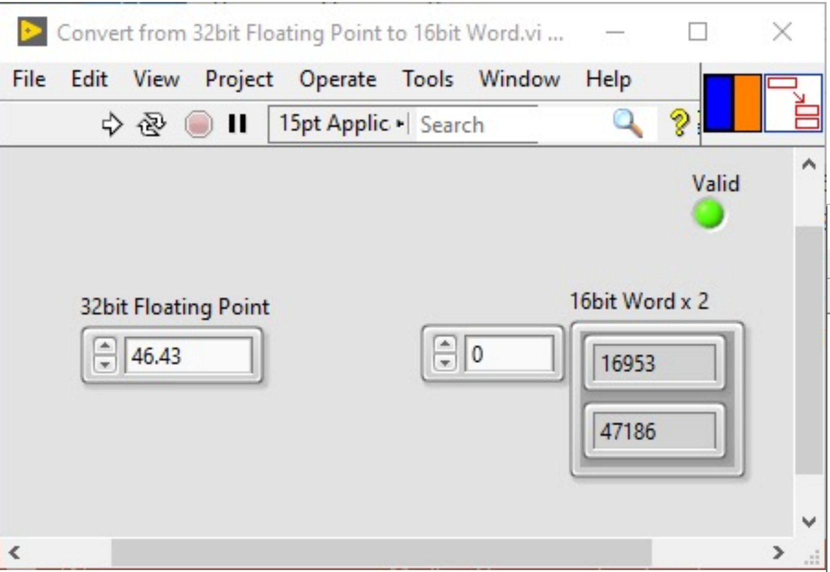
Memory Type	Data Type	Master Access	Slave Access
Input Register	**Unsigned Word**	Read-only	Read/Write

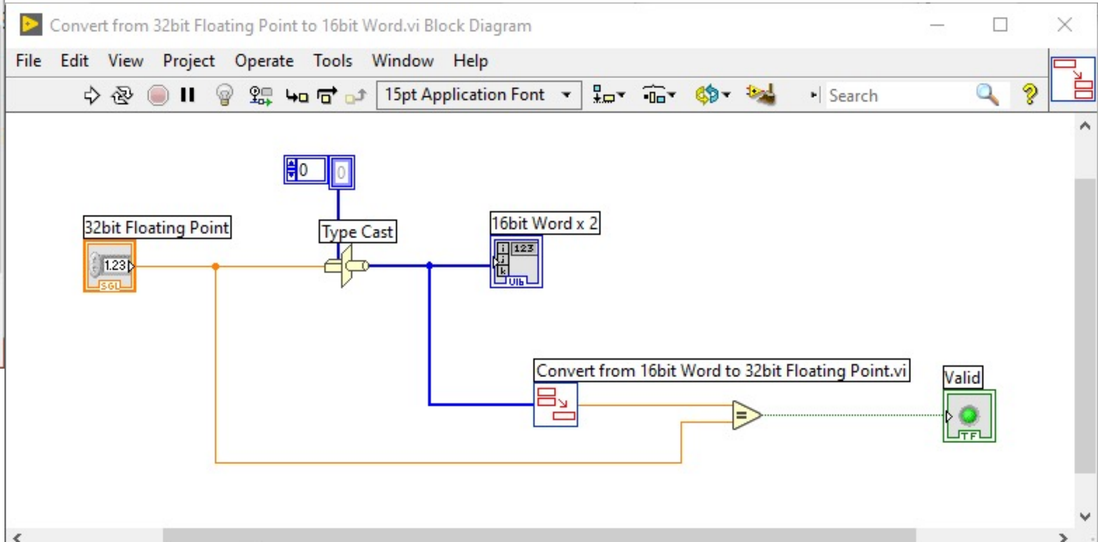
An **Unsigned Word** is a 16-bit nonnegative Integer Value between 0 – 65535 (2^16)

- How do you deal with Decimal/Floating-point Numbers? In Modbus, the default practice is to split a 32-bit floating point value across two 16-bit registers.
- In this example I just Multiply with 100 in the the Slave Application, then I divide by 100 in the Master Application, which work when you deal with numbers with 2 decimals, and you only need one register per number
- Example: 2.56 => 2.56x100=256 => 256/100 = 2.56

32-bit floating point across two 16-bit registers

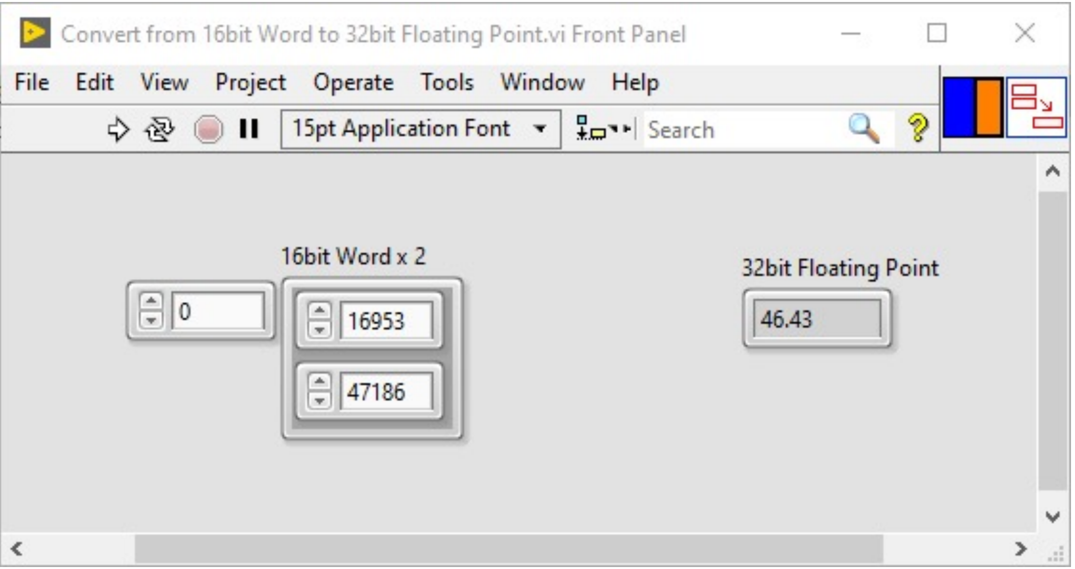
Here we have split a 32-bit floating point value across two 16-bit registers

