

# It's a Synchronized Beacon! by Expanded Spectrum Systems

## The time has come!

The beacon bands are filling up. Propagation is constantly changing. Piecing together a picture of the prevailing propagation by scanning the bands is becoming increasingly difficult. There must be some way to coordinate these beacons. Some way to listen to a single frequency and assess a continent, a state, or a hemisphere. Synchronized Beacon controller to the rescue! Just like the IARU beacons, the Synchronized Beacon controller uses precise, globally available GPS timing to enable multiple beacons to initiate their messages right on cue. The Synchronized Beacon was intended from day one to be as straight forward and as general purpose as possible. This no nonsense approach made the Synchronized Beacon easy for us to design and easy for you to program and use. No special skills or equipment are required. Just connect the Synchronized Beacon to any PC with a terminal emulator, turn it on, and type in your message. Those of you familiar with the popular Freakin' Beacon controller already know how easy this is! The unique command set uses capital letters as instructions to the beacon, and lower case letters, numbers, and punctuation as "sent" characters. That's it! Just type in the character string, which is stored in non-volatile EEPROM inside the PIC microcontroller on the Synchronized Beacon, and you are ready to go. Then plug the Synchronized Beacon into the key jack of your beacon transmitter, connect your GPS receiver, and let'er rip.

## GPS Synchronized Beacon

The Synchronized Beacon is simply a GPS synchronized version of the Freakin' Beacon. The only difference is the PIC firmware. Use a low cost GPS receiver to trigger your beacon in the time slots you choose for even and odd minutes. The SB1 and SB2 Synchronized Beacons use the same great boards as the FB1 and FB2 Freakin' Beacons. You can even upgrade your FB1 or FB2 to the SB1 or SB2 functionality. The required files are available on the ESS web site. Contact ESS for assistance. The SB1/SB2 used a reduced command set in order to fit the code required to set up the GPS time slots and respond to the NMEA sentences from the GPS receiver. The SB1 and SB2 will synchronize to any GPS receiver that outputs the \$GPRMC sentence at 4800b using an RS-232 compatible interface. Additional NMEA sentences will be ignored. Some GPS receivers only output the required sentence every two seconds. In this case, your beacon message could trigger a second later than expected.

## How it works

The Synchronized Beacon is based on the Microchip PIC 16F628 microcontroller. The software for the Synchronized Beacon was written using the PicBasic Pro compiler from microEngineering Labs, Inc. A listing of the PicBasic Pro source code is available on the Expanded Spectrum Systems web site. The PIC 16F628 is a relatively new member of the PIC family, and it was selected for its low cost and high degree of integration. It is a pin compatible replacement for the popular 16F84, but it features lower cost and built-in brown-out reset, plus double the memory capacity for RAM, EEPROM, and flash program storage. There are even analog inputs, which are not being used for this project. The best way to program your own PIC 16F628 from scratch is with the PICSTART Plus Development Programmer from Microchip.

## Connecting it to your transmitter

There are two functionally equivalent versions of the Synchronized Beacon. The SB1 is the compact version, designed to fit into tight spaces. Connections to the SB1 are via 100 mil spacing, 25 mil square post headers. The SB2 is the larger version, designed to make interfacing fast and easy. The SB2 uses PCB-mount connectors for the power, push-to-talk (PTT), key, and serial programming interfaces. The SB2 also includes a PCB-mount ON-OFF switch. With some transmitters, the only connection required is the key line. For others, it may be desirable to use the PTT line to activate the transmit mode and insert a short time delay before starting the message. The Synchronized Beacon provides 4 logic outputs at the P3 connector intended to select 1 of 4 output power levels from a specially equipped transmitter, but the outputs are available for general purpose use. A strip of approximately 18 socket contacts is provided with each SB1 and SB2 kit for interfacing with the headers. Break or snip off the desired number of contacts for each connection. Strip and tin the signal wires, and tack solder to the contact solder tails. If you have access to heatshrink sleeving and a heat gun, add heatshrink sleeving to the solder connections to make the connections more durable.

