Equipment Utilization Chart

The following Lab-Volt equipment is required to perform the exercises in this manual.

EQUIPMENT		EXERCISE							
MODEL	**DESCRIPTION**	**1-1**	**1-2**	**1-3**	**1-4**	**1-5**	**2-1**	**2-2**	**2-3**
3103 (or 8110 or 8134)	Mobile Workstation	1	1	1	1	1	1	1	1
3110	Push Buttons		1						
3112	Switches	1	1	2	1	1	1	1	2
3114	Emergency Button						1	1	1
3115	Pilot Lights		1						
3115-A	Pilot Lights	1	1	1	1	1	1		1
3119	Dual Contactors								1
3125	Lockout Module	1	1	1	1	1	1	1	1
3127	Contactor						1	1	
3128	Programmable Logic Controller	1	1	1	1	1	1	1	1
3129	Interposing Relays						1	1	1
3130	Control Relay		1						
3131	Overload Relay						1	1	1
3138	Control Transformer	1	1	1	1	1	1	1	1
3139	DC Power Supply	1	1	1	1	1	1	1	1
3147 (or 9126)	Inertia Wheel							1	1
3176-A (or 3176-B)	Brake Motor						1	1	1
3196 (or 8821)	AC Power Supply	1	1	1	1	1	1	1	1
8951	Connection Leads	1	1	1	1	1	1	1	1
8951-E	Connection Leads	1	1	1	1	1	1	1	1
N/A	Voltmeter (1)	1	1	1	1	1	1	1	1

(1) The Lab-Volt multimeter model 70-38707 can be used in all exercises requiring a voltmeter, a clamp-on ammeter, or an ohmmeter.

Diagram Symbols

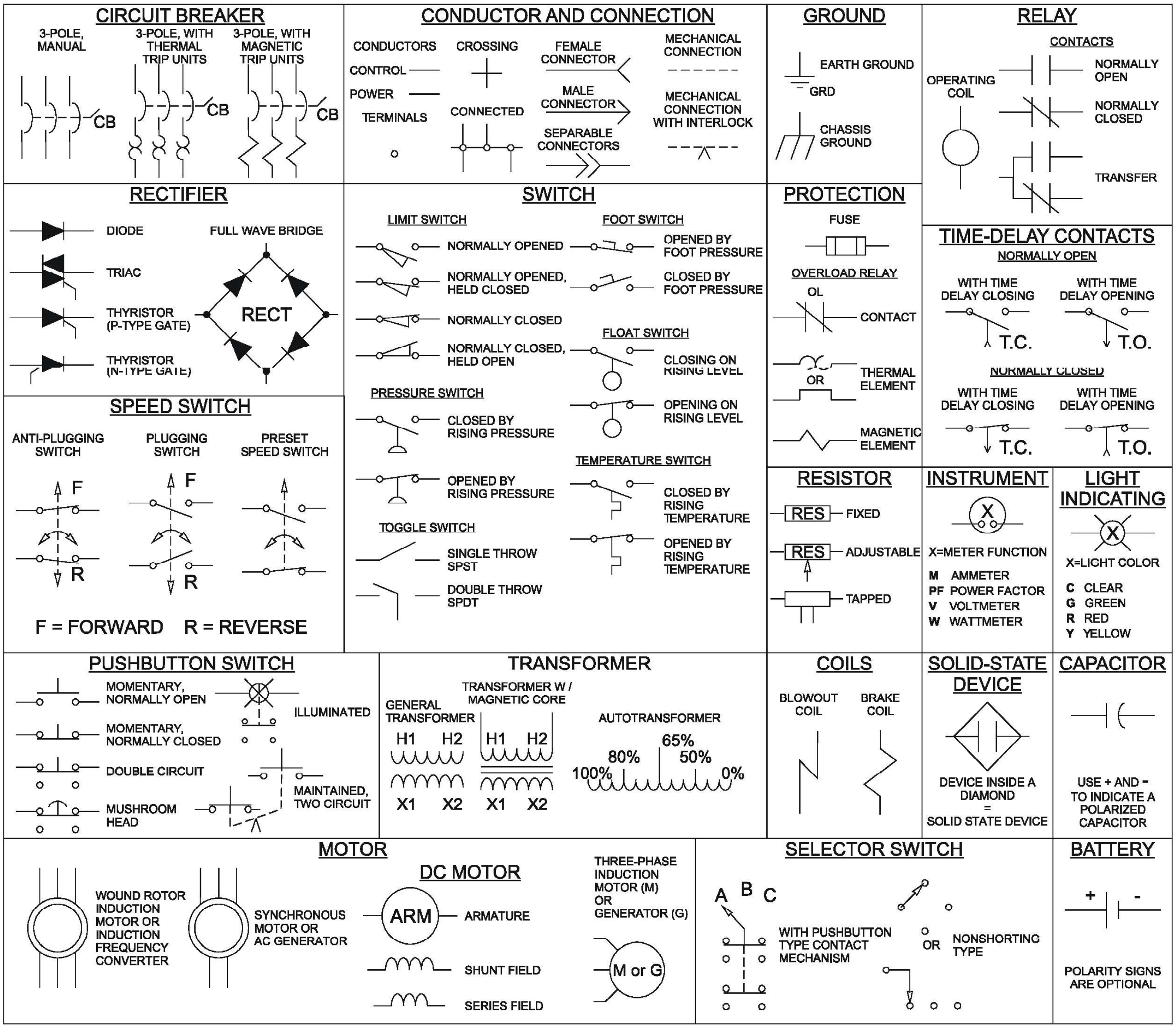


Figure B-1. NEMA symbols.

FUNCTION OR DEVICE	DESIGNATION	FUNCTION OR DEVICE	DESIGNATION
Accelerating	A	Overload	OL
Ammeter	AM	Overvoltage	OV
Braking	B	Plugging or Potentiometer	P
Capacitor, Capacitance	C or CAP	Power Factor Meter	PFM
Circuit Breaker	CB	Pressure Switch	PS
Closing Coil	CC	Push Button	PB
Control Relay	CR	Reactor, Reactance	X
Current Transformer	CT	Rectifier	REC
Demand Meter	DM	Resistor, Resistance	R or RES
Diode	D	Reverse	R or REV
Disconnect Switch	DS or DISC	Rheostat	RH
Dynamic Braking	DB	Selector Switch	SS
Field Accelerating	FA	Silicon Controlled Rectifier	SCR
Field Contactor	FC	Solenoid Valve	SV
Field Decelerating	FD	Squirrel Cage	SC
Field-Loss	FL	Starting Contactor	S
Forward	F or FWD	Suppressor	SU
Frequency Meter	FM	Tachometer Generator	TACH
Fuse	FU	Terminal Block or Board	TB
Ground Protective	GP	Time-Delay Closing Contact	TC or TDC
Holding Coil	HC	Time-Delay Opening Contact	TO or TDO
Hoist	H	Time Relay	TR
Jog	J	Transformer	T
Latch Coil	LC	Transistor	Q
Limit Switch	LS	Trip Coil	TC
Lower	L	Unlatch Coil	ULC
Main Contactor	M	Undervoltage	UV
Master Control Relay	MCR	Voltmeter	VM
Master Switch	MS	Watthour Meter	WHM
Overcurrent	OC	Wattmeter	WM

Figure B-2. Device designations.

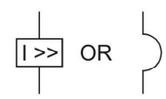
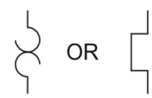
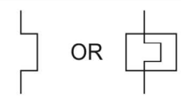
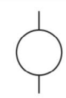
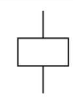
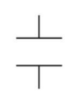
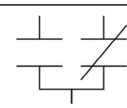
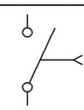
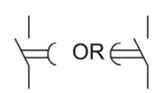
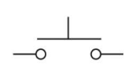
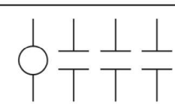
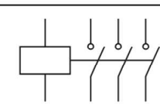
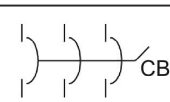
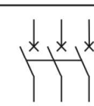
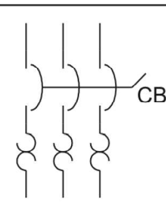
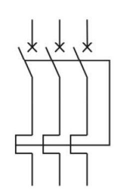
	NEMA	IEC
MAGNETIC OVERLOAD ELEMENT (SHORT-CIRCUIT)		
THERMAL OVERLOAD ELEMENT		
RELAY COIL		
NORMALLY OPEN CONTACT		
NORMALLY CLOSED CONTACT		
TRANSFER CONTACTS		
NORMALLY OPEN CONTACT DELAYED WHEN CLOSING		
NORMALLY OPEN CONTACT (LIMIT SWITCH)		
NORMALLY OPEN PUSHBUTTON CONTACT		
CONTACTOR		
THREE-POLE SWITCH-DISCONNECTOR		
THREE-POLE CIRCUIT-BREAKER WITH THERMAL OVERLOAD RELEASES		