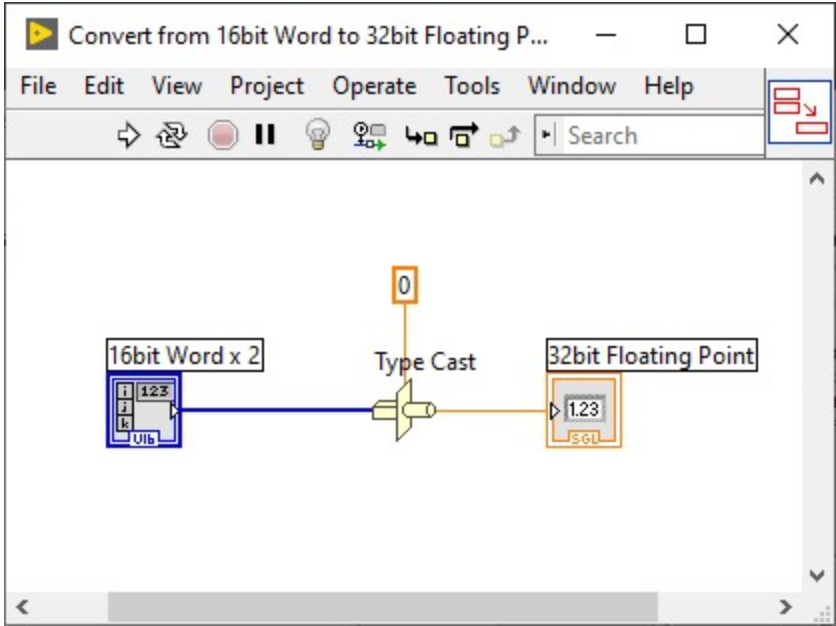




32-bit floating point across two 16-bit registers

Here we get the 32-bit floating point from two 16-bit registers





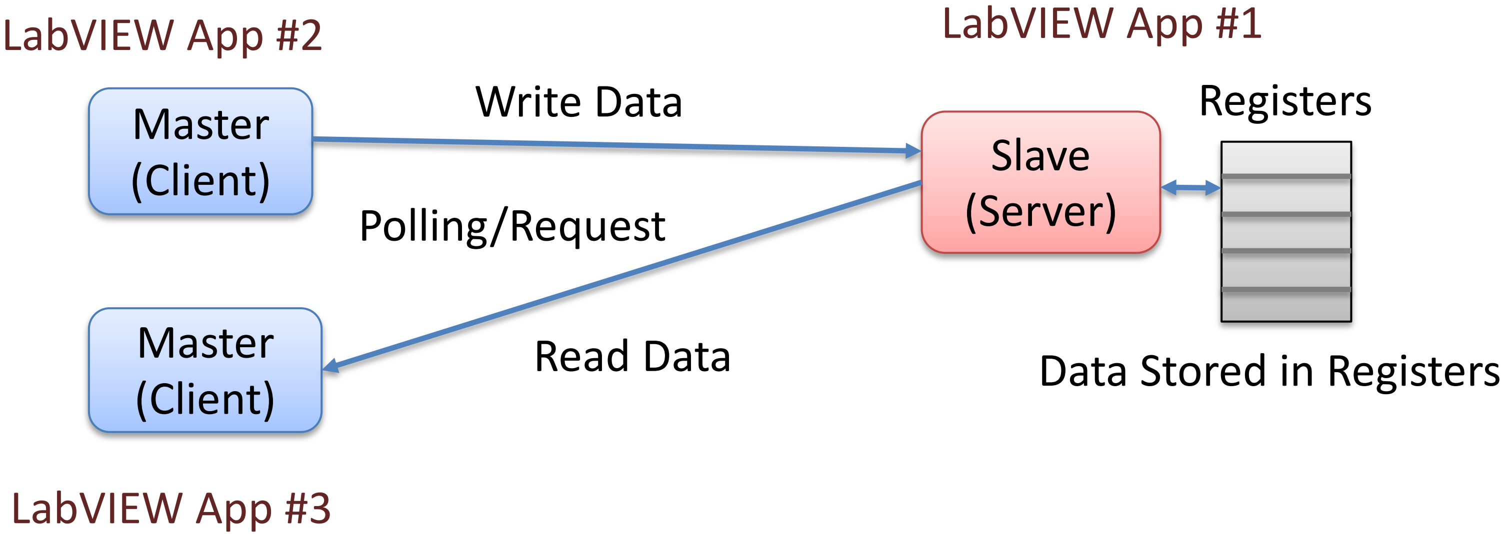
