CHAPTER 4
OPERATION

This chapter describes the operation of a Series Three PC. An understanding of the features is required to effectively use the programming unit. An illustration of the CPU/Programmer is shown, followed by descriptions of the mode switch, keys, displays and connectors. The basic steps required for building a ladder diagram logic program are shown in a keystroke-by-keystroke sequence. Detailed programming sequences for each function can be found in Chapter 5, Programming.

Figure 4.1 is an illustration of the CPU/Programmer.

NOTE

As each key on the programmer is depressed, a tone is generated. This is an audible operator aid indicating that the keystroke has been entered.

After most keystrokes, the ENTER (ENT) key must be depressed. This puts the required key or keys in program memory. When a value such as a timer or counter preset is required a prompt is given by the programmer. This prompt is a long tone and indicates a two-word instruction.

Certain operations, such as a Delete or Insert, require an additional keystroke as a verification that the action is to be completed.

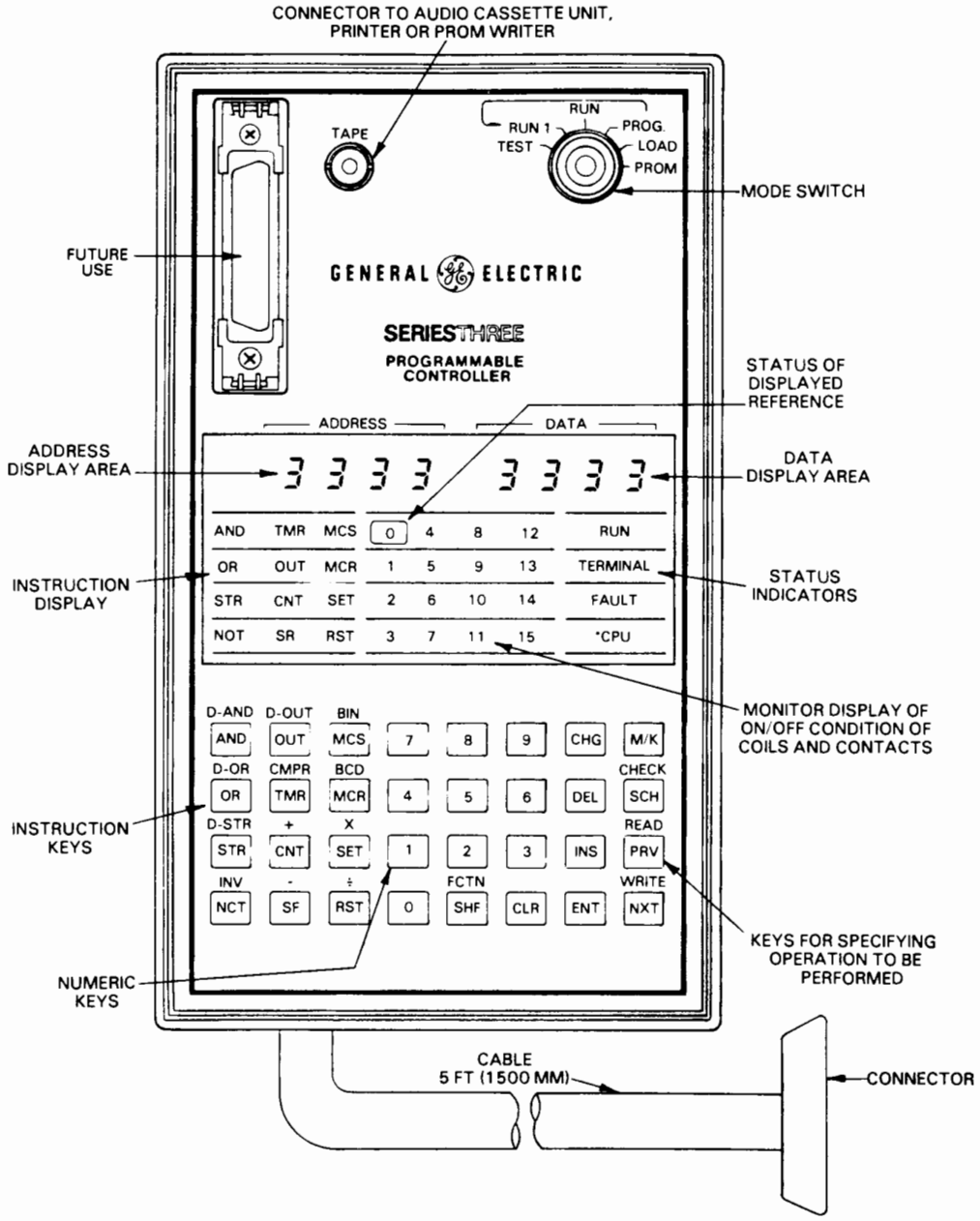


Figure 4.1
CPU/PROGRAMMER FEATURES

MODE SELECT KEYSWITCH

This is a 6 position keyswitch for selection of the PC operating mode. The 6 positions are shown in Figure 4.1 and include; TEST, RUN 1, RUN, PROG, LOAD, and PROM. The functions of each operating mode are listed below.

TEST

- Stops execution of program while in this position. Outputs are disabled.
- Allows a one-scan execution of program.
- Individual rung execution can be monitored by assigning coils or contacts to the 16 monitor LEDs.
- Most programming functions allowed.

RUN 1

- Program execution with outputs enabled.
- Timer and Counter preset values can be changed.
- Monitor display can be observed.
- Program can be read using address and data display.
- Allows entering I/O configuration into memory if the configuration has changed since the previous power-up condition.

RUN

- Program execution with outputs enabled.
- Monitor display can be observed.
- Program can be read using address and data display.
- No program changes can be made.
- Key removable in this position.

PROG

- Stops execution of program.
- Allows all of the program entered into memory to be erased.
- Programs can be entered and edited (changed).

LOAD

- Stops execution of program.
- Allows operation (reading, writing and verifying) with a cassette tape unit.
- Allows operation with a logic printer unit.
- Key can be removed.
- Allows operation with PROM writer

PROM

- Stops execution of program.
- Allows the contents of a PROM to be transferred to the CMOS RAM memory in the PC.
- Allows the transferred contents from PROM to CMOS RAM to be verified.

The following table lists the keys on the programmer and their functions.

Table 4.1
KEY DEFINITIONS

KEY	DEFINITION	DESCRIPTION
M/K	M MONITOR	Causes PC to enter the Monitor mode.
	K CONSTANT	Value entered after this key will be a constant
CHECK	CHECK	Shifted function (depress SHF SCH), used with cassette recorder and PROM writer to check validity of data transfer.
SCH	SCH SEARCH	Search for specified information
READ	READ	Shifted function, Causes data to be read into the PC from peripherals such as a cassette recorder.
PRV	PRV PREVIOUS	Scrolls back to previous program memory address.
WRITE	WRITE	Shifted function causes program memory contents to be outputted to a peripheral.
NXT	NXT NEXT	Scrolls ahead to the next program memory address.
CHG	CHANGE	Used with SET or RST to force the state of a coil/contact ON or OFF. Also used to change a reference number.
DEL	DELETE	Causes the displayed instruction to be deleted. All instructions at a higher program memory address will move back one address.
INS	INSERT	Adds an instruction at program memory address displayed, all instructions from that address up move one address higher.
ENT	ENTER	Used after instruction keys are depressed to enter the information into program memory.
CLR	CLEAR	Clears displayed data information when depressed one time and displayed address when depressed two times.

Table 4.1
KEY DEFINITIONS (Continued)

KEY	DEFINITION		DESCRIPTION
FCTN	FCTN	FUNCTION	When depressed before a two-digit value, causes a Function (F20, F81, etc.) instruction assigned to that value to be specified.
[SHF]	SHIFT		When depressed before another key, the shifted function of that key will be executed.
0 - 9	NUMERIC KEYS		Used to specify numeric values for entry into program. Also to specify a program memory address
BIN	BIN	BINARY	Shifted function used to convert a BCD value stored in the accumulator to a binary value.
[MCS]	MCS	MASTER CONTROL START	Specifies start of a Master Control Relay function.
BCD	BCD	BINARY CODED DECIMAL	Shifted function used to convert a binary value stored in the accumulator to a BCD value.
[MCR]	MCR	MASTER CONTROL RESET	Specifies end of a Master Control Relay function.
×	×	MULTIPLY	Arithmetic function used when specifying multiplication.
[SET]	SET		Used to turn a coil ON. Also, when forcing a coil or contact to the ON state.
÷	÷	DIVIDE	Shifted function used when specifying division in an arithmetic operation.
[RST]	RST	RESET	Used to turn a coil OFF. Also, when forcing a coil or contact to the OFF state.
D•OUT	D•OUT	DATA OUT	Used in a data instruction sequence to move data from the accumulator to a specified location.
[OUT]	OUT		Used before a numeric value to assign an output coil to a rung of ladder diagram logic.

Table 4.1
KEY DEFINITIONS (Continued)

KEY	DEFINITION		DESCRIPTION
CMPR	CMPR	COMPARE	Shifted function use to specify a compare operation (> = <)
[TMR]	TMR	TIMER	When used before a numeric value, assigns a Timer function to a line of logic.
+	+	ADD	Shifted function used to specify addition in an arithmetic operation.
[CNT]	CNT	COUNTER	Used to assign a Counter function to a line of logic.
—	—	SUBTRACT	Shifted function used to specify subtraction in an arithmetic operation.
[SR]	SR	SHIFT REGISTER	Assigns a Shift Register function to a line of logic.
D•AND	D•AND	DATA AND	Specifies a logical AND operation.
[AND]	AND		Adds referenced status to previously entered logic in series.
D•OR	D•OR	DATA OR	Specifies a logical OR operation.
[OR]	OR		Adds referenced status to previously entered logic in parallel.
D•STR	D•STR	DATA STORE	Used in a data instruction sequence to move data into the accumulator from a specified location or as a constant value. Always used to start a data operation sequence.
[STR]	STR	START	Used with a reference to begin a rung of ladder diagram logic.
INV	INV	INVERT	Used to invert the 16 bits of the accumulator. Use after the D.STR instruction to invert before performing a data operation or immediately before D.OUT to invert before outputting data.
[NOT]	NOT		Specifies a contact reference to be normally closed.

In order to enter programs and for other operations of the PC, an understanding of the use of each key is required. Table 4.2 lists the various operations, the keystrokes required and the mode or modes in which the operation can be performed. The mode abbreviations used in the table heading are:

T = TEST
R1 = RUN 1
R = RUN
P = PROGRAM
L = LOAD
PM = PROM

Table 4.2
PC OPERATION SEQUENCES

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	R1	R	P	L	PM
Insert or Remove Keyswitch				X		X	
Switch to RUN mode	RUN 1 ⟶ RUN (Required sequence to enable outputs)	X	X		X	X	X
Update I/O configuration (After an I/O module change).	Error code (E41) and tone are generated. Enter SET and CLR (Clear).		X				
Erase all program memory	CLR SHF 348 NXT				X		
Clear instruction display	CLR	X	X	X	X		
Clear instruction display and memory address	CLR CLR	X	X	X	X		
Select program memory address	CLR XXXX NXT	X	X	X	X		
Next memory address	(Current address and data) NXT	X	X	X	X		
Previous memory address	(Current address and data) PRV	X	X	X	X		
Entering an instruction. TEST mode entries limited (See Mode Select Keyswitch, Page 4-3)	[Program Address] - Instruction - Numeric Value - Enter Example: 0001 STR 25 ENT	X			X		
Editing a program.	Same as above. Select program address and enter change.	X			X		
Changing a reference number.	Old reference New reference CLR XXXX CHG XXXX NXT (Changes reference in all locations in program from old to new).				X		
Insert instruction in existing program	[Program Address] (Address where instruction is to be inserted) INSTRUCTION INS NXT (Instruction at this address and rest in program move ahead 1 address)	X			X		
Deleting an instruction in existing program.	[Program Address] DEL PRV (All instructions after this address move back 1 address)	X			X		

Table 4.2
PC OPERATION SEQUENCES (Continued)

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	R1	R	P	L	PM
Search for specific information • Instruction • Relay Contact • Timer/Counter Contact • Next available program address	Reference Number [Instruction] XXXX SCH CLR XXXX SCH Reference Number CLR TMR or CNT XXXX SCH Timer/Counter Number CLR SCH	X X X X	X X X X	X X X X	X X X X		
Program Check	CLR SCH (Checks for invalid entry. Displays address with error and error code. Tone is generated IF no error detected, next available program address is displayed.	X	X	X	X		
Entering Timer or Counter constant present value.	TMR XXX ENT K 5.0 ENT Timer/Counter Number Constant Value (Timer.1-999.9, Counter 1-9999)	X	X		X		
Changing constant value of Timer or Counter	[Program Address] K [New value] ENT	X	X		X		
Changing Data instruction value	[Program Address] XXXX ENT . If D.STR, enter set value into accumulator. . If a constant to be acted upon, use K before value.	X	X		X		
Monitoring Operation • ON/OFF state of contact or coil	[Instruction] XXXXX SCH reference (Monitor display 0 LED will be ON or OFF)	X	X	X	X		

Table 4.2
PC OPERATION SEQUENCES (Continued)

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	R1	R	P	L	PM
• Data Register contents - looks at 16 consecutive bits	CLR CLR M XXX NXT Lower Byte Number	X	X	X	X		
• Accumulated value of Timer of Counter	CLR CLR M XXX NXT 200 + T/C Number	X	X	X	X		
Monitor Display • Display contact or coil status at a specified monitor point.	CLR XX M [Reference] NXT Monitor Display LED (0-15)	X	X	X	X		
• Advance display to next monitor point	CLR XX M [Reference] NXT NXT (After reaching 15, display will wrap-around to 00). NOTE When in Monitor Display Mode, all instruction keys except TMR and CNT are disabled.	X	X	X	X		
• Leave Monitor display mode	CLR CLR	X	X	X	X		
Forced setting and resetting • Turn ON (Input, Output, Internal Relay)	CLR [I/O Reference Number] CHG SET	X	X		X		
• Turn OFF (Input, Output, Internal Relay)	CLR [I/O Reference Number] CHG RST	X	X		X		

Table 4.2
PC OPERATION SEQUENCES (Continued)

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	R1	R	P	L	PM
• Turn Timer/ Counter ON	TMR or CNT XXX SCH CHG SET	X	X		X		
• Turn Timer/ Counter OFF	TMR or CNT XXX SCH CHG RST	X	X		X		
• Turn Shift Register or Retentive Relay ON	CLR [SR or Relay Number] CHG SET	X	X		X		
• Turn Shift Register or Retentive Relay OFF	CLR [SR or Relay Number] CHG RST	X	X		X		
One-Scan Program Execution	[Program Address] SET OUT NXT • Each time the SET OUT NXT sequence is entered, the next scan will be executed. ON/OFF status of coils or contacts can be observed by assigning them to Monitor Display LEDs and observing the LEDs.	X					
Cassette Recorder Operation • Write to Tape • Read From Tape • Compare Read or Write Operation	Program Number CLR SHF WRITE XXXX NXT CLR SHF READ XXXX NXT CLR SHF CHECK XXXX NXT • Compare should be done immediately after a Read or Write Refer to Chapter 6 for further details.					X X X	

Table 4.2
PC OPERATION SEQUENCES (Continued)

OPERATION	KEYSTROKES OR OPERATION SEQUENCE	MODE					
		T	R1	R	P	L	PM
PROM Writer Operation	Refer to Chapter 6 for this operation.					X	
Printer Operation	Refer to Chapter 6 for this operation.					X	
Transfer Contents of PROM to CMOS RAM	CLR SHF READ NXT						X
Verify PROM to CMOS RAM	CLR SHF CHECK NXT						X

PROGRAMMING REFERENCES

Programming references for the Series Three are listed in the following tables. These references are fixed internally and must be assigned as shown for proper system operation.

Table 4.3
DISCRETE I/O POINTS (400)

GROUP	000	001	002	003	004	005	006	007	010	011	012	013	014	015	016	017
	0000	0010	0020	0030	0040	0050	0060	0070	0100	0110	0120	0130	0140	0150	0160	0170
I/O	0001	0011	0021	0031	0041	0051	0061	0071	0101	0111	0121	0131	0141	0151	0161	0171
Number	0002	0012	0022	0032	0042	0052	0062	0072	0102	0112	0122	0132	0142	0152	0162	0172
	0003	0013	0023	0033	0043	0053	0063	0073	0103	0113	0123	0133	0143	0153	0163	0173
	0004	0014	0024	0034	0044	0054	0064	0074	0104	0114	0124	0134	0144	0154	0164	0174
	0005	0015	0025	0035	0045	0055	0065	0075	0105	0115	0125	0135	0145	0155	0165	0175
	0006	0016	0026	0036	0046	0056	0066	0076	0106	0116	0126	0136	0146	0156	0166	0176
	0007	0017	0027	0037	0007	0057	0067	0077	0107	0117	0127	0137	0157	0157	0167	0177

GROUP	020	021	022	023	024	025	026	027	030	031	032	033	034	035	036	037
	0200	0210	0220	0230	0240	0250	0260	0270	0300	0310	0320	0330	0340	0350	0360	0370
I/O	0201	0211	0221	0231	0241	0251	0261	0271	0301	0311	0321	0331	0341	0351	0361	0371
Number	0202	0212	0222	0232	0242	0252	0262	0272	0302	0312	0322	0332	0342	0352	0362	0372
	0203	0213	0223	0233	0243	0253	0263	0273	0303	0313	0323	0333	0343	0353	0363	0373
	0204	0214	0224	0234	0244	0254	0264	0274	0304	0314	0324	0334	0344	0354	0364	0374
	0205	0215	0225	0235	0245	0255	0265	0275	0305	0315	0325	0335	0345	0355	0365	0375
	0206	0216	0226	0236	0246	0256	0266	0276	0306	0316	0326	0336	0346	0356	0366	0376
	0207	0217	0227	0237	0247	0257	0267	0277	0307	0317	0327	0337	0347	0357	0367	0377

GROUP	040	041	042	043	044	045	046	047	050	051	052	053	054	055	056	057
	0400	0410	0420	0430	0440	0450	0460	0470	0500	0510	0520	0530	0540	0550	0560	0570
I/O	0401	0411	0421	0431	0441	0451	0461	0471	0501	0511	0521	0531	0541	0551	0561	0571
Number	0402	0412	0422	0432	0442	0452	0462	0472	0502	0512	0522	0532	0542	0552	0562	0572
	0403	0413	0423	0433	0443	0453	0463	0473	0503	0513	0523	0533	0543	0553	0563	0573
	0404	0414	0424	0434	0444	0454	0464	0474	0504	0514	0524	0534	0544	0554	0564	0574
	0405	0415	0425	0435	0445	0455	0465	0475	0505	0515	0525	0535	0545	0555	0565	0575
	0406	0416	0426	0436	0446	0456	0466	0476	0506	0516	0526	0536	0546	0556	0566	0576
	0407	0417	0427	0437	0447	0457	0467	0477	0507	0517	0527	0537	0547	0557	0567	0577

GROUP	060	061
	0600	0610
I/O	0601	0611
Number	0602	0612
	0603	0613
	0604	0614
	0605	0615
	0606	0616
	0607	0617

Table 4.4
INTERNAL RELAYS (298 PLUS 6 SPECIAL)

GROUP	400	401	402	403	404	405	406	407	410	411	412	413	414	415	416	417
	4000	4010	4020	4030	4040	4050	4060	4070	4100	4110	4120	4130	4140	4150	4160	4170
Bit	4001	4011	4021	4031	4041	4051	4061	4071	4101	4111	4121	4131	4141	4151	4161	4171
Number	4002	4012	4022	4032	4042	4052	4062	4072	4102	4112	4122	4132	4142	4152	4162	4172
	4003	4013	4023	4033	4043	4053	4063	4073	4103	4113	4123	4133	4143	4153	4163	4173
	4004	4014	4024	4034	4044	4054	4064	4074	4104	4114	4124	4134	4144	4154	4164	4174
	4005	4015	4025	4035	4045	4055	4065	4075	4105	4115	4125	4135	4145	4155	4165	4175
	4006	4016	4026	4036	4046	4056	4066	4076	4106	4116	4126	4136	4146	4156	4166	4176
	4007	4017	4027	4037	4047	4057	4067	4077	4107	4117	4127	4137	4147	4157	4167	4177

GROUP	420	421	422	423	424	425	426	427	430	431	432	433	434	435	436	437
	4200	4210	4220	4230	4240	4250	4260	4270	4300	4310	4320	4330	4340	4350	4360	4370
Bit	4201	4211	4221	4231	4241	4251	4261	4271	4301	4311	4321	4331	4341	4351	4361	4371
Number	4202	4212	4222	4232	4242	4252	4262	4272	4302	4312	4322	4332	4342	4352	4362	4372
	4203	4213	4223	4233	4243	4253	4263	4273	4303	4313	4323	4333	4343	4353	4363	4373
	4204	4214	4224	4234	4244	4254	4264	4274	4304	4314	4324	4334	4344	4354	4364	4374
	4205	4215	4225	4235	4245	4255	4265	4275	4305	4315	4325	4335	4345	4355	4365	4375
	4206	4216	4226	4236	4246	4256	4266	4276	4306	4316	4326	4336	4346	4356	4366	4376
	4207	4217	4227	4237	4247	4257	4267	4277	4307	4317	4327	4337	4347	4357	4367	4377

GROUP	440	441	442	443	444	445
	4400	4410	4420	4430	4440	4450
Bit	4401	4411	4421	4431	4441	4451
Number	4402	4412	4422	4432	4442	4452
	4403	4413	4423	4433	4443	4453
	4404	4414	4424	4434	4444	4454
	4405	4415	4425	4435	4445	4455
	4406	4416	4426	4436	4446	4456
	4407	4417	4427	4437	4447	4457

} Special purpose coils. Used as flags for certain conditions as a result of a computation.

4452 Compare > (greater than)
4453 Compare = (equal to)
4454 Compare < (less than)
4455 Carry or Borrow
4456 Zero
4457 Overflow

} Arithmetic Computations

Table 4.5
RETENTIVE RELAYS (64)

GROUP	700	701	702	703	704	705	706	707
Bit Number	7000	7010	7020	7030	7040	7050	7060	7070
	7001	7011	7021	7031	7041	7051	7061	7071
	7002	7012	7022	7032	7042	7052	7062	7072
	7003	7013	7023	7033	7043	7053	7063	7073
	7004	7014	7024	7034	7044	7054	7064	7074
	7005	7015	7025	7035	7045	7055	7065	7075
	7006	7016	7026	7036	7046	7056	7066	7076
	7007	7017	7027	7037	7047	7057	7067	7077

These are internal coils that will retain last ON or OFF state under power-down condition.

} Special purpose (See below)

7076 Turns on when voltage of Lithium back-up battery drops below 2.7 Vdc.

7077 When on, indicates an error during a data transfer between CPU and peripheral equipment.

Table 4.6
SHIFT REGISTERS (128)
(RETENTIVE)

GROUP	900	901	902	903	904	905	906	907	910	911	912	913	914	915	916	917
Bit	9000	9010	9020	9030	9040	9050	9060	9070	9100	9110	9120	9130	9140	9150	9160	9170
Number	9001	9011	9021	9031	9041	9051	9061	9071	9101	9111	9121	9131	9141	9151	9161	9171
	9002	9012	9022	9032	9042	9052	9062	9072	9102	9112	9122	9132	9142	9152	9162	9172
	9003	9013	9023	9033	9043	9053	9063	9073	9103	9113	9123	9133	9143	9153	9163	9173
	9004	9014	9024	9034	9044	9054	9064	9074	9104	9114	9124	9134	9144	9154	9164	9174
	9005	9015	9025	9035	9045	9055	9065	9075	9105	9115	9125	9135	9145	9155	9165	9175
	9006	9016	9026	9036	9046	9056	9066	9076	9106	9116	9126	9136	9146	9156	9166	9176
	9007	9017	9027	9037	9047	9057	9067	9077	9107	9117	9127	9137	9147	9157	9167	9177

Table 4.7
DATA REGISTERS, 8-BIT (128)

	500	501	502	503	504	505	506	507	510	511	512	513	514	515	516	517
	520	521	522	523	524	525	526	527	530	531	532	533	534	535	536	537
	540	541	542	543	544	545	546	547	550	551	552	553	554	555	556	557
Number	560	561	562	563	564	565	566	567	570	571	572	573	574	575	576	577
	600	601	602	603	604	605	606	607	610	611	612	613	614	615	616	617
	620	621	622	623	624	625	626	627	630	631	632	633	634	635	636	637
	640	641	642	643	644	645	646	647	650	651	652	653	654	655	656	657
	660	661	662	663	664	665	666	667	670	671	672	673	674	675	676	677

see below

Register 674 Fault diagnosis, error condition storage.
Register 675 Fault diagnosis, error condition storage.
Register 676 Auxiliary accumulator, lower byte.
Register 677 Auxiliary accumulator, upper byte.

Table 4.8
TIMER OR COUNTER NUMBERS AND REGISTERS (128)

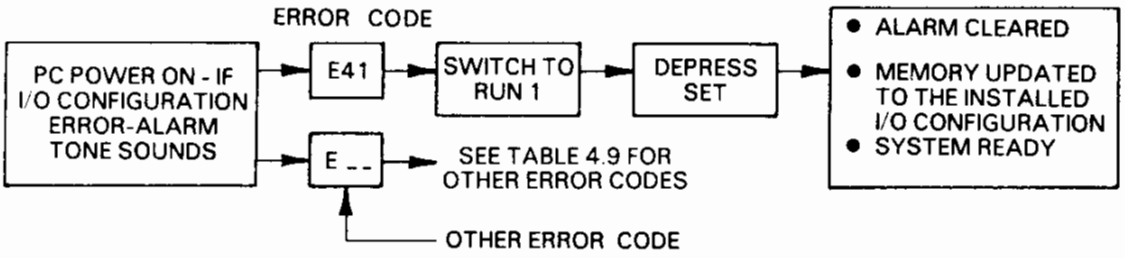
The T/C Numbers are not I/O points, they are only Timer or Counter identification numbers.

T/C Number	000	001	002	003	004	005	006	007	010	011	012	013	014	015	016	017
Accumulate Reg.	200	201	202	203	204	205	206	207	210	211	212	213	214	215	216	217
T/C Number	020	021	022	023	024	025	026	027	030	031	032	033	034	035	036	037
Accumulate Reg.	220	221	222	223	224	225	226	227	230	231	232	233	234	235	236	237
T/C Number	040	041	042	043	044	045	046	047	050	051	052	053	054	055	056	057
Accumulate Reg.	240	241	242	243	244	245	246	247	250	251	252	253	254	255	256	257
T/C Number	060	061	062	063	064	065	066	067	070	071	072	073	074	075	076	077
Accumulate Reg.	260	261	262	263	264	265	266	267	270	271	272	273	274	275	276	277
T/C Number	100	101	102	103	104	105	106	107	110	111	112	113	114	115	116	117
Accumulate Reg.	300	301	302	303	304	305	306	307	310	311	312	313	314	315	316	317
T/C Number	120	121	122	123	124	125	126	127	130	131	132	133	134	135	136	137
Accumulate Reg.	320	321	322	323	324	325	326	327	330	331	332	333	334	335	336	337
T/C Number	140	141	142	143	144	145	146	147	150	151	152	153	154	155	156	157
Accumulate Reg.	340	341	342	343	344	345	346	347	350	351	352	353	354	355	356	357
T/C Number	160	161	162	163	164	165	166	167	170	171	172	173	174	175	176	177
Accumulate Reg.	360	361	362	363	364	365	366	367	370	371	372	373	374	375	376	377

The top number in each row (000-177) is the number assigned to a Timer or Counter. The number (200-377) under the Timer or Counter number is the 16-bit register that stores the accumulated value of that Timer or Counter.

POWER-UP SEQUENCE

When power is turned on, the CPU performs a self-check diagnostic, including checking the I/O configuration installed and comparing it to the configuration previously entered in a portion of internal memory reserved for that data. The type of I/O module (Input or Output) and number of I/O points are checked. If a change in the configuration is detected, an alarm will sound and an error code will be displayed. This sequence is shown below.



An I/O slot that does not have a module installed is interpreted as being a 16 point Output module. This must be considered when assigning I/O references. The I/O configuration as stored in memory is retained by the lithium back-up battery.

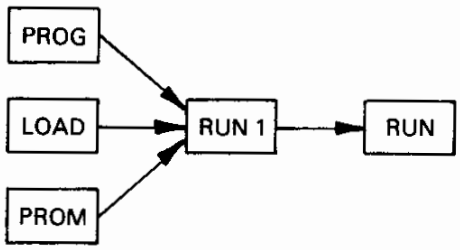
Several other diagnostics are performed during the self-check portion of the power-up sequence. If an error is detected, an alarm is sounded and an error code is displayed. The alarm tone and error code are present until cleared by the operator. The error codes and their definitions are listed in Table 4.9. A complete list of system error codes can be found in Table 4.13.

Table 4.9
SELF-CHECK ERROR CODES

Error Code	Definition
E13	Instantaneous power failure.
E21	Program memory parity error.
E22	Memory back-up battery has dropped below 2.7 Vdc. Will not retain memory.
E31	CPU watchdog timer timed out (> 300 ms).
E41	Change in I/O module configuration. or I/O to CPU data transfer error.
E50	Error in data transfer to peripheral device.

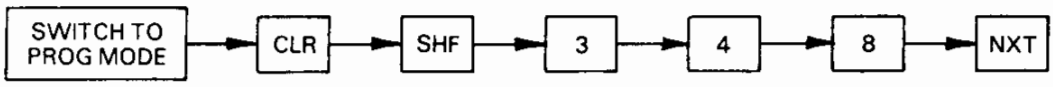
SWITCHING TO RUN MODE

Insertion of the key in the keyswitch slot allows switching between modes. However; a specific sequence must be followed when switching to the RUN mode. When switching directly to RUN from PROG, LOAD or PROM, all operations are disabled. You must first switch to RUN 1, then RUN as shown below.



CLEARING PROGRAM MEMORY

Before entering a program initially or if all of the contents of program memory are to be cleared, use the following procedure. This will clear all program memory addresses of any instructions and data previously entered.



When the above procedure is executed parts of the CPUs internal memory are also cleared, while other parts are retained.

Memory cleared

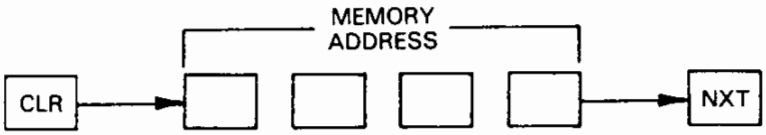
- User program memory
- Contents of 16-bit monitor display
- Operating state of internal retentive relays
- Operating state of shift registers

Memory not cleared

- I/O configuration
- Data registers
- Timers, Counters and their accumulated value registers

SELECTING A PROGRAM MEMORY ADDRESS

To display a particular program memory address, use the following key sequence. The address will be displayed along with the data entered at that address.

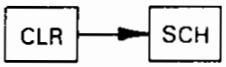


START OF MEMORY

To access the start of program memory (Address 0000), use the following key sequence.

SEARCH FOR NEXT UNUSED ADDRESS

To access and have displayed the next unused program memory address without stepping through a program one address at a time, enter the following key sequence. The CPU will search for the next available address and display that address.



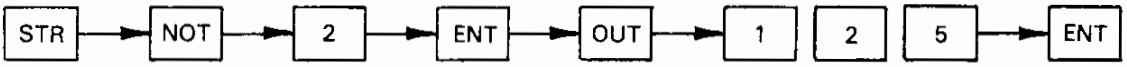
ENTERING INSTRUCTIONS

Instructions for a ladder diagram program are entered by pushing an instruction key or a combination of up to 3 instruction keys, up to 4 numerical keys and ENT.

Example:

TO ENTER:

PUSH

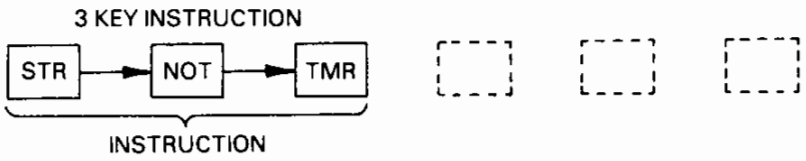


There are 24 Instruction keys (12 plus 12 shifted) as shown in Figure 4.1. Additional instructions are entered by pushing these keys as the second or third key of a combined sequence of keys. Table 4.10 shows the key legends and their allowable locations in a combined key sequence. Combinations of the keys allow 50 instructions to be entered.

Table 4.10
INSTRUCTION KEY SEQUENCE POSITIONS

Key \ Position	1	2	3	Key \ Position	1	2	3
STR	0	0		D•STR	0		
AND	0			D•AND	0		
OR	0			D•OR	0		
NOT		0		COM	0		
OUT	0	0		D•OUT	0		
TMR	0	0	0	>=<	0		
CNT	0	0	0	+	0		
SR	0			-	0		
MCS	0	0		BIN	0		
MCR	0	0		BCD	0		
SET	0			X	0		
RST	0		0	÷	0		

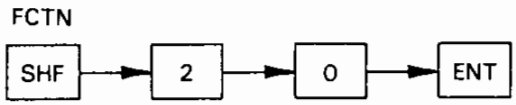
Example:



Notice that STR is pushed first, then NOT, and finally TMR. The Keys are in positions as shown in the table. This instruction would specify the first contact in a rung of logic as a closed contact referencing a Timer coil for the contact.

If keys are pushed in an invalid sequence, an alarm tone will sound and an error code will be displayed on the programmer. When this happens, push CLR, then enter the correct sequence.

In addition to the keys in Table 4.10, there are 7 instructions which can be entered using the FCTN (Function) key and a two-digit numeric sequence. For example, to specify Function 20, the following key sequence is pushed.



The data display will display F20 as those keys are pushed. When ENT is pushed, a long tone will sound, the data display clears and then displays 0.0.0.0.; simultaneously the program memory address display will advance one address. This is a CPU prompt indicating that a second entry must be made to complete the instruction since it is a two-word instruction.

Using the above described key sequences, a total of 57 instructions are available for programming a Series Three PC system. Chapter 5 lists and describes all of the programming instructions.

ENTERING DATA

After entering an instruction, the required data is entered using the numerical keys 0-9. The value entered with the numerical keys is displayed on the data display, with digits shifting left as they are entered. If more than four numerical keys are pushed, the left digit(s) are lost and the four remaining are considered valid data. Leading zeros can be omitted from a sequence; i.e. to enter 123, you only need to push 1, 2, 3 and not 0, 1, 2, 3. Table 4.11 lists the instructions requiring numerical entries and the ranges of those entries.

Table 4.11
VALID NUMERICAL RANGES

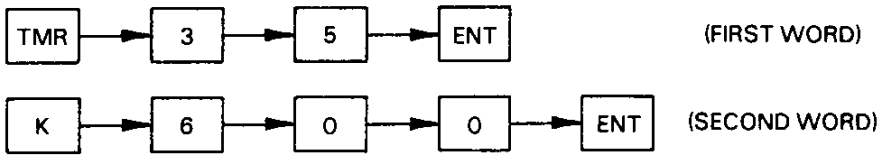
INSTRUCTION	NUMERICAL LIMITS	
STR, AND, OR, OUT, SR SET, RST, SET.OUT, SET.OUT.RST	0000-0617 4000-4457 7000-7077 9000-9177	Relay Number Bit References
D • STR, D • OUT > = < ,+,-,x,÷ D • AND, D • OR	000-061 400-445 700-707 900-917 500-677 200-377	Byte References
Timer Preset	0000-999.9	System Enters Decimal Point
Counter Preset	0000-9999	
Timer and Counter Reference Numbers	000-177	
FUN 80, FUN 81 (Instructions For Data Shifts)	1-15	Number of Steps To Be Shifted
FUN 20 (Fault Diagnosis)	Fault Identification Number 0000-9999	

If a numerical entry is attempted, but is out of range for the Instruction an alarm will sound and an error code (E01) will be displayed. Push CLR, the data display will clear, then enter the correct data.

Examples of numerical entries:

- Instruction referencing an internal relay, STR 4265.

- Instruction specifying a Timer number (35) with a constant preset value of 60.0 seconds.

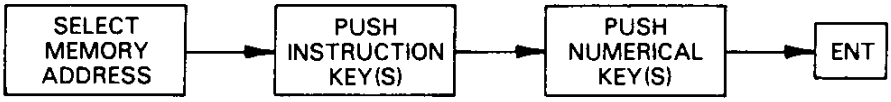


PROGRAMMING PROCEDURES

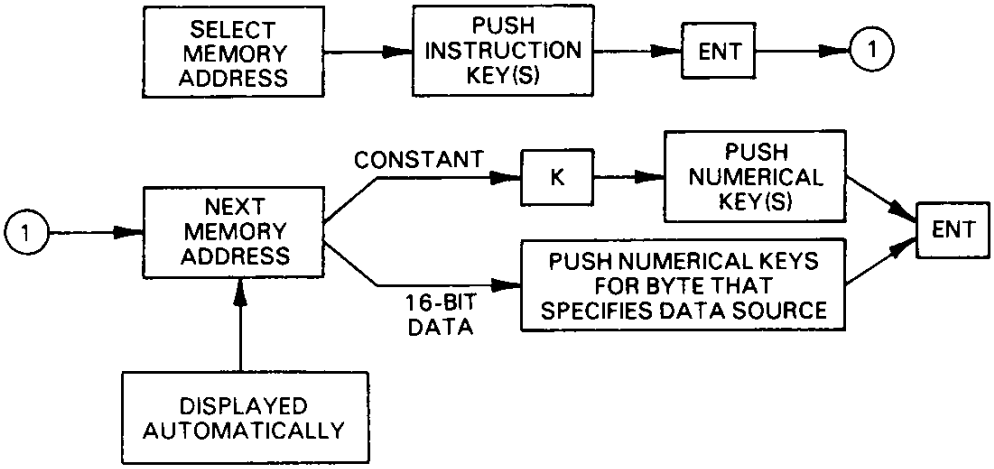
Some general information required for entering ladder diagram programs is as follows:

- Instructions are written (entered) in program memory when the ENT key is pushed.
- Instructions use either 1 or 2 words of memory.

1. Entering a one-word instruction.



2. Entering a two-word instruction.



- The program memory address must be displayed for an instruction to be entered; otherwise, the ENT key has no effect.

- When entering a two-word instruction, the program memory address advances 1 address when the ENT key is pushed after the instruction key(s).

- Invalid ENT key operation
  1. ENT key does not respond.
     - Program memory address not displayed.
     - ENT key pushed before instruction key
     - ENT key pushed before numerical key (instruction key has been pushed) - except for a two-word instruction.
     - Keys other than numerical pushed for second word of a two-word instruction.

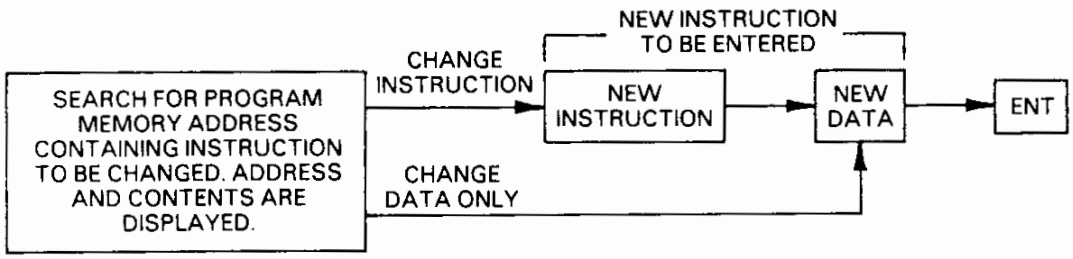
  2. ENT key responds, but alarm sounds and entry is invalid (error code E01 or E02).
     - Only numerical keys pushed (except two-word commands).
     - Data entry exceeds the legal limits.

In any of the above examples, push CLR and re-enter the instruction.

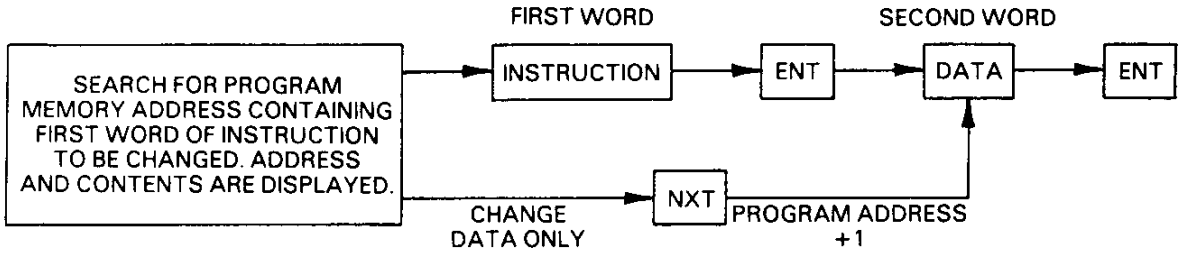
EDITING A PROGRAM

Editing a program previously entered in program memory is a relatively easy procedure requiring a minimum of keystrokes. The two following block diagrams show the general steps for editing a one-word or a two-word instruction.

1. Editing a one-word instruction



2. Editing a 2-word instruction



If a one-word instruction is changed to a two-word instruction, the program memory address advances for the second word; all following instructions are shifted ahead one address. Conversly, if a two-word instruction is changed to a one-word instruction the data contained in the second word is deleted and all following instructions are shifted back one address.

USING THE OPERATION KEYS

Most of the Keys in the Operation Key group are used when editing. The use of these Keys when making changes in a program are described in this paragraph.

CLR CLEAR. An instruction can be rewritten by pushing the CLR key and re-entering the instruction; however, the instruction can be written over simply by entering the new instruction without pushing CLR.

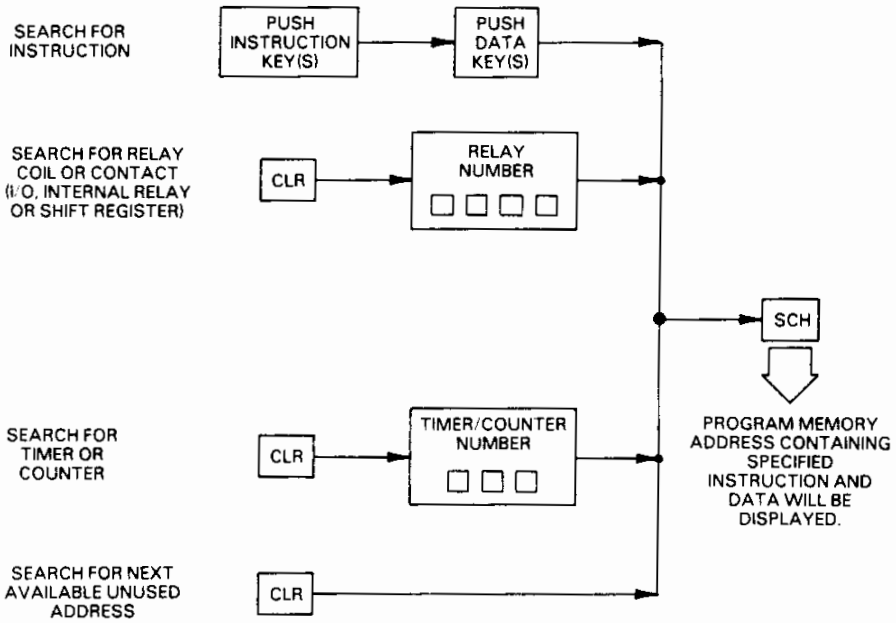
ENT ENTER. Pushing the ENT key after the instruction and numeric keys will cause the specified instruction to be entered at the displayed address in program memory.

PRV PREVIOUS. When reading the contents of program memory, pushing the PRV Key will allow the program memory address to be displayed which preceeds the one currently displayed. The contents of that address will also be displayed.

NXT NEXT. Pushing the NXT Key will advance the displayed program memory address to the next higher address. The program memory address and its contents will be displayed.

SCH

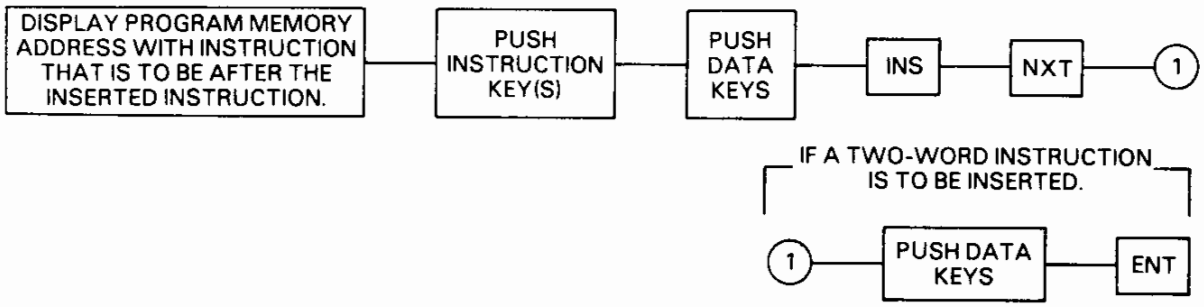
SEARCH. The SCH key is used to find an instruction, or a coil, contact, Timer or Counter reference in a program. The specified item will be displayed with its program memory address. The keys specifying the item to be searched for are pushed, then the SCH key. The address will be displayed containing the instruction and the instruction is read by observing the LEDs on the instruction display and the data display. If the instruction or reference is used more than one time in a program, the display will show the first time it is used. Pushing SCH again will advance the program memory address and display the information at its next location. If the instruction or reference is not used again, the address displayed will not change. A block diagram of the SCH key operation is shown below.



If the reference numbers pushed before the SCH key are out of range, error code E01 will be displayed. If the specified instruction or data is not found, error code E99 (instruction or data not found) will be displayed.

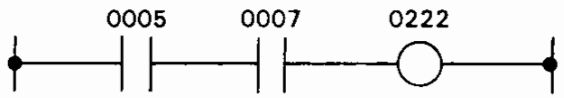
INS INSERT. The INS key provides a method of adding a new instruction or any number of instructions to an existing program. To insert an instruction, first search for and display the program memory address containing the instruction that will be after the instruction to be inserted. Push the keys for the instruction and data to be added, then push INS. The display will alternate On and Off with a tone, then push NXT (this is a two key operation as a precaution against accidental insertion of an instruction). The added instruction and data will be inserted in the program at the displayed address. All instructions following will advance one address. If the new instruction is a two-word instruction, the existing program will advance two addresses.

The mode switch must be in the PROG or TEST position to do an insert operation. An insert operation sequence is shown in block diagram form.

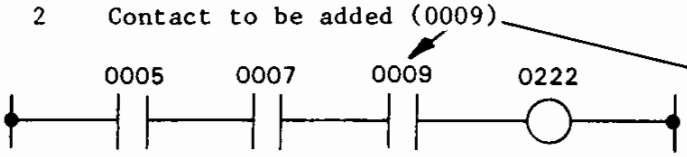


Example of the results of an insert operation:

1 Relay logic rung in program



2 Contact to be added (0009)



- Before Insert -

Address	Instruction	Data
0345	STR	5
0346	AND	7
0347	OUT	222

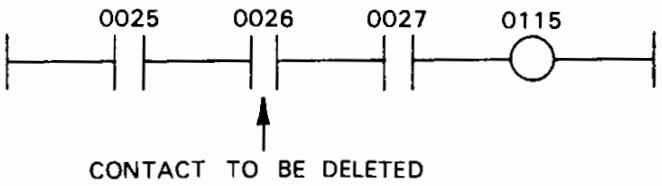
- After Insert -

Address	Instruction	Data
0345	STR	5
0346	AND	7
0347	AND	9
0348	OUT	222

DEL DELETE. The DEL key provides a method of removing an instruction from a relay ladder logic program. Display the program memory address containing the instruction to be deleted, then push the DEL key. The display will alternate On and Off with a tone, then push PRV (this is a two key operation to prevent accidental deletions). The instruction located at that address will be deleted and all instructions that had been after the one deleted will move back one address.