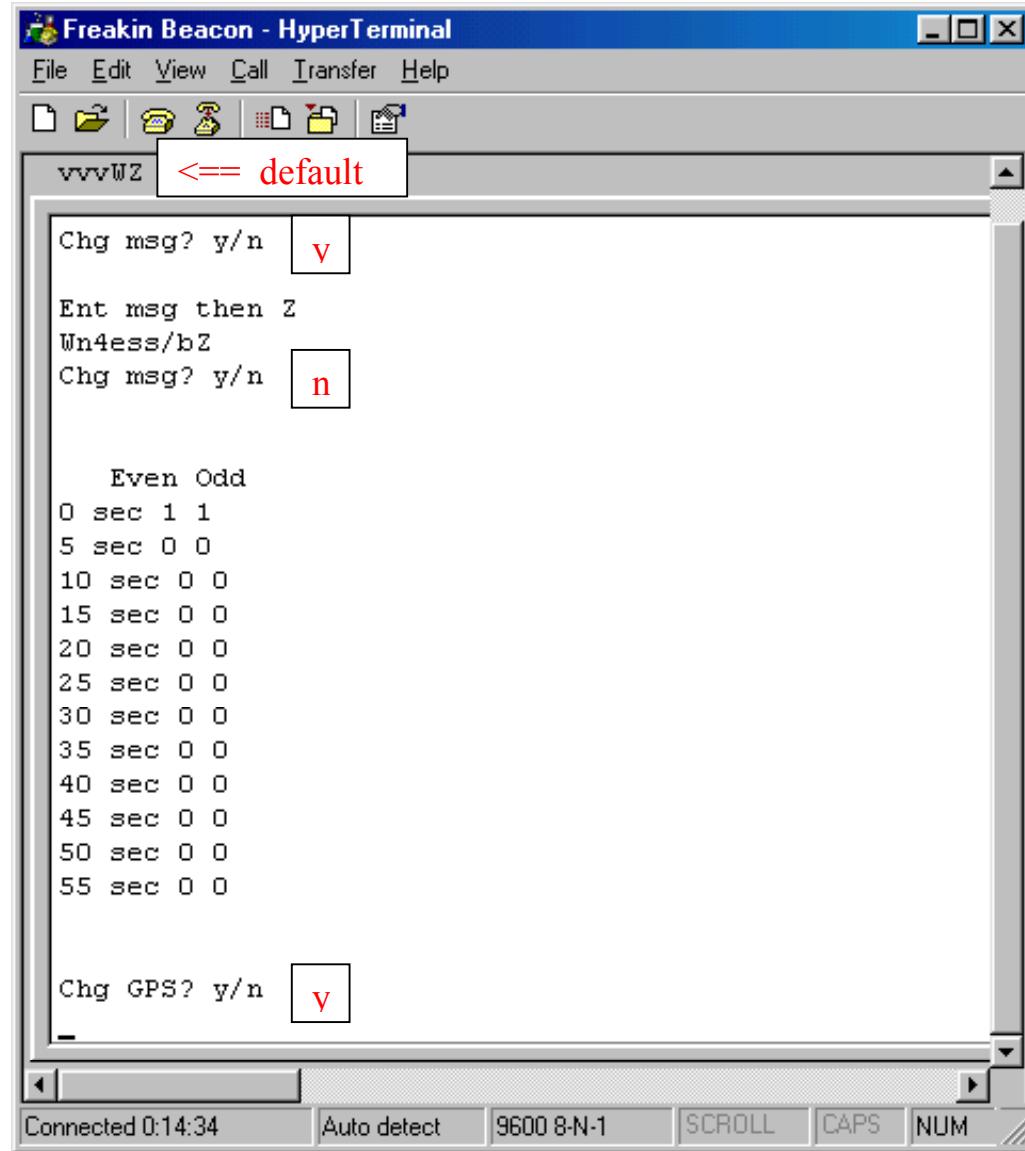
## Loading your message

Loading your message into the Synchronized Beacon is super easy, and requires no special skills or equipment. If you own a Personal Computer (PC), you already have everything you need. There is no software to load. Just use the terminal emulator in your PC, such as HyperTerminal, to type in a single character string that contains a combination of control characters and message characters. See HyperTerminal setup instructions at the end of this document. Upper case letters are reserved for commands. Lower case letters, numbers, and punctuation are the "sent" characters, and are used to compose your message. The serial programming interface operates at 9600 baud.

Before attempting to program your own message, be sure your Synchronized Beacon is operational using the default message. Until you program your own message, the Synchronized Beacon will generate the following message: vvvWZ

The translation is: send "vvv", Wait for GPS trigger, Z end of message. See the following tables for the complete command and character set. Observe the green Key LED and listen to the message on any speaker connected to P2 (pins 3 and 4 for SB1, or pins 1 and 2 for SB2).

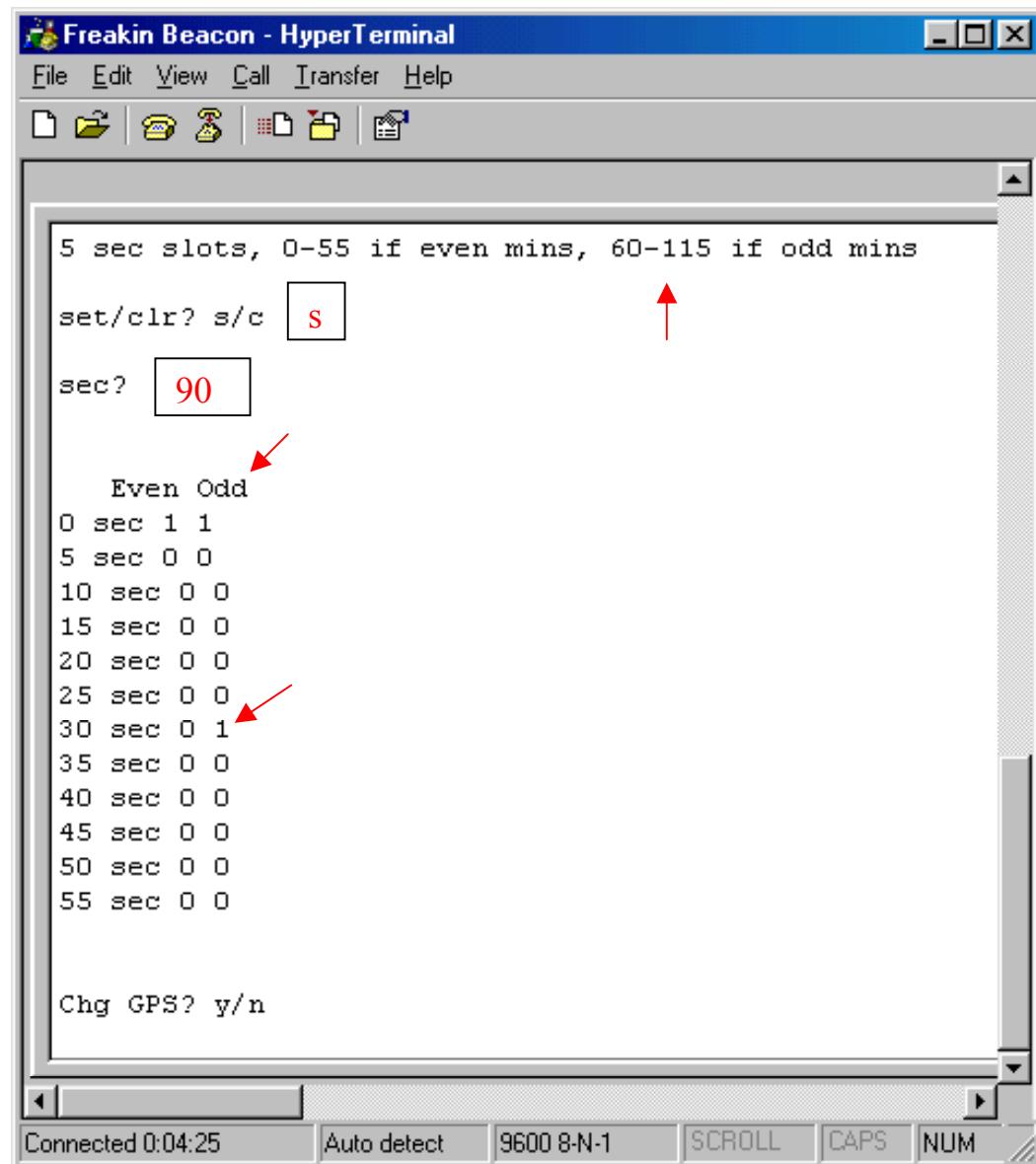
The default code speed is 20 WPM for any new messages. To program a message, install the Program- jumper on P1, between pins 2 and 3, and connect the serial port to your PC. Turn on the power to the SB1 or SB2 board. The terminal emulator on the PC will *display the present message*, followed by "Chg msg? y/n".



Type a lower case "y" within 10 seconds to enter your own message. If the character "y" is not typed within 10 seconds, the Synchronized Beacon will start sending its existing message. You can choose to leave the Program- jumper always in place to make message programming more convenient, or you can choose to remove the jumper after programming to prevent accidental erasure of the message. Once you type the "y", the previous message is erased, and whatever you type until you reach the end of the 99 character EEPROM memory area or type a "Z" becomes the new message. There are no editing options, and no backspace. You must type the message correctly, or type it over! This message programming format was chosen to be easy to design and easy to learn to use. There are no frills, but you have lots of control over the operation of your Synchronized Beacon.

### Selecting your GPS time slots

After you load your message, you will be prompted to see if you want to change your GPS time slot settings. Follow the simple menu prompts. The SB1/SB2 will display the present GPS time slot table, which lists a 0 or a 1 for each time slot. A 0 indicates that a time slot is not selected, and a 1 indicates that a time slot is selected. The valid time slots are 0-55 seconds after each even and odd minute, in 5 second intervals. If you want your beacon to trigger 7 seconds after the minute, select the time slot for 5 seconds after, and insert two "S" commands after the "W" Wait for GPS command. The SB1/SB2 will ask if you want to change the GPS settings. Enter a "y" if you wish to change the settings. Commands are case sensitive. The SB1/SB2 will ask if you want to set or clear a time slot. Pick "s" to set a time slot, or enter "c" to clear a time slot. The SB1/SB2 will ask which time slot you wish to set for clear. Enter the number of seconds after the minute in 5 second intervals using 2 digit format. For even minutes, enter the number of seconds directly (e.g.: 25). To set a time slot for an odd minute, add 60 to the number of seconds after the off minute (e.g.: 85 for 25 seconds after each odd minute.). In actuality, the number of seconds entered is ALWAYS the number of seconds after an even minute. You set or clear a time slot for an odd minute by adding 60 to the argument for the even minute. The time slot table will be updated and displayed.



Look it over and make any additional changes. When you are finished, enter "n" for no when asked if you wish to make further changes to the GPS settings. The SB1/SB2 will display "run..." on the PC. Trust me, this is so much easier to do than it is to explain in words.

## Synchronized Beacon Command Set

B = 10 WPM

C = 15 WPM

D = 20 WPM

H = High power. (Default) (Sets P3 pin 1 high)

K = Key. Keys the transmitter.

L = Low power. (Sets P3 pin 3 high)

M = Medium power. (Sets P3 pin 2 high)

P = PTT. Activates PTT.

Q = Quit PTT. Releases PTT.

S = Second. Holds present state for one second. Useful when Keyed or Unkeyed.

T = Tenth second. Hold present state for one Tenth of a second. Useful when Keyed or Unkeyed.

U = Unkey. Unkeys the transmitter.

W = Wait for GPS trigger at selected time slots.

X = eXtra low power. (Sets P3 pin 4 high)

Z = End of message.

Notes: Sync2 command set. Code speeds and delay times are approximate. Always verify that performance meets your requirements before deployment.

## Synchronized Beacon Character Set ("Sent" Characters)

a = .-  
b = -...  
c = -.-.  
d = -..  
e = .  
f = ...-.  
g = --.  
h = ....  
i = ..  
j = .---

k = -.-  
l = .-..  
m = --  
n = -.  
o = ---  
p = .---.  
q = ---.-  
r = .-.  
s = ...  
t = -

u = ...-  
v = ....-  
w = .--  
x = -...-  
y = -.--  
z = ---..  
1 = .-----  
2 = ..----  
3 = .....  
4 = .....-

5 = .....  
6 = -....  
7 = ---...  
8 = ----..  
9 = -----.  
0 = -----  
<sp> = < >  
/ = -...-.

Example messages:

Wn4essZ

Waits for GPS trigger, sends "n4ess", repeats. This is what the Synchronized Beacon is all about!

PTCn4essSKSSSSUQSSSSZ

Activates PTT, waits one Tenth of a second, speed C (15 WPM), sends "n4ess", waits one Second, Keys the transmitter for five Seconds, Unkeys the transmitter, Quits PTT, waits five Seconds, repeats.

*Note: To verify message entry, cycle the power to the Synchronized Beacon with the programming jumper in place. The present message will be displayed on the serial terminal.*

### Constructing a Synchronized Beacon

The Synchronized Beacon uses a high quality, double sided, plated through hole, circuit board with solder mask and silk screened part legends. Only through hole components are used. The result is quick and easy assembly, with minimized risk of solder bridges and incorrect part locations.

Assembling the Synchronized Beacon is not difficult, but a few helpful hints are in order. If possible, use a temperature-controlled soldering iron with a small tip. Set the soldering iron between 600 and 700 degrees F. The soldering iron should have a 3-wire cord and a grounded tip to prevent damage to the active components due to electrostatic discharge (ESD). If a grounded soldering iron is not available, always remove U1 before soldering on the board. Use proper ESD techniques when handling the active devices and the assembled board. Use only rosin core solder, of course. It is also a good idea to keep a roll of braided solder wicking wire handy in case a part has to be removed. Please note the proper orientation of the integrated circuits (IC's), IC sockets, diodes, and polarized capacitors. The microcontroller, U1, installs in socket XU1. XU1 should be the first part installed, while the board will lie flat on the inverted socket. The microcontroller included in the kