

LynX-10™ PC
Bi-directional X-10 Controller for
PC Compatible Computers
Model: 104

Marrick Limited LynX-10™ PC
Manual revision 1.01
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1.0 OVERVIEW OF X-10 TECHNOLOGY

X-10 control is one of the most prolific and low cost means to automate a home or business, especially if running new wiring is prohibitive. The only major drawback to the system is the computer interface. There have been many attempts to provide a reliable two-way connection from the computer or computer like equipment to the X-10 world. The first effort was by the Power House (X-10) people themselves. This was the TW523 module which provided the optically isolated connections to the power line. It did not provide the timing required to generate the correct control commands. Next came several simple interfaces that were merely level translators to the TW523 to hook into the computer's serial or parallel ports. These interfaces required the computer to perform all the monitoring and timing requirements greatly loading the computer system. Today with the advent of multitasking systems such as Microsoft Windows™ and UNIX™, the computer cannot service a single task for 1 or 2 seconds. This would cause disastrous results in the software. Next came the chips! This was the first attempt to free the computer from the burden of the X-10 timing. These chips have parallel interfaces on one side and the TW523 interface on the other. They also suffer from several problems in that the device still needs to be polled very rapidly so as not to miss any incoming X-10 signals. X10 signals can appear at any zero crossing of the 60 Hz power or every 16.67 mS.

The Marrick Limited solution was to go back to ground zero. We designed a complete TW523 (X-10) compatible controller and interface into a single chip. The LynX-10™ PC off loads the computer of the complex timing and constant polling to ensure data integrity. This add-in card provides a 1200 bps serial port that directly controls a TW523 X-10 interface module. ALL the timing and monitoring is performed by this add-in card. It also has many built in commands to automatically handle Dimming, Brightening and Broadcast messaging. This version also provides a 32 BYTE receive FIFO on the serial port, X10 collision detection and auto retransmission, a debug mode, and many, many other exciting features.

2.0 TECHNICAL OVERVIEW

2.1. INTRODUCTION TO A LynX-10™ SESSION

The computer interface uses ASCII commands to carry out its functions. These commands are outlined below. The basic structure is a letter command such as 'N' for ON, followed by data to determine the house code, address, and type of action (all on, one unit, etc.). For example, if you wanted to turn on unit A4, you would send the ASCII string 'N003'. The controller would respond with an asterisk (*) when completed, or an 'E' if there was an error followed by a number to further explain the error. All return strings are terminated with an optional "Return String Terminator" (RST). The default RST is the carriage return character (ASCII 0x0D). Here is a typical X-10 session using a terminal emulator on the PC...

```
COMPUTER:      N000      ; Turn on unit A1
CONTROLLER:    *          ; Done... (asterisk is followed by the programmed return string)
COMPUTER:      D705      ; Dim unit A6 to level 7 (mode 0)
CONTROLLER:    *          ; Done...
CONTROLLER:    X004      ; Controller reports X-10 Received (HC=A, Unit 5)
CONTROLLER:    X102      ; Controller reports X-10 Received (HC=A, On)
COMPUTER:      F21       ; Turn off all units, house code B.
CONTROLLER:    *          ; Done...
```

Look at the last command from the computer. It instructed the controller to send an X-10 ALL UNITS OFF command to house code B. There was no need to send the address of the unit since the command applies to all addresses on that house code. This is true of all commands that address more than one unit. RESET ('R') for instance does not require any other byte to reset the controller. If the controller needs more data, the green 'BUSY' LED will stay lit until enough bytes have been received to satisfy the command requested. The first byte is the COMMAND byte, the next byte (if required) is the TYPE byte and is used to further define the action. The next byte is the HOUSE CODE byte (ASCII letters for 0-F HEX) and describes house codes A-P. The last byte (if required) is the ADDRESS byte (0-F HEX) that describes the unit address. The exception for the address byte is when sending raw X-10 commands with the 'X' command (also receiving). If byte following the 'X' is '0', then the last byte is the address. If the byte following the 'X' is a '1', then the last byte is an X-10 command code such as ALL UNITS ON. See the above example. Following is an overview of all the commands and their extensions.

2.2. LynX-10™ PROTOCOL

The LynX-10™ PC uses a condensed method for addressing and reporting unit codes. Since there are exactly 16 house codes (A-P) and 16 unit codes (1-16), it is convenient to use a hexadecimal equivalent mapping. For those not completely familiar with the hexadecimal number system, refer to Appendix B. Each house code is mapped to a hex number to allow only 1 digit per house code and 1 digit for unit code address.

Commands can take several forms, but most follow these simple rules.

1. All characters sent to the LynX-10 PC are printable ASCII codes. That is, you can send them to a terminal or printer and see the letter or number. The actual value of the code is quite different. For example, the letter "A" is ASCII code 0x41 in hexadecimal or 65 decimal. The letter "A" in our context stands for 10 decimal. One exception is the carriage return character, used in some commands, and the return string characters returned after an X-10 reception. See MODE register for details on return string terminators (RST).
2. The code structure always begins with a command code. These codes are listed in table 3 along with examples of their structure. For example, to turn on a single unit the command is "N0xy" where "xy" are found in table 1 from the house and unit code of the module you desire to turn on. If you wanted to turn on unit C3, the string of characters would be "N022"
3. Some commands use both the house code and unit code (or key code), and some only use the house code. For commands that activate every unit on a particular house code, such as ALL UNITS ON, only the house code is needed. These commands take a form similar to above, but with one less digit. For example, to turn on all units this house code for house code A, the string would be "N10" where the "1" is ALL UNITS this house code, and the "0" is for house code A from table 2.

