DL205 User Manual
Table of Contents

Chapter 1 - Getting Started

Introduction **1-2**
- The Purpose of this Manual 1-2
- Where to Begin 1-2
- Supplemental Manuals 1-2
- Technical Support 1-2

Conventions Used **1-3**
- Key Topics for Each Chapter 1-3

DL205 System Components **1-4**
- CPUs 1-4
- Bases 1-4
- I/O Configuration 1-4
- I/O Modules 1-4
- DL205 System Diagrams 1-5

Programming Methods **1-7**
- DirectSOFT Programming for Windows 1-7
- Handheld Programmer 1-7

DirectLOGIC™ Part Numbering System **1-8**

Quick Start for PLC Validation and Programming **1-10**

Steps to Designing a Successful System **1-13**

Chapter 2 - Installation , Wiring and Specifications

Safety Guidelines **2-2**
- Plan for Safety 2-2
- Three Levels of Protection 2-3
- Emergency Stops 2-3
- Emergency Power Disconnect 2-4

Orderly System Shutdown 2-4
Class 1, Division 2, Approval 2-4

Mounting Guidelines 2-5
Base Dimensions 2-5
Panel Mounting and Layout 2-6
Enclosures 2-7
Environmental Specifications 2-8
Power 2-8
Agency Approvals 2-9
24 VDC Power Bases 2-9

Installing DL205 Bases 2-10
Choosing the Base Type 2-10
Mounting the Base 2-10
Using Mounting Rails 2-11

Installing Components in the Base 2-12

Base Wiring Guidelines 2-13
Base Wiring 2-13

I/O Wiring Strategies 2-14
PLC Isolation Boundaries 2-14
Powering I/O Circuits with the Auxiliary Supply 2-15
Powering I/O Circuits Using Separate Supplies 2-16
Sinking / Sourcing Concepts 2-17
I/O “Common” Terminal Concepts 2-18
Connecting DC I/O to “Solid State” Field Devices 2-19
Solid State Input Sensors 2-19
Solid State Output Loads 2-19
Relay Output Guidelines 2-21
Relay Outputs – Transient Suppression for Inductive Loads in a Control System 2-21

I/O Module Positioning, Wiring, and Specification 2-26
Slot Numbering 2-26
Module Placement Restrictions 2-26
Special Placement Considerations for Analog Modules 2-27
Discrete Input Module Status Indicators 2-27
Color Coding of I/O Modules 2-27
Wiring the Different Module Connectors 2-28

I/O Wiring Checklist 2-29

DL205 I/O Module Specifications 2-30

DL205 Input Module Chart 2-30

DL205 Output Module Chart 2-30

Glossary of Specification Terms 2-52

Inputs or Outputs Per Module 2-52

Commons Per Module 2-52

Input Voltage Range 2-52

Output Voltage Range 2-52

Peak Voltage 2-52

AC Frequency 2-52

ON Voltage Level 2-52

OFF Voltage Level 2-52

Input impedance 2-52

Input Current 2-52

Minimum ON Current 2-52

Maximum OFF Current 2-52

Minimum Load 2-52

External DC Required 2-52

ON Voltage Drop 2-52

Maximum Leakage Current 2-53

Maximum Inrush Current 2-53

Base Power Required 2-53

OFF to ON Response 2-53

ON to OFF Response 2-53

Terminal Type 2-53

Status Indicators 2-53

Weight 2-53

Fuses 2-53

Chapter 3 - CPU Specifications and Operations

CPU Overview 3-2

General CPU Features 3-2

D2-230 CPU Features 3-2

D2-240 CPU Features 3-2

D2-250–1 CPU Features 3-3
D2-260 and D2-262 CPU Features 3-3

CPU General Specifications 3-4

CPU Base Electrical Specifications 3-5

CPU Hardware Setup 3-6
Communication Port Pinout Diagrams 3-6
Port 1 Specifications (D2-230 and D2-240 CPUs) 3-7
Port 1 Specifications (D2-250–1, D2-260 and D2-262 CPUs) 3-7
Port 2 Specifications (D2-240) 3-8
Port 2 Specifications (D2-250–1, D2-260 and D2-262) 3-9

Selecting the Program Storage Media 3-10
Built-in EEPROM 3-10
EEPROM Sizes 3-10
EEPROM Operations 3-10
Installing the CPU 3-11
Connecting the Programming Devices 3-11
CPU Setup Information 3-12
Status Indicators 3-13
Mode Switch Functions 3-13
Changing Modes in the DL205 PLC 3-14
Mode of Operation at Power Up 3-14

Using Battery Backup 3-15
Battery Backup 3-15
D2-250-1, D2-260 and D2-262 3-15
D2-230 and D2-240 3-15
Auxiliary Functions 3-16
Clearing an Existing Program 3-17
Initializing System Memory 3-17
Setting the Clock and Calendar 3-17
Setting the CPU Network Address 3-18
Setting Retentive Memory Ranges 3-18
Using a Password 3-19
Setting the Analog Potentiometer Ranges 3-20

