

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
DL305 System Components	1-4
CPUs	1-4
Bases	1-4
I/O Configuration	1-4
I/O Modules	1-4
Programming Methods	1-4
<i>Direct</i> SOFT Programming for Windows	1-4
Handheld Programmer	1-4
DL305 System Diagrams	1-5
<i>Direct</i>LOGIC Part Numbering System	1-8
Quick Start for PLC Validation and Programming	1-10
Steps to Designing a Successful System	1-13
Step 1: Review the Installation Guidelines	1-13
Step 2: Understand the CPU Setup Procedures	1-13
Step 3: Understand the I/O System Configurations	1-13
Step 4: Determine the I/O Module Specifications and Wiring Characteristics	1-13
Step 5: Understand the System Operation	1-13
Step 6: Review the Programming Concepts	1-14
Step 7: Choose the Instructions	1-14
Step 8: Understand the Maintenance and Troubleshooting Procedures	1-14

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

Agency Approvals	2-8
Marine Use	2-8
Power	2-9
Component Dimensions	2-10
Installing DL305 Bases	2-11
Choosing the Base Type	2-11
Mounting the Base	2-11
Installing Components in the Base	2-12
Base Wiring Guidelines	2-13
Base Wiring	2-13
Expansion 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
Surge Suppression For Inductive Loads	2-21
Prolonging Relay Contact Life	2-23
I/O Modules Position, Wiring, and Specification	2-24
Slot Numbering	2-24
I/O Module Placement Rules	2-24
Discrete Module Status Indicators	2-25
Color Coding of I/O Modules	2-25
Wiring the Different Module Connectors	2-25
I/O Wiring Checklist	2-26
Glossary of Specification Terms	2-27
D3-08ND2, 24 VDC Input Module	2-29
D3-16ND2-1, 24 VDC Input Module	2-30
D3-16ND2-2, 24 VDC Input Module Module	2-31
D3-16ND2F, 24 VDC Fast Response Input Module	2-32
F3-16ND3F, TTL/24 VDC Fast Response Input Module	2-33
Selection of Operating Mode	2-34
D3-08NA-1, 110 VAC Input Module	2-35
D3-08NA-2, 220 VAC Input Module	2-36
D3-16NA, 110 VAC Input Module	2-37
D3-08NE3, 24 VAC/DC Input Module	2-38
D3-16NE3, 24 VAC/DC Input Module	2-39
D3-08SIM, Input Simulator	2-40
D3-08TD1, 24 VDC Output Module	2-41
D3-08TD2, 24 VDC Output Module	2-42

D3-16TD1-1, 24 VDC Output Module	2-43
D3-16TD1-2, 24 VDC Output Module	2-44
D3-16TD2, 24 VDC Output Module	2-45
D3-04TAS, 110-220 VAC Output Module	2-46
F3-08TAS, 250 VAC Isolated Output Module	2-47
F3-08TAS-1, 125 VAC Isolated Output Module	2-48
D3-08TA-1, 110-220 VAC Output Module	2-49
D3-08TA-2, 110-220 VAC Output Module	2-50
F3-16TA-2, 20-125 VAC Output Module	2-51
D3-16TA-2, 15-220 VAC Output Module	2-52
D3-08TR, Relay Output Module	2-53
F3-08TRS-1, Relay Output Module	2-54
F3-08TRS-2, Relay Output Module	2-55
D3-16TR, Relay Output Module	2-56

Chapter 3: CPU Specifications and Operations

Overview	3-2
General CPU Features	3-2
DL350 CPU Features	3-2
CPU General Specifications	3-3
CPU Hardware Features	3-4
Mode Switch Functions	3-4
Status Indicators	3-4
Port 1 Specifications	3-5
Port 2 Specifications	3-5
Using Battery Backup	3-6
Enabling the Battery Backup	3-6
CPU Setup	3-7
Installing the CPU	3-7
Connecting the Programming Devices	3-7
Auxiliary Functions	3-8
Clearing an Existing Program	3-9
Setting the Clock and Calendar	3-9
Initializing System Memory	3-9
Setting the CPU Network Address	3-10
Setting Retentive Memory Ranges	3-10
Password Protection	3-10
CPU Operation	3-11
CPU Operating System	3-11
Program Mode Operation	3-12
Run Mode Operation	3-12
Read Inputs	3-13
Read Inputs from Specialty and Remote I/O	3-13

