4.0 PROGRAMMING

This section describes how the data is organized in the Remote I/O module, Remote I/O Head, Remote Drive Interface Head, and Shark Interface module, and provides examples of how the module is accessed by the application software. For more detailed information on programming, refer to the AutoMax Programming Reference Binder.

4.1 Master Remote I/O Module Dual Port Memory

The dual-port memory in the master module contains an image of the status of all the inputs and outputs on the digital and analog I/O modules in the slave drops. Application tasks running on AutoMax Processors in the master rack reference the I/O on the network in the dual port. The master Remote I/O module manages the data in the image area and communicates this data to the slave drops on the Remote I/O network.

4.2 Register Organization

The dual port memory of the master module is divided into 8 image areas, one for each drop and the master. Refer to Appendix I for more detailed information on memory mapping. Drop 0 registers are used for status and control in the master.

In the master all drop 0 registers are READ ONLY. Refer to figure 4.1 for drop 0 (Status) register assignments.

The master drop maintains status for all slave drops on the network. The drop status bits (register 4) are TRUE or ON when the corresponding drop is active. A FALSE or OFF state indicates that the drop is either not present or has failed to communicate.

You can view this status information for the master Remote I/O module using the I/O Monitor or “S” (Status) command (see section 5) from the serial port. You can view status information for slave Remote I/O modules or Heads using the “S” (Status) command. You cannot view status information for Shark drops.

Register	Description
0-3	Not used
4	Status of drop 1-7 in bits 1-7
5-11	Not used
12	Drop number
13	Program mode (keyswitch position 1 = memory protect, 2 = setup, 3 = program)
14	Messages received
15	Receive timeouts
16	CRC/parity errors
17	Overrun errors
18	Abort errors
19	Messages transmitted
20-511	Not used

Figure 4.1 - Drop 0 Status Register Assignments

4.3 Data Access

Multibus, Shark, and Remote Head input registers are Read Only. Multibus, Shark, and Remote Head output registers are Read/Write. Registers in dual port memory will acknowledge Multibus accesses just like the module does in the slave drop. A register on a particular module in a slave drop that is Read Only will be Read Only in the master drop dual port memory. A bus error will occur if a register in the master dual port memory is referenced and that register does not exist in the slave Multibus, Shark, or Remote Head drop.

Registers 0 through 7 on a Shark I/O module are always reserved for input data. Registers 8 through 15 are always reserved for output data. Registers 16 through 32 are not accessible. Note that in the case of a digital module in a mixed (both digital and analog modules) Shark rack, a bus error will NOT be reported if an invalid register is referenced. An invalid register may be a register that is not valid for the particular module in the slot, or that is not valid for Shark modules at all, i.e., 16 through 32. See Appendix I for a listing of the individual Shark module memory maps.

Registers 0-3 on an M/N 57C328 Remote I/O Head are always reserved for input data, and registers 4-7 are always reserved for output data. These registers are divided into four input/output pairs. Each pair is reserved for a Rail; therefore, you can mix input and output modules in a Rail. Registers 8-31 on an M/N 57C328 Remote I/O Head are not accessible. Refer to Appendix I for more information.

Registers 0 and 1 on a Remote Drive Interface Head are always AutoMax outputs (information to the drive) and registers 2 and 3 are always AutoMax inputs (information from the drive). See appendix I for a memory map of the Remote Drive Interface Head.

Non-Reliance Multibus I/O modules (modules not manufactured by Reliance Electric) that are Write Only will be Read/Write in the master drop dual port memory. Non-Reliance modules used in slave drops are subject to the following limitations:

- The module base address must begin on a 64K boundary.

- The module must be memory-mapped, not I/O mapped.
- The module must support 16-bit data transfers.
- Interrupts will be ignored.
- Input and output registers must be located at separate addresses. Modules that do not have separate addresses will be considered output modules.

4.4 Data Transmission

At power up, the master will poll all of the slave drops to determine which drops are connected to the network and the total number of Multibus modules in each drop. You can assign Multibus slave drop numbers (1 through 7) or (9 through F for Shark digital racks) arbitrarily, but each drop must have a unique number. The physical order of drop connections has no effect on the system.