CPU Operation 3-22
CPU Operating System 3-22

Program Mode Operation 3-23
Run Mode Operation 3-23
Read Inputs 3-24
Read Inputs from Specialty and Remote I/O 3-24
Service Peripherals and Force I/O 3-24
CPU Bus Communication 3-25
Update Clock, Special Relays and Special Registers 3-25
Solve Application Program 3-26
Solve PID Loop Equations 3-26
Write Outputs 3-26
Write Outputs to Specialty and Remote I/O 3-27
Diagnostics 3-27

I/O Response Time 3-28
Is Timing Important for Your Application? 3-28
Normal Minimum I/O Response 3-28
Normal Maximum I/O Response 3-28
Improving Response Time 3-29

CPU Scan Time Considerations 3-30
Initialization Process 3-31
Reading Inputs 3-31
Reading Inputs from Specialty I/O 3-32
Service Peripherals 3-32
CPU Bus Communication 3-33
Update Clock/Calendar, Special Relays, Special Registers 3-33
Writing Outputs 3-33
Writing Outputs to Specialty I/O 3-34
Diagnostics 3-34
Application Program Execution 3-35

PLC Numbering Systems 3-36
PLC Resources 3-36
V–Memory 3-37
Binary-Coded Decimal Numbers 3-37
Hexadecimal Numbers 3-37

Memory Map 3-38
Octal Numbering System 3-38

Discrete and Word Locations 3-38
V–Memory Locations for Discrete Memory Areas 3-38
Input Points (X Data Type) 3-39
Output Points (Y Data Type) 3-39
Control Relays (C Data Type) 3-39
Timers and Timer Status Bits (T Data Type) 3-39
Timer Current Values (V Data Type) 3-40
Counters and Counter Status Bits (CT Data Type) 3-40
Counter Current Values (V Data Type) 3-40
Word Memory (V Data Type) 3-40
Stages (S Data type) 3-41
Special Relays (SP Data Type) 3-41
Remote I/O Points (GX Data Type) 3-41

D2-230 System V-memory 3-42

D2-240 System V-memory 3-44

D2-250–1 System V-memory (D2-250 also) 3-47

D2-260 and D2-262 System V-memory 3-50

DL205 Aliases 3-53

D2-230 Memory Map 3-54

D2-240 Memory Map 3-55

D2-250–1 Memory Map (D2-250 also) 3-56

D2-260 and D2-262 Memory Map 3-57

X Input/Y Output Bit Map 3-58

Control Relay Bit Map 3-60

Stage Control/Status Bit Map 3-64

Timer and Counter Status Bit Maps 3-66

Remote I/O Bit Map 3-67

Chapter 4 - System Design and Configuration

DL205 System Design Strategies 4-2

I/O System Configurations 4-2
Networking Configurations 4-2

Module Placement **4-3**
Slot Numbering 4-3
Module Placement Restrictions 4-3
Automatic I/O Configuration 4-4
Manual I/O Configuration 4-4
Removing a Manual Configuration 4-5
Power–On I/O Configuration Check 4-5
I/O Points Required for Each Module 4-6

Calculating the Power Budget **4-7**
Managing Your Power Resource 4-7
CPU Power Specifications 4-7
Module Power Requirements 4-7
Power Budget Calculation Example 4-9
Power Budget Calculation Worksheet 4-10

Local Expansion I/O **4-11**
D2–CM Local Expansion Module 4-11
D2–EM Local Expansion Module 4-12
D2–EXCBL–1 Local Expansion Cable 4-12
D2-260/D2-262 Local Expansion System 4-13
D2-250-1 Local Expansion System 4-14
Expansion Base Output Hold Option 4-15
Enabling I/O Configuration Check using ***Direct***SOFT 4-16

Expanding DL205 I/O **4-17**
I/O Expansion Overview 4-17
Ethernet Remote Master, H2-ERM100 4-17
Ethernet Remote Master Hardware Configuration 4-18
Installing the ERM Module 4-19
Ethernet Base Controller, H2-EBC100 4-22
Install the EBC Module 4-23
Set the Module ID 4-23
Insert the EBC Module 4-23
Network Cabling 4-24
10BaseFL Network Cabling 4-25
Maximum Cable Length 4-25

Add a Serial Remote I/O Master/Slave Module
(No longer available for new applications) 4-26
Configuring the CPU's Remote I/O Channel 4-27
Configure Remote I/O Slaves 4-29
Configuring the Remote I/O Table 4-29
Remote I/O Setup Program 4-30
Remote I/O Test Program 4-31

