Overview of PLC Functions

Course Number: EE-02-511

PDH: 7

Approved for: AK, AL, AR, DE, FL, GA, IA, ID, IL, IN, KS, KY, LA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, and WY

State Board Approvals

Florida Provider # 0009553 License #868
Indiana Continuing Education Provider #CE21800088
Maryland Approved Provider of Continuing Professional Competency
New Jersey Professional Competency Approval #24GP00025600
North Carolina Approved Sponsor #S-0695
NYSED Sponsor #274

How Our Written Courses Work

This document is the course text. You may review this material at your leisure before or after you purchase the course.
After the course has been purchased, review the technical material and then complete the quiz at your convenience.
A Certificate of Completion is available once you pass the exam (70% or greater). If a passing grade is not obtained, you may take the quiz as many times as necessary until a passing grade is obtained).
If you have any questions or technical difficulties, please call (508) 298-4787 or email us at admin@PDH Pro.com.

Module 34: Function Reference

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the core function categories and instruction sets for Micrologix and PLC-5 processors.
- **Select** appropriate program control, timer, counter, and comparison instructions for specific automation tasks.
- **Evaluate** the compatibility and data requirements for different PLC models and function types.

Executive Summary: This comprehensive reference guide details the instruction set architecture for Micrologix and PLC-5 PLCs, covering general logic, program flow control, timing, counting, math, and advanced string/file operations to facilitate effective programming and debugging.

Function Descriptions

The following instructions apply to both the **Micrologix** and **PLC-5** processor families. While most logic is shared, engineers must note that **floating point operations** are exclusively available on the PLC-5 and not supported on the Micrologix.

General Functions

These are the most fundamental building blocks for ladder logic development.

XIC, XIO, OTE - Examine If Closed, Examine If Open, Output Enable

- **XIC**: A normally open contact; evaluates as true when the input is energized.
- **XIO**: A normally closed contact; evaluates as true when the input is NOT energized.
- **OTE**: A standard output instruction that is energized when the rung logic is true.

OTL, OTU - Output Latch, Output Unlatch

- **OTL**: Latches an output or memory bit into the "on" state.
- **OTU**: Unlatches the bit.
- **Behavior**: Latched values remain fixed even if the PLC is restarted.

IIN, IOT - Immediate Input, Immediate Output

- **Function**: Updates specific I/O during the program scan instead of waiting for the standard beginning/end scan update.

- **Example**: An IIN will update inputs on 'I:001' immediately if the preceding logic is true.

AFI - Always False Instruction

- **Application**: Primarily used for **debugging** programs by forcing a line to be false regardless of other logic.

Program Control

These instructions manage the execution flow and scan behavior of the PLC.

JMP, LBL - Jump, Label

- **JMP**: Allows the PLC to bypass segments of ladder logic and move directly to a specified **LBL**.
- **Execution**: If the jump condition is true, the scan continues normally from the label.

MCR - Master Control Relay

- **Requirement**: Must always be used in **pairs**.
- **Logic**: If the master rung is false, all outputs within the MCR zone are **FORCED OFF**.

ONS, OSR, OSF - One Shot Instructions

- **ONS (One Shot)**: Forces a rung to be true for exactly **one scan** upon a transition.
- **OSR (One Shot Rising)**: Triggers on a false-to-true transition.
- **OSF (One Shot Falling)**: Triggers on a true-to-false transition.

TND - Temporary End

- **Function**: Stops the ladder logic examination immediately, acting as a manual end-of-program statement.

Timers and Counters

Timers and counters utilize specific registers and status bits to manage time-based or event-based logic.

CTU and CTD - Count Up and Count Down

- **CTU**: Increments the accumulator (ACC) on a false-to-true transition.
- **CTD**: Decrements the ACC on a false-to-true transition.
- **Done Bit (DN)**: Sets when the ACC reaches or exceeds the Preset (PRE).

TON, TOF, RTO - Timer Instructions

- **TON (Timer On Delay)**: Delays turning on the DN bit until the PRE time is reached; resets ACC to zero if input goes false.
- **TOF (Timer Off Delay)**: Delays turning off the DN bit after the input goes false.
- **RTO (Retentive Timer On)**: Functions like TON but **retains** the ACC value if the input goes false. Requires a **RES** (Reset) instruction to clear.

Comparison Instructions

Used to evaluate data relationships between two sources.

- **CMP (Compare)**: Allows free-form expressions (up to 80 characters) using symbols like =, >, >=, <>, <, <=.
- **LIM (Limit Test)**: Checks if a value is between low and high limits.
- **MEQ (Masked Equal)**: ANDs a source and mask before comparing the result to a reference value.
- **EQU, GEQ, GRT, LEQ, LES, NEQ**: Standard comparison blocks for equal, greater than, or less than operations.

Calculation and Conversion

Math operations range from basic binary arithmetic to advanced trigonometry.

- **Binary Math**: Includes **ADD** (Addition), **SUB** (Subtraction), **MUL** (Multiplication), and **DIV** (Division).
- **Unary Math**: Includes **SQR** (Square Root), **NEG** (Sign change), and trigonometric functions like **SIN**, **COS**, and **TAN**.
- **CPT (Compute)**: A complex instruction allowing combined mathematical expressions in a single block. **Note**: Available only on PLC-5.
- **Statistical**: **AVE** (Average) and **STD** (Standard Deviation) perform calculations across a file range.

Logical and Move Operations

- **Boolean**: **AND**, **OR**, **XOR**, and **NOT** perform bitwise logic on integers.
- **MOV (Move)**: Copies data from a source to a destination; can perform data type conversion (e.g., integer to floating point).

- **BTD (Bit Distribute)**: Copies a specific string of bits from one address to another.

File and Advanced I/O

File instructions handle lists of data and often offer different **Modes** of execution: **All** (entire file in one scan), **Incremental** (one step per trigger), or a specific **Number** of iterations per scan.

- **COP (File Copy)**: Copies one list to another; does not convert data types.
- **FLL (File Fill)**: Populates a range of memory with a single source value.
- **BSL/BSR**: Shifts bits left or right through a designated file.
- **PID**: Proportional Integral Derivative controller used for closed-loop process control.

Data Types

The following table details the arguments and data requirements for standard PLC functions.

Table 1: Instruction Data Types

Function	Argument	Data Types	Edge Triggered
BSR	file control, bit address length	#B,#N R, any bit, immediate int [0-16000]	yes
BTD	source source bit destination, destination bit length	N,B,immediate N,immediate int [0-15] N, immediate int [0-15], immediate int [0-15]	no
BTR	rack group module, control block data file length continuous	immediate octal [000-277], immediate octal [0-7], immediate octal [0-1] BT,N, N, immediate int [0-64] 'yes','no'	yes
BTW	rack group module, control block data file length continuous	immediate octal [000-277], immediate octal [0-7], immediate octal [0-1] BT,N, N, immediate int [0-64] 'yes','no'	yes
CLR	destination	N,F	no
CMP	expression	expression	no
COP	source destination length	#any #any, immediate int [0-1000]	no
COS	source destination	F,immediate F	no
CPT	destination expression	N,F, expression	no
CTD	counter preset accumulated	C, returns N returns N	yes
CTU	counter preset accumulated	C, returns N returns N	yes
DDT	source reference result, compare control length, position result control length position	binary	-

Checkpoint Quiz

1. **Which instruction should be used to ensure an output remains "on" even if the PLC is power-cycled, assuming it was active before the shutdown?**
   a) OTE
   b) ONS
   c) OTL
   d) MCR

Answer: (c). Latched values (OTL) stay fixed even if the PLC has been restarted.

2. **A Micrologix user attempts to perform a calculation involving a 32.5 value using a unary math block. Why will this fail?**
   a) The instruction name changed in newer models.
   b) Floating point operations are not available on the Micrologix.
   c) The result would trigger a minor fault bit S2:17/8.
   d) The CPT instruction must be used for decimals.

Answer: (b). The documentation explicitly states these operations are restricted to the PLC-5 family.

3. **In an MCR zone, what happens to the outputs if the first MCR rung evaluates as false?**
   a) They remain in their last state.
   b) They are bypassed until the next scan.
   c) They are forced off.
   d) They trigger an immediate interrupt.

Answer: (c). If the first MCR line is not true, the outputs on the lines after will be forced off.

Purchase this course to see the remainder of the technical materials.