Through the Multibus backplane, the slave Remote I/O module collects and stores input and output data associated with up to 15 general purpose I/O modules in its remote rack. The Shark Interface module collects I/O data from up to 10 modules in its remote rack(s). The Remote I/O Head collects I/O data from up to 128 2-bit modules in its attached rails. The Remote Drive Interface Head collects I/O data from up to four drives. This data is sent to the master Remote I/O module when it polls the slave drop.

The master module collects and stores the data in its dual port memory, which is accessible to the Processor module in the master rack. After polling all active slave drops, the master then polls one inactive drop to determine whether or not another drop has been added to the network. If a response is received, the new drop will be added to the list of active drops. The cycle then repeats.

All messages are checked for correctness by the receiving drop. Messages received in error are re-transmitted up to three times. Drops unable to correctly transmit and receive data will go off-line. Status information about the slave drops is maintained in the master and can be accessed by applications tasks or the Monitor function in the AutoMax Programming Executive software.

4.5 Data Update Rate

The time required for the master Remote I/O module to update all of the registers in one slave drop is dependent on the number of registers being transferred to/from each slave on the Remote I/O network, i.e., the total number of I/O in the rack.

The update time for each I/O register on the Remote I/O network is equal to the time needed to service each slave drop plus the amount of time required by system overhead.

The time required to service each slave drop (DROP_TIME) can be calculated as follows:

For a Multibus rack slave drop,

$$DROP\_TIME = [1.5 + (N \times 0.018)] \text{ milliseconds}$$

where: N = Total number of registers being transferred to/from the slave drop

For an M/N 57C330 Remote I/O Head slave drop,

DROP_TIME = [1.9 + (X x 0.08) + (Y x 0.036)] milliseconds

where: X = Total number of output registers being transferred to the slave drop

Y = Total number of input registers being transferred from the slave drop

For an M/N 57C328 Remote I/O Head drop,

DROP_TIME=[1.7 + R $\times$ 0.036] milliseconds

where: R = number of connected rails

For a Remote Drive Interface Head slave drop,

DROP_TIME = 2.1 milliseconds

For a Shark slave drop (all digital I/O) with a drop number of 9 to F,

DROP_TIME = 1.8 milliseconds

For a Shark slave drop (analog and digital I/O) with a drop number of 1 to 7,

DROP_TIME = 4.0 milliseconds

The update period of each I\O register on the Remote I/O network is equal to the sum of the drop time for each drop on the network plus 2.7 milliseconds to poll any inactive drops.

For example, a Remote I/O network with four drops has the following update rate:

Drop 1, Multibus Rack: 5 inputs, 8 outputs
Drop 2, Multibus Rack: 5 inputs, 6 outputs
Drop 3, Remote I/O Head: 6 inputs, 5 outputs
Drop 4, Digital Shark Rack

Drop 1 Time = [1.5 + (13 x .018)]	= 1.734 msec
Drop 2 Time = [1.5 + (11 x .018)]	= 1.698 msec
Drop 3 Time = [1.7 + (5 x .013) + (6 x .028)]	= 1.933 msec
Drop 4 Time =	= 1.900 msec
Time to poll inactive drops	= 2.700 msec
Update period for each Remote I/O register	9.965 msec

Each register on the Remote I/O network in this example will be updated by the master Remote I/O module every 9.965 milliseconds.

4.6 Configuration

Before running any application tasks, the system must be configured using the AutoMax Programming Executive software. The major function of configuration is to assign meaningful symbolic names to physical points in the system. This feature allows you to construct application tasks using variable names instead of actual physical locations.

The products mentioned in this manual are supported by the current version of the AutoMax Programming Executive software. To configure any of the modules using an older version of the

Programming Executive software, use a Generic I/O card in the Rack Configurator. If a feature of the module is not supported in your version of the Programming Executive software or you need more information, contact Reliance Electric.

4.6.1 Shark Configuration

In addition to configuring the Shark Interface module in the rack configuration, the programmer must also write a special configuration word to slot 0, register 0 in an application task if the Shark rack does not contain all digital modules and the rotary drop number switch has been set to a number between 1 and 7. This configuration word specifies the type of module that is found in each slot of the Shark drop as shown in figure 4.2. Set bit 15 of the configuration word equal to one once bits 1 through 10 have been properly set.