2.3. MAPPING X-10 UNITS TO LynX-10™ CODES

To make interfacing to computers easier, a special code system is used for addressing specific units and house codes. In table 1, every possible code that can be set on an X-10 module is mapped to its hexadecimal value used with the LynX-10™ protocol. For example, if you want to address unit E10, you would look up the letter "E" along the left axis, and the number "10" on the top axis of table 1. Where the two columns intersect are the two characters used with the LynX-10™ PC to address that unit. If a command addresses an entire house code, then table 2 is used. This maps the house code to a single character for the LynX-10 protocol.

2.4. LynX-10™ PROTOCOL LOOKUP TABLES

Table 1 - Unit code to LynX-10™ protocol cross reference

UC HC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
B	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
C	20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F
D	30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
E	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
F	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
G	60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F
H	70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F
I	80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F
J	90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F
K	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
L	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
M	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
N	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
O	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
P	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF

(HC = House code, UC = Unit code -> mapping to 2 ASCII printable characters)

Table 2 - X-10 house codes mapped to LynX-10™ protocol

X-10	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
LynX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

2.4.1 LynX-10™ Protocol Lookup Table Notes

The programmer should use the tables above to determine the actual characters sent to address a unit within a command. For instance, if the command requires a house code and a unit code such as the ON command “N0”, use table 1 to look up the two characters that follow the “N0” to address the unit. Let’s say we want to address unit M15 for the ON command. We would go to table 1 and find the house code M on the left and the unit number or unit code 15 on the top. Tracing the intersection of these two we would find the two characters “CE” which is a character string representing the hexadecimal value of 0xCE. Therefore the entire ON command string sent to the LynX-10™ PC would be represented by “N0CE”. That’s the letter “N” followed by the number “0” (zero), followed by the letter “C” followed by the letter “E”. If only the house code is required as with the “N1” command, table 2 is used. The house code is on the top, and the corresponding code is on the bottom. For house code H, the character would be the number “7”, so the whole command string would be “N17”.

3.0 COMMAND SUMMARIES

3.1. OFF Command Summary

Command	Description	Example / Comments
F0xy	Turn off single unit xy (xy from table 1)	“F03F” turns off unit D16
F1x	Turn off all lights house code x (x from table 2)	“F12” turns off all lights on house code C
F2x	Turn off all units house code x (x from table 2)	“F29” turns off all units on house code J
F3	Turn off all lights, all house codes	“F3” turns off all lights on every house code
F4	Turn off all units, all house codes	“F4” turns off all units on every house code
F5	(Reserved)	Returns error E1
F6	(Reserved)	Returns error E1
F7	(Reserved)	Returns error E1
F8	(Reserved)	Returns error E1
F9	(Reserved)	Returns error E1
FA	(Reserved)	Returns error E1
FB	(Reserved)	Returns error E1
FC	(Reserved)	Returns error E1
FD	(Reserved)	Returns error E1
FE	(Reserved)	Returns error E1
FF	(Reserved)	Returns error E1

3.1.1 OFF Command Notes

The OFF commands have several flavors. Since there is a distinction between lights and units, there are OFF commands for each. When addressing a single unit, it is immaterial which it is. But when addressing groups of units, there are commands that affect only the light modules, and some that affect all modules. Marrick Limited has done some experimentation and found that some units will only respond to the ALL UNITS OFF code such as appliance modules and some light modules. These can be addressed individually, but when an ALL LIGHTS OFF command is sent, they do not turn off. Only the ALL UNITS OFF command will turn them off. You may want to experiment with your modules to see how they respond.

3.2 ON Command Summary

Command	Description	Example / Comments
N0xy	Turn on single unit xy (xy from table 1)	“N0F0” turns on unit P1
N1x	Turn on all units this house code (x from table 2)	“N15” turns off all units on house code F
N2	Turn on all units, all house codes	“N2” turns on all units on every house code
N3	(Reserved)	Returns error E1
N4	(Reserved)	Returns error E1
N5	(Reserved)	Returns error E1
N6	(Reserved)	Returns error E1
N7	(Reserved)	Returns error E1
N8	(Reserved)	Returns error E1
N9	(Reserved)	Returns error E1
NA	(Reserved)	Returns error E1
NB	(Reserved)	Returns error E1
NC	(Reserved)	Returns error E1
ND	(Reserved)	Returns error E1
NE	(Reserved)	Returns error E1
NF	(Reserved)	Returns error E1

3.2.1 ON Command Notes

The “N2” command is very useful for PANIC button implementations. With one command to the LynX-10™ PC, every unit on every house code in the house (or your neighbor’s house!) will turn on. This is a great way to scare an intruder, since it carries this out in about 6 seconds. Light is a great deterrent to intruders, since they usually try hard to avoid identification.

3.3. DIM Commands

3.3.1 DIM Command Summary (MODE 0)

Command	Description	Example / Comments
Dnxy	Dims unit <i>xy</i> to level <i>n</i> (<i>xy</i> from table 1, <i>n</i> from table 3)	“DB00” Dims unit A1 to level 11

3.3.2 DIM Command Summary (MODE 1)

Command	Description	Example / Comments
D0xn	Sends <i>n</i> number of DIMs to house code <i>x</i> (<i>x</i> from table 2, <i>n</i> from table 4)	“D035” sends 5 DIMs to house code D
D1xn	Sends <i>n</i> number of BRIGHTs to house code <i>x</i> (<i>x</i> from table 2, <i>n</i> from table 4)	“D124” sends 4 BRIGHTs to house code C
D2	(Reserved)	Returns error E1
D3	(Reserved)	Returns error E1
D4	(Reserved)	Returns error E1
D5	(Reserved)	Returns error E1
D6	(Reserved)	Returns error E1
D7	(Reserved)	Returns error E1
D8	(Reserved)	Returns error E1
D9	(Reserved)	Returns error E1
DA	(Reserved)	Returns error E1
DB	(Reserved)	Returns error E1
DC	(Reserved)	Returns error E1
DD	(Reserved)	Returns error E1
DE	(Reserved)	Returns error E1
DF	(Reserved)	Returns error E1

