



## Data Exchange Test of MODBUS® Serial Connectivity

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This whitepaper describes testing of a specific PLC and serial card setup to determine the data exchange.

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## Introduction

The testing documented in this paper demonstrated the data transfer between a DeltaV controller with a serial card and a Modicon (Schneider Electric) Quantum PLC. The serial communication was via MODBUS® Protocol at 19.2 kbaud. Results discussed in this whitepaper are valid only for the test equipment and setup used in the test scenarios described.

## Summary

Three test conditions were performed on the same test system equipment. The three tests performed are:

- Test 1 contained 120 DeltaV control modules all having scans rates of 500 ms
- Test 2 contained 120 DeltaV control modules with all of the analog modules and 36 of the discrete modules having a 500 ms scan rate and the remaining 36 discrete modules with a scan rate of 200 ms.
- Test 3 combined the 48 analog control modules into 24, each containing 8 analog input function blocks writing to 8 analog output function blocks, the discrete control modules remaining configured the same as test 1 & 2. All control modules scan rate was 500 ms.

All three tests demonstrated little variation in the overall average input-to-output time and the average port scan rates of the serial card. The main difference was the additional loading on the DeltaV controller due to changing the scan rate from 500 ms to 200 ms for 36 of the discrete control modules.

Table 1 shows a summary of the results from the three test scenarios. Details of each test condition and the test result is shown under Test Conditions and Results.

TEST	Overall Average Input to Output Time, seconds	Serial Card Average Port Scan Rate, seconds	Average DeltaV Controller Free Time, %
1	1.795	0.876	55.45
2	1.687	0.899	31.70
3	1.876	0.748	57.60

Table 1 Summary of Test Results

## Test System Equipment Setup

Figure 1 shows a graphical layout of the test system used for the three test conditions. The test system comprises the following:

- 1) DeltaV digital automation system:
  - 1—DeltaV ProfessionalPLUS Station
  - 1—DeltaV MD controller
  - 1—DeltaV serial card with MODBUS®
- 2) Quantum PLC system:
  - 1—140 CPU 113 02 controller
  - 1—140 CRP 932 00 remote I/O head
  - 1—PC with configuration software
- 3) mimic® simulation of Quantum remote I/O
  - 1—PC with mimic software
  - 1—SSTech 5136 MODCARD (remote quantum I/O interface card)

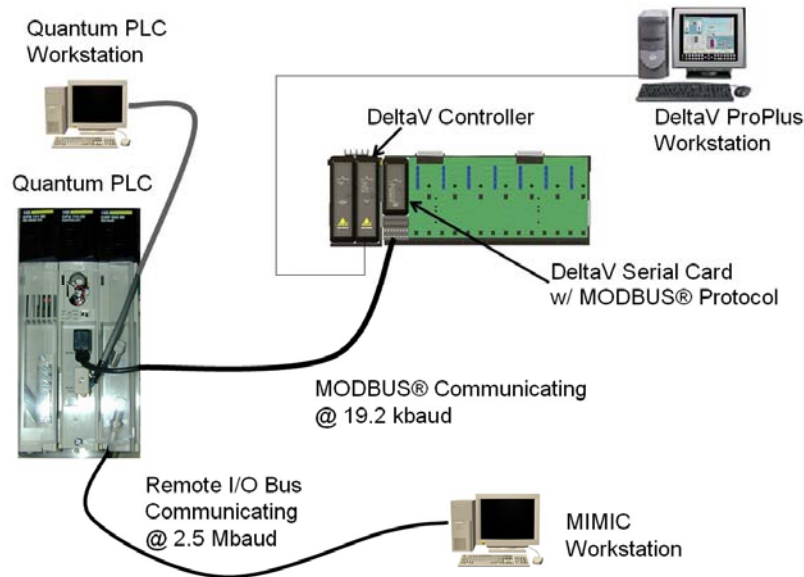


Figure 1 Test System Layout

### Data Model and Test Setup

The data model used for the tests is representative of a PLC configuration in the field. The purpose of the test was to document the average time required to: write data changes from the remote I/O input channels to the PLC, communicate those changes to the DeltaV serial card via MODBUS®, and have modules in the DeltaV system read the change and write it back to the PLC remote I/O output channels.

Figure 2 shows a block representation of the data communication path.

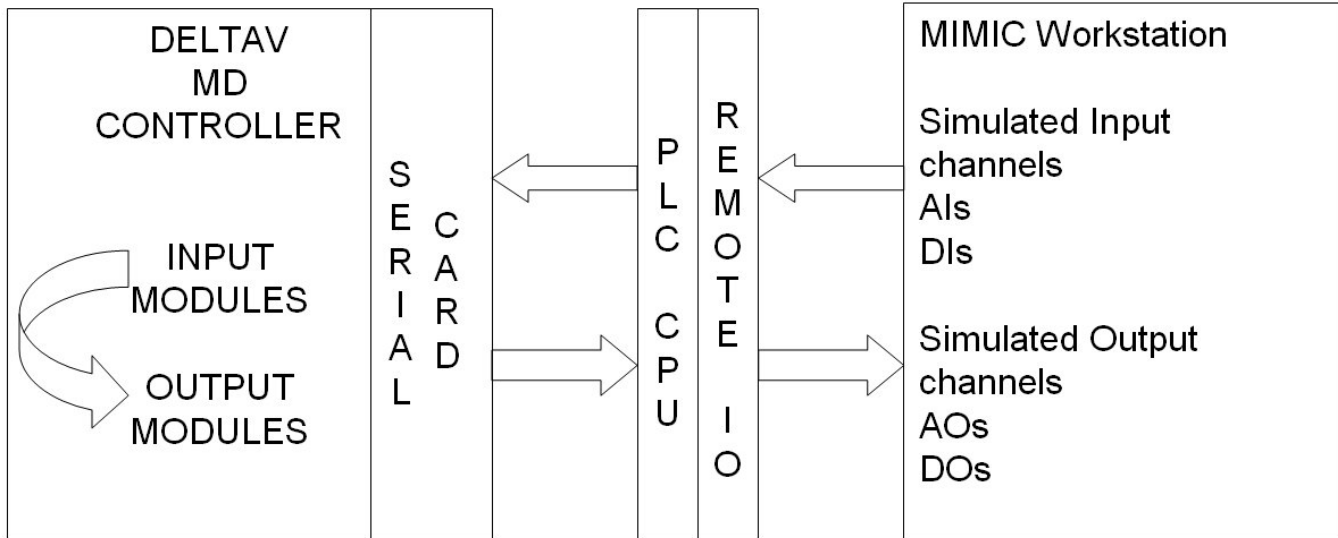


Figure 2 Data Communication Path

### Data Model

The DeltaV control modules configured for the tests contained:

- Analog input control modules where each module contains 8 AI function blocks
- Analog output control modules where each module contains 8 AO function blocks written to/from the corresponding AI blocks
- Discrete input control modules where each module contains 96 DI function blocks
- Discrete output control modules where each module contains 96 DO function blocks written to/from the corresponding AI blocks
- Module scan rates were set to maintain 100% module execution.

Note: Variable scan rates were investigated but test results of any scan rate that did not result in 100% block execution were not reported.

The PLC data model developed included:

- Analog inputs registers: 189
- Analog outputs registers: 189
- Discrete inputs registers: 576
- Discrete outputs registers: 576
- Total number of registers: 1530

The DeltaV serial card, port 1 properties included:

- Enabled
- Protocol type: RTU
- Mode: Master
- Retry count: 1
- Message timeout (ms): 1000
- Transmit delay (ms): 0



The port 1 dataset properties are detailed in Table 2.

DeltaV SERIAL CARD DATA SET #	DATA DIRECTION	OUTPUT MODE	DeltaV DATA TYPE	PLC DATA TYPE	PLC BASE REGISTER ADDRESS	NUMBER OF VALUES
1	INPUT	N/A	16 BIT INTEGER W/STATUS	INPUT REGISTERS	30003	93
2	OUTPUT	COMPLETE BLOCK	16 BIT INTEGER W/STATUS	HOLDING REGISTERS	40003	93
3	INPUT	N/A	16 BIT INTEGER W/STATUS	INPUT REGISTERS	30201	96
4	OUTPUT	COMPLETE BLOCK	16 BIT INTEGER W/STATUS	HOLDING REGISTERS	40101	96
5	INPUT	N/A	BOOLEAN WITH STATUS	INPUT STATUS	10001	96
6	OUTPUT	COMPLETE BLOCK	BOOLEAN WITH STATUS	COILS	00001	96
7	INPUT	N/A	BOOLEAN WITH STATUS	INPUT STATUS	10101	96
8	OUTPUT	COMPLETE BLOCK	BOOLEAN WITH STATUS	COILS	00101	96
9	INPUT	N/A	BOOLEAN WITH STATUS	INPUT STATUS	10201	96
10	OUTPUT	COMPLETE BLOCK	BOOLEAN WITH STATUS	COILS	00201	96
11	INPUT	N/A	BOOLEAN WITH STATUS	INPUT STATUS	10301	96
12	OUTPUT	COMPLETE BLOCK	BOOLEAN WITH STATUS	COILS	00301	96
13	INPUT	N/A	BOOLEAN WITH STATUS	INPUT STATUS	10401	96
14	OUTPUT	COMPLETE BLOCK	BOOLEAN WITH STATUS	COILS	00401	96
15	INPUT	N/A	BOOLEAN WITH STATUS	INPUT STATUS	10501	96
16	OUTPUT	COMPLETE BLOCK	BOOLEAN WITH STATUS	COILS	00501	96

Table 2 PLC and DeltaV Serial Card Configuration Design



The data model configuration design used for the test is detailed in Table 3:

DATA TYPE	MODBUS TYPE	PLC Starting ADDRESS	PLC REGISTERS USED	DeltaV SERIAL CARD DATA SET NUMBER	DeltaV CONTROL MODULES
AI	INTEGER REGISTERS	30003	93	1	12
AO	HOLDING REGISTERS	40003	93	2	12
AI	INTEGER REGISTERS	30201	96	3	12
AO	HOLDING REGISTERS	40101	96	4	12
DI	STATUS REGISTERS	10001	96	5	6
DO	COILS	00001	96	6	6
DI	STATUS REGISTERS	10101	96	7	6
DO	COILS	00101	96	8	6
DI	STATUS REGISTERS	10201	96	9	6
DO	COILS	00201	96	10	6
DI	STATUS REGISTERS	10301	96	11	6
DO	COILS	00301	96	12	6
DI	STATUS REGISTERS	10401	96	13	6
DO	COILS	00401	96	14	6
DI	STATUS REGISTERS	10501	96	15	6
DO	COILS	00501	96	16	6
Totals			1530		120

Table 3 Data Type Design Details



## Test Setup

The test was set up to a) programmatically, via a C program, cause changes to all of the inputs via MIMIC and b) determine the time for all of the output channels to be changed to the new corresponding input values. In MIMIC, channels were assigned to data groups that correspond to the serial card data sets. See Table 4 below for details on data group set-up.

mimic Data Group	DeltaV SERIAL CARD DATA SET NUMBER	DATA TYPE	MODBUS TYPE	PLC Starting ADDRESS	PLC REGISTERS USED	DeltaV CONTROL MODULES
1	1	AI	INTEGER REGISTERS	30003	93	12
	2	AO	HOLDING REGISTERS	40003	93	12
2	3	AI	INTEGER REGISTERS	30201	96	12
	4	AO	HOLDING REGISTERS	40101	96	12
3	5	DI	STATUS REGISTERS	10001	96	6
	6	DO	COILS	00001	96	6
4	7	DI	STATUS REGISTERS	10101	96	6
	8	DO	COILS	00101	96	6
5	9	DI	STATUS REGISTERS	10201	96	6
	10	DO	COILS	00201	96	6
6	11	DI	STATUS REGISTERS	10301	96	6
	12	DO	COILS	00301	96	6
7	13	DI	STATUS REGISTERS	10401	96	6
	14	DO	COILS	00401	96	6
8	15	DI	STATUS REGISTERS	10501	96	6
	16	DO	COILS	00501	96	6

Table 4 mimic® Data Group Setup



The following was the test sequence, via a C program, to determine the time recorded for the three test conditions:

1. Start timer
2. Concurrently change all 8 input mimic data groups
3. Monitor all 8 output mimic data groups until they match the changes in step 2
4. Stop the timer
5. Record the time for each output data group to change to the input data group
6. Wait 2 seconds
7. Repeat test until test is run 500 times.

## Test Conditions and Results

The following three sections show the results of each Test Condition performed on the test system.

### **Test 1 Conditions**

All 120 modules at 500 ms scan rate. Analog input and output function blocks are in separate DeltaV Control Modules:

mimic® Data Group	DELTA V SERIAL CARD DATA SET NUMBER	DATA TYPE	DELTA V CONTROL MODULES	Control Module Scan Rate, ms	Average Input to Output Time, seconds
1	1	AI	12	500	1.831
	2	AO	12	500	
2	3	AI	12	500	1.783
	4	AO	12	500	
3	5	DI	6	500	1.847
	6	DO	6	500	
4	7	DI	6	500	1.925
	8	DO	6	500	
5	9	DI	6	500	1.619
	10	DO	6	500	
6	11	DI	6	500	1.853
	12	DO	6	500	
7	13	DI	6	500	1.751
	14	DO	6	500	
8	15	DI	6	500	1.752
	16	DO	6	500	

Table 5 Test 1 Results per mimic® Data Group



Table 6 provides the test 1 overall average input to output time for all 8 mimic data groups and from the DeltaV diagnostics: the serial card's port 1 average scan time to update all of the datasets and the average controller free time.

Overall Average Input to Output Time, seconds	Serial Card Average Scan Time to Scan all Data Sets, seconds	Average DeltaV Controller Free Time, %
1.759	0.876	55.45

Table 6 Test 1 Average Results

**Test 2 Condition**

All analog modules and half of the discrete modules at 500 ms scan rate, with half of the discrete modules at 200 ms scan rate. Analog input and output function blocks are in separate DeltaV control modules

MIMIC Data Group	DELTA V SERIAL CARD DATA SET NUMBER	DATA TYPE	DELTA V CONTROL MODULES	Control Module Scan Rate, ms	Average Input to Output Time, seconds
1	1	AI	12	500	1.906
	2	AO	12	500	
2	3	AI	12	500	1.719
	4	AO	12	500	
3	5	DI	6	500	1.685
	6	DO	6	500	
4	7	DI	6	500	1.852
	8	DO	6	500	
5	9	DI	6	500	1.806
	10	DO	6	500	
6	11	DI	6	200	1.527
	12	DO	6	200	
7	13	DI	6	200	1.554
	14	DO	6	200	
8	15	DI	6	200	1.446
	16	DO	6	200	

Table 7 Test 2 Results per mimic Data Group



Table 8 provides the test 2 overall average input to output time for all 8 mimic data groups and from the DeltaV diagnostics: the serial card's port 1 average scan time to update all of the datasets and the average controller free time.

Overall Average Input to Output Time, seconds	Serial Card Average Scan Time to Scan all Data Sets, seconds	Average DeltaV Controller Free Time, %
1.687	0.899	31.70

Table 8 Test 2 Average Results

**Test 3 Condition**

All analog input and output function blocks in the same modules, with 8 AIN and 8 AOUT blocks/module. All 120 modules at 500 ms scan rate:

Mimic® Data Group	DeltaV SERIAL CARD DATA SET NUMBER	DATA TYPE	DeltaV CONTROL MODULES	Control Module Scan Rate, ms	Average Input to Output Time, seconds
1	1	AI	12	500	2.058
	2	AO			
2	3	AI	12	500	2.234
	4	AO			
3	5	DI	6	500	1.908
	6	DO	6	500	
4	7	DI	6	500	1.908
	8	DO	6	500	
5	9	DI	6	500	1.563
	10	DO	6	500	
6	11	DI	6	500	1.873
	12	DO	6	500	
7	13	DI	6	500	1.764
	14	DO	6	500	
8	15	DI	6	500	1.698
	16	DO	6	500	

Table 9 Test 3 Results per mimic Group



Table 10 provides the test 3 overall average input to output time for all 8 mimic data groups and from the DeltaV diagnostics: the serial card's port 1 average scan time to update all of the datasets and the average controller free time.

<b>Overall Average Input to Output Time, seconds</b>	<b>Serial Card Average Scan Time to Scan all Data Sets, seconds</b>	<b>Average DeltaV Controller Free Time, %</b>
1.876	0.748	57.60

Table 10 Test 3 Average Results