Example of the results of a delete operation:

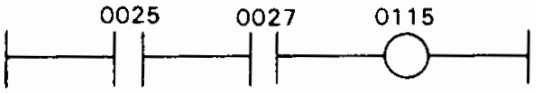
1 Relay logic rung in program



- Before Deletion -

Address	Instruction	Data
0211	STR	25
0212	AND	26
0213	AND	27
0214	OUT	115

2 Rung after deletion

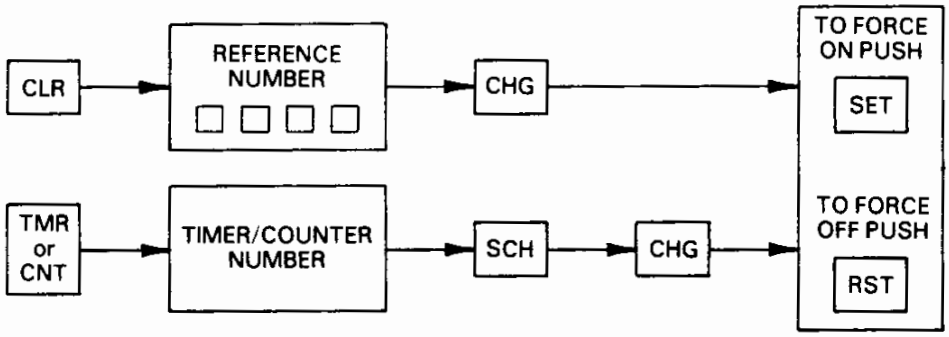


- After Deletion -

Address	Instruction	Data
0211	STR	25
0212	AND	27
0213	OUT	115

If the instruction to be deleted is a two-word instruction, all following instructions will move back two addresses.

CHG CHANGE. The CHG key is used in a key sequence when forcibly turning Inputs, Outputs, Timer or Counter coils, Shift Register coils or Internal coils ON or OFF. This key is used with the SET key when forcing to the ON condition and with the RST key when forcing to the OFF condition. Examples of these key sequences are shown below.

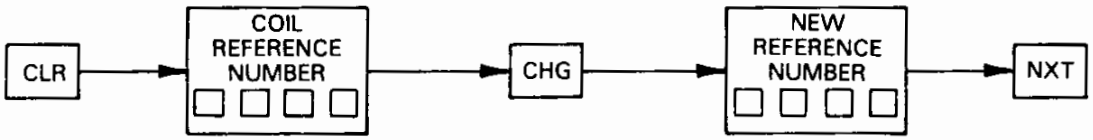


The forcing ON or OFF of contacts or coils provides a convenient way of testing the operation of system devices and debugging a program. Table 4.12 shows the operation of contacts and coils when they are forced either ON or OFF.

Table 4.12
RESULTS OF FORCED SET OR RESET

Contact or Relay Type	Operation when forced by SET	Operation when forced by RST
Input Contact	Normally - open contact is closed for 1 scan.	Normally - closed contact is opened for 1 scan.
Output or Internal Relay	When the normal operating condition is OFF, the Output or Internal Relay is turned ON. During the next program execution, the Output or Relay will turn OFF.	If the normal operating condition is ON, the Output or Internal Relay is turned OFF. During the next program execution, the Output or Relay will turn back ON.
Shift Register	If OFF, is forced to ON.	If ON, is forced to OFF.
Timer	Timer is forced to begin timing. If the timer was running it would continue. If the timer had not been running, it would reset on the next scan.	Timer is reset to the preset value.
Counter	Counter will count up.	If the counter is counting, it will reset.

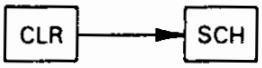
The CHG key can also be used in a sequence to change the reference number of a coil (output or internal) and all subsequent contact references to that coil. For instance, consider an output coil reference as 0122 with several contacts in the program referenced to that coil. If, using the CHG key, that output coil reference is changed to 0132, all of the contact references will automatically change to 0132. The sequence to change a coil reference is shown in the following block diagram. To do this, the mode switch must be in the PROG position.



PROGRAM CHECK AND ERROR CODES

As a program is being entered, the CPU automatically performs a check for the validity of each entry. Instructions are checked for proper key sequence, range of numerical data, etc. If an error is detected, an error code will be generated and a tone will sound. When this happens, pushing CLR will remove the tone and error code. Refer to the error code listing in Table 4.13 and correct the program step.

A program check can also be made at any time while in the TEST, RUN 1, RUN or PROG mode by using the following key sequence.



The CPU will perform a program error check. If a program error is found, the address containing the error will be displayed, a tone will sound, and an error code will be displayed alternately with the address and its contents. If no errors are found when the CLR, SCH sequence is pushed, the next available unused program memory address will be displayed.

The CPU also automatically performs the program error check any time that the system is switched to the RUN mode. Error codes are also generated for system problems such as watch-dog timer timing out, back-up battery voltage low, etc. These error codes are also listed in Table 4.13.

Table 4.13
ERROR CODE DEFINITIONS

ERROR CODE	WHEN DETECTED				CAUSE OF ERROR	ACTION TO CLEAR ALARM
	LOAD MODE	PROG. CHECK	SWITCH TO RUN	POWER UP		
E 01	O				Incorrect entry of instruction or data.	CLR (Push CLR key)
E 02		O			Instruction and I/O data wrong. Input programmed as an Output.	CLR Change reference
E 03		O			Instructions that can be stacked (MCS, MCR, etc.) exceed 8 levels.	CLR
E 05		O			Output coil, Internal relay, timer or Counter reference already used.	CLR Use new reference
E 06		O			Number of MCR instructions greater than number of MCS instructions.	CLR
E 07		O			Timer, Counter or Shift Register required condition incomplete.	CLR Check program
E 08		O	O		No Timer or Counter preset value	CLR
E 09		O			Incomplete rung	CLR Check program entered
E 10	O				Two-word instruction written to last program memory address (4095), no room for second word.	CLR
E 11		O			All program memory locations used.	CLR
E 13	●	●	●	●	Momentary power failure.	CLR
E 21		●	●	●	Program memory parity error	Switch to PROG, push CLR
E 22			●	●	Lithium back-up battery <2.7 V dc.	CLR Change battery
E 25	O				Contents of cassette tape and PC memory not equal.	CLR and Clear relay 7066 with forced RST
E 28	O				Improper level of recorder volume control.	CLR Adjust volume control to about mid-range
E 31	●	●	●	●	Watch-dog timer >300 msec (timed out).	CLR Switch to PROG, push CLR
E 41				O	I/O module configuration change since last power-up.	Switch to RUN 1, push SET then CLR (Updates I/O map)
					Invalid I/O→CPU transfer	Switch to RUN 1→RST→CLR
E 50	O				Invalid data to or from peripheral device.	CLR, then clear relay 7077 with forced RST.
E 75	O				Contents of PROM and CMOS RAM are not equal.	CLR
E 76	O				PROM to CMOS RAM data transfer invalid or defective CMOS RAM.	CLR
E 99	O				Instruction or data not found when a SEARCH operation is initiated.	CLR

1. O indicates an improper programming operation.
2. ● indicates a system problem.

MONITORING OPERATION

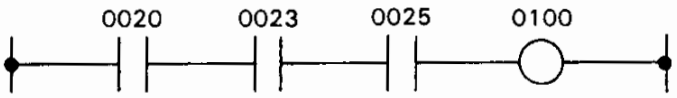
There are several ways to monitor the operation of a Series Three PC system. The monitoring operations are convenient in that that not only provide a means of checking system operation; but they are also a useful tool for debugging and troubleshooting. The items that can be easily monitored are:

- The ON or OFF state of contacts and coils while stepping through a program.
- The operating state (ON or OFF) of any 16 contacts or coils can be observed simultaneously on the monitor display.
- The accumulated value of Timers and Counters.
- Fault condition identification numbers.
- The contents of two consecutive bytes of data. This is an advanced capability of the system. The procedure for this can be found in Appendix A.

ON/OFF STATE OF CONTACTS OR COILS

Any time that a program memory address is displayed, the state (ON or OFF) of the referenced contact or coil is displayed on LED 0 of the monitor display.

Example:



ADDRESS			
0009	STR	20	PROGRAMMING SEQUENCE FOR RUNG
0010	AND	23	
0011	AND	25	
0012	OUT	100	

When program memory address 0012 is displayed by using the NXT or PRV keys or the SCH key sequence, the data display will contain 0100, which is the output coil for the rung. The 0 position on the 0-15 LED display will reflect the state of the coil or contact on the data display. The LED will be ON for an ON condition and OFF for an OFF condition.

MONITOR DISPLAY

The monitor display area on the CPU/Programmer is the center section with the numerals 0 to 15; each number having an LED directly behind it. The reference number of a relay coil or contact or a Timer/Counter reference number can be assigned to one of the monitor display numbers. A bit in an internal register will then be ON or OFF to reflect the ON or OFF status of the coil or contact assigned to that point. The associated LED will turn ON or OFF to give a visual display of that status. Since there are 16 monitor points, any 16 coils, contacts or Timer/Counter references can be assigned to the 16 points. It is recommended that monitor points 1 through 16 be used for the monitor display since the 0 position always reflects the ON/OFF state of the coil or contact whose address is displayed on the programmer. These assignments can be random or in consecutive order. This provides a convenient way of observing all of the contacts and the output coil of a rung of logic, and is helpful when debugging or troubleshooting a ladder diagram program.

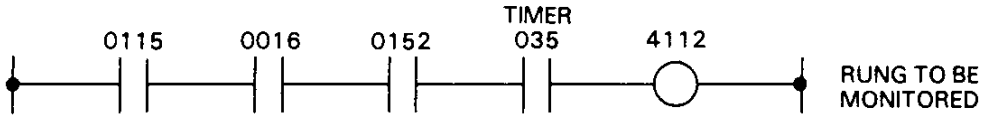
The monitor display can be accessed when in the TEST, RUN 1, RUN or PROG mode. While in the Monitor mode, the LED assignments can be made.

NOTE

While in the Monitor mode all other key operations are disabled.

Normally, when assigning the LEDs, the first contact, coil, Timer or Counter reference should be assigned to the 1 position. Once the assignments have been made and the Monitor mode is left, the LEDs will continue to show the status of the assigned reference number. The status of the monitor display is retained during power failure. The references for the monitor display can be changed as required. The contents of the monitor display register can be totally cleared only by totally erasing program memory, or by individually clearing the contact or coil assigned to each LED.

- The following sequence shows how a rung of logic can be monitored for power flow by assigning all of the contacts and the output coil to consecutive monitor LEDs. Assigning the references consecutively is not necessary; however it is easier to monitor a series of contacts or coils grouped together if they are assigned in this manner.



MONITOR DISPLAY ASSIGNMENT	CONTACT OR COIL REFERENCE
01	0015
02	0016
03	0152
04	TMR 035
05	4112

MONITOR DISPLAY ASSIGNMENT CHART

It is suggested that a record of monitor LED assignments for each program be kept for future reference. A sample form can be found in Appendix B.

Keystroke	Address Display	Data Display	
CLR	0134	----	
1	0134	1	Specifies Monitor Display LED 1
M/K	01	----	
1 5	01	15	Assigns contact 0015 to LED 1
NXT	01	15	
NXT	02	----	Advances to next LED
1 6	02	16	
NXT	02	16	
NXT	03	----	
1 5 2	03	152	
NXT	03	152	
NXT	04	----	
TMR	04	----	Assigns Timer 035 to monitor LED 04
3 5	04	35	
NXT	04	35	
NXT	05	----	
4 1 1 2	05	4112	
NXT	05	4112	

- The operating state of the assigned references can now be monitored by observing the ON or OFF condition of LEDs 1 through 5 on the monitor display.

While in the monitor display mode, the contents of each position (0 - 15) can be checked by displaying the monitor position LED number. Pushing the NXT key advances to the next position, i.e., 00, 01, 02, 03, etc. Pushing the PRV key will display the previous position, i.e., 03, 02, 01, etc. When advancing the display forward and 15 is displayed, depressing the NXT key will cause the display to wrap around to 00. Conversly, when going in the reverse direction with the PRV key; when 00 is reached, the display will next go to 15.

- To **change a reference** assigned to a monitor LED, display the LED number, enter the new reference and push NXT. That position will now contain the new reference to be monitored.

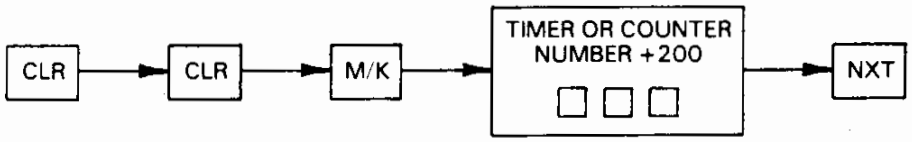
- To **clear a reference** assigned to a monitor LED, display the LED number push the CLR key, then NXT, NXT. All of the monitor references can be cleared by repeating this procedure for each monitor position.

- To **leave the Monitor mode**, push the CLR key two times; i.e. CLR ——→ CLR.

ACCUMULATED VALUE, TIMERS AND COUNTERS

The accumulated value of any Timer or Counter in a program can be monitored by entering the Timer/Counter number and observing the LED display under Address and Data on the CPU/Programmer. The Timer/Counter number can be specified while in the TEST, RUN 1, RUN or PROG mode. The changing of the accumulated value can be monitored during system operation in the RUN 1 or RUN mode.

The sequence for specifying a Timer or Counter accumulated value register and displaying the contents for monitoring purposes is shown below.

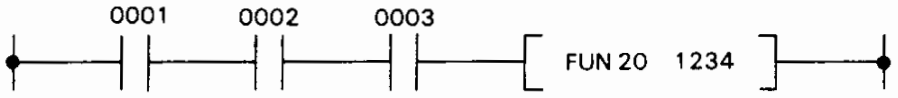


- The register reference for the accumulated value of a Timer or Counter is always the Timer or Counter number (0 to 177) plus 200. The accumulate register references are then 200 to 377 (see Table 4.8).

EXTERNAL DEVICE CHECK FAULT DETECTION DISPLAY

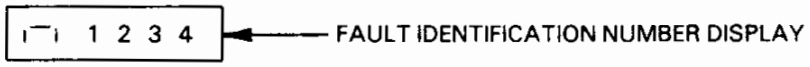
One of the special functions in the Series Three is a Function 20 instruction, which allows external devices to be monitored for a fault condition. This provides an easy way of monitoring 2 or more limit switches (for example) that should not be made at the same time without using complex ladder diagram logic. This function is described in more detail in Chapter 5. This paragraph will describe only the display generated as the result of a fault detection.

Example:



- The references 0001, 0002 and 0003 are for 3 switches that should not be closed at the same time. They are programmed in a rung of logic with a FUN20. FUN20 is a two-word instruction, the second word is a 4 digit BCD value (0000 to 9999) which when displayed indicates that the specified fault condition has occurred. The normally-open FAULT contacts on the power supply terminal board will close when a fault condition is detected by using the FUN20.

If the 3 switches in the example were closed at the same time, the fault would be detected and the fault identification number would be displayed as shown below. The FAULT LED on the CPU/Programmer will also turn on



Two data registers, 674 and 675 are used to store the fault identification number when a fault condition occurs. These registers can then be programmed to turn on an audible or visual alarm.

Any number of fault conditions can be detected by using the FUN20 with different identification numbers for each FUN20. If more than one fault occurs, the identification number of the last one to occur will be displayed. When a fault condition occurs all key operations are disabled except CLR. The display can be cleared by pushing the CLR key.

HALTING PROGRAM EXECUTION

Program execution can be temporarily stopped by switching from RUN or RUN 1 to the TEST mode. The PC scan is stopped, the condition of the program execution up to that time is retained and outputs programmed with an OUT instruction are inhibited. Outputs programmed with SET, SET OUT or D*OUT are not inhibited, inputs are updated by one scan and program execution using those commands is enabled.

SINGLE SCAN PROGRAM EXECUTION

While in the TEST mode programs can be executed one scan at a time. This is a convenient feature for testing and debugging of programs. The operation of contacts, outputs using the OUT instruction, Internal coils, Timer, Counter and SR coils can be monitored by assigning their reference numbers to the 16 point monitor display. As the program is stepped through one scan at a time, the monitor display LEDs will then reflect the state of the coils assigned to them.