

**D**

id you ever wish you could control the light blazing through your skylights on a summer afternoon? That collimated beam sears the

plants, nullifies the air conditioning, and slices anything that passes through it like a carbon-dioxide laser. Wouldn't it be nice to have the same command of your home's natural lighting that you have of its artificial lighting?

This project was conceived from just such need.

My wife Kim loves interior designing and, as a result, things get moved around from time to time. She decided the entertainment étagère should be moved from its old location and centered on the large window in our living room. She claimed it would balance the room and back light the figurines in the cubbyholes.

The rearrangement did exactly that as well as creating a magnificent light sculpture! Unfortunately, it introduced a contrast problem for daytime TV viewing and rendered the window's two miniblinds nearly inaccessible.

Operating the blinds became a dreaded task which involved scaling the furniture. To solve this problem, one option was a commercial blind motor. Rocker-switch operated, it offered little more than manual control and sold for around \$300.

# The Blind Robot

## An X-10 Miniblind Automation System



Our other option of leaving the blinds permanently closed solved the problem of scaling furniture, but left us without our recently acquired backlighting and light sculpture.

Dissatisfied with those choices, I pondered a "techno-cure" that would address all problems involving the blinds, including those throughout the rest of our home. At this point in time, we were making rounds twice a day to open and close them all.

My efforts to eliminate this chore, ultimately coalesced in the X-10 Miniblind Automation System or, if you'd rather, XMAS, the blind robot. Photo 1 shows the final prototype and Figure 1 illustrates the simplicity of the system.

XMAS has control circuits and a drive motor which fit within the blind's header assembly. An adapter unit connects to an

HERBERT **McKINNEY, JR.**

For Herb, home automation includes not only control of artificial lighting, but also control of natural lighting. The X-10 Miniblind Automation System offers individuals the possibility to reach beyond the confines of their home and stop the impact of a blistering summer day.

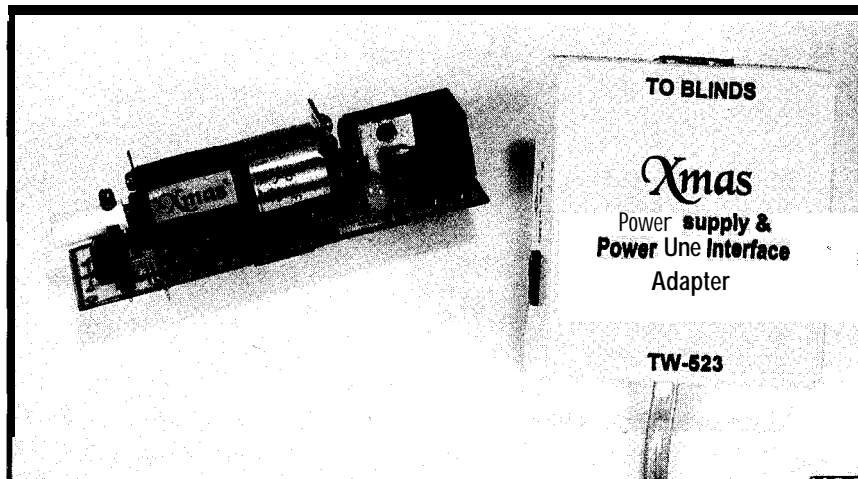


Photo 1: The final prototype was constructed on a single-sided PCB.



X-10 interface module (TW523) and power supply. A modular cable connects the adapter and blind units. The cable may be concealed in a traditional installation manner along baseboards or run through walls to outlets in the window sills for a more professional installation. Up to 256 units may be connected with each unit having a unique address or up to eight units may be grouped into one unique address.

XMAS operates almost as a lamp module. It interprets X-10 on, off, bright, and dim commands as open, close, up step, and down step, respectively. There are 16 stages between full up and full down. Additionally, the closed position (i.e., off) is jumper selected between up or down. Control and programming of XMAS units can be supplied by virtually any controller capable of transmitting X-10 commands.

### THE DEMON SEED

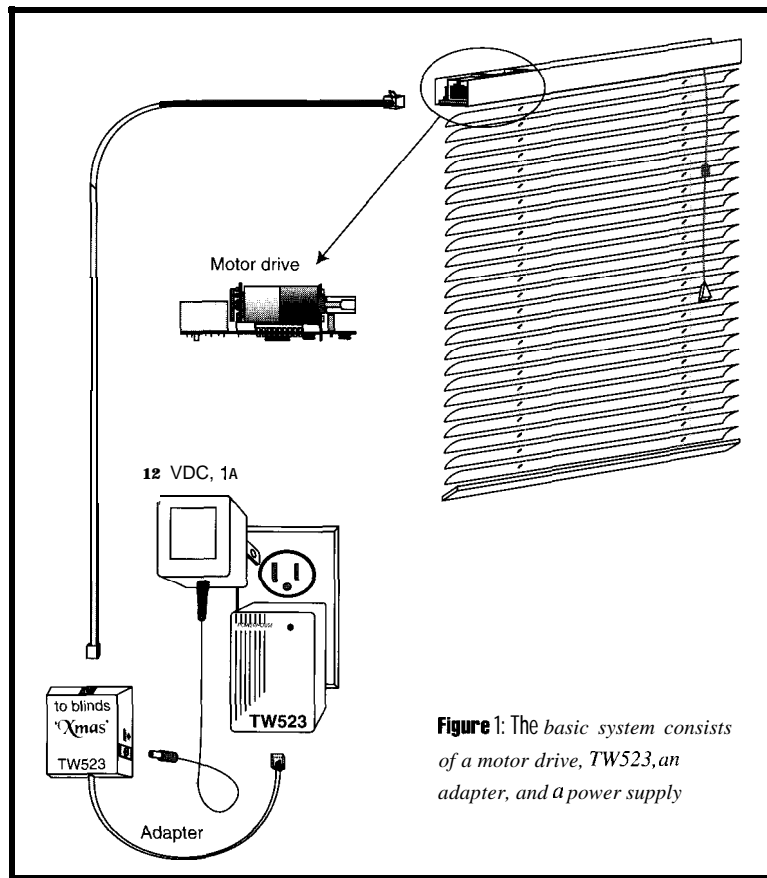
The humble beginning of XMAS was as elementary as a surplus motor and a VCR load-motor driver. Life was easy.

XMAS evolved from my knack for taking something that is extremely simple and making it much more complicated. XMAS needed to be X-10 controlled and considerably smaller. It also had to be totally manufactured in my workshop.

After some thinking, I concluded that the primary goals for XMAS were that it be cost effective, easily installed, universal, and retrofittable. Twice, I completely designed it in my mind-ach time allowing ample time for the idea to pass as a silly notion. But, after the code was about half done, I finally pulled out the stops and put it to the drawing board. Kim wanted it next week. Sound familiar?

### THE MECHANICS

As Figure 2 demonstrates, the drive motor attaches to the blind's actuator rod with a coupler suitable to the model of blind.



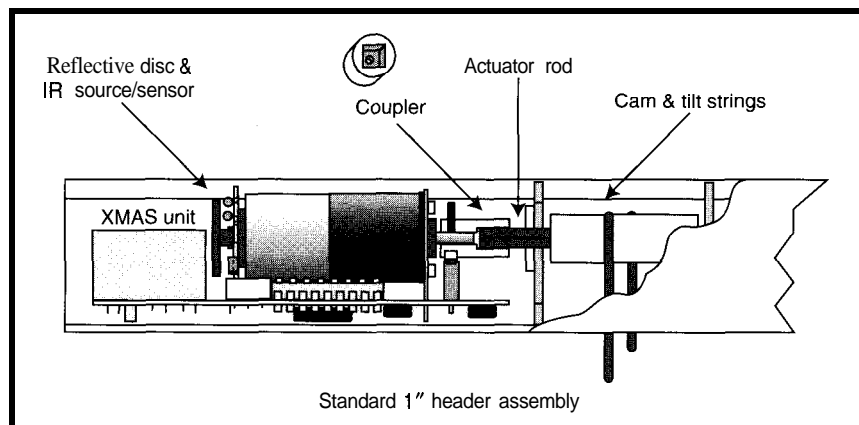
**Figure 1:** The basic system consists of a motor drive, TW523, an adapter, and a power supply

A set screw, which secures the coupler to the motor shaft, also actuates the limit switches.

The motor is a 16-mm, 6-V, 15,200-RPM, 3/8-W unit with an extended rear shaft. To this shaft, I attach a photo-reflective disk and sensing PCB to count revolutions. Coupled to the front shaft is a 1670:1 gearhead. The complete assembly develops an intermittent torque of 14.2 oz.-in. and a continuous torque of 7 oz.-in. This easily exceeds the load of two of the largest blinds

and actuator rod in the smallest header. The motor and RJ-11 jack placements are relatively fixed and occupy 52% of the board space. So, the remaining components are placed for the tightest fit that routes without DRC errors.

I managed to keep all components on grid, albeit a small one. The mounting tabs of the RJ-11 connector and forward motor support provide



**Figure 2:** First, the worm and sector (drive) must be removed from the stock header. This is usually a pop-in plastic assembly in newer blinds. The XMAS unit then slides into the header and mates with the actuator rod.



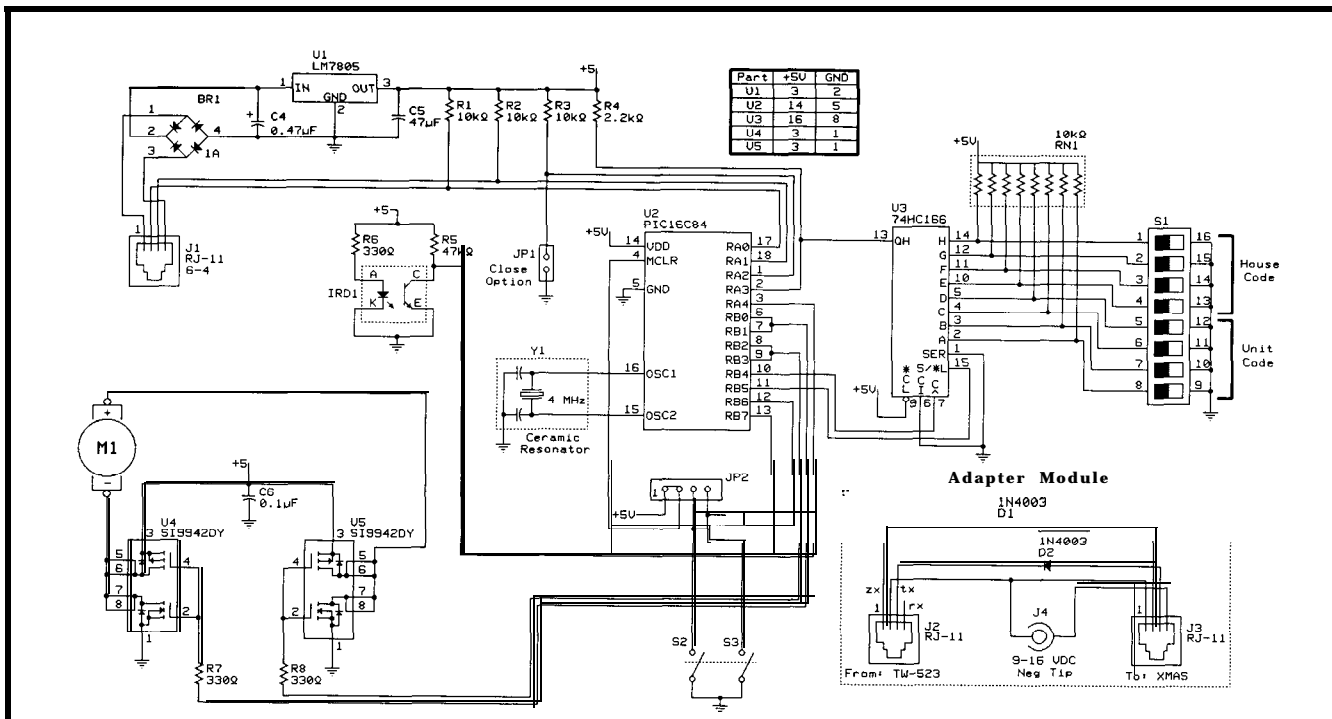


Figure 3: Thanks to small outline packaging, this circuit (excluding the adapter module) fits onto a 2.8 square inch PCB

stand-off for the bottom-layer components. There is a 5-mil Lexan sheet beneath for additional protection. I use 0.031" or 0.062" FR-4 material in larger headers that may need motor alignment.

### THE ELECTRONICS

The processor is a Microchip PIC 16C84 clocked by a 4-MHz ceramic resonator. Since the PIC16C84 has been covered in prior issues of *INK*, I'll go straight into the details of this application.

The design takes advantage of the PIC's in-circuit programmability. The applicable pins may be accessed after assembly through a jumper header. The EEPROM lets me program the controller and revise firmware on a completed unit without having to remove the chip. This convenience, coupled with the small footprint of the SO-18 package, makes the PIC16C84 the perfect controller for the job.

Figure 3 provides a schematic. The RA port accommodates the ZERO CROSSING, DATA IN, the revolution counter (RTCC), and CLOSE option signals. The specific house and unit codes are set by an 8-bit DIP switch (see Table 1) and read serially through a 74LS166 shift register by RA3.

The 74LS 166 (SO-16) occupies Park Place real estate, but it liberates five I/O pins for needed functions. RB 0: 1 and 2:3 are motor control bits paralleled to increase drive current for future motor driver improvements. (Note: The original driver was a BAL6686, available only in small quantities. It's a 9-pin, SIP, SOP IC used in RC servo motors.)

I'm pleased to say the board has already been updated to accommodate two Siliconix "Little Foot," dual-complementary, power MOSFETs. This switch involved only minor layout changes on one end of the PCB and greatly improved performance.

Listing 1: CFG\_PINS determines which pins are ZX and DATA.

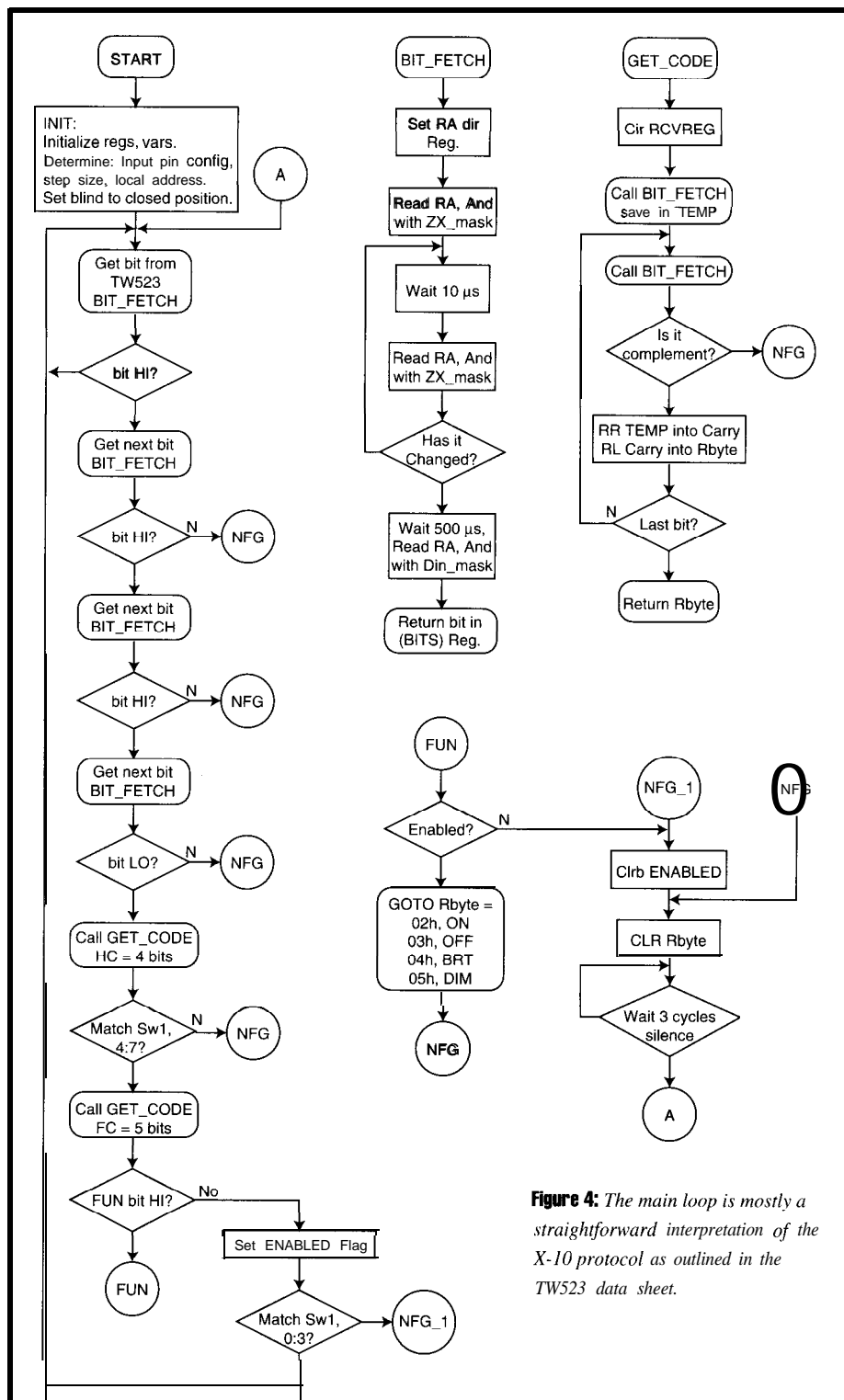
```

CFG_PINS call LILY_10 μs
sb PIN17 ;Wait for a quiet cycle
snb PIN17 ;with positive going ZX
sb PIN18 ;(i.e., both HI)
jmp CFG_PINS
chk_lo nop
jnb PIN17,hav_lo ;wait for 1st low to
nop
jnb PIN18,hav_lo ;come along (either pin)
call DLY_10 μs
jmp chk_lo
hav_lo mov count,#10 ;wait ~ 5 ms longer to insure
:loop call DLY_500 μs ;data bit time has past in case
djnz count,:loop ;data is coincident with ZX
; (the spec. could allow this).
jnb PIN17,:pin17 ;The one that's still
nop
jnb PIN18,:pin18 ;low is LX.
jmp CFG_PINS

:pin17 mov ZX_mask,#01b ;Zero Crossing = Pin 17
mov Din_mask,#10b ;Din = Pin 18
ret

:pin18 mov ZX_mask,#10b ;Zero Crossing = Pin 18
mov Din_mask,#01b ;Din = Pin 17
ret