LabVIEW Holding Registers Examples

Hans-Petter Halvorsen

Table of Contents

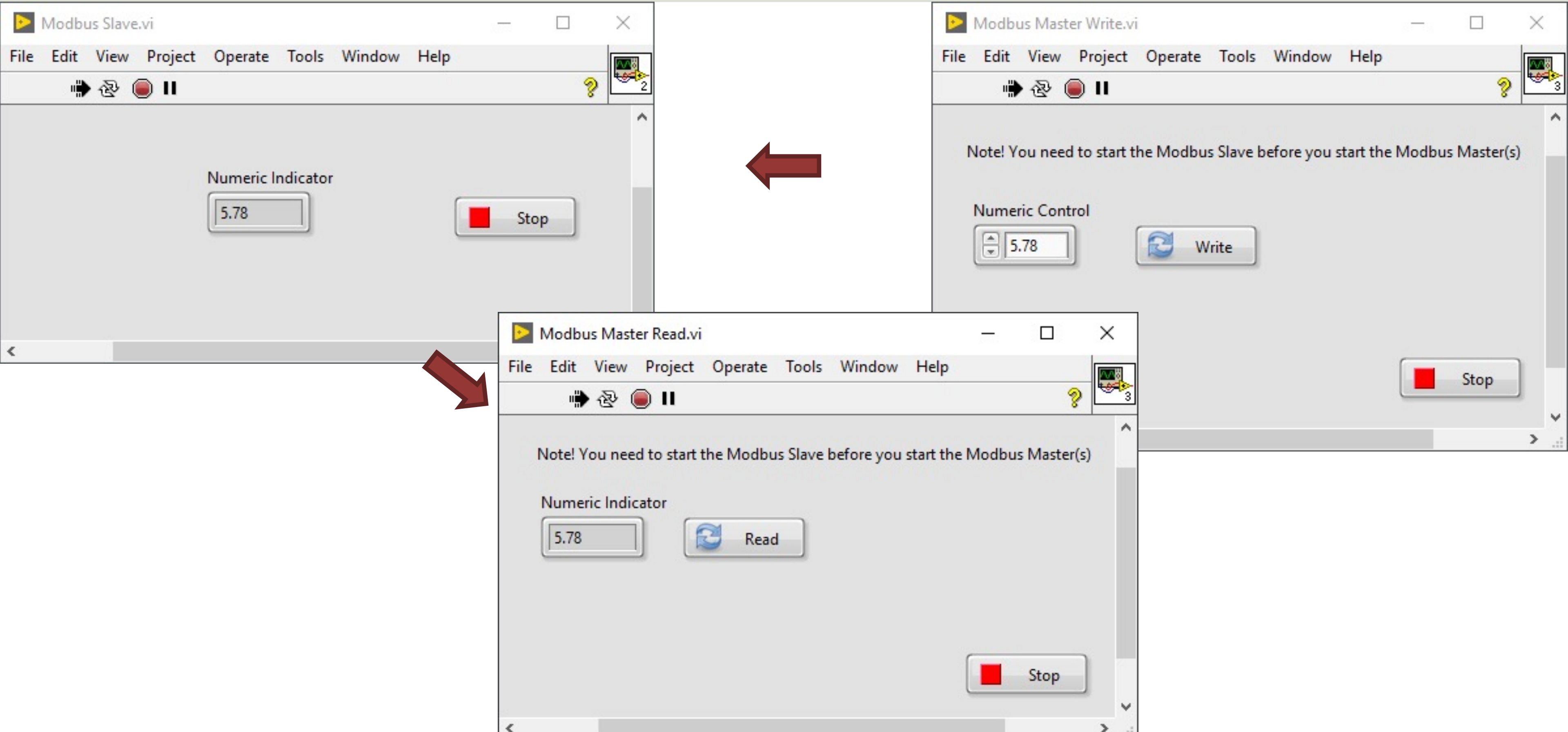
LabVIEW Holding Registers Example

In this Example we Create 3 different LabVIEW Applications:

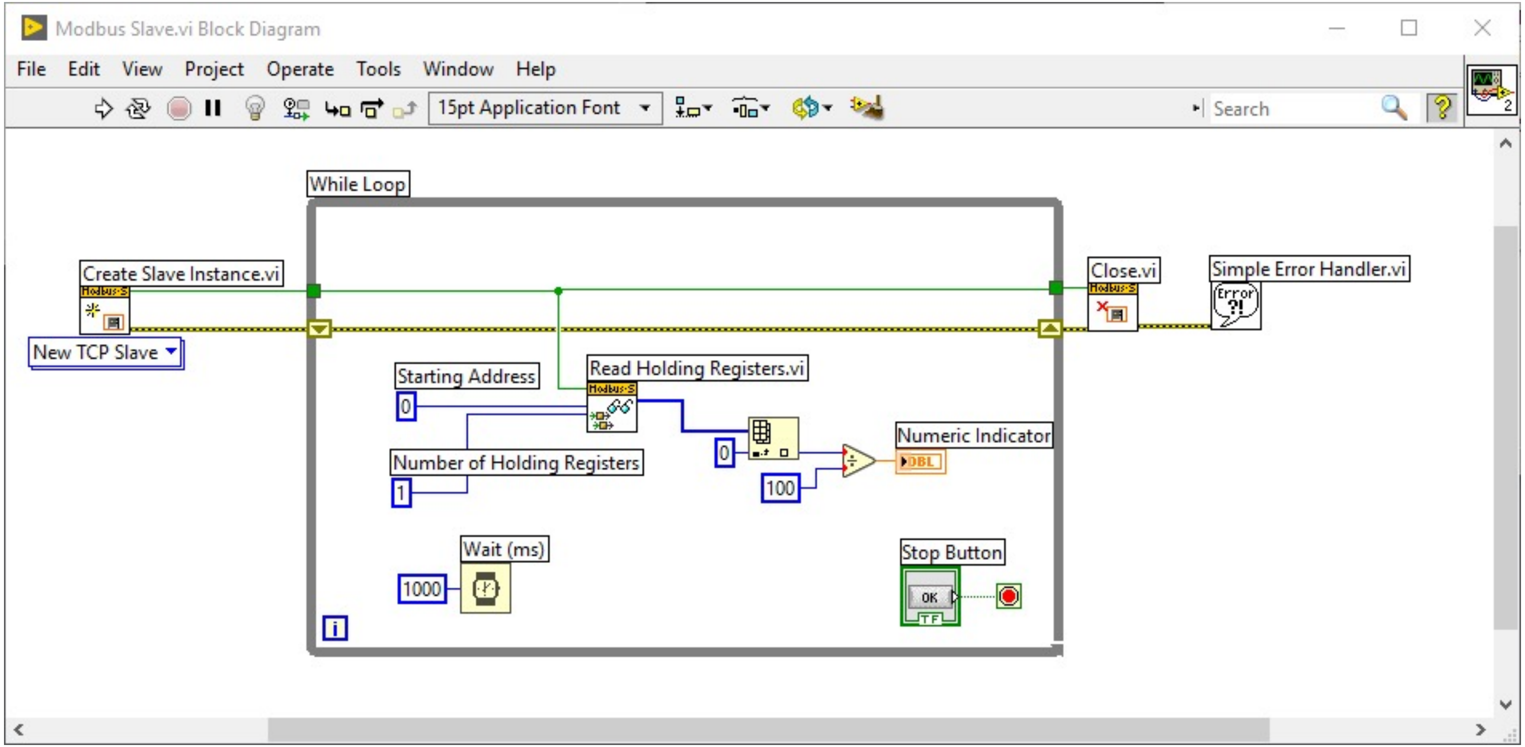


Memory Type	Data Type	Master Access	Slave Access
Holding Register	Unsigned Word	Read/Write	Read/Write