Bit 1 = 0: Remote slot 1 contains an analog module
= 1: Remote slot 1 contains a digital module

Bit 2 = 0: Remote slot 2 contains an analog module
= 1: Remote slot 2 contains a digital module

.
.
.

Bit 9 = 0: Remote slot 9 contains an analog module
= 1: Remote slot 9 contains a digital module

Bit 10 = 0: Remote slot 10 contains an analog module
= 1: Remote slot 10 contains a digital module

Bit 15 = 1: Configuration word is complete

Figure 4.2 - Shark I/O Module Configuration Word

A Shark rack can be configured once after it is powered up or after it is reconnected to the network. If you want to change the configuration, you must either issue a Stop-All command from the AutoMax/DCS 5000 Processor or disconnect the drop cable, change the configuration word, and then re-connect the drop cable.

4.6.2 Rail I/O Configuration (M/N 57C328)

The Remote I/O network transmits rail data from the master drop to the slave drop and from the slave drop to the master drop depending on whether the rail contains output or input modules, respectively. You can mix input and output modules in a rail. Each rail maps to one input register and one output register in the Remote I/O master.

When a slave drop is initially polled by the Remote I/O master, it will transmit the rail configuration to the master. The master will use this information to control access to that drop's registers in the master's dual port memory via the Multibus. It will allow Read/Write access for registers defined as OUTPUT and Read Only access to registers defined as INPUT. All other registers (those without rails connected) will have no access allowed.

Whenever you change the rail configuration (i.e., you add or remove rails), the drop will disconnect from the network, re-run the power-up

diagnostics, and then communicate the new rail configuration to the Remote I/O master.

WARNING

REMOVING OR INSERTING A MODULE OR I/O INTERCONNECT CABLE WITH POWER APPLIED MAY RESULT IN UNEXPECTED MACHINE MOTION OR LOSS OF PROCESS CONTROL. STOP THE MACHINE OR PROCESS IN AN ORDERLY FASHION AND DISCONNECT THE POWER TO THE SYSTEM BEFORE YOU REMOVE OR INSERT A MODULE OR I/O INTERCONNECT CABLE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

4.6.3 Rail I/O Configuration (M/N 57C330)

The Remote I/O network transmits rail data from the master drop to the slave drop or from the slave drop to the master drop depending on whether the rail contains output or input modules, respectively. Therefore, input and output modules cannot be mixed within a rail. Each rail can contain up to eight input or output modules.

The rail configuration is determined approximately every 20 milliseconds while the Remote I/O network is active. The Remote I/O Head can determine if there is a rail connected at any port but cannot directly determine whether the rail contains input or output modules. The system determines whether a particular rail contains input modules or output modules based on the data going to or from the rail.

When a rail is first determined to exist at a particular port, that rail is marked as “undefined.” If an “undefined” rail passes back data that has non-zero values, it is then defined as an input register whose data will be transmitted to, but not from, the master drop. Conversely, if non-zero data is written to an “undefined” rail, it is then defined as an output register to which data will be transmitted from, but not to, the master drop. Once a particular register is defined as input or output, it will remain defined as such regardless of future data values until one of the following occurs:

WARNING

REMOVING OR INSERTING A MODULE OR I/O INTERCONNECT CABLE WITH POWER APPLIED MAY RESULT IN UNEXPECTED MACHINE MOTION OR LOSS OF PROCESS CONTROL. STOP THE MACHINE OR PROCESS IN AN ORDERLY FASHION AND DISCONNECT THE POWER TO THE SYSTEM BEFORE YOU REMOVE OR INSERT A MODULE OR I/O INTERCONNECT CABLE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

a.) power is cycled to the remote drop;

b.) the line goes from an ACTIVE state to INACTIVE;

c.) the rail is removed (disconnected) from the Remote I/O system.

When a slave drop is initially polled by the Remote I/O master, it will transmit the rail configuration to the master. The master will use this information to control access to that drop’s registers in the master’s dual port memory via the Multibus. It will allow Read/Write access for registers defined as OUTPUT or not yet defined, and Read Only

access to registers defined as INPUT. All other registers (those without rails connected) will have no access allowed.

Whenever the rail configuration is to be physically changed (i.e., rails added or removed), the drop should first be disconnected from the network (disconnect the BNC Tee Adapter from the Remote I/O Head). The drop should then be powered down before the rail configuration is modified.

WARNING

INPUTS SHOULD NOT BE FORCED. DURING A POWER CYCLE, THE FORCED INPUTS ARE INTERPRETED AS OUTPUTS AND, THEREFORE, WILL NOT FUNCTION PROPERLY. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY INJURY.

4.6.4 Remote Drive Interface Head Configuration

The Remote Drive Interface Head can control up to four drives that use a rail-type interface (e.g., the Reliance V★S GP-2000/VTAC V controller). **The AutoMax Remote Drive Interface Head must not be connected to Local Heads, digital rails, or Analog Rails, LED modules, or Thumbwheel Switch modules**.

The Remote Drive Interface Head uses a fixed configuration of two inputs and two outputs per I/O port. The Head assumes that the first two registers (0 and 1) are AutoMax outputs (information to the drive) and the second two registers (2 and 3) are AutoMax inputs (information from the drive). This configuration cannot be changed.

The Remote Drive Interface Head will communicate with a device connected to a port only if that device responds as a Local Head. The Head will not reset when communication re-tries to a port are exhausted. The Ready Relay will not drop out. The Head will clear input registers and continuously attempt to re-establish communication with the device connected to the port.

AutoMax application tasks must be used to determine whether a drive is communicating with the Head using a register or bit generated by the drive. Refer to the documentation for the Rail Interface module (D2-3170) and the GP-2000/VTAC V Main Controller Installation, Operation and Maintenance instruction manual for more information.

WARNING

REMOVING OR INSERTING A MODULE OR I/O INTERCONNECT CABLE WITH POWER APPLIED MAY RESULT IN UNEXPECTED MACHINE MOTION OR LOSS OF PROCESS CONTROL. STOP THE MACHINE OR PROCESS IN AN ORDERLY FASHION AND DISCONNECT THE POWER TO THE SYSTEM BEFORE YOU REMOVE OR INSERT A MODULE OR I/O INTERCONNECT CABLE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

Whenever the configuration is to be physically changed (i.e., drives added or removed), the drop should first be disconnected from the network (disconnect the BNC Tee Adapter from the Remote Drive Interface Head). The drop should then be powered down before the configuration is modified.

4.7 Application Programming

The variable names assigned to registers and bits during configuration are referred to as common variables. These are made available to BASIC and Control Block application tasks through the COMMON statement. Ladder Logic/PC tasks can access these variables simply by referencing them in their sequences. The remainder of this section provides application task examples.

4.7.1 Multibus and Remote I/O Programming Examples

The sample programs that follow reference the physical points illustrated in figure 4.3.

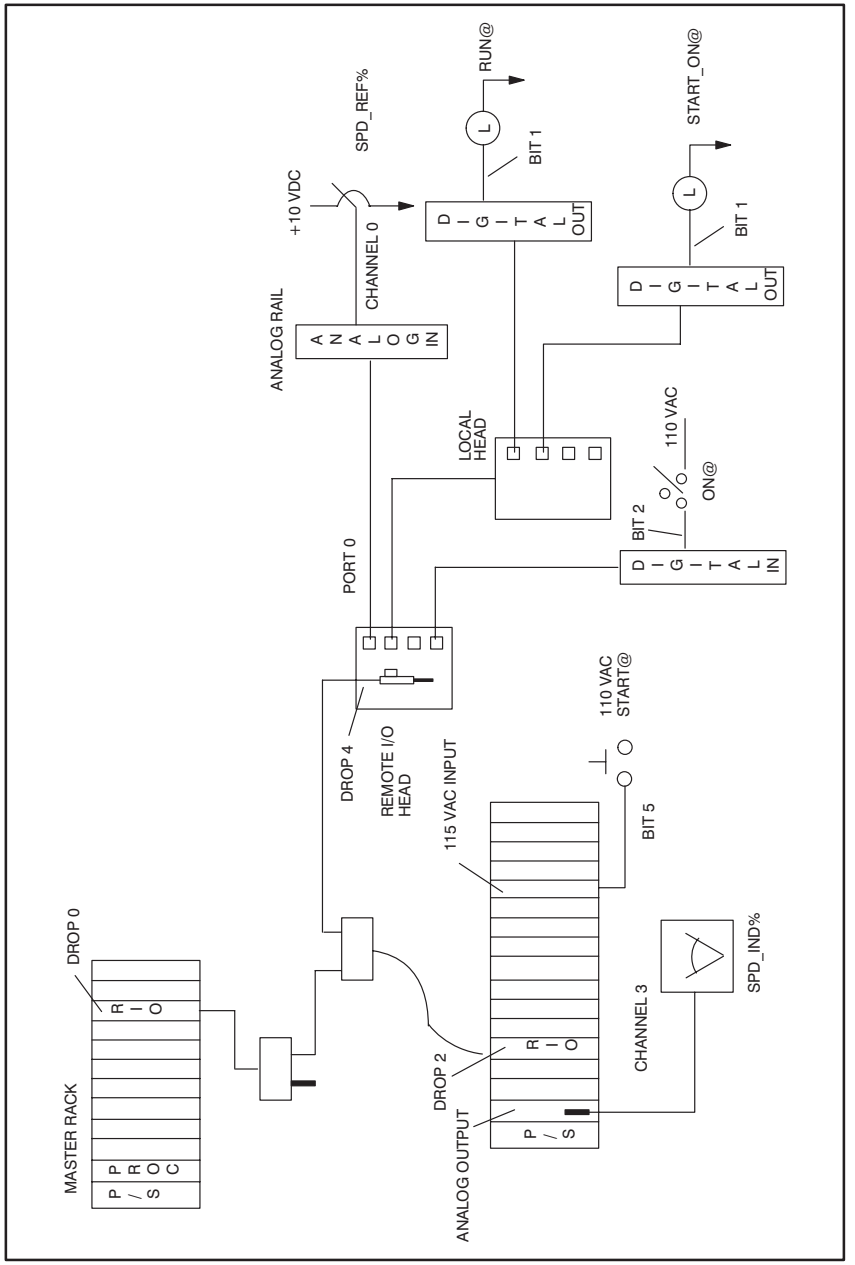


Figure 4.3 -Sample Coaxial Cable Remote I/O Network With Multibus Rack and Remote I/O Head Drops

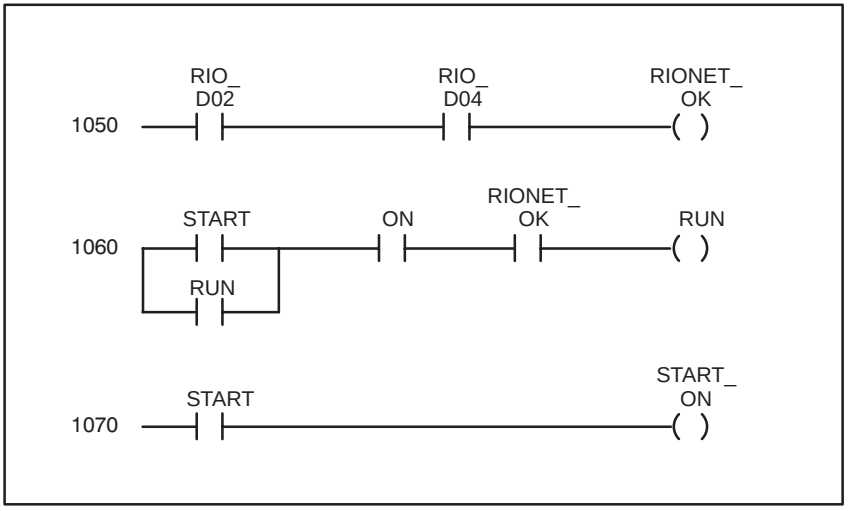
4.7.1.1 Configuration Task Example

The following is an example of a configuration task for the master Remote rack in figure 4.3. Note that a configuration task is required only if you are using AutoMax Version 2.1 or earlier. If you are using AutoMax Version 3.0 or later, you use the AutoMax Programming Executive Software to assign symbolic names to the same physical I/O points.

```
1000  !
1100  ! remote I/O network protection
1200  !
1300  IODEF RIO_D02@[SLOT=8,REGISTER=4,BIT=2]
1400  IODEF RIO_D04@[SLOT=8,REGISTER=4,BIT=4]
1500  !
1600  ! remote digital I/O
1700  !
1800  RIODEF    START@[MASTER_SLOT=8,DROP=2,SLOT=11,REGISTER=0,          &
                BIT=5]
1900  RIODEF    ON@[MASTER_SLOT=8,DROP=4,SLOT=3,REGISTER=0,BIT=2]
2000  RIODEF    RUN@[MASTER_SLOT=8,DROP=4,SLOT=1,REGISTER=0 BIT=1]
2010  !         For an M/N 57C328 Remote I/O Head, the statement would be:
      RIODEF    RUN@[MASTER_SLOT=8,DROP=4,SLOT=1,REGISTER=4,BIT=1)
2100  RIODEF    START_ON@[MASTER_SLOT=8,DROP=4,SLOT=1,REGISTER=1,        &
                BIT=1]
2110  !         For an M/N 57C328 Remote I/O Head, the statement would be:
      RIODEF    START_ON@[MASTER_SLOT=8,DROP=4,SLOT=1,REGISTER=5,BIT=1
2200  !
2300  ! remote analog I/O
2400  !
2500  RIODEF    SPD_REF%[MASTER_SLOT=8,DROP=04,SLOT=0,REGISTER=0] 2600
      RIODEF    SPD_IND%[MASTER_SLOT=8,DROP=02,SLOT=0,REGISTER=3] 2700
      MEMDEF    RIONET_OK@
```

4.7.1.2 Ladder Logic Task Example

The following is an example of a Ladder Logic task for the Remote I/O network in figure 4.3. This task verifies that both slave drops are on-line before application tasks use the speed reference value.



RIONET_OK should be included in the READY sequence. Note that the trailing “at” symbol (@) is not used for Boolean variables in ladder logic tasks.

4.7.1.3 BASIC Task Example

The following is an example of a BASIC task for the Remote I/O network in figure 4.3. This task reads a speed reference value and writes it to a speed indicator.

```
1000    COMMON SPD_REF%
1010    COMMON SPD_IND%
1020    COMMON RUN@
1030    START EVERY 10 TICKS
1040    IF NOT RUN@ THEN SPD_IND% = 0 \GOTO 10000
1050    SPD_IND% = SPD_REF%
10000   END
```

The symbolic names defined as “COMMON” reference the I/O points defined in the configuration for the Remote I/O network.

4.7.2 Shark Programming Examples

The sample programs that follow reference the physical points illustrated in figure 4.4.

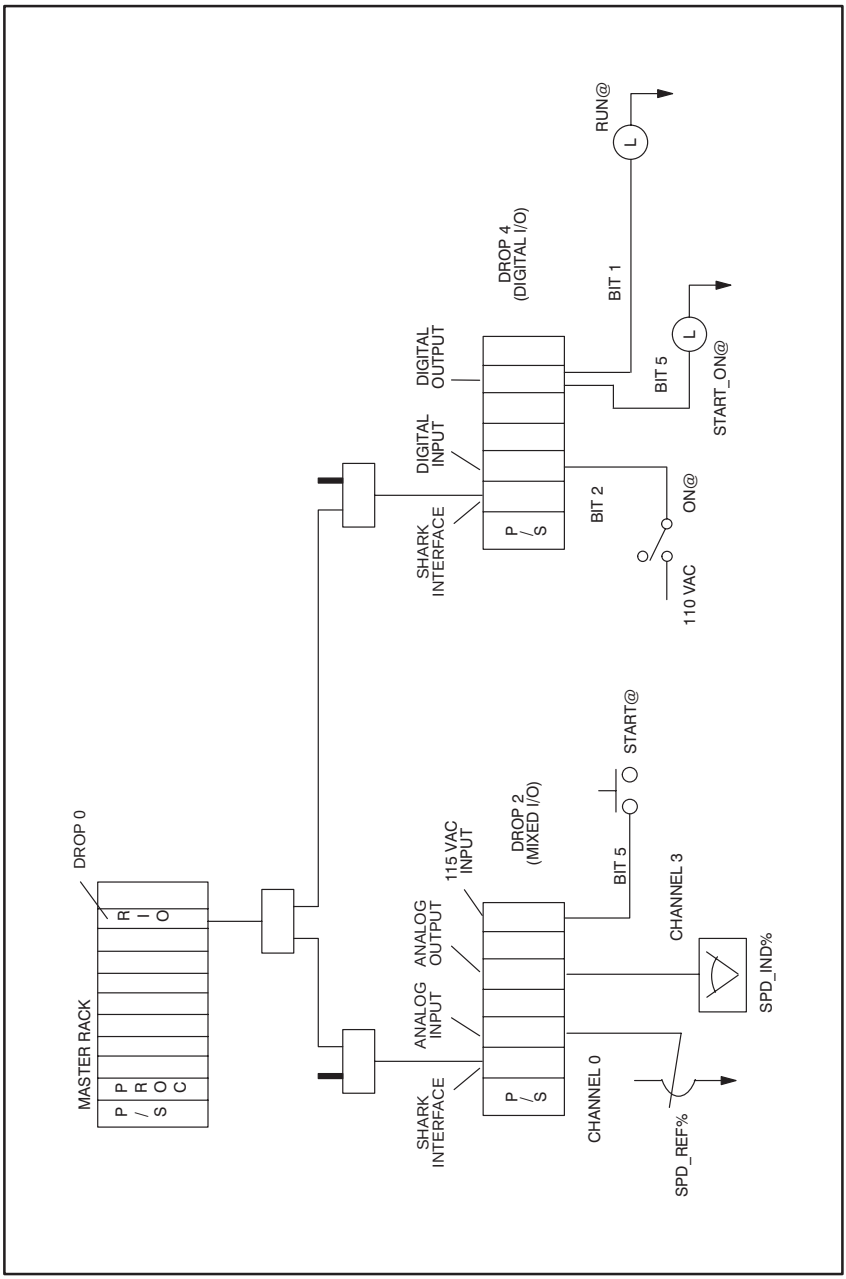


Figure 4.4 - Sample Coaxial Cable Remote I/O Network With Shark Rack Drops

4.7.2.1 Configuration Task Example

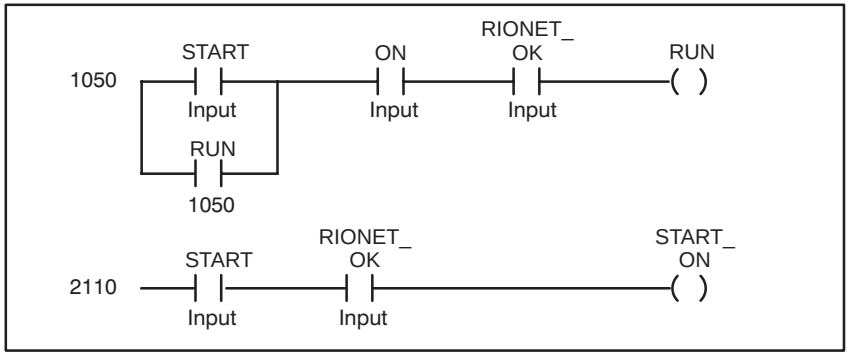
The following is an example of a configuration task for the Remote I/O network in figure 4.4. The two variables, DO_CFG% and DO2_CFG_RDY@, are used to configure drop 2. It is not necessary to configure drop 4 since it is an all digital rack as specified by the setting of the Shark Interface module's rotary switch to the "C" position.