```



**Figure 4:** The main loop is mostly a straightforward interpretation of the X-10 protocol as outlined in the TW523 data sheet.

Bits 4 and 5 are CLK and LOAD, respectively, for the shift register. Bits 6 and 7 read the LIMIT switches (normally open) and are connected to the programming header as well. NCLR is jumped to VCC through the programming header. I had to forego the recommended ESD protection on /MCLR due to lack of board space. However, with an awareness of this, in concert

with reasonable handling, it presents no problem. All rebukes acknowledged!

Overall power for the system is supplied by a 9-16-VDC wall module. Input power to XMAS is wired to the outside terminals of the RJ-11 connector. A bridge was added to allow for polarity reversal after which it is further regulated by a simple 7805 circuit.



The ZX and TX pins are rerouted to the inside pins on the XMAS RJ-11 connector. Diodes are placed in these lines to match the signal levels to the elevated ground.

A software routine determines which inner RJ-11 terminals are ZX and D<sub>in</sub>. This scheme allows for straight- or reverse-wired modular cables and a variety of AC/DC converter options. However, it requires a properly wired adapter for the TW523 and DC converter. This seemed to be a worthwhile tradeoff.

To pacify the inspectors, I specify a maximum of eight units sharing a unique address. This restriction is due to a limitation of the wiring. Even though the recommended supply is a power-limited source, it can be easily replaced with a heftier one. Considering a 100% demand factor for these common units, the number should be limited so that the ampacity of the branch wiring is not exceeded.

For a permanent installation in or near a window, 22-24-AWG telephone hook-up wire is highly recommended. This standard allows up to eight units to share a unique address. When using only 26-AWG modular cable, the maximum number of common address units is reduced to four.

One XMAS unit draws 62 mA under a normal load and 220 mA under a maximum, stall-condition load. Fortunately, about the only way to stall this hummer is on the motor shaft itself through a bearing seizure or such. Stalling from the gearhead end produces gear failure. This test is unnecessary. However, it yields about \$40 worth of catastrophic failure data for those who feel they absolutely need it!

## THE SOFTWARE

To begin, let me confess I've never been accused of generating tight code. I welcome any criticism that advances my capabilities.

Because of having primarily a hardware background, I expected that coding would be more difficult, especially since this was my first PIC project. I chose the Parallax tools to

take advantage of my residual 80xx assembler experience, which expedited the task.

As the flowchart in Figure 4 indicates, the software consists of a main loop which lies in wait for a start code from the TW523. It then snares and interprets house, unit, and function codes, and subsequently directs calls to peripheral control routines. A multifunction interrupt routine initially calculates step sizes, then monitors motor movement and effects limit stops.

The I N I T routine is a little more involved than the flow diagram indicates. After initializing INTCON, OPTION, port direction registers, and the variables, the I N I T routine calls CONFIG\_PINS (Listing 1). CONFIG\_P I N S determines which of pins 17 and 18 are the ZX and D\_in signals for later use in the B I T\_F E T C H routine.

BIT\_FETCH is the routine that reads the TW523. A call to GET\_ADD R reads the local HC/UC serially from the shift register into Paddr. It is later compared with the TW523 received

code. I N I T then runs the motor between the high and low limits while accumulating the number of revolutions betwixt the twain with the RTCC using the RT interrupt (the revolutions accumulate in the SVC\_I N T routine).

RTCC rollovers are stored in the upper byte of Range while RTCC leftovers are placed in the lower byte of Range. Range is then divided by 16 to obtain Step Size, which is later loaded back into the RTCC to generate the interrupt that stops the motor after each step of bright or dim.

I N I T has already read the JP1 jumper to decide which way to drive the motor to the first (open) limit. After reversing the motor, it leaves the blind in the closed position when the second limit has been found. Notably, the routines MTR\_U P and MTR\_DN always correspond to bright and dim, respectively, but on and off depend on the JP1 condition. On is the center, open position and off is selected between the up or down position with JP1.

#### CAVIAR & CAVEATS

From the start, I searched for a small-outline motor driver since



board space was so limited. My eventual discovery of the Si9942DY MOSFET drivers was as appetizing as a tin of fine Russian roe-the Siliconix chips aren't as expensive, but they're almost as rare in quantities under 500.

I finally obtained some samples and performed the upgrade. The pair of SO-8s significantly reduce motor run-on after removing the drive signal. The free-wheeling diodes, coupled with the fact that the low-side MOSFETs can conduct during the motor's off state, effectively produce automatic braking.

The improvement was so dramatic that I removed a call to the BRAKE routine that previously terminated the STEP function. This enabled the main loop to run nearly 200 ms faster in the STEP mode. The result was more clearly defined steps and almost a three-fold increase in the continuous step rate.

I chose not to incorporate the X-10 all-units-off and -on commands into my personal units. I may include those commands in the future strictly for compatibility. When CEBus technology stabilizes and miniaturizes (hopefully), I will then

## HOME AUTOMATION IS HERE TO STAY!



Get Your Copy of The Best Source of Home Automation Products Absolutely Free.

Largest Selection of Home Automation products in the World

Call 24hrs for Free 64 page Color Catalog

### 800-SMART-HOME

(800-762-7846)

Hundreds of hard-to-find home automation and wireless control products. Computer control of your home, security systems, surveillance cameras, infra red audio/video control, HVAC, pet care automation, wiring supplies and much more

HOME AUTOMATION SYSTEMS, INC.  
151 Kalmus Dr., Ste. M6, Costa Mesa, CA 92626  
Questions 714-708-0610 Fax 714-708-0614

## What Do You Need To Be a WINNER

### In the Fast-Growing Home Automation Industry?

Find out when you join the Home Automation Association (HAA)!

Clip and fax today for more information.

Name \_\_\_\_\_  
 Title \_\_\_\_\_  
 Company \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_  
 State/Zip \_\_\_\_\_  
 Phone \_\_\_\_\_  
 Fax \_\_\_\_\_

Home Automation Association  
 Fax: 202/223-9569

E-mail:  
 75250.1274@compuserve.com  
 Voice: 202/223-9669

CCI295

endeavor to make this now-simple affair yet more complicated.