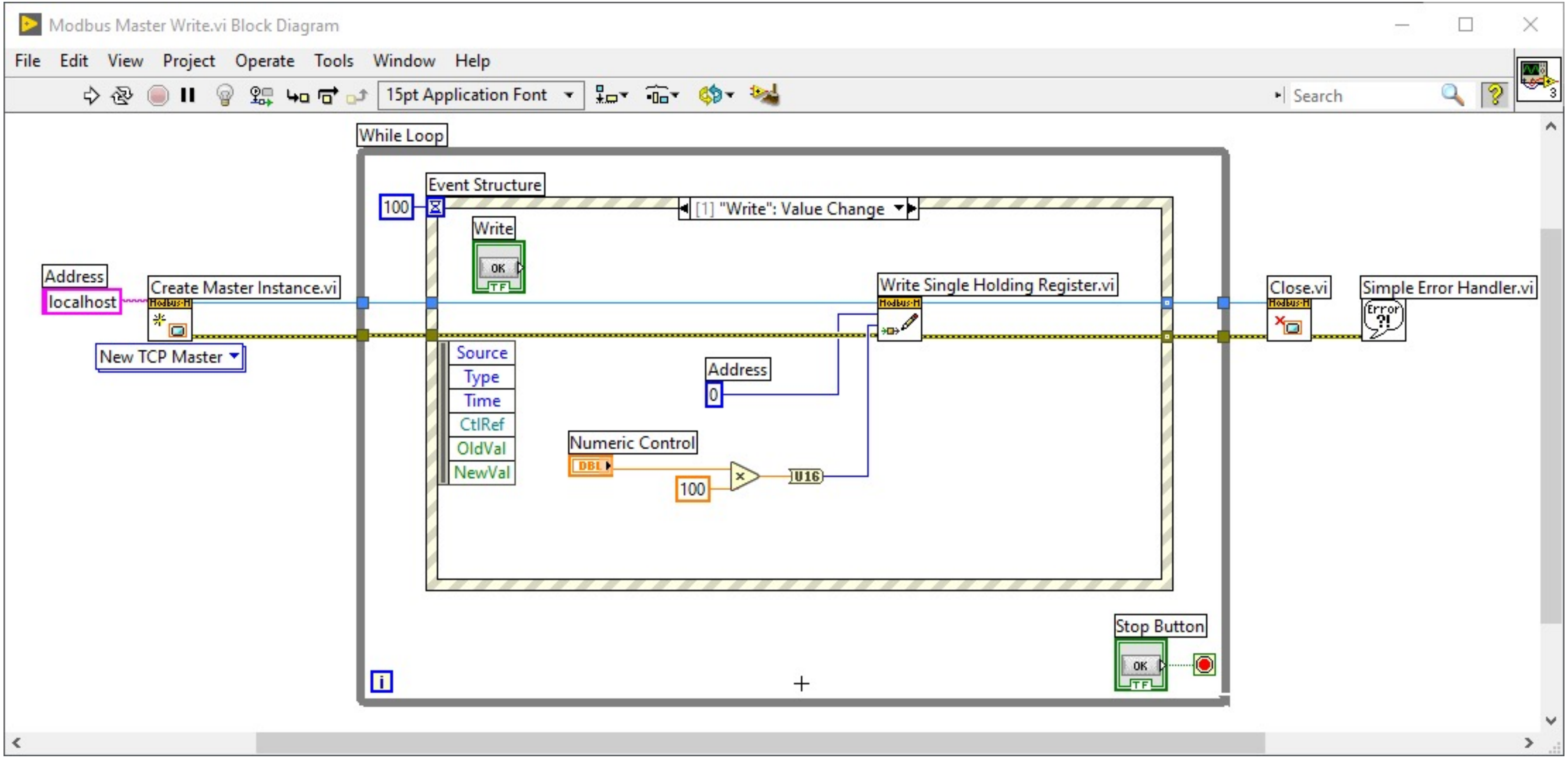
LabVIEW Holding Registers Example



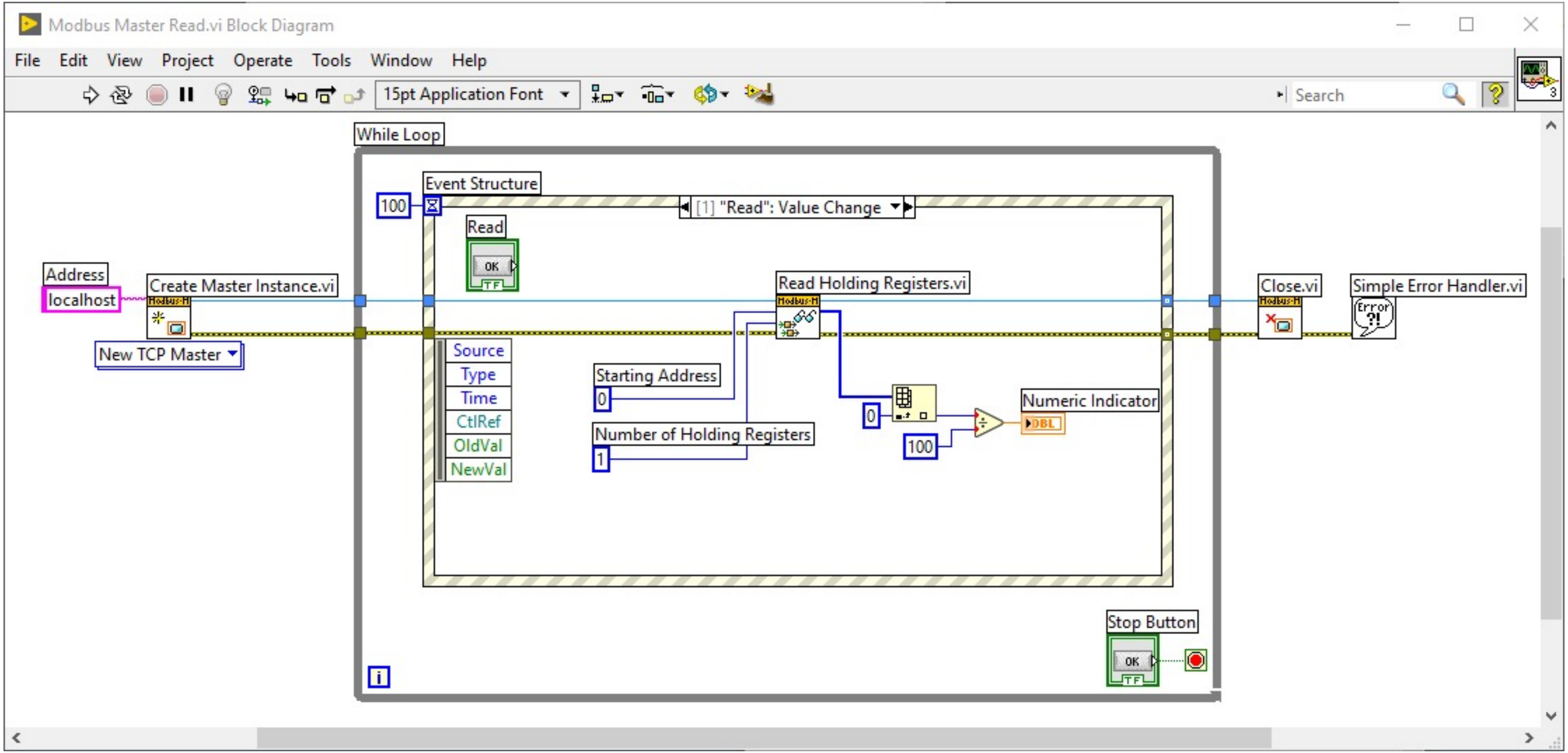
Modbus Slave



Modbus Master (Write)



Modbus Master (Read)