Service Peripherals and Force I/O	3-13
Update Clock, Special Relays, and Special Registers	3-13
Solve Application Program	3-14
Solve PID Loop Equations	3-14
Write Outputs	3-14
Write Outputs to Specialty and Remote I/O	3-15
Diagnostics	3-15
I/O Response Time	3-16
Is Timing Important for Your Application?	3-16
Normal Minimum I/O Response	3-16
Normal Maximum I/O Response	3-16
Improving Response Time	3-17
CPU Scan Time Considerations	3-18
Initialization Process	3-19
Service Peripherals	3-19
CPU Bus Communication	3-19
Update Clock / Calendar, Special Relays, Special Registers	3-19
Diagnostics	3-19
Application Program Execution	3-20
PLC Numbering Systems	3-21
PLC Resources	3-21
V-Memory	3-22
Binary-Coded Decimal Numbers	3-22
Hexadecimal Numbers	3-22
Memory Map	3-23
Octal Numbering System	3-23
Discrete and Word Locations	3-23
V-Memory Locations for Discrete Memory Areas	3-23
Input Points (X Data Type)	3-24
Output Points (Y Data Type)	3-24
Control Relays (C Data Type)	3-24
Timers and Timer Status Bits (T Data type)	3-24
Timer Current Values (V Data Type)	3-25
Counters and Counter Status Bits (CT Data type)	3-25
Counter Current Values (V Data Type)	3-25
Word Memory (V Data Type)	3-26
Stages (S Data type)	3-26
Special Relays (SP Data Type)	3-26
DL350 System V-memory	3-27
DL350 Memory Map	3-29
DL350 Aliases	3-30
X Input / Y Output Bit Map	3-31
Control Relay Bit Map	3-32
Stage Control / Status Bit Map	3-34
Timer and Counter Status Bit Maps	3-36
 Chapter 4: System Design and Configuration	
DL305 System Design Strategies	4-2

I/O System Configurations	4-2
Networking Configurations	4-2
Base Configurations	4-2
Module Placement	4-3
Slot Numbering	4-3
I/O Module Placement Rules	4-3
I/O Configuration	4-3
Calculating the Power Budget	4-4
Managing your Power Resource	4-4
Base Power Specifications	4-4
I/O Points Required for Each Module	4-5
Module Power Requirements	4-5
Power Budget Calculation Example	4-7
Power Budget Calculation Worksheet	4-8
Local I/O Expansion	4-9
Base Uses Table	4-9
Local/Expansion Connectivity	4-9
Connecting Expansion Bases	4-10
Setting the Base Switches	4-11
Jumper Switch	4-11
I/O Configurations with a 5 Slot Local CPU Base	4-12
Switch settings	4-12
5 Slot Base	4-12
5 Slot Base and up to two 5 Slot Expansion Bases	4-12
I/O Configurations with an 8 Slot Local CPU Base	4-13
8 Slot Base	4-13
8 Slot Base and 5 Slot Expansion Base	4-13
8 Slot Base and One 8 slot and one 5 slot Expansion Bases	4-13
8 Slot Base and two 8 slot Expansion Bases	4-14
I/O Configurations with a 10 Slot Local CPU Base	4-15
10 Slot Base	4-15
10 Slot Base and 5 Slot Expansion Base with 16 Point I/O	4-15
10 Slot Base and 10 Slot Expansion Base with 16 Point I/O	4-15
Remote I/O Expansion	4-16
How to Add Remote I/O Channels	4-16
Configuring the CPU's Remote I/O Channel	4-17
Configure Remote I/O Slaves	4-19
Configuring the Remote I/O Table	4-19
Remote I/O Setup Program	4-20
Remote I/O Test Program	4-21
Network Connections to MODBUS and DirectNET	4-22
Configuring the CPU's Comm Port	4-22
MODBUS Port Configuration	4-23
DirectNET Port Configuration	4-24
Network Slave Operation	4-25
MODBUS Function Codes Supported	4-25
Determining the MODBUS Address	4-25
If Your Host Software Requires the Data Type and Address... ..	4-26
Example 1: V2100	4-27