	Low					Med					Hi					
Level	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
n	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

Table 3 - Dim levels for DIM command (n for MODE 0 DIM command)

Count	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
n	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

Table 4 - Number of DIMs or BRIGHTs (n for MODE 1 DIM command)

(Note: In DIM MODE 1, sending a count of 0 sends 1 DIM or BRIGHT command)

3.3.3 DIM Command Notes

The DIM command can run in either of two modes defined by BIT 1 of the MODE register. MODE 0 is the legacy or original mode where an absolute level is specified. MODE 1 sends up to 15 DIMs or BRIGHTs in a row. This is useful for BRIGHT up from DIM.

3.4. X-10 STATUS Command Summary

Command	Description	Example / Comments
S0x	Sends a status OFF command for the unit requested (<i>x</i> from table 2) note: see text	“S0F” sends OFF status for house code P unit
S1x	Sends a status ON command for the unit requested (<i>x</i> from table 2) note: see text	“S11” sends ON status for house code B unit
S2xy	Requests status of unit <i>xy</i> (<i>xy</i> from table 1) note: see text	“S2CA” requests current status for unit M11
S3	(Reserved)	Returns error E1
S4	(Reserved)	Returns error E1
S5	(Reserved)	Returns error E1
S6	(Reserved)	Returns error E1
S7	(Reserved)	Returns error E1
S8	(Reserved)	Returns error E1
S9	(Reserved)	Returns error E1
SA	(Reserved)	Returns error E1
SB	(Reserved)	Returns error E1
SC	(Reserved)	Returns error E1
SD	(Reserved)	Returns error E1
SE	(Reserved)	Returns error E1
SF	(Reserved)	Returns error E1

3.4.1 X-10 STATUS Command Notes

These codes were defined by Power House to check the status of individual units. There is only one known unit from them that uses it. This is the model number PR511 outdoor floodlight. This unit will respond with a STATUS OFF or STATUS ON code when addressed and its status requested. Other Marrick Limited products such as our LynX-PORT™ X-10 compatible input/output board uses these status commands.

3.5. DIRECT X-10 ACCESS Command Summary

Command	Description	Example / Comments
X0xy	Addresses unit xy for next command (xy from table 1)	“X067” address X-10 unit G8
X1x0	Sends an ALL UNITS OFF command to house code x (x from table 2)	“X1F0” sends ALL UNITS OFF to house code P
X1x1	Sends an ALL LIGHTS ON command to house code x (x from table 2)	“X141” sends ALL LIGHTS ON to house code E
X1x2	Sends an ON command to house code x (x from table 2)	“X102” sends ON to house code A
X1x3	Sends an OFF command to house code x (x from table 2)	“X113” sends OFF to house code B
X1x4	Sends a single DIM to house code x (x from table 2)	“X154” sends DIM to house code F
X1x5	Sends a single BRIGHT to house code x (x from table 2)	“X155” sends BRIGHT to house code F
X1x6	Sends ALL LIGHTS OFF command to house code x (x from table 2)	“X106” sends ALL LIGHTS OFF to house code A
X1x7	Sends EXTENDED CODE to house code x (x from table 2) note: see text	“X127” sends EXTENDED CODE to house code C
X1x8	Sends HAIL REQUEST to house code x (x from table 2) note: see text	“X1B8” sends HAIL REQ to house code L
X1x9	Sends HAIL ACKNOWLEDGE to house code x (x from table 2) note: see text	“X1B9” sends HAIL ACK from house code L
X1nA	Sends PRESET DIM with MSB of 0 and n level (n from table 3) note: see text	“X15A” commands last addressed light to level 5
X1nB	Sends PRESET DIM with MSB of 1 and n level (n from table 3) note: see text	“X12B” commands last addressed light to level 18
X1xC	Sends EXTENDED DATA to house code x (x from table 2) note: see text	“X10C” sends EXTENDED DATA to house code A
X1xD	Sends STATUS ON for house code x (x from table 2) note: see text	“X15D” sends STATUS ON to house code F
X1xE	Sends STATUS OFF for house code x (x from table 2) note: see text	“X15E” sends STATUS OFF to house code F
X1xF	Sends STATUS REQUEST to house code x (x from table 2) note: see text	“X12F” requests status from last addressed unit on house code C

3.5 DIRECT X-10 ACCESS Command Summary (Continued)

Command	Description	Example / Comments
X2	(Reserved)	Returns error E1
X3	(Reserved)	Returns error E1
X4	(Reserved)	Returns error E1
X5	(Reserved)	Returns error E1
X6	(Reserved)	Returns error E1
X7	(Reserved)	Returns error E1
X8	(Reserved)	Returns error E1
X9	(Reserved)	Returns error E1
XA	(Reserved)	Returns error E1
XB	(Reserved)	Returns error E1
XC	(Reserved)	Returns error E1
XD	(Reserved)	Returns error E1
XE	(Reserved)	Returns error E1
XF	(Reserved)	Returns error E1

3.5.1 Direct X-10 Access Command Notes

The direct access commands allow the programmer to have direct control over X-10 modules and subsystems. This provides the most flexibility, but also requires more attention to detail. Code X0 is used to address units, and can be used several times in a row on the same house code to address a group of units. The X1 command along with its subcommand is used to tell the unit or units what to do, or to request information from advanced X-10 units. If a group is addressed, only a single command is needed to cause all the units to respond. This is useful when turning on or off several units together. It is also quicker to do so in that the individual commands are not sent. So if seven units are addressed and then a single on command is sent, there will be a net savings of 6 commands or over 2 seconds.

Certain X-10 codes such as HAIL REQUEST or STATUS REQUEST require advanced X-10 modules to operate. Not all modules will respond to these commands. Ask the manufacturer for details on what commands are supported and how they are implemented. There are two commands called EXTENDED CODE and EXTENDED DATA. These commands can be transmitted with the LynX-10 PC board, but their documented implementation cannot do to the limits of the TW-523 interface module. These codes require a continuous data stream without the normal 3 power line cycle idle periods between them. The TW-523 will not receive these codes. Therefore, only the command itself without the data can be sent. This still can be utilized to activate remote equipment, or to tell a unit the next address it receives is data, not address. This would allow a “nibble” mode of data transfer between LynX-10 subsystems. The Marrick Limited LynX-PORT™ remote I/O board uses this method for remote programming of settings and parameters.

3.6 X-10 HAIL Command Summary

Command	Description	Example / Comments
H0	Requests if any other controller is using house code A. note: see text	"H0" requests control of house code A
H1	Requests if any other controller is using house code B. note: see text	"H0" requests control of house code B
H2	Requests if any other controller is using house code C. note: see text	"H0" requests control of house code C
H3	Requests if any other controller is using house code D. note: see text	"H0" requests control of house code D
H4	Requests if any other controller is using house code E. note: see text	"H0" requests control of house code E
H5	Requests if any other controller is using house code F. note: see text	"H0" requests control of house code F
H6	Requests if any other controller is using house code G. note: see text	"H0" requests control of house code G
H7	Requests if any other controller is using house code H. note: see text	"H0" requests control of house code H
H8	Requests if any other controller is using house code I. note: see text	"H0" requests control of house code I
H9	Requests if any other controller is using house code J. note: see text	"H0" requests control of house code J
HA	Requests if any other controller is using house code K. note: see text	"H0" requests control of house code K
HB	Requests if any other controller is using house code L. note: see text	"H0" requests control of house code L
HC	Requests if any other controller is using house code M. note: see text	"H0" requests control of house code M
HD	Requests if any other controller is using house code N. note: see text	"H0" requests control of house code N
HE	Requests if any other controller is using house code O. note: see text	"H0" requests control of house code O
HF	Requests if any other controller is using house code P. note: see text	"H0" requests control of house code P

3.6.1 X-10 HAIL Command Notes

The HAIL command was devised by Power House to enable automatic switching of house codes on simple, low module count systems. It was only implemented on a few systems and in general can be used for anything the programmer decides. The intent of the command was to send out a HAIL REQUEST on a house code to see if anyone else (like a neighbor) was using it. If another intelligent controller received the HAIL REQUEST on its house code, it would respond with a HAIL ACKNOWLEDGE. The initiating controller would then try another house code until an unused one could be isolated. The Marrick Limited LynX-PORT™ remote IO controller responds to this code with Hail Acknowledge.

3.7 RESET Command Summary

Command	Description	Example / Comments
R	Resets LynX-10™ PC	“R” Clears “SINCE RESET” timer (see below). Reloads settings from EEPROM

3.8 TIMER REQUEST Command Summary

Command	Description	Example / Comments
T	Request time since LynX-10™ PC reset. Returned as DD:HH:MM:SS where DD is number of days 00-99, HH is hours 00-23, MM is minutes 00-59, and SS is seconds 00-59.	“T” reports time since power line carrier present or reset.

3.8.1 TIMER REQUEST Command Notes

The timer can be used to determine if the carrier has returned after an E7 (carrier lost) error is received at the computer. The timer will always remain at 00:00:00:00 until the power at the TW-523 returns. The programmer can check every several seconds or so to see if this timer has started incrementing again. This would indicate the return of the power at the TW-523 module. Since this is the only command that returns a number first, it can be easily parsed by checking for either a colon (“:”) or a number without a command identifier such as “X” or “E”.

The status command ‘S3’ can also be used to check the presence of power at the TW-523 and the time can be used to indicate elapsed time since last power failure.

3.9 LynX-10™ MICROCODE VERSION REQUEST Command Summary

Command	Description	Example / Comments
V0	Returns current version number of LynX-10™ PC's microcode to computer in the form Vxxx-xxx where xxx-xxx is the version.	"V0" returns current version to computer.
V1	Returns copyright of LynX-10™ microcode to computer. This is always "Copyright (c) xxxx Marrick Limited, Inc." where xxxx is the year of release.	"V1" returns current date of copyright to computer.
V2	(Reserved)	Returns error E1
V3	(Reserved)	Returns error E1
V4	(Reserved)	Returns error E1
V5	(Reserved)	Returns error E1
V6	(Reserved)	Returns error E1
V7	(Reserved)	Returns error E1
V8	(Reserved)	Returns error E1
V9	(Reserved)	Returns error E1
VA	(Reserved)	Returns error E1
VB	(Reserved)	Returns error E1
VC	(Reserved)	Returns error E1
VD	(Reserved)	Returns error E1
VE	(Reserved)	Returns error E1
VF	(Reserved)	Returns error E1

Note: Sending carriage return after the "V" returns both the copyright and the version number.

3.10 LynX-10™ STATISTICS COUNTER REQUEST Command Summary

Command	Description	Example / Comments
C00 ↵	Returns value of statistics counter 00 in form C00=xxxx where xxxx is character string representing the HEX value of the count. This counter is for error E0 - X-10 RECEPTION ERRORS. NOTE: This counter can be cleared by sending the string "C00=0" to the LynX-10 board.	"C00" followed by a carriage returns to the computer "C00=0045" which would indicate that 0x0045 X-10 reception errors have occurred since the counter was cleared.
C01 ↵	Same as above for errors E1 - BAD COMMAND FROM COMPUTER.	(see above example)
C02 ↵	Same as above for errors E2 - BAD DATA FROM COMPUTER.	(see above example)
C03 ↵	Same as above for errors E3 - X10 COLLISIONS DETECTED.	(see above example)
C04 ↵	Same as above for errors E4 - X10 TRANSMISSION FAILURE.	(see above example)
C05 ↵	Same as above for errors E5 - X10 LOST RECEPTION.	(see above example)
C06 ↵	Same as above for errors E6 - SERIAL RECEIVE BUFFER OVER-RUN.	(see above example)
C07 ↵	Same as above for errors E7 - LOST CARRIER (no power at TW-523)	(see above example)
C08 through CFF	(Reserved)	Returns error E2

3.10.1 STATISTICS COUNTER REQUEST Command Notes

The symbol ↵ represents a carriage return or ASCII 0x0D. Also, all counters can be cleared in the same fashion as C00 shown above. For example, to clear C07, send "C07=0" to the LynX-10™ PC. Counters C08 through CFF are reserved for future revisions of the microcode and will return an error E2.

3.11 LynX-10™ REGISTER ACCESS Command Summary

Command	Description	Example / Comments
M00 ↵ or M00=xx	<u>MODE REGISTER</u> M00 followed by a carriage return will return to the computer the current value of the MODE register. M00=xx will set the MODE register to the hexadecimal value represented by the character string xx. NOTE: See MODE register for details	The MODE register is used to set the operation of the LynX-10™ PC. Example: "M00=01" will enable DEBUG mode by setting bit 0 of the MODE register.
M01 ↵ or M01=xx	<u>SERIAL FIFO THRESHOLD</u> M01 followed by a carriage return will return to the computer the current value of the SERIAL FIFO THRESHOLD register. M01=xx will set the register to the hexadecimal value represented by the character string xx. This value can be anything between 01 and 1C.	The threshold is set from the factory at hexadecimal 10 or decimal 16. This puts it at the half way point of the FIFO for best results with 16550 UARTS. "M01=1A" would set it to decimal 26.
M02 ↵ or M02=xx	<u>X-10 RETRANSMISSION ATTEMPTS</u> M02 followed by a carriage return will return to the computer the current value of the X-10 RETRANSMISSION ATTEMPT register. M02=xx will set the register to the hexadecimal value represented by the character string xx. This value can be anything between 00 and FF.	The X-10 retransmission attempt register is used to adjust the number of tries for the X-10 transmission routine after collisions occur. This is set to hexadecimal 10 or decimal 16 from the factory. It can be set anywhere from 00 (no attempts after collision) to FE (254 attempts). NOTE: Setting this register to FF will cause continuous attempts forever until a successful transmission occurs without a collision.
M03 through MFF	(Reserved)	Returns error E2

3.11.1 REGISTER ACCESS Command Notes

The symbol ↵ represents a carriage return or ASCII 0x0D. See section 6.1 regarding the functions of each bit in the MODE register. Also, be careful when setting the retransmission counter to "FF" or decimal 255 which will continue to transmit *FOREVER* or until the transmission is successful. This will prevent any other command from getting in front of it including the RESET command.

3.12 LynX-10™ WRITE TO EEPROM Command Summary

Command	Description	Example / Comments
W0	Saves current settings into the EEPROM. This includes the MODE register, the SERIAL FIFO THRESHOLD register, and the X-10 RETRANSMISSION ATTEMPTS register.	“W0” will save all setting for next reset or power-on.
WF	Restores all factory settings to the LynX-10™ PC board. This will set the MODE register to 00, and set both the FIFO threshold and the X-10 retransmission attempts to 16 (10 hexadecimal). <i>It also will clear ALL statistics counters to 0 and reset the run timer to 0.</i>	“WF” restores all factory settings and resets the board.

NOTE: During power-up or reset, all settings are read from the EEPROM and restored into memory. If a temporary change is made and it is not desired to remain after reset, do not save the settings to the EEPROM.

4.0 ERROR CODES

4.1 LynX-10™ PC ERROR CODES : (LEDS)

NOTE: ALL LEDS TURN ON FOR TEST, ALL GO OFF IF HEALTHY, ELSE...

1. ERROR & TW523 LED : BAD ACCUMULATOR (**FATAL**)
2. ERROR & BUSY LED : BAD REGISTER (**FATAL**)
3. ERROR & X-10 LED : BAD MEMORY LOCATION (**FATAL**)
4. ERROR LED ONLY : INTERNAL ERROR (**NON-FATAL**) - SEE BELOW

4.2 LynX-10™ PC ERROR CODES:

NOTE: SENT TO COMPUTER FROM LynX-10™ PC

- E0 : RECEPTION ERROR (X10)
- E1 : BAD COMMAND RECEIVED FROM COMPUTER
- E1 : BAD DATA RECEIVED FROM COMPUTER
- E3 : X10 COLLISION DETECTED DURING TRANSMISSION
- E4 : X10 TRANSMISSION FAILURE (TIME OUT)
- E5 : X10 LOST RECEPTION (LOST TX ECHOES FROM TW-523)
- E6 : SERIAL COMMUNICATION RX FIFO OVER-RUN
- E7 : CARRIER LOST (50/60Hz POWER FAILURE AT TW-523)

NOTE: All error codes map to statistics counters one to one. Example: if an E4 error is received by the computer, the statistics counter 04 (C04) will be incremented by 1.