Although I have not actually tested 256 of these units connected to *x* miles of cable, I suspect that the system succumbs to the same pitfalls as many distribution schemes. No doubt, cable capacitance eventually wins over rise times. Therefore, the number of units that can be connected to the same TW523 is not guaranteed.

Last, but not least, what can I say? When the power goes off, you're just plain outta luck!

**AND TO ALL A GOOD NIGHT...**

I initially tried doggedly to dismiss this XMAS idea as cornier than The Clapper, but climbing speakers to close the blinds had become untenable. After contemplating other possible arenas for XMAS such as office buildings, schools, passive solar control, green houses, hospitals, and homes of handicapped individuals, I continued my quest. At approximately \$120 per blind (excluding power and control), we consider our dilemma totally resolved.

Perhaps, The Clapper isn't so corny after all!

For now, I'll rest well knowing that XMAS defends our privacy "as visions of sugar plums dance in my head.. ."

*Herb McKinney is a former Hewlett-Packard service engineer who currently owns Multi-Tech, a small service consulting and engineering business. He enjoys working with all forms of automation and process control. He may be reached at 75227.2753@compuserve.com.*

**REFERENCES**

**PIC16C84, PIC16C84** Reference Manual, and **DS30081B** Microchip Technology, Inc. 2355 West Chandler Blvd. Chandler, AZ 85224 (602) 786-7200 Fax: (602) 899-9210

**PIC16Cxx** Development Tools Parallax, Inc. 3805 Atherton Rd., #102 Rocklin, CA 95765 (916) 624-8333 Fax: (9 16) 624-8003


X-10 Technical Note: Two-Way, Power-Line Interface Model #523 X-10 (USA), Inc. 185A LeGrand Ave. Northvale, NJ 07647 (201) 784-9700

---

**SOURCES**

Digi-Key Corp. 701 Brooks Ave. P.O. Box 677 Thief River Falls, MN 56701-0677 (800) 344-4539 Fax: (218) 681-3380

**1616E006ST123/16A1670:1 gearhead** motor Micro Moe 742 Second Avenue South St. Petersburg, FL 33701 (8 13) 822-2529 Fax: (8 13) 82 1-6220

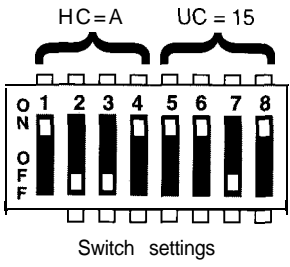


Mouser Electronics, Inc. 12 Emery Ave. Randolph, NJ 07869 (800) 346-6873 Fax: (201) 328-7120

Siliconix **Si9942DY** Rep, Inc. Temic Group P.O. Box 728 Jefferson City, TN 37760 (615) 475-9012 Fax: (6 15) 475-6340

BAL 6686 (**#T39900**) Futuba Corp. 4 Stedebaker Irvine, CA 92718 (714) 455-9888

**I R S**  
 419 Very Useful  
 420 Moderately Useful  
 421 Not Useful



HC	1	2	3	4	5	6	7	8	UC
A	ON	OFF	OFF	ON	ON	OFF	OFF	ON	1
B	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	2
C	ON	OFF	ON	ON	ON	OFF	ON	ON	3
D	ON	OFF	ON	OFF	ON	OFF	ON	OFF	4
E	OFF	ON	ON	ON	OFF	ON	ON	ON	5
F	OFF	ON	ON	OFF	OFF	ON	ON	OFF	6
G	OFF	ON	OFF	ON	OFF	ON	OFF	ON	7
H	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	8
I	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	9
J	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	10
K	OFF	OFF	ON	ON	OFF	OFF	ON	ON	11
L	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	12
M	ON	ON	ON	ON	ON	ON	ON	ON	13
N	ON	ON	ON	OFF	ON	ON	ON	OFF	14
O	ON	ON	OFF	ON	ON	ON	OFF	ON	15
P	ON	ON	OFF	OFF	ON	ON	OFF	OFF	16

ON = UP = INACTIVE                      OFF = DOWN = ACTIVE

**Table 1:** Cost considerations and layout constraints made a DIP switch and negative logic compulsory for address setting. The address is encoded by the switch settings. After serializing, it assumes the correct order for direct comparison with the received code. This eliminates the need for a software conversion table.