Note that a configuration task is required only if you are using AutoMax Version 2.1 or earlier. If you are using Version 3.1 you must upgrade to at least AutoMax Version 3.2 if you are using Shark drops. If you are using AutoMax Version 3.2 or later, you use the AutoMax Programming Executive Software to assign symbolic names to the same physical I/O points.

```
10      ! Shark RIO example
20      !
30      !
100     TASK EX[TYPE=BASIC, PRIORITY=7, SLOT=0, CRITICAL=FALSE]
110     TASK EXPC[TYPE=PC, PRIORITY=8, SLOT=0, CRITICAL=FALSE]
120     !
1100    !    remote I/O network protection
1200    !
1300    IODEF       RIO_D02@[SLOT=8,REGISTER=4,BIT=2]
1400    IODEF       RIO_D04@[SLOT=8,REGISTER=4,BIT=4]
1500    !
1600    !    Shark drop 2 (mixed rack)
1700    !
1800    RIODEF      D02_CFG%[MASTER_SLOT=8,DROP=2,SLOT=0,REGISTER=0]
1900    RIODEF      D02_CFG_RDY@[MASTER_SLOT=8,DROP=2,SLOT=0,              &
                    REGISTER=0,BIT=15]
2000    RIODEF      SPD_REF%[MASTER_SLOT=8,DROP=2,SLOT=1,REGISTER=0]
2100    RIODEF      SPD_IND%[MASTER_SLOT=8,DROP=2,SLOT=3,REGISTER=11]
2200    RIODEF      START@[MASTER_SLOT=8,DROP=2,SLOT=5,REGISTER=0,         &
                    BIT=5]
2300    !
2400    ! Shark drop 4 (all digital rack)
2500    !
2600    RIODEF      ON@[MASTER_SLOT=8,DROP=4,SLOT=1,REGISTER=0,BIT=2]
2700    RIODEF      RUN@[MASTER_SLOT=8,DROP=4,SLOT=4,REGISTER=8,BIT=1]
2800    RIODEF      START_ON@[MASTER_SLOT=8,DROP=4,SLOT=4,REGISTER=8, &
                    BIT=5]
3200    MEMDEF      RIONET_OK@
```

4.7.2.2 Ladder Logic Task Example

The following is an example of a Ladder Logic task for the Remote I/O network in figure 4.4. This task verifies that both slave drops are on-line before application tasks use the speed reference value.



RIONET_OK should be included in the READY sequence. It is set by the BASIC task shown in 4.7.2.3. Note that the trailing “at” symbol (@) is not used for Boolean variables in ladder logic tasks.

4.7.2.3 BASIC Task Example

The following is an example of a BASIC task for the Remote I/O network in figure 4.4. The task is composed of three main sections. The first section, lines 1300 to 1500, checks to see if network drops 2 and 4 are recognized by the master. If they are not recognized, the program will continue to loop until they are. The second section, lines 2400 to 2500, configures drop 2. This is done by writing to variable D02_CFG%, the configuration register. Once the configuration word has been written, the configuration ready bit (10) is set. Note that drop 4 does not need to be configured in this way since it is an all digital rack. The last section of the task, lines 3300 to 3700, simply writes the analog input value SPD_REF% to indicator SPD_IND%. If either drop 2 or drop 4 malfunctions, the program will go to line 300 and wait for the affected drop to recover.

```
10      !
20      ! Shark RIO BASIC Example
30      !
100     COMMON RIO_D02@
200     COMMON RIO_D04@
300     COMMON SPD_REF%
400     COMMON SPD_IND%
500     COMMON RUN@
600     COMMON RIONET_OK@
700     COMMON D02_CFG@
800     COMMON D02_CFG_RDY@
1000    !
1100    !    Wait for slave drops to come on-line. The program will
1200    !    loop until drops two and four come on-line.
1300    RIONET_OK@ = FALSE      \ SPD_IND% = 0
1400    DELAY 1 TICKS
1500    IF NOT (RIO_D02@ AND RIO_D04@) THEN GOTO 1400
1600    !
1700    !   Configure Shark Remote I/O racks
1800    !   Drop 4 is an all digital rack and does not need to be
1900    !      configured
2000    !   Drop 2 is a mixed rack. By default slots are configured
2100    !      as analog. Configure slot 5 as digital and set
2200    !      the configuration ready bit (15).
2300    !
2400    D02_CFG% = 20H              \!Set the configuration word
2500    D02_CFG_RDY@ = TRUE     \!Set the configuration complete bit
2600    !
2700    !   Set RIO ready for pc task
2800    !
2900    RIONET_OK@ = TRUE
3000    !
3100    !   Task loop
3200    !
3300    IF NOT RUN@ THEN SPD_IND% = 0 \ GOTO 3500
3400    SPD_IND% = SPD_REF%
3500    IF NOT (RIO_D02@ AND RIO_D04@) THEN GOTO 1300
3600    DELAY 1 TICKS
3700    GOTO 3300
3800    END
```

The symbolic names defined as “COMMON” reference the I/O points defined in the configuration for the Remote I/O network.