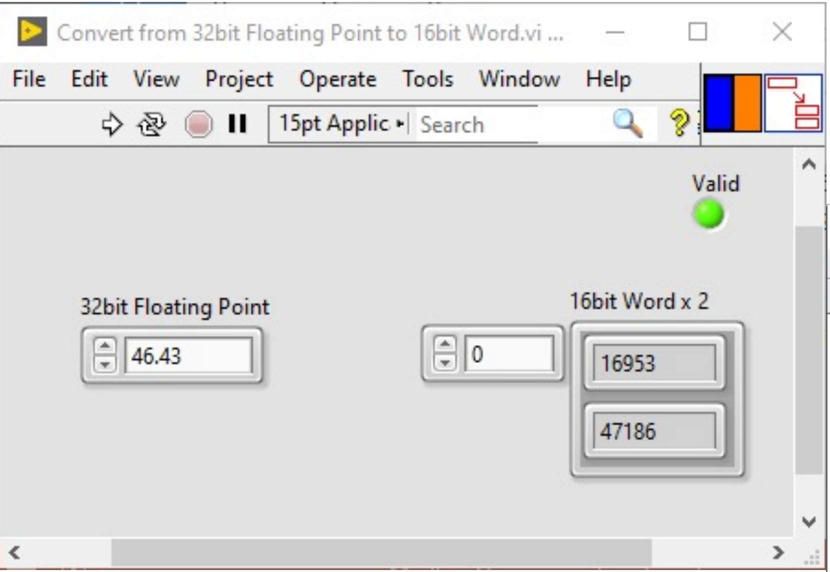


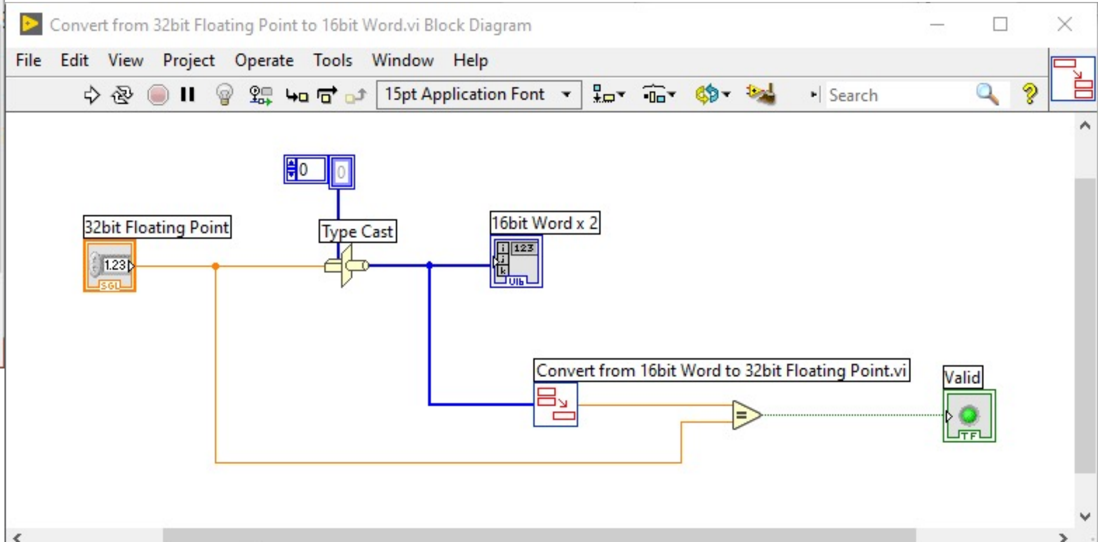
Alt Solution

- How do you deal with Decimal/Floating-point Numbers?
- Previously we implemented a simple solution by multiplying and dividing with 100, which worked fine for 2 decimal numbers
- In Modbus, the default practice is to split a 32-bit floating point value across two 16-bit registers.
- The disadvantage is that we need to use 2 Modbus register for representing one number

32-bit floating point across two 16-bit registers

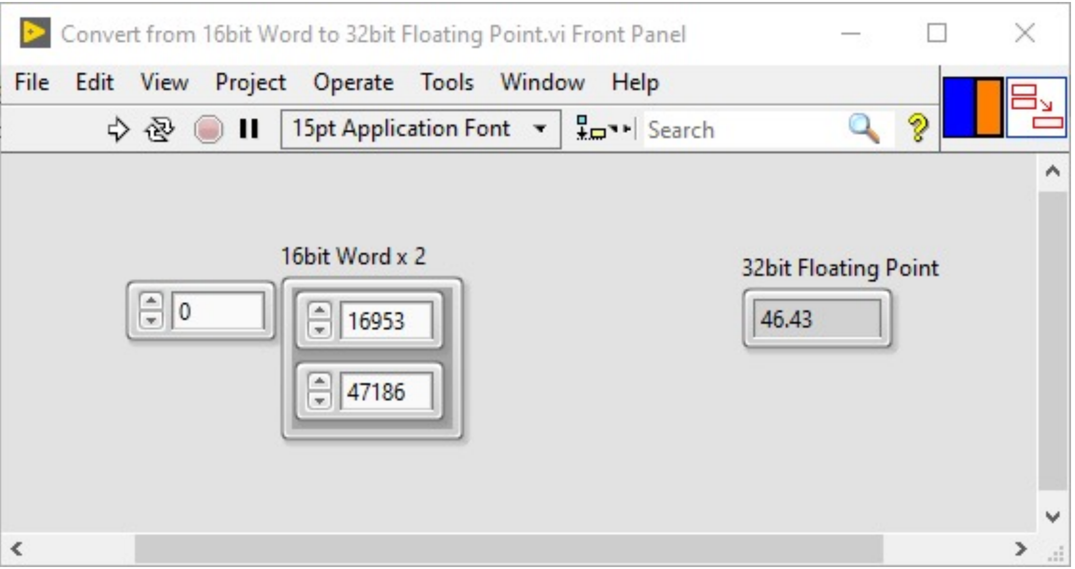
Here we have split a 32-bit floating point value across two 16-bit registers

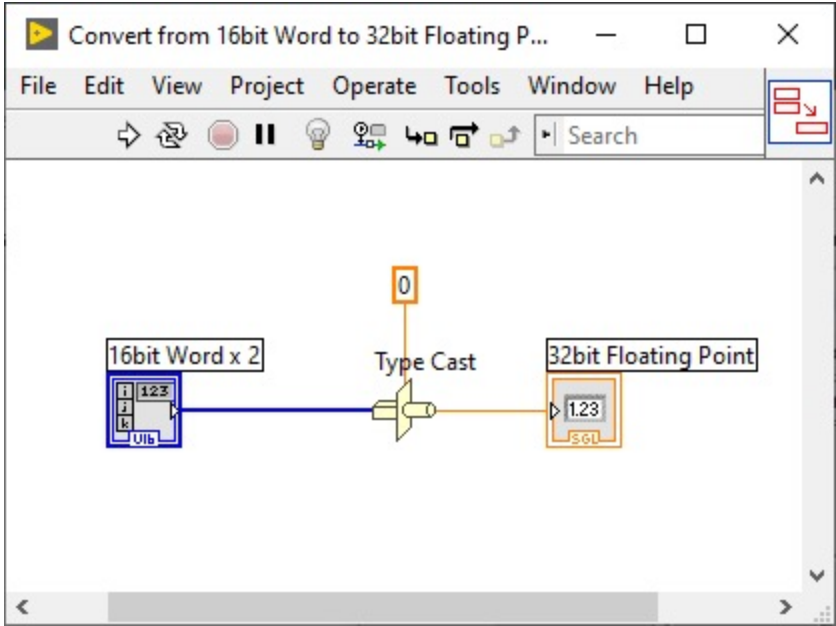




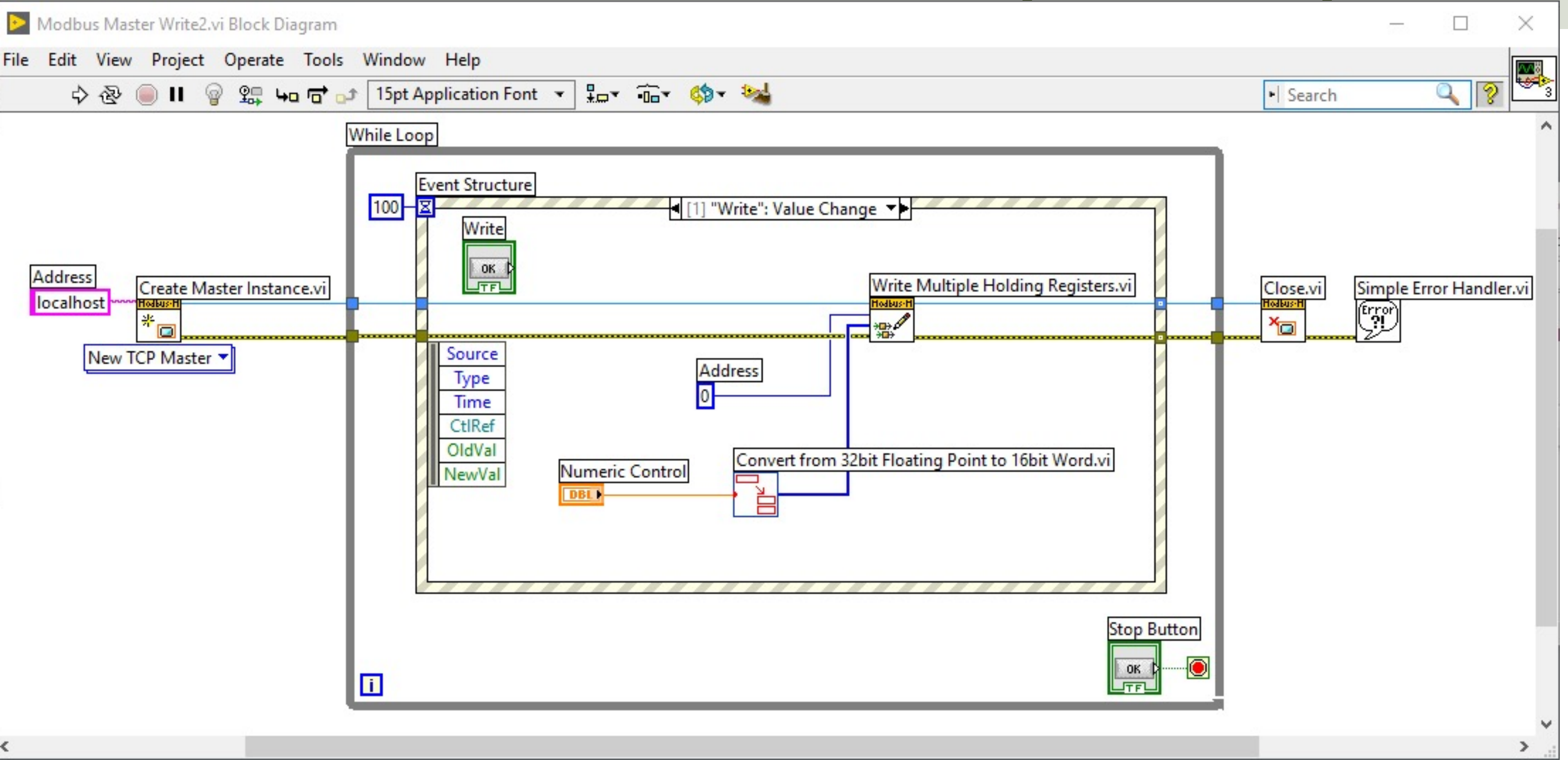
32-bit floating point across two 16-bit registers