Example 2: Y20	4-27
Example 3: T10 Current Value	4-27
Example 4: C54	4-27
If Your MODBUS Host Software Requires an Address ONLY	4-28
Example 1: V2100 584/984 Mode	4-29
Example 2: Y20 584/984 Mode	4-29
Example 3: T10 Current Value 484 Mode	4-29
Example 4: C54 584/984 Mode	4-29
Determining the <i>DirectNET</i> Address	4-29
Network Master Operation	4-30
Step 1: Identify Master Port # and Slave #	4-31
Step 2: Load Number of Bytes to Transfer	4-31
Step 3: Specify Master Memory Area	4-32
Step 4: Specify Slave Memory Area	4-32
Communications from a Ladder Program	4-33
Multiple Read and Write Interlocks	4-33

Chapter 5: Standard RLL Instructions

Introduction	5-2
Using Boolean Instructions	5-4
END Statement	5-4
Simple Rungs	5-4
Normally Closed Contact	5-4
Contacts in Series	5-4
Midline Outputs	5-5
Parallel Elements	5-5
Joining Series Branches in Parallel	5-5
Joining Parallel Branches in Series	5-5
Combination Networks	5-6
Boolean Stack	5-6
Comparative Boolean	5-7
Immediate Boolean	5-7
Boolean Instructions	5-8
Store (STR)	5-8
Store Not (STRN)	5-8
Store Bit-of-Word (STRB)	5-9
Store Not Bit-of-Word (STRNB)	5-9
Or (OR)	5-10
Or Not (ORN)	5-10
Or Bit-of-Word (ORB)	5-11
Or Not Bit-of-Word (ORNB)	5-11
And (AND)	5-12
And Not (ANDN)	5-12
And Bit-of-Word (ANDB)	5-13
And Not Bit-of-Word (ANDNB)	5-13
And Store (AND STR)	5-14
Or Store (OR STR)	5-14
Out (OUT)	5-15
Out Bit-of-Word (OUTB)	5-16
Or Out (OR OUT)	5-17
Not (NOT)	5-17
Positive Differential (PD)	5-18

Store Positive Differential (STRPD)	5-19
Store Negative Differential (STRND)	5-19
Or Positive Differential (ORPD)	5-20
Or Negative Differential (ORND)	5-20
And Positive Differential (ANDPD)	5-21
And Negative Differential (ANDND)	5-21
Set (SET)	5-22
Reset (RST)	5-22
Set Bit-of-Word (SETB)	5-23
Reset Bit-of-Word (RSTB)	5-23
Comparative Boolean	5-24
Store If Equal (STRE)	5-24
Store If Not Equal (STRNE)	5-24
Or If Equal (ORE)	5-25
Or If Not Equal (ORNE)	5-25
And If Equal (ANDE)	5-26
And If Not Equal (ANDNE)	5-26
Store (STR)	5-27
Store Not (STRN)	5-27
Or (OR)	5-28
Or Not (ORN)	5-28
And (AND)	5-29
And Not (ANDN)	5-29
Immediate Instructions	5-30
Store Immediate (STRI)	5-30
Store Not Immediate (STRNI)	5-30
Or Immediate (ORI)	5-31
Or Not Immediate (ORNI)	5-31
And Immediate (ANDI)	5-32
And Not Immediate (ANDNI)	5-32
Out Immediate (OUTI)	5-33
Or Out Immediate (OROUTI)	5-33
Set Immediate (SETI)	5-34
Reset Immediate (RSTI)	5-34
Timer, Counter and Shift Register Instructions	5-35
Using Timers	5-35
Timer (TMR) and Timer Fast (TMRF)	5-36
Timer Example Using Discrete Status Bits	5-37
Timer Example Using Comparative Contacts	5-37
Accumulating Timer (TMRA) Accumulating Fast Timer (TMRAF)	5-38
Accumulating Timer Example using Discrete Status Bits	5-39
Accumulator Timer Example Using Comparative Contacts	5-39
Counter (CNT)	5-40
Counter Example Using Discrete Status Bits	5-41
Counter Example Using Comparative Contacts	5-41
Stage Counter (SGCNT)	5-42
Stage Counter Example Using Discrete Status Bits	5-43
Stage Counter Example Using Comparative Contacts	5-43
Up Down Counter (UDC)	5-44
Up / Down Counter Example Using Discrete Status Bits	5-45
Up / Down Counter Example Using Comparative Contacts	5-45
Shift Register (SR)	5-46
Accumulator / Stack Load and Output Data Instructions	5-47

Using the Accumulator	5-47
Copying Data to the Accumulator	5-47
Changing the Accumulator Data	5-48
Using the Accumulator Stack	5-49
Using Pointers	5-51
Load (LD)	5-52
Load Double (LDD)	5-53
Load Formatted (LDF)	5-54
Load Address (LDA)	5-55
Load Accumulator Indexed (LDX)	5-56
Load Accumulator Indexed from Data Constants (LDSX)	5-57
Load Real Number (LDR)	5-58
Out (OUT)	5-59
Out DOUBLE (OUTD)	5-60
Out Formatted (OUTF)	5-61
Out Indexed (OUTX)	5-62
Pop (POP)	5-63
Accumulator Logical Instructions	5-64
And (AND)	5-64
And Double (ANDD)	5-65
And Formatted (ANDF)	5-66
Or (OR)	5-67
Or Double (ORD)	5-68
Or Formatted (ORF)	5-69
Exclusive Or (XOR)	5-70
Exclusive Or Double (XORD)	5-71
Exclusive Or Formatted (XORF)	5-72
Compare (CMP)	5-73
Compare Double (CMPD)	5-74
Compare Formatted (CMPF)	5-75
Compare Real Number (CMPR)	5-76
Math Instructions	5-77
Add (ADD)	5-77
Add Double (ADDD)	5-78
Add Real (ADDR)	5-79
Subtract (SUB)	5-80
Subtract Double (SUBD)	5-81
Subtract Real (SUBR)	5-82
Multiply (MUL)	5-83
Multiply Double (MULD)	5-84
Multiply Real (MULR)	5-85
Divide (DIV)	5-86
Divide Double (DIVD)	5-87
Divide Real (DIVR)	5-88
Increment (INC)	5-89
Decrement (DEC)	5-89
Add Binary (ADDB)	5-90
Subtract Binary (SUBB)	5-91
Multiply Binary (MULB)	5-92
Divide Binary (DIVB)	5-93
Increment Binary (INCB)	5-94
Decrement Binary (DECB)	5-95
Bit Operation Instructions	5-96

Sum (SUM)	5-96
Shift Left (SHFL)	5-97
Shift Right (SHFR)	5-98
Rotate Left (ROTL)	5-99
Rotate Right (ROTR)	5-100
Encode (ENCO)	5-101
Decode (DECO)	5-102
Number Conversion Instructions (Accumulator)	5-103
Binary (BIN)	5-103
Binary Coded Decimal (BCD)	5-104
Invert (INV)	5-105
Ten's Complement (BCDCPL)	5-106
Binary to Real Conversion (BTOR)	5-107
Real to Binary Conversion (RTOB)	5-108
ASCII to HEX (ATH)	5-109
HEX to ASCII (HTA)	5-110
Segment (SEG)	5-112
Gray Code (GRAY)	5-113
Shuffle Digits (SFLDGT)	5-114
Shuffle Digits Block Diagram	5-114
Table Instructions	5-116
Move (MOV)	5-116
Move Memory Cartridge / Load Label (MOVMC) (LDLBLE)	5-117
Copy Data From a Data Label Area to V-Memory	5-118
Copy Data From V-Memory to a Data Label Area	5-119
Clock / Calendar Instructions	5-120
Date (DATE)	5-120
Time (TIME)	5-121
CPU Control Instructions	5-122
No Operation (NOP)	5-122
End (END)	5-122
Stop (STOP)	5-123
Reset Watch Dog Timer (RSTWT)	5-123
Program Control Instructions	5-124
Goto Label (GOTO) (LBL)	5-124
For / Next (FOR) (NEXT)	5-125
Goto Subroutine (GTS) (SBR)	5-127
Subroutine Return (RT)	5-127
Subroutine Return Conditional (RTC)	5-127
Master Line Set (MLS)	5-130
Master Line Reset (MLR)	5-130
Understanding Master Control Relays	5-130
MLS/MLR Example	5-131
Interrupt Instructions	5-132
Interrupt (INT)	5-132
Interrupt Return (IRT)	5-133
Interrupt Return Conditional (IRTC)	5-133
Enable Interrupts (ENI)	5-133
Disable Interrupts (DISI)	5-133
Interrupt Example for Software Interrupt	5-134

Intelligent I/O Instructions	5-135
Read from Intelligent Module (RD)	5-135
Write to Intelligent Module (WT)	5-136
Network Instructions	5-137
Read from Network (RX)	5-137
Write to Network (WX)	5-139
Message Instructions	5-141
Fault (FAULT)	5-141
Fault Example	5-142
Data Label (DLBL)	5-143
ASCII Constant (ACON)	5-143
Numerical Constant (NCON)	5-143
Data Label Example	5-144
Print Message (PRINT)	5-145

Chapter 6: Drum Instruction Programming

Introduction	6-2
Purpose	6-2
Drum Terminology	6-2
Drum Chart Representation	6-3
Output Sequences	6-3
Step Transitions	6-4
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
Drum Instructions	6-12
Timed Drum with Discrete Outputs (DRUM)	6-12
Event Drum with Discrete Outputs (EDRUM)	6-14
Masked Event Drum with Discrete Outputs(MDRUMD)	6-18
Masked Event Drum with Word Output (MDRUMW)	6-20

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} 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 <i>DirectSOFT</i>	7-28
Questions and Answers about Stage Programming	7-29

Chapter 8: PID Loop Operation

DL350 PID Loop Features	8-2
Main Features	8-2
Introduction to PID Control	8-4
What is PID Control?	8-4
Introducing DL350 PID Control	8-6
Process Control Definitions	8-8
PID Loop Operation	8-9
PID Position Algorithm	8-9
Reset Windup Protection	8-10
Freeze Bias	8-11
Adjusting the Bias	8-11
Step Bias Proportional to Step Change 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 Loop 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	8-19
Loop Table Word Definitions	8-21
PID Mode Setting 1 Bit Descriptions (Addr + 00)	8-22
PID Mode Setting 2 Descriptions (Addr + 01)	8-23
Mode/Alarm Monitoring Word (Addr + 06)	8-24
Ramp/Soak Table Flags (Addr + 33)	8-24
Ramp/Soak Table Location (Addr + 34)	8-25
Ramp/Soak Table Programming Error Flags (Addr + 35)	8-25
Configure the PID Loop	8-26
PID Loop Tuning	8-40
Open-Loop Test	8-40
Manual Tuning Procedure	8-41
Auto Tuning Procedure	8-44
Use <i>DirectSOFT</i> 5 Data View with PID View	8-48
Open a New Data View Window	8-48
Open PID View	8-48
Using Other PID Features	8-51

How to Change Loop Modes	8-51
Operator Panel Control of PID Modes	8-52
PLC Modes' Effect on Loop Modes	8-52
Loop Mode Override	8-52
Creating an Analog Filter in Ladder Logic	8-53
Use the <i>DirectSOFT</i> 5 Filter Intelligent Box Instruction	8-54
FilterB Example	8-54
Ramp/Soak Generator	8-55
Introduction	8-55
Ramp/Soak Table	8-56
Ramp/Soak Table Flags	8-58
Ramp/Soak Generator Enable	8-58
Ramp/Soak Controls	8-58
Ramp/Soak Profile Monitoring	8-59
Ramp/Soak Programming Errors	8-59
Testing Your Ramp/Soak Profile	8-59
DirectSOFT Ramp/Soak Example	8-60
Setup the Profile in PID Setup	8-60
Program the Ramp/Soak Control in Relay Ladder	8-61
Program the Ramp/Soak Control in Relay Ladder	8-62
Cascade Control	8-63
Introduction	8-63
Cascaded Loops in the DL350 CPU	8-64
Tuning Cascaded Loops	8-65
Time-Proportioning Control	8-66
On/Off Control Program Example	8-67
Feedforward Control	8-68
Feedforward Example	8-69
PID Example Program	8-70
Program Setup for the PID Loop	8-70
Troubleshooting Tips	8-72
Glossary of PID Loop Terminology	8-74
Bibliography	8-76

Chapter 9: Maintenance and Troubleshooting

Hardware Maintenance	9-2
Diagnostics	9-3
CPU Indicators	9-9
PWR Indicator	9-10
RUN Indicator	9-12
CPU Indicator	9-12
BATT Indicator	9-12
Communications Problems	9-12
I/O Module Troubleshooting	9-13

Noise Troubleshooting	9-16
Machine Startup and Program Troubleshooting	9-17

Appendix A: Auxiliary Functions

Introduction	A-2
What are Auxiliary Functions?	A-2
Accessing AUX Functions via <i>DirectSOFT</i>	A-3
Accessing AUX Functions via the Handheld Programmer	A-3
AUX 2* — RLL Operations	A-4
AUX 21, 22, 23 and 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-4
AUX 31 Clear V-Memory	A-4
AUX 4* — I/O Configuration	A-5
AUX 41 Show I/O Configuration	A-5
AUX 5* — CPU Configuration	A-5
AUX 51 - 58	A-5
AUX 51 Modify Program Name	A-5
AUX 52 Display /Change Calendar	A-5
AUX 53 Display Scan Time	A-6
AUX 54 Initialize Scratchpad	A-6
AUX 55 Set Watchdog Timer	A-6
AUX 56 CPU Network Address	A-6
AUX 57 Set Retentive Ranges	A-7
AUX 5C Display Error History	A-7
AUX 6* — Handheld Programmer Configuration	A-8
AUX 61 Show Revision Numbers	A-8
AUX 7* — EEPROM Operations	A-8
AUX 71 - 76	A-8
AUX 71 CPU to HPP EEPROM	A-8
AUX 72 HPP EEPROM to CPU	A-8
AUX 73 Compare HPP EEPROM to CPU	A-8
AUX 74 HPP EEPROM Blank Check	A-8
AUX 75 Erase HPP EEPROM	A-8
AUX 76 Show EEPROM Type	A-8
AUX 8* — Password Operations	A-9
AUX 81 - 83	A-9
AUX 81 Modify Password	A-9
AUX 82 Unlock CPU	A-9
AUX 83 Lock CPU	A-9

Appendix B: Error Codes

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-3
Boolean Instructions	C-4
Comparative Boolean	C-5
Immediate Instructions	C-11
Timer, Counter, Shift Register Instructions	C-12
Accumulator Data Instructions	C-13
Logical Instructions	C-14
Math Instructions	C-15
Bit Instructions	C-16
Number Conversion Instructions	C-16
Table Instructions	C-17
CPU Control Instructions	C-17
Program Control Instructions	C-17
Interrupt Instructions	C-18
Network Instructions	C-18
Message Instructions	C-18
RLL^{PLUS} Instructions	C-18
Clock / Calendar Instructions	C-19
Drum Instructions	C-19

Appendix D: Special Relays

DL350 CPU Special Relays	D-2
Startup and Real-Time Relays	D-2
CPU Status Relays	D-2
System Monitoring Relays	D-3
Accumulator Status Relays	D-3
Communications Monitoring Relays	D-4

Appendix E: DL305 Product Weights

Product Weight Table	E-2
-----------------------------------	------------

Appendix F: I/O Addressing Conventional Method

Understanding Conventional I/O Numbering	F-2
DL305 I/O Configuration History	F-2
Octal Numbering System	F-2
Fixed I/O Numbering	F-2
I/O Numbering Guidelines	F-3
Number of I/O Points Required for Each Module	F-3
I/O Module Placement Rules	F-4
Conventional Base Specifications	F-5
Auxiliary 24VDC Output at Base Terminal	F-5
Power Supply Schematics	F-6
Using the Run Relay on the Base Power Supply	F-7
Local or Expansion I/O Systems	F-8
Base Uses Table	F-8
Local/Expansion Connectivity	F-8
Connecting Expansion Bases	F-9
Setting the Base Switches	F-10
5 Slot Bases	F-10
10 Slot Base	F-10
Example I/O Configurations	F-11
16 Point I/O Allocation Example	F-11
Examples Show Maximum I/O Points Available	F-11
I/O Configurations with a 5 Slot Local CPU Base	F-12
Switch settings	F-12
5 Slot Base with 8 Point I/O	F-12
5 Slot Base with 16 Point I/O	F-12
5 Slot Base and 5 Slot Expansion Base with 8 Point I/O	F-13
5 Slot Base and 5 Slot Expansion Base with 16 Point I/O	F-13
5 Slot Base and Two 5 Slot Expansion Bases with 8 Point I/O	F-14
5 Slot Base and Two 5 Slot Expansion Bases with 16 and 8 Point I/O	F-14
I/O Configurations with an 8 Slot Local CPU Base	F-15
8 Slot Base with 8 Point I/O	F-15
8 Slot Base with 16 Point I/O	F-15
8 Slot Base and 5 Slot Expansion Base with 8 Point I/O	F-15
8 Slot Base and 5 Slot Expansion Base with 16 Point I/O	F-15
I/O Configurations with a 10 Slot Local CPU Base	F-16
Switch settings	F-16
Last Slot Address Range 100 to 107	F-16
Last Slot Address Range 700 to 707	F-16
10 Slot Expansion Base with 16 Point I/O	F-17
Configuration 1	F-17
Configuration 2	F-17
10 Slot Base and 5 Slot Expansion Base with 16 Point I/O	F-18
Expansion Addresses Depend on Local CPU Base Configuration.	F-19
10 Slot Base and 10 Slot Expansion Base with 8 Point I/O	F-19
10 Slot Base and 10 Slot Expansion Base with 16 Point I/O	F-19

Appendix G: PLC Memory

DL350 PLC Memory	G-2
Non-volatile V-memory in the DL350	G-3

Appendix H: ASCII Table

Table	H-2
--------------------	------------

Appendix I: Numbering Systems

Introduction	I-2
Binary Numbering System	I-2
Hexadecimal Numbering System	I-3
Octal Numbering System	I-4
Binary Coded Decimal (BCD) Numbering System	I-5
Real (Floating Point) Numbering System	I-6
BCD/Binary/Decimal/Hex/Octal - What is the Difference?	I-7
Data Type Mismatch	I-8
Signed vs. Unsigned Integers	I-9
AutomationDirect.com Products and Data Types	I-10
DirectLOGIC PLCs	I-10
C-more/C-more Micro-Graphic Panels	I-10

Appendix J: European Union Directives (CE)

European Union (EU) Directives	J-2
Member Countries	J-2
General Safety	J-4
Special Installation Manual	J-4
Other Sources of Information	J-4
Basic EMC Installation Guidelines	J-5
Enclosures	J-5
Suppression and Fusing	J-5
Internal Enclosure Grounding	J-6
Equi-potential Grounding	J-6
Communications and Shielded Cables	J-6
Analog and RS232 Cables	J-7
Multidrop Cables	J-7
Shielded Cables within Enclosures	J-8
Caution Regarding RF Interference near Analog Modules	J-8
Network Isolation	J-8
Items Specific to the DL350	J-9

Index