5.0 HARDWARE CONSIDERATIONS

5.1 COMMUNICATIONS

The LynX-10™ PC communicates with the computer at a fixed rate of 1200 bits per second (bps). This may seem slow, but the actual symbol rate on the power line is only 60 symbols per second. It takes 11 symbols to complete 1 address or command and each group of 11 symbols are transmitted twice to assure reception. Most commands such as “ON” and “OFF” require an address (House code and unit ID) and a command (House code and command). Each are 11 symbols long including the start field. These are sent twice which means the actual rate at which things turn on or off is about 44 cycles of the 60 cycle power or over 2/3 of a second per 4 bytes of data from the computer or about 22 bps. The full setup for the computer’s serial port is:

1200 BPS, NO PARITY, 8 DATA BITS, 1 STOP BIT

5.2 HAND SHAKING

The LynX-10™ PC has a 32 byte queue that holds transmitted data from the computer. Once the command begins sending X-10 data on the power line, the LynX-10™ PC can continue to receive data until the FIFO threshold is reached. At this point, the coprocessor chip de-asserts Clear To Send (CTS) and will optionally send an XOFF (0x13) code to the computer (see MODE register settings). When the level of the internal FIFO falls below the threshold level, the CTS signal is re-asserted and optionally the XON (0x11) code is sent to the computer. From the factory, the threshold is set at 16 (half the size of the FIFO). This will allow a 16550 UART to flush it’s FIFO if the computer’s serial driver software is emulating hardware handshaking without losing data. Optionally this threshold can be set anywhere between 1 and 31 bytes. We recommend leaving it set for 16 bytes for optimal performance and best communications integrity. **NOTE: If the internal FIFO is over-run, data will be lost and an E6 error will be sent to the computer for each dropped character.**

Return data from the power line is decoded into raw X10 commands that all begin with an ‘X’ as described in the command section above and sent directly to the computer with no handshaking. A receive queue must be large enough or serviced frequently enough to prevent overrun of receive data. Most communications drivers have sufficient queues including those for Windows, Windows NT, Windows 95, UNIX, OS/2, and DOS.

6.0 SOFTWARE CONSIDERATIONS

6.1 MODE REGISTER

The mode control register sets the programmable features of the LynX-10™ PC. This register can be copied to the non-volatile EEPROM on the LynX-10™ PC. When the controller is powered up or reset, the settings saved in the EEPROM will be automatically reloaded. The usage of each bit is described below. To set these bits, the programmer must write an entire hexadecimal value to the mode register using the "M00=xx" command where xx is the hexadecimal byte. The mode register can be read back out by issuing a "M00" string followed by a carriage return (0x0D). For example if the programmer wishes to set bits 1 and 6, that would be a hexadecimal 42 (0x42). The string would be "M00=42". This would enable DIM MODE 1, and set the return string terminator to a LINE FEED.

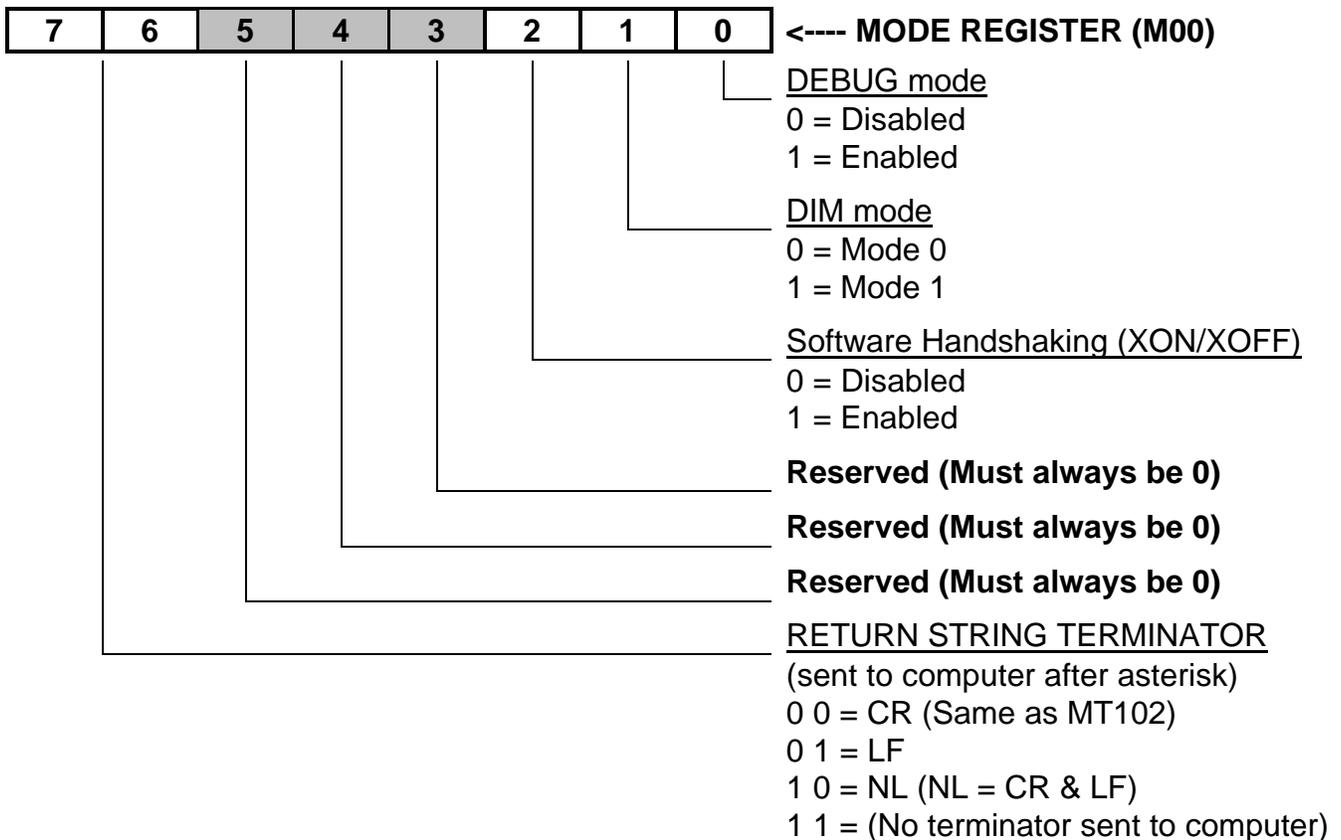


Figure 1 - Mode register bit definitions

6.1.1 DEBUG Mode

The LynX-10™ PC can be put into a mode that will send both the 'X' command and the raw bits received off the power line to the computer. When DEBUG mode is enabled in the MODE register, any data received from the TW-523 will be sent to the computer as raw bits followed by the 'X' interpreted commands. The raw bits are prefaced by the letter "Y" to indicate the data type to allow software parsing. Example: Received data might look like this in DEBUG mode.

```
Y1110010101010101100101  
X0C2  
Y1110010101010101100110  
X1C2
```

The characters after the "Y" represent the undecoded raw X-10 bits from the TW-523. A "1" character represents the presence of the 120kHz signal on a zero crossing. A "0" character represents the absence of the 120kHz signal. See the Power House TW-523 specification for details on how these bits are encoded. This mode is enabled by setting bit 0 of the MODE register (see MODE register above)

6.1.2 Return String Terminators

When a command is successfully completed, the LynX-10™ PC sends an asterisk ("*" - 0x2A) to the computer. The LynX-10™ PC has the ability to return several string termination characters following the asterisk. These are CR (carriage return - 0x0D), LF (line feed - 0x0A), NL (new line - CR & LF), or no string terminator. This allows the programmer to use the return string character that the operating system can handle. See the MODE register for details on how to set this up.

6.1.3 50/60Hz Automatic Detection and Switching

The LynX-10™ PC automatically detects the frequency of the line current. This is monitored every cycle of the power line and the internal timing is automatically adjusted to either 50 Hz (Europe) or 60 Hz (USA and Canada). No user intervention is required.

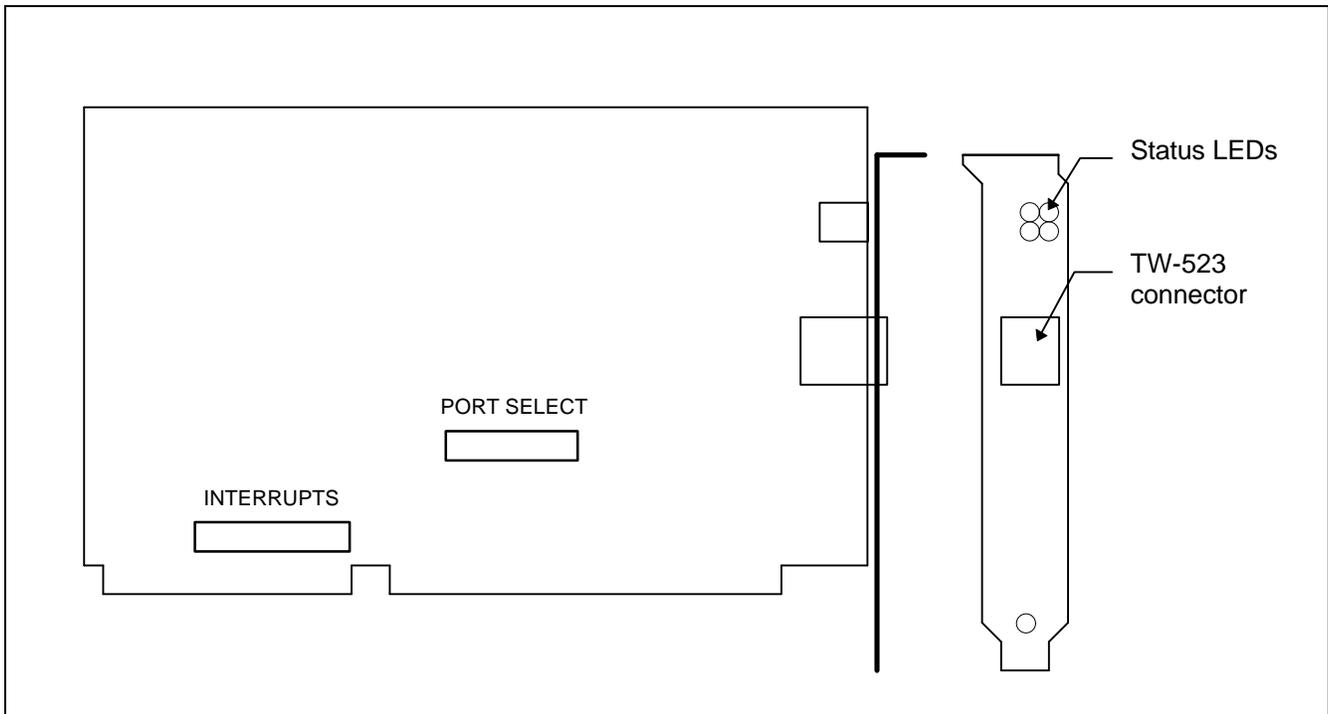
NOTE: The Power House TW-523 must be the correct version for the region of the world in which it will be used.

Appendix A - Interrupt and COM Port Selection

Shown below in figure 2 is the location of the LynX-10™ PC add-in card jumpers for selecting the interrupt and COM port. Only one COM port and one interrupt can be selected at any time. To select an interrupt, move the shorting shunt so that it lines up with the desired interrupt number printed on the LynX-10™ PC add-in card. Do the same for the COM port number.

The LynX-10™ PC supports up to 8 COM port addresses. The first four communication ports use the standard addresses for COM1 through COM4. COM5 through COM8 are non-standard (see table 5), but can be used with Windows 3.1, Windows 95, Windows NT, or many other communications drivers by changing the default address of the communications port in your operating system's configuration software such as Window's control panel. Microsoft Windows will support 9 communications ports using the standard COMM.DRV communications driver. See your operating system documentation for details.

Figure 2 - Locations of jumpers for interrupt and port selection

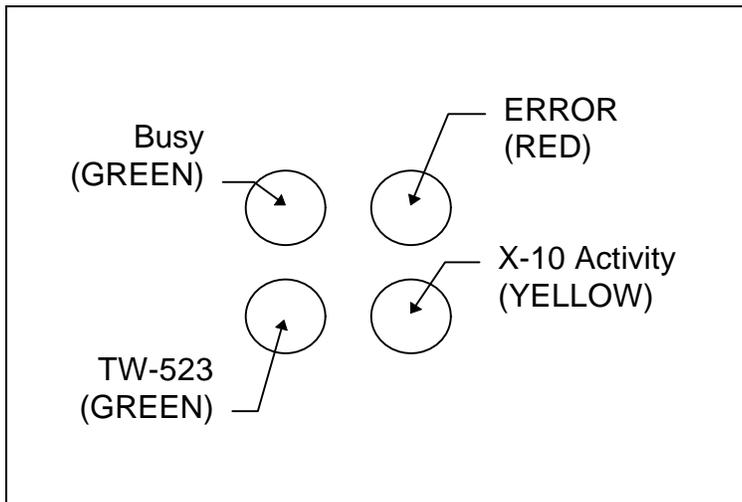


Appendix A - Interrupt and COM Port Selection (continued)

Table 5 - COM port addresses

COM Port	Address (HEX)
COM1	0x03F8
COM2	0x02F8
COM3	0x03E8
COM4	0x02E8
COM5	0x0300
COM6	0x0320
COM7	0x0340
COM8	0x0360

Figure 3 - LEDs view from back bracket



Appendix B - Hexadecimal Numbering Overview

Table 6 - Hexadecimal and decimal relationship

Bit 3	Bit 2	Bit 1	Bit 0	Decimal	Hexadecimal
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	2	2
0	0	1	1	3	3
0	1	0	0	4	4
0	1	0	1	5	5
0	1	1	0	6	6
0	1	1	1	7	7
1	0	0	0	8	8
1	0	0	1	9	9
1	0	1	0	10	A
1	0	1	1	11	B
1	1	0	0	12	C
1	1	0	1	13	D
1	1	1	0	14	E
1	1	1	1	15	F

The HEXADECIMAL system is an outgrowth of the binary system of 1's and 0's used in computers. In hexadecimal, one character is used to define four bits. This is handy when using a large number of bits as in today's 32 bit microprocessors. Writing 32 ones and zeros in a row can take up some space. In hexadecimal (usually called "HEX"), it would only take 4. In the table above, all the possible combinations of the 1's and 0's are defined with both the decimal (known as base 10 - the numbers we humans use) and hexadecimal (base 16) numbers. Since our normal base 10 system only has 10 characters in it, we need to extend the characters with letters to reach 16. This is why A,B,C and so on, up to the letter F are used. This provides 6 more characters to indicate the remaining combinations. Putting two hex characters next to each other now provides a place holder for not 10 but 16. That is, the most significant digit stands for the number of 16's there are. For example, if you had the hex value 32 (usually represented by 0x32 to indicate hex), there would be (3x16) + (2x1) counts or a decimal 50. The next digit would be the counts of 256 (16x larger), and the next would be the counts for 4096. If we had the hex value 1A5F, that would be equal to the decimal value of,

$$(1 \times 4096) + (10 \times 256) + (5 \times 16) + (15 \times 1) = 6751$$

or in binary: 0001101001011111. You can break the binary apart into 4 bit groups and see where the hex number is derived from. The 0001 is 1, 1010 is A, 0101 is 5, and 1111 is F. You can see how convenient this method is. There are calculators designed to do math in base 16. The Windows 3.1 Calculator program has a scientific mode that supports hex arithmetic. Try it out for your self. Hexadecimal numbers are sometime written with a

subscript 16 like this: 19_{16} which indicates base 16. The 19 in this case would be equivalent to a decimal 25. If they are mixed with base 10 numbers, this notation really helps.

Most computer books discuss hexadecimal arithmetic, so if this is still not clear, you may wish to make a trek to your favorite book store and check out the ever growing computer section for some help.

Shown below in table 6 is the American Standard Code for Information Interchange or ASCII. The left axis is the least significant digit in both hex and binary, and the top is the most significant digit. This table is provided for your reference.

MSD LSD	0 0000	1 0001	2 0010	3 0011	4 0100	5 0101	6 0110	7 0111
0 0000	NUL	DLE	SP	0	@	P	'	p
1 0001	SOH	DC1	!	1	A	Q	a	q
2 0010	STX	DC2	"	2	B	R	b	r
3 0011	ETX	DC3	#	3	C	S	c	s
4 0100	EOT	DC4	\$	4	D	T	d	t
5 0101	ENG	NAK	%	5	E	U	e	u
6 0110	ACK	SYN	&	6	F	V	f	v
7 0111	BEL	ETB	'	7	G	W	g	w
8 1000	BS	CAN	(	8	H	X	h	x
9 1001	HT	EM	)	9	I	Y	i	y
A 1010	LF	SUB	*	:	J	Z	j	z
B 1011	VT	ESC	+	;	K	[	k	{
C 1100	FF	FS	,	<	L	\	l	|
D 1101	CR	GS	-	=	M	]	m	}
E 1110	SO	RS	.	>	N	↑	n	~
F 1111	SI	VS	/	?	O	←	o	DEL