Network Connections to Modbus and DirectNET 4-32
Configuring Port 2 For DirectNET 4-32
Configuring Port 2 For Modbus RTU 4-32
Modbus Port Configuration 4-33
DirectNET Port Configuration 4-34

Network Slave Operation 4-35
Modbus Function Codes Supported 4-35
Determining the Modbus Address 4-35
If Your Host Software Requires the Data Type and Address 4-35
If Your Modbus Host Software Requires an Address ONLY 4-38
Example 1: V2100 584/984 Mode 4-40
Example 2: Y20 584/984 Mode 4-40
Example 3: T10 Current Value 484 Mode 4-40
Example 4: C54 584/984 Mode 4-40
Determining the DirectNET Address 4-41
Network Master Operation 4-41
Step 1: Identify Master Port # and Slave # 4-42
Step 2: Load Number of Bytes to Transfer 4-42
Step 3: Specify Master Memory Area 4-43
Step 4: Specify Slave Memory Area 4-43
Communications from a Ladder Program 4-44
Multiple Read and Write Interlocks 4-44

Network Modbus RTU Master Operation
(D2-260 and D2-262 only) 4-45
Modbus Function Codes Supported 4-45
Modbus Port Configuration 4-46

RS–485 Network (Modbus Only) 4-47
RS–232 Network 4-47
Modbus Read from Network (MRX) 4-48
MRX Slave Memory Address 4-49
MRX Master Memory Addresses 4-49
MRX Number of Elements 4-49
MRX Exception Response Buffer 4-49
Modbus Write to Network (MWX) 4-50
MWX Slave Memory Address 4-51
MWX Master Memory Addresses 4-51
MWX Number of Elements 4-51
MWX Exception Response Buffer 4-51
MRX/MWX Example in DirectSOFT 4-52

Non–Sequence Protocol (ASCII In/Out and PRINT) 4-54
RS–485 Network 4-55
RS–232 Network 4-55
RS–422 Network 4-57
RS–232 Network 4-57

Chapter 5 - RLL and Intelligent Box Instructions

Introduction 5-2

Using Boolean Instructions 5-5
END Statement 5-5
Simple Rungs 5-5
Normally Closed Contact 5-6
Contacts in Series 5-6
Midline Outputs 5-6
Parallel Elements 5-7
Joining Series Branches in Parallel 5-7
Joining Parallel Branches in Series 5-7
Combination Networks 5-7
Comparative Boolean 5-8
Boolean Stack 5-8
Immediate Boolean 5-9

Boolean Instructions 5-10

Comparative Boolean **5-27**

Immediate Instructions **5-33**

Timer, Counter and Shift Register Instructions **5-41**

Using Timers 5-41
Timer Example Using Discrete Status Bits 5-43
Accumulating Timer (TMRA) 5-44
Accumulating Timer Example using Discrete Status Bits 5-45
Accumulator Timer Example Using Comparative Contacts 5-45
Counter Example Using Discrete Status Bits 5-47
Counter Example Using Comparative Contacts 5-47
Stage Counter Example Using Discrete Status Bits 5-49
Stage Counter Example Using Comparative Contacts 5-49
Up/Down Counter Example Using Discrete Status Bits 5-51
Up/Down Counter Example Using Comparative Contacts 5-51

Accumulator/Stack Load and Output Data Instructions **5-53**

Using the Accumulator 5-53
Copying Data to the Accumulator 5-53
Using the Accumulator Stack 5-54
Changing the Accumulator Data 5-56
Using Pointers 5-57
Load (LD) 5-58

Logical Instructions (Accumulator) **5-71**

Exclusive Or Double (XORD) 5-80

Math Instructions **5-88**

Add Real (ADDR) 5-90
Subtract (SUB) 5-91
Subtract Double (SUBD) 5-92
Subtract Real (SUBR) 5-93
Multiply (MUL) 5-94
Multiply Double (MULD) 5-95
Multiply Real (MULR) 5-96
Divide (DIV) 5-97
Divide Double (DIVD) 5-98
Divide Real (DIVR) 5-99
Increment (INC) 5-100

Decrement (DEC) 5-100
Add Binary (ADDB) 5-101
Add Binary Double (ADDBD) 5-102
Subtract Binary (SUBB) 5-103
Subtract Binary Double (SUBBD) 5-104
Multiply Binary (MULB) 5-105
Divide Binary (DIVB) 5-106
Increment Binary (INCB) 5-107
Decrement Binary (DECB) 5-108
Add Formatted (ADDF) 5-109
Subtract Formatted (SUBF) 5-110
Multiply Formatted (MULF) 5-111
Divide Formatted (DIVF) 5-112
Add Top of Stack (ADDS) 5-113
Subtract Top of Stack (SUBS) 5-114
Multiply Top of Stack (MULS) 5-115
Divide by Top of Stack (DIVS) 5-116
Add Binary Top of Stack (ADDBS) 5-117
Subtract Binary Top of Stack (SUBBS) 5-118
Multiply Binary Top of Stack (MULBS) 5-119
Divide Binary by Top of Stack (DIVBS) 5-120

Transcendental Functions (D2-260 and D2-262 only) 5-121
Sine Real (SINR) 5-121
Cosine Real (COSR) 5-121
Tangent Real (TANR) 5-121
Arc Sine Real (ASINR) 5-121
Arc Cosine Real (ACOSR) 5-122
Arc Tangent Real (ATANR) 5-122
Square Root Real (SQRTR) 5-122

Bit Operation Instructions 5-123
Sum (SUM) 5-123
Shift Left (SHFL) 5-124
Shift Right (SHFR) 5-125
Rotate Left (ROTL) 5-126

Rotate Right (ROTR) 5-127
Encode (ENCO) 5-128
Decode (DECO) 5-129

Number Conversion Instructions (Accumulator) 5-130
Binary (BIN) 5-130
Binary Coded Decimal (BCD) 5-131
Invert (INV) 5-132
Ten's Complement (BCDCPL) 5-133
Binary to Real Conversion (BTOR) 5-134
Real to Binary Conversion (RTOB) 5-135
Radian Real Conversion (RADR) 5-136
Degree Real Conversion (DEGR) 5-136
ASCII to HEX (ATH) 5-137
HEX to ASCII (HTA) 5-138
Segment (SEG) 5-140
Gray Code (GRAY) 5-141
Shuffle Digits (SFLDGT) 5-142
Shuffle Digits Block Diagram 5-142

Table Instructions 5-144
Move (MOV) 5-144
Move Memory Cartridge (MOVMC) 5-145
Load Label (LDLBL) 5-145
Copy Data From a Data Label Area to V-Memory 5-146
Copy Data From V-Memory to a Data Label Area 5-147
Set Bit (SETBIT) 5-148
Reset Bit (RSTBIT) 5-148
Fill (FILL) 5-150
Find (FIND) 5-151
Find Greater Than (FDGT) 5-152
Table to Destination (TTD) 5-154
Remove from Bottom (RFB) 5-157
Source to Table (STT) 5-160
Remove from Table (RFT) 5-163
Add to Top (ATT) 5-166
Table Shift Left (TSHFL) 5-169

Table Shift Right (TSHFR) 5-169
AND Move (ANDMOV) 5-171
OR Move (ORMOV) 5-171
Exclusive OR Move (XORMOV) 5-171
Find Block (FINDB) 5-173
Swap (SWAP) 5-174

Clock/Calendar Instructions 5-175
Date (DATE) 5-175
Time (TIME) 5-176

CPU Control Instructions 5-177
No Operation (NOP) 5-177
End (END) 5-177
Stop (STOP) 5-177
Reset Watch Dog Timer (RSTWT) 5-178

Program Control Instructions 5-179
Goto Label (GOTO) (LBL) 5-179
For/Next (FOR) (NEXT) 5-180
Goto Subroutine (GTS) (SBR) 5-182
Subroutine Return (RT) 5-182
Subroutine Return Conditional (RTC) 5-182
Master Line Set (MLS) 5-185
Master Line Reset (MLR) 5-185
Understanding Master Control Relays 5-185
MLS/MLR Example 5-186

Interrupt Instructions 5-187
Interrupt (INT) 5-187
Interrupt Return (IRT) 5-188
Interrupt Return Conditional (IRTC) 5-188
Enable Interrupts (ENI) 5-188
Disable Interrupts (DISI) 5-188
Interrupt Example for Interrupt Module 5-189
Interrupt Example for Software Interrupt 5-190

Intelligent I/O Instructions 5-191
Read from Intelligent Module (RD) 5-191

Write to Intelligent Module (WT) 5-192

Network Instructions 5-193

Read from Network (RX) 5-193

Write to Network (WX) 5-195

Message Instructions 5-197

Fault (FAULT) 5-197

Fault Example 5-198

Data Label (DLBL) 5-199

ASCII Constant (ACON) 5-199

Numerical Constant (NCON) 5-199

Data Label Example 5-200

Print Message (PRINT) 5-201

Modbus RTU Instructions (D2-260/D2-262) 5-205

Modbus Read from Network (MRX) 5-205

MRX Slave Memory Address 5-206

MRX Master Memory Addresses 5-206

MRX Number of Elements 5-207

MRX Exception Response Buffer 5-207

MRX Example 5-207

Modbus Write to Network (MWX) 5-208

MWX Slave Memory Address 5-209

MWX Master Memory Addresses 5-209

MWX Number of Elements 5-210

MWX Exception Response Buffer 5-210

MWX Example 5-210

ASCII Instructions (D2-260/D2-262) 5-211

Reading ASCII Input Strings 5-211

Writing ASCII Output Strings 5-211

Managing the ASCII Strings 5-212

ASCII Input (AIN) 5-212

AIN Fixed Length Examples 5-214

AIN Variable Length Example 5-216

ASCII Find (AFIND) 5-217

AFIND Search Example 5-218

AFIND Example Combined with AEX Instruction 5-219

ASCII Extract (AEX) 5-220
ASCII Compare (CMPV) 5-221
CMPV Example 5-221
ASCII Print to V-memory (VPRINT) 5-222
VPRINT Time/Date Stamping 5-222
VPRINT V-memory element 5-223
VPRINT V-memory text element 5-224
VPRINT Bit element 5-224
Text element 5-225
VPRINT Example Combined with PRINTV Instruction 5-226
ASCII Print from V-memory (PRINTV) 5-227
ASCII Swap Bytes (SWAPB) 5-228
SWAPB Example 5-229
ASCII Clear Buffer (ACRB) 5-229
ACRB Example 5-229

Intelligent Box (IBox) Instructions (D2-250-1, D2-260 and D2-262 Only) 5-230

Analog Input/Output Combo Module Pointer Setup (ANLGCMB) (IB-462) 5-233
ANLGCMB Example 5-234
ANLGIN Example 5-236
ANLGOUT Example 5-238
ANSCL Example 5-239
ANSCLB Example 5-240
FILTER Example 5-242
FILTERB Example 5-244
HILOAL Example 5-246
HILOALB Example 5-248
ONDTMR Example 5-252
ONESHOT Example 5-253
PONOFF Example 5-254
MOVEW Example 5-255
MOVED Example 5-256
BCDTOR Example 5-257
BCDTORD Example 5-258
MATHBCD Example 5-260
MATHBIN Example 5-262

MATHR Example 5-263
RTOBCD Example 5-264
RTOBCDD Example 5-265
SQUARE Example 5-266
SQUAREB Example 5-267
SQUARER Example 5-268
SUMBCD Example 5-269
SUMBIN Example 5-270
SUMR Example 5-272
ECOM100 Example 5-274
ECDHCPD Example 5-276
ECDHCPE Example 5-278
ECDHCPQ Example 5-280
ECEMAIL Example 5-286
ECEMRDS Example 5-288
ECEMSUP Example 5-292
ECIPSUP Example 5-295
ECRDDES Example 5-297
ECRDGWA Example 5-299
ECRDIP Example 5-301
ECRDMID Example 5-303
ECRDNAM Example 5-305
ECRDSNM Example 5-307
ECWRDES Example 5-309
ECWRGWA Example 5-311
ECWRIP Example 5-313
ECWRMID Example 5-315
ECWRNAM Example 5-317
ECWRSNM Example 5-319
ECRX Example 5-321
ECWX Example 5-324
NETCFG Example 5-327
NETRX Example 5-329
NETWX Example 5-332
CTRIO Example (local base) 5-335
CTRIO Example (EBC base) 5-335

CTRADPT Example 5-337
CTRCLRT Example 5-340
CTREDPT Example 5-343
CTREDRL Example 5-347
CTRINPT Example 5-351
CTRINTR Example 5-355
CTRLDPR Example 5-359
CTRRDER Example 5-362
CTRRTLM Example 5-364
CTRRTPM Example 5-367
CTRVELO Example 5-370
CTRWFTR Example 5-373

Chapter 6 - Drum Instruction Programming (D2-250-1, D2-260 and D2-262 Only)

Introduction 6-2
Purpose 6-2
Drum Terminology 6-2
Drum Chart Representation 6-3
Output Sequences 6-3

Step Transitions6-4
Drum Instruction Types 6-4
Timer-Only Transitions 6-4
Timer and Event Transitions 6-5
Event-Only Transitions 6-6
Counter Assignments 6-6
Last Step Completion 6-7

Overview of Drum Operation 6-8
Drum Instruction Block Diagram 6-8
Powerup State of Drum Registers 6-9

Drum Control Techniques 6-10
Drum Control Inputs 6-10
Self-Resetting Drum 6-11
Initializing Drum Outputs 6-11
Using Complex Event Step Transitions 6-11

Drum Instructions 6-12

Timed Drum with Discrete Outputs (DRUM) 6-12
Event Drum (EDRUM) 6-14
Handheld Programmer Drum Mnemonics 6-16
Masked Event Drum with Discrete Outputs (MDRMD) 6-19
Masked Event Drum with Word Output (MDRMW) 6-21

Chapter 7 - RLL^{Plus} Stage Programming

Introduction to Stage Programming 7-2
Overcoming "Stage Fright" 7-2
Learning to Draw State Transition Diagrams 7-3
Introduction to Process States 7-3
The Need for State Diagrams 7-3
A 2-State Process 7-3
RLL Equivalent 7-4
Stage Equivalent 7-4
Let's Compare 7-5
Initial Stages 7-5
What Stage Bits Do 7-6
Stage Instruction Characteristics 7-6
Using the Stage Jump Instruction for State Transitions 7-7
Stage Jump, Set, and Reset Instructions 7-7
Stage Program Example: Toggle On/Off Lamp Controller 7-8
A 4-State Process 7-8
Four Steps to Writing a Stage Program 7-9
Stage Program Example: A Garage Door Opener 7-10
Garage Door Opener Example 7-10
Draw the Block Diagram 7-10
Draw the State Diagram 7-11
Add Safety Light Feature 7-12
Modify the Block Diagram and State Diagram 7-12
Using a Timer Inside a Stage 7-13
Add Emergency Stop Feature 7-14
Exclusive Transitions 7-14
Stage Program Design Considerations 7-15

Stage Program Organization 7-15
How Instructions Work Inside Stages 7-16
Using a Stage as a Supervisory Process 7-17
Stage Counter 7-17
Unconditional Outputs 7-18
Power Flow Transition Technique 7-18

Parallel Processing Concepts 7-19
Parallel Processes 7-19
Converging Processes 7-19
Convergence Stages (CV) 7-19
Convergence Jump (CVJMP) 7-20
Convergence Stage Guidelines 7-20

Managing Large Programs 7-21
Stage Blocks (BLK, BEND) 7-21
Block Call (BCALL) 7-22

RLL*PLUS* (Stage) Instructions 7-23
Stage (SG) 7-23
Initial Stage (ISG) 7-24
Jump (JMP) 7-24
Not Jump (NJMP) 7-24
Converge Stage (CV) and Converge Jump (CVJMP) 7-25
Block Call (BCALL) 7-27
Block (BLK) 7-27
Block End (BEND) 7-27
Stage View in DirectSOFT 7-28

Questions and Answers about Stage Programming 7-29

Chapter 8 - PID Loop Operation (D2-250-1/D2-260/D2-262)

D2-250-1, D2-260 and D2-262 PID Loop Features 8-2
Main Features 8-2

Introduction to PID Control 8-4
What is PID Control? 8-4

Introducing DL205 PID Control 8-6
Process Control Definitions 8-8

PID Loop Operation **8-9**
Position Form of the PID Equation 8-9
Reset Windup Protection 8-10
Freeze Bias 8-11
Adjusting the Bias 8-11
Step Bias Proportional to Step Change in SP 8-12
Eliminating Proportional, Integral or Derivative Action 8-12
Velocity Form of the PID Equation 8-12
Bumpless Transfer 8-13
Loop Alarms 8-13
Loop Operating Modes 8-14
Special Loop Calculations 8-14

Ten Steps to Successful Process Control **8-16**
Step 1: Know the Recipe 8-16
Step 2: Plan Loop Control Strategy 8-16
Step 3: Size and Scale Loop Components 8-16
Step 4: Select I/O Modules 8-16
Step 5: Wiring and Installation 8-17
Step 6: Loop Parameters 8-17
Step 7: Check Open Loop Performance 8-17
Step 8: Loop Tuning 8-17
Step 9: Run Process Cycle 8-17
Step 10: Save Parameters 8-17

PID Loop Setup **8-18**
Some Things to Do and Know Before Starting 8-18
PID Error Flags 8-18
Establishing the Loop Table Size and Location 8-18
Loop Table Word Definitions 8-20
PID Mode Setting 1 Bit Descriptions (Addr + 00) 8-21
PID Mode Setting 2 Bit Descriptions (Addr + 01) 8-22
Mode/Alarm Monitoring Word (Addr + 06) 8-23
Ramp/Soak Table Flags (Addr + 33) 8-23
Ramp/Soak Table Location (Addr + 34) 8-24
Ramp/Soak Table Programming Error Flags (Addr + 35) 8-24
PV Auto Transfer (Addr + 36) from I/O Module Base/Slot/Channel Option 8-25

PV Auto Transfer (Addr + 36) from V-memory Option 8-25
Control Output Auto Transfer (Addr + 37) 8-25
Configure the PID Loop 8-26

PID Loop Tuning 8-41
Open-Loop Test 8-41
Manual Tuning Procedure 8-42
Alternative Manual Tuning Procedures by Others 8-45
Tuning PID Controllers 8-45
Auto Tuning Procedure 8-46
Use DirectSOFT Data View with PID View 8-50
Open a New Data View Window 8-50
Open PID View 8-51

Using the Special PID Features 8-53
How to Change Loop Modes 8-53
Operator Panel Control of PID Modes 8-54
PLC Modes Effect on Loop Modes 8-54
Loop Mode Override 8-54
PV Analog Filter 8-55
Creating an Analog Filter in Ladder Logic 8-56
Use the DirectSOFT Filter Intelligent Box Instruction 8-57
FilterB Example 8-57

Ramp/Soak Generator 8-58
Introduction 8-58
Ramp/Soak Table 8-59
Ramp/Soak Table Flags 8-61
Ramp/Soak Generator Enable 8-61
Ramp/Soak Controls 8-61
Ramp/Soak Profile Monitoring 8-62
Ramp/Soak Programming Errors 8-62
Testing Your Ramp/Soak Profile 8-62

DirectSOFT Ramp/Soak Example 8-63
Set Up the Profile in PID Setup 8-63
Program the Ramp/Soak Control in Relay Ladder 8-63
Test the Profile 8-64

Cascade Control **8-65**
Introduction 8-65
Cascaded Loops in the DL205 CPU 8-66
Tuning Cascaded Loops 8-67
Time-Proportioning Control **8-68**
On/Off Control Program Example 8-69
Feedforward Control **8-70**
Feedforward Example 8-71
PID Example Program **8-72**
Program Setup for the PID Loop 8-72
Troubleshooting Tips **8-75**
Q. The Ramp/Soak Generator does not operate when I activate the Start bit. 8-75
Glossary of PID Loop Terminology **8-77**
Bibliography **8-79**

Chapter 9 - Maintenance and Trouble Shooting

Hardware Maintenance **9-2**
Standard Maintenance 9-2
Air Quality Maintenance 9-2
Low Battery Indicator 9-2
CPU Battery Replacement 9-2
Diagnostics **9-3**
Diagnostics 9-3
Fatal Errors 9-3
Non-fatal Errors 9-3
Finding Diagnostic Information 9-4
V-memory Locations Corresponding to Error Codes 9-4
Special Relays (SP) Corresponding to Error Codes 9-5
I/O Module Codes 9-6
Error Message Tables 9-7
System Error Codes 9-8
Program Error Codes 9-9
CPU Error Indicators **9-10**
PWR Indicator **9-11**

Incorrect Base Power 9-11
Faulty CPU 9-11
Device or Module causing the Power Supply to Shutdown 9-12
Power Budget Exceeded 9-12
Run Indicator 9-13
CPU Indicator 9-13
BATT Indicator 9-13

Communications Problems 9-13

I/O Module Troubleshooting 9-14
Things to Check 9-14
I/O Diagnostics 9-14
Some Quick Steps 9-15
Testing Output Points 9-16
Handheld Programmer Keystrokes Used to Test an Output Point 9-16

Noise Troubleshooting 9-17
Electrical Noise Problems 9-17
Reducing Electrical Noise 9-17

Machine Startup and Program Troubleshooting 9-18
Program Syntax Check 9-18
Duplicate Reference Check 9-19
TEST-PGM and TEST-RUN Modes 9-20
Special Instructions 9-22
Run Time Edits 9-24
Forcing I/O Points 9-26
Regular Forcing with Direct Access 9-28
Bit Override Forcing 9-29
Bit Override Indicators 9-29

Appendix A - Auxiliary Functions

Introduction A-2
What are Auxiliary Functions? A-2
Accessing AUX Functions via DirectSOFT A-3
Accessing AUX Functions via the Handheld Programmer A-3

AUX 2* — RLL Operations A-4

AUX 21-24 ..... A-4
AUX 21 Check Program A-4
AUX 22 Change Reference A-4
AUX 23 Clear Ladder Range A-4
AUX 24 Clear Ladders A-4

AUX 3* — V-memory Operations A-5
AUX 31 ..... A-5
AUX 31 Clear V-Memory A-5

AUX 4* — I/O Configuration A-5
AUX 41-46 ..... A-5
AUX 41 Show I/O Configuration A-5
AUX 42 I/O Diagnostics A-5
AUX 44 Power-up Configuration Check A-5
AUX 45 Select Configuration A-6
AUX 46 Configure I/O A-6

AUX 5* — CPU Configuration A-7
AUX 51-5C A-7
AUX 51 Modify Program Name A-7
AUX 52 Display/Change Calendar A-7
AUX 53 Display Scan Time A-8
AUX 54 Initialize Scratchpad A-8
AUX 55 Set Watchdog Timer A-8
AUX 56 CPU Network Address A-8
AUX 57 Set Retentive Ranges A-9
AUX 58 Test Operations A-9
AUX 59 Bit Override A-10
AUX 5B Counter Interface Configuration A-10
AUX 5C Display Error History A-11

AUX 6* — Handheld Programmer Configuration A-12
AUX 61, 62 and 65 ..... A-12
AUX 61 Show Revision Numbers A-12
AUX 62 Beeper On/Off A-12
AUX 65 Run Self Diagnostics A-12

AUX 7* — EEPROM Operations A-12

AUX 71 – 76 ..... A-12
Transferable Memory Areas A-13
AUX 71 CPU to HPP EEPROM A-13
AUX 72 HPP EEPROM to CPU A-13
AUX 73 Compare HPP EEPROM to CPU A-13
AUX 74 HPP EEPROM Blank Check A-13
AUX 75 Erase HPP EEPROM A-13
AUX 76 Show EEPROM Type A-13

AUX 8* — Password Operations A-14
AUX 81 - 83 ..... A-14
AUX 81 Modify Password A-14
AUX 82 Unlock CPU A-14
AUX 83 Lock CPU A-14

Appendix B - DL205 Error Codes

DL205 Error Codes B-2

Appendix C - Instruction Execution Times

Introduction C-2
V-memory Data Registers C-2
V-Memory Bit Registers C-2
How to Read the Tables C-2

Boolean Instructions C-3

Comparative Boolean Instructions C-4

Bit of Word Boolean Instructions C-13

Immediate Instructions C-14

Timer, Counter and Shift Register Instructions C-15

Accumulator Data Instructions C-16

Logical Instructions C-18

Math Instructions C-20

Differential Instructions C-23

Bit Instructions C-24

Number Conversion Instructions **C-25**
Table Instructions **C-25**
CPU Control Instructions **C-27**
Program Control Instructions **C-27**
Interrupt Instructions **C-28**
Network Instructions **C-28**
Intelligent I/O Instructions **C-28**
Message Instructions **C-29**
RLL*PLUS* Instructions **C-29**
DRUM Instructions **C-29**
Clock / Calender Instructions **C-30**
Modbus Instructions **C-30**
ASCII Instructions **C-30**

Appendix D - Special Relays

D2-230 CPU Special Relays **D-2**
Startup and Real-Time Relays D-2
CPU Status Relays D-2
System Monitoring D-2
Accumulator Status D-3
Counter Interface Module Relays D-3
Equal Relays for Multi-step Presets with Up/Down Counter #1 (for D2-230)
(for use with the Counter Interface Module, D2-CTRINT) D-4
D2-240, D2-250-1, D2-260 and D2-262 CPU Special Relays **D-5**
Startup and Real-Time Relays D-5
CPU Status Relays D-5
System Monitoring Relays D-6
Accumulator Status Relays D-6
Counter Interface Module Relays D-7
Communications Monitoring Relays D-8
Equal Relays for Multi-step Presets D-9

Appendix E - PLC Memory

DL205 PLC Memory **E-2**
Non-volatile V-memory in the DL205 ..... E-3
PLC Memory Processes E-5
Backup E-5
Restore E-5
Retentive Memory E-6

Appendix F - DL205 Product Weight Table

DL205 Product Weight Table **F-2**

Appendix G - ASCII Table

ASCII Conversion Table **G-2**

Appendix H - Numbering Systems

Hexadecimal Numbering System **H-3**
Octal Numbering System **H-4**
Binary Coded Decimal (BCD) Numbering System **H-5**
Real (Floating Point) Numbering System **H-5**
BCD/Binary/Decimal/Hex/Octal - What is the Difference? **H-6**
Data Type Mismatch **H-7**
Signed vs Unsigned Integers **H-8**
AutomationDirect.com Products and Data Types **H-9**
DirectLOGIC PLCs H-9
C-more/C-more Micro-Graphic Panels H-9

Appendix I – European Union Directives (CE)

European Union (EU) Directives **I-2**
Member Countries I-2
Applicable Directives I-2
Compliance I-3
With respect to the D2-262: I-4
General Safety I-4
Other Sources of Information I-5

Basic EMC Installation Guidelines **I-6**
Enclosures I-6
AC Mains Filters I-6
Suppression and Fusing I-6
Internal Enclosure Grounding I-7
Equipotential Grounding I-7
Communications and Shielded Cables I-8
Analog and RS232 Cables I-8
Shielded Cables within Enclosures I-9
Analog Modules and RF Interference I-9
Network Isolation I-9
DC Powered Versions I-10
Items Specific to the DL205 ..... I-10

Appendix J - D2-262 CPU

CPU Overview **J–2**
General CPU Features J–2
D2-262 CPU Features J–2
D2-262 CPU Environmental Specifications **J–3**
DL205 CPU Bases Electrical Specifications **J–3**
D2-260/D2-262 CPU General Specifications **J–4**
D2-262 CPU General Specifications **J–5**
D2-260/D2-262 CPU Program/Memory Specifications **J–6**
D2-260/D2-262 CPU Program/Memory Specifications **J–7**
Users Memory J–7
Bit map - D2-260/ D2-262 ..... J–7
V-Memory Map - D2-260/ D2-262 ..... J–7
Expansion Modules Supported by D2-260 and D2-262 ..... **J–8**