Figure B-3. Comparison of NEMA and IEC symbols.

PLC and Software Reference

EASY500 PLC

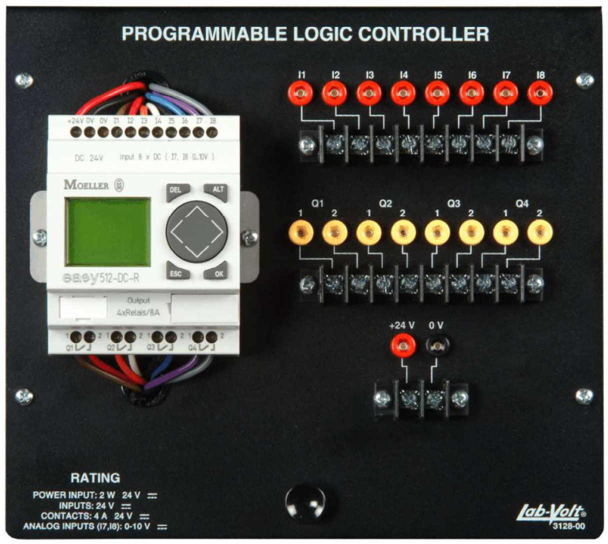


Figure C-1. Programmable Logic Controller module, Model 3128.

Purpose of the buttons

- DEL: Delete object in circuit diagram.
- ALT: Special function in circuit diagram, status display.
- ESC: Previous menu level, cancel.
- OK: Next menu level, save your entry.
- Cursor buttons: Move cursor, select menu items, change values.

Programmable Logic Controller module's main features

- Power supply: 24 V dc
- Digital inputs: I1 to I8

- Analog inputs: I7 and I8
- Digital 0 signal: < 5 V dc (I1 to I8)
- Digital 1 signal: > 8 V dc (I7 and I8); > 15 V dc (I1 to I6)
- Counters: C1 to C16
- Analog value comparator: A1 to A16
- Text display function relays: D1 to D16
- Markers: M1 to M16; N1 to N16
- Operating hours counters: O1 to O4
- Cursor buttons: P1 to P4
- Conditional jump: :1 to :8
- Time function relays: T1 to T16
- Master reset: Z1: Q outputs reset; Z2: M and N markers reset; Z3: Q, M, and N reset
- Output contacts: Q1 to Q4

EASY-SOFT SOFTWARE

Your Programmable Logic Controller module, Model 3128, is provided with the Easy-Soft software from Moeller. This software enables developing, storing, testing, and managing ladder circuit diagrams on a personal computer (PC). The data transfer between the PLC and the PC is done through a special serial cable, called Easy-PC-CAB.

Although you can program the PLC directly on the device, it is often more convenient to enter the ladder circuit on a PC. Selection menus and the use of a mouse greatly simplify connection of the elements. Additionally, by developping a circuit diagram on a PC, you can work on different versions without having to stop the PLC, thereby reducing production down time. It is also possible to test circuits directly on the PC by using the offline simulation mode. Therefore, you ensure that the circuit functions as intended before connecting the hardware.

EASY-SOFT SYSTEM REQUIREMENTS

To use the Easy-Soft software, you will need a personal computer running under Windows NT, 2000, or XP.