Here we get the 32-bit floating point from two 16-bit registers

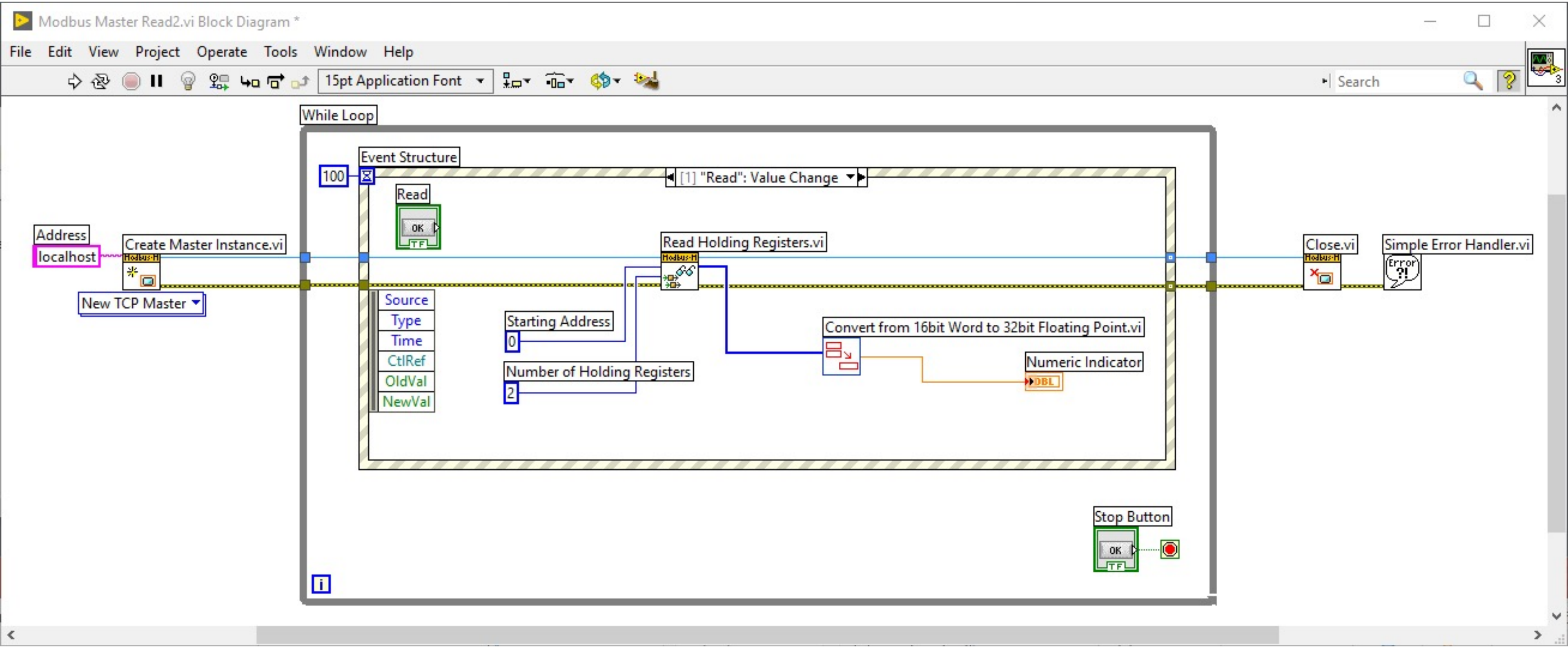




Modbus Master (Write)



Modbus Master (Read)



Modbus Registers Summary

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- Modbus (Wikipedia): https://en.wikipedia.org/wiki/Modbus
- Introduction to Modbus (National Instruments): http://www.ni.com/white-paper/7675/en/
- Connect LabVIEW to Any PLC With Modbus (National Instruments): http://www.ni.com/tutorial/13911/en/
- Modbus 101 - Introduction to Modbus: http://www.csimn.com/CSI_pages/Modbus101.html
- Modbus TCP/IP: http://www.rtaautomation.com/technologies/modbus-tcpip/
- Modbus RTU: http://www.rtaautomation.com/technologies/modbus-rtu/
- Using Modbus for Process Control and Automation (PDF): http://www.miinet.com/Portals/0/articles/Using_MODBUS_for_Process_Control_and_Automation.pdf

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