PROCEDURE TO ENTER AND TEST A PROGRAM VIA EASY-SOFT

☐ 1. Start the Easy-Soft program on your PC. On the left menu, choose the EASY 512-DC-R icon and drag it to the empty space on the right. A small window will appear. Click OK for a device version starting with 01-. You may now assign a program name in the dedicated box, located at the bottom of the screen. Figure C-2 shows how the project window looks like.

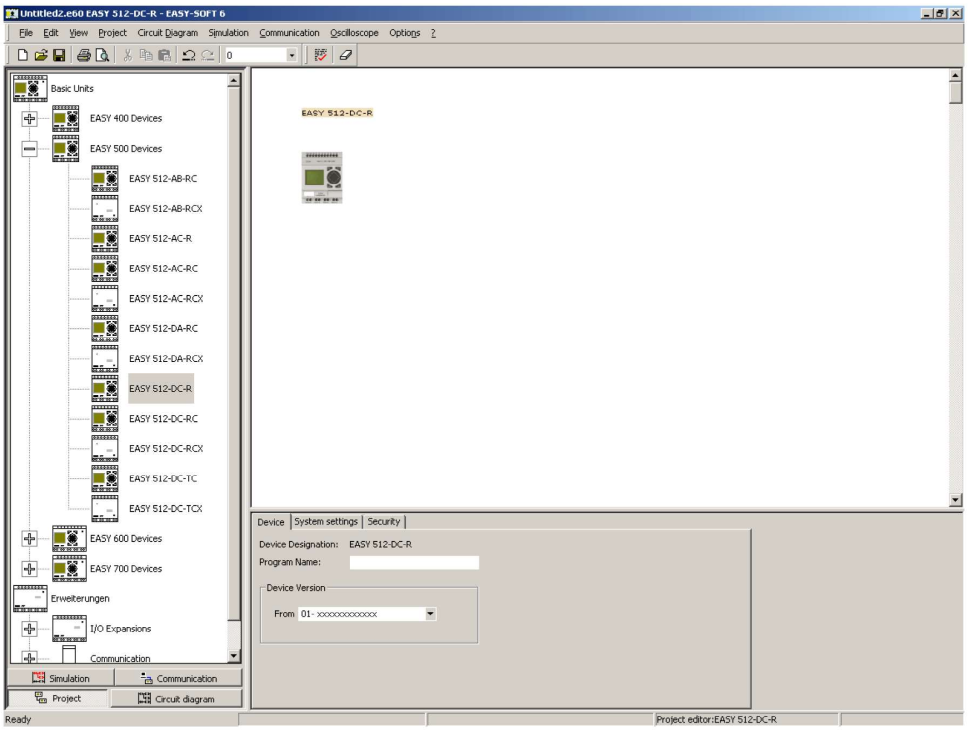


Figure C-2. Starting a project with Easy-Soft.

At the bottom left of the screen, you will find buttons that give access to the different windows of the program (Simulation, Communication, Project, and Circuit diagram). Click on the Circuit diagram button. You are now ready to enter your program. The Circuit diagram window is displayed in Figure C-3.

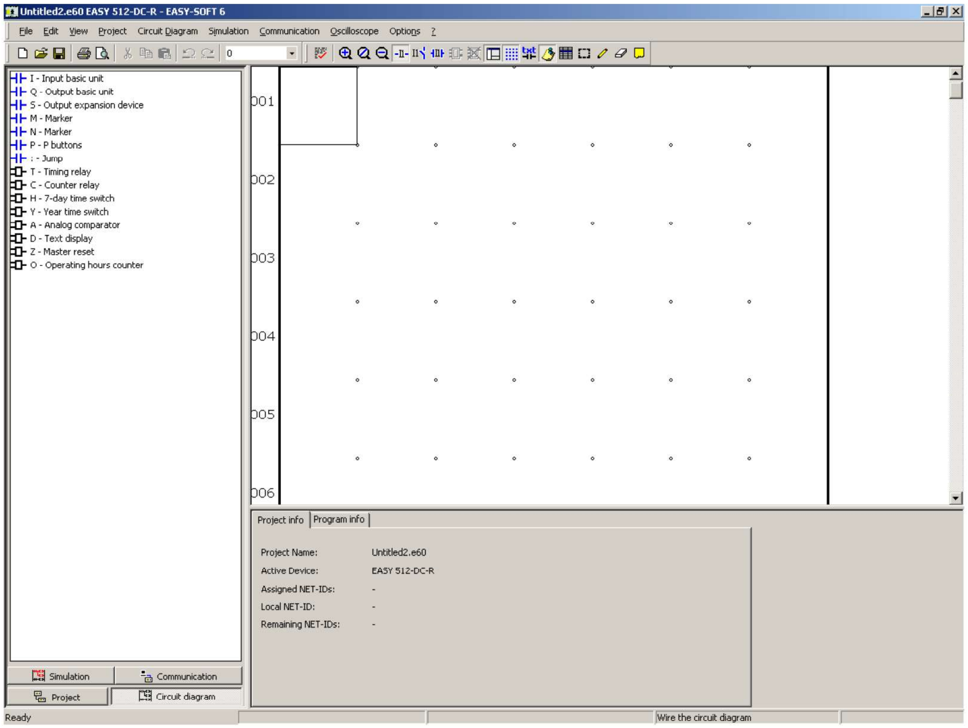


Figure C-3. Circuit diagram window.

☐ 2. Enter your program. To add an item, drag the appropriate icon from the left menu to the ladder diagram on the right. Parameters of the items can be modified on the bottom right of the screen. By clicking on the right button of your mouse, you have access to the Eraser and Pencil tools that enable editing the lines of the circuit.

> **Note:** *Easy-Soft offers you relevant information while you work. Just press F1 any time you need some help.*

PROGRAM SIMULATION

☐ 3. Once the program is entered, switch to the Simulation window to test your circuit. Start the simulation by clicking on the Start option in the Simulation menu, at the top of the window, as Figure C-4 shows.

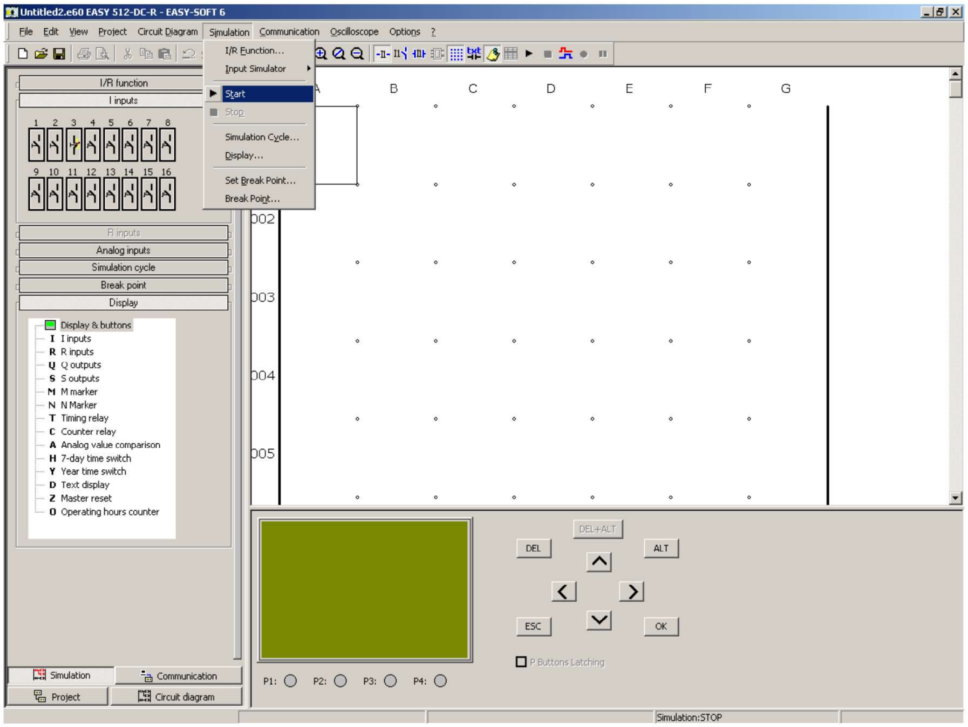


Figure C-4. Starting the simulation.

From now on, the diagram lines and contacts will change color, indicating what contacts are energized or not. To simulate the activation of an input, click on the button entitled "I inputs" on the left, before clicking on input number icons. To visualize the effect of the program on the PLC, click first on the "Display" button, before choosing "Display & buttons". You will then see a simulated PLC status window that will react to stimulations.

TRANSFERRING DATA AND OPERATION

☐ 4. Make sure that the serial cable is installed correctly between the computer and the PLC. Turn on the DC Power Supply and check if the PLC is turned on. Set the PLC to the STOP mode and return to the status window.

Access the communication window of the Easy-soft program. Press the Connection button and choose the Online function to make the PC connect to the PLC. Press the Program button and choose the PC=>Device option. The program data will transfer from the PC to the PLC, as you can see in Figure C-5.

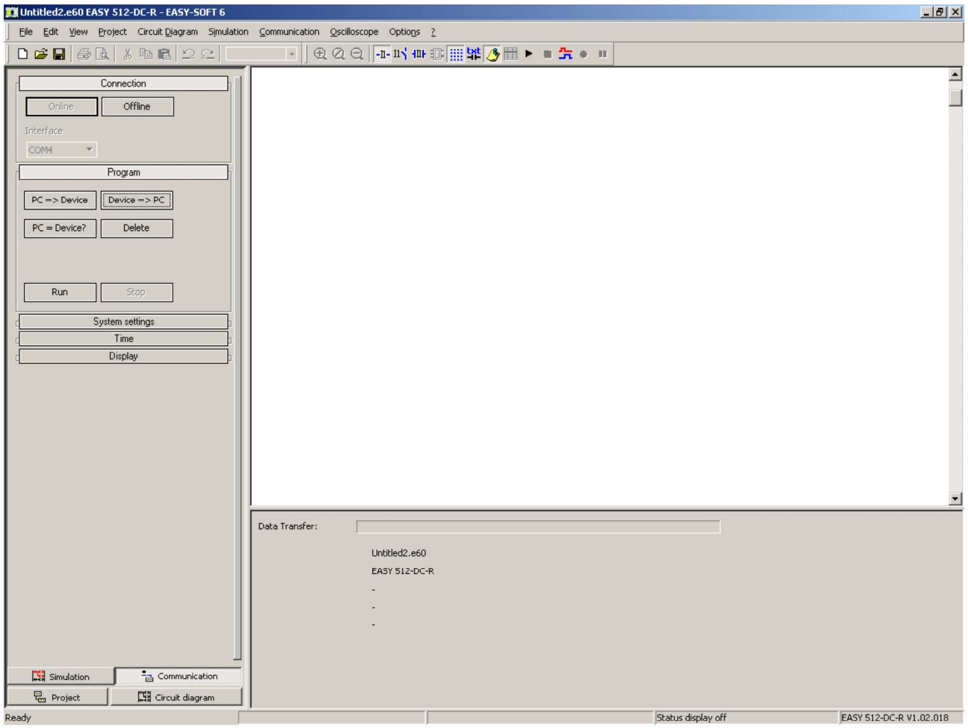


Figure C-5. Transferring PC data to the PLC.

Note: *On the Easy-soft Communication screen, you can change the PLC mode by pressing the RUN or STOP button, while the connection between the two devices is on.*

Basic Setup and Lockout/Tagout ProceduresAnswers to Unit Test Questions

This appendix is divided into three sections:

- *Basic Setup procedure*, explains the basic operations that must be performed at the beginning of the exercise procedures.
- *Lockout/Tagout procedure (de-energizing procedure)*, describes the lockout/tagout procedure used to de-energize the Industrial Controls Training System before setting up a circuit.
- *Energizing procedure*, gives details on how to end a lockout/tagout procedure and energize the Industrial Controls Training System.

I. Basic Setup procedure

This procedure is recommended at the beginning of every experiment. It insures that the system is safe prior to cabling specific circuits.

☐ 1. Make sure that the power switch of the power supply is set to the off position.

> **Note:** *The power supply should already be installed in the workstation.*

☐ 2. Install the Lockout Module in the workstation.

☐ 3. Turn off the Lockout Module.

☐ 4. Connect the Lockout Module leads to the power supply terminals, respecting the phase sequence.

II. Lockout/Tagout procedure (de-energizing procedure)

☐ 1. Turn off the Lockout Module.

☐ 2. Install the lockout hasp and the student padlocks and tags on the Lockout Module. Ask the instructor to install the lab padlock and tag as well.

☐ 3. Check that the Lockout Module switch cannot be opened. With a voltmeter, verify that no voltage is present between the Lockout Module output terminals to confirm that the circuit is de-energized. You may now set up your circuit.

III. Energizing procedure

☐ 1. Connect the green chassis terminals (on the modules) to the earth (ground) terminal of the Lockout Module.

☐ 2. Make sure the security guard is installed if you are using a motor.

☐ 3. Identify the push buttons, selector switches, and pilot lights with magnetic labels in accordance with the circuit schematic diagram.

☐ 4. Once the connections are made, ask for the instructor to check the circuit. When the circuit is correctly wired, notify all the people working around the workstation that the system will be energized.

☐ 5. Remove the lockout hasp, padlocks and tags.

> **Note:** *If you are using the Power Supply, Model 8821, make sure that the voltage control knob is set to 0%.*
>
> *AC and DC voltages (fixed or variable) are available on the Power Supply, Model 8821. For all exercises requiring AC voltage, use the AC variable output (terminals 4, 5 and 6).*

☐ 6. Turn on the power supply and Lockout Module, and return to your exercise.

> **Note:** *If you are using the Power Supply, Model 8821, set the voltage control knob to 100%.*

Boolean Algebra and Digital Logic

Boolean algebra is a mathematical solution applied to logic problems. It is based on problems which have only two outcomes, such as true or false, on or off, 0 or 1, and opened or closed.

There are three basic operators in Boolean algebra. They are logical NOT, logical AND and logical OR.

The logical NOT operator inverts a function or variable. The inverse of 1 is 0 and the inverse of 0 is 1. The logical NOT is indicated by a bar above the function or variable.

The logical AND operator is performed on two or more variables such as A or B. The result of ANDing two or more variables is a logical 1 if every variable is a logical 1. The result is a logical 0 if any variable is a logical 0. The logical AND is indicated by a dot between the variables, such as:

$$A \cdot B$$

The logical OR operator is performed on two or more variables, such as A and B. The result of ORing two or more variables is a logical 1 if any variable is a logical 1. The result is a logical 0 if every variable is a logical 0. The logical OR is indicated by a plus sign between the variables, such as:

$$A + B$$

A Boolean statement is a shorthand method of describing a logic statement using Boolean operators. The statement $A \cdot B + C = Y$ is read A AND B, OR C equals Y. This means that the variable Y will be a logical 1 if both A and B are logical 1's, or if C is a logical 1.

In a Boolean statement, there is an order of precedence for the operators. This is listed in Table E-1.

1. Statements within brackets and under bars are performed first. A bar over two or more variables is considered the same as placing the variables within brackets. In this case, the statement under the bar is performed first, and then inverted.
2. Perform all NOT (invert) function on single variables.
3. Perform all AND functions.
4. Perform all OR functions.

Table E-1. Order of Precedence in a Boolean Statement.

Postulates are the basic assumptions from which the properties, rules, and theorems of a system can be deduced.

The postulates that are the basis for Boolean algebra are listed in Table E-2.

1. X = 0 or X = 1 2. 0· 0 = 0 3. 1 + 1 = 1 4. 0 + 0 = 0	5. 1·1 = 1 6. 1· 0 = 0, 0·1 = 0 7. 1 + 0 = 1, 0 + 1 = 1

Table E-2. Postulates that are the basis for the Boolean algebra.

The theorems of Boolean algebra are derived from these postulates. Table E-3 lists the theorems of Boolean algebra.

THEOREM 1.	Commutative Law	THEOREM 6.	Redundance Law
	(a) A+B=B+A		(a) A+A·B=A
	(b) A·B=B·A		(b) A·(A+B)=A
THEOREM 2.	Associative Law	THEOREM 7.	(a) 0+A=A
	(a) (A+B)+C=A+(B+C)		(b) 1+A=1
	(b) (A·B)·C=A·(B·C)		(c) 0·A=0
THEOREM 3.	Distributive Law		(d) 1·A=A
	(a) A·(B+C)=A·B+A·C	THEOREM 8.	(a) $\overline{A}+A=1$
	(b) A+(B·C)=(A+B)·(A+C)		(b) $\overline{A}\cdot A=0$
THEOREM 4.	Identity Law	THEOREM 9.	(a) $A+\overline{A}\cdot B=A+B$
	(a) A+A=A		(b) $A\cdot(\overline{A}+B)=A\cdot B$
	(b) A·A=A	THEOREM 10.	DeMorgan's Theorem
THEOREM 5.	Negation Law		(a) $\overline{A+B}=\overline{A}\cdot\overline{B}$
	(a) $(A)=\overline{A}$		(b) $\overline{A\cdot B}=\overline{A}+\overline{B}$
	(b) $(\overline{A})=A$		

Table E-3. Boolean Theorems.

Digital logic is a method of implementing Boolean statements into a control circuit or program. The Boolean operators (AND, OR, and NOT) are performed by logic gates. A logic gate receives input signals and transmits an output signal. The output signal will be a function of the input signal. Six common logic gates are: AND, OR, NOT, NAND, XOR, and XNOR.

The AND, OR, and NOT gates perform the same function as the AND, OR, and NOT operators in Boolean algebra. A NAND gate performs the inverse function of an AND gate. The NOR gate performs the inverse function of an OR gate. The XOR gate has tow inputs; if one input or the other input, but not both, are logical 1s, then the output is a logical 1. The XNOR gate performs the inverse function of an XOR gate. The table of Figure E-1 lists the types of gates, gate symbols, and truth tables for each gate. The gate inputs are indicated as either A or B, and the gate outputs are indicated by Y.

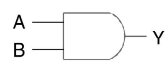
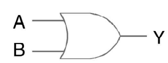
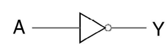
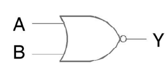
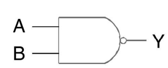
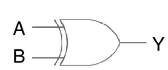
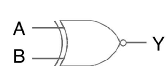
GATE	SYMBOL	TRUTH TABLE
AND		A B Y 0 0 0 0 1 0 1 0 0 1 1 1
OR		A B Y 0 0 0 0 1 1 1 0 1 1 1 1
NOT		A Y 0 1 1 0
NOR		A B Y 0 0 1 0 1 0 1 0 0 1 1 0
NAND		A B Y 0 0 1 0 1 1 1 0 1 1 1 0
XOR		A B Y 0 0 0 0 1 1 1 0 1 1 1 0
XNOR		A B Y 0 0 1 0 1 0 1 0 0 1 1 1

Figure E-1. Logic Gates.

Programmable Controllers often use Boolean operators or logic gate functions as program instructions. These instructions are often used in combination with programmed NO and NC contacts.

The AND instruction is used to connect programmed contacts or ladder program sections in series. The OR instruction is used to connect programmed contacts or ladder program sections in parallel. The NOT instruction changes a NO programmed contact to a NC programmed contact.

Figure E-2 shows two contacts ANDed together.

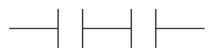


Figure E-2. Two ANDed Contacts.

Figure E-3 shows two contacts ORed together.

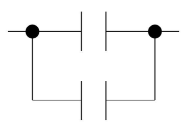


Figure E-3. Two ORed Contacts.

Figure E-4 shows two sets of ORed contacts ANDed together.

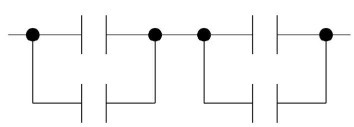


Figure E-4. Two ANDed Ladder Program Sections.

Figure E-5 shows two sets of ANDed contacts ORed together.

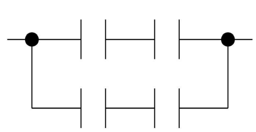


Figure E-5. Two ORed Ladder Program Sections.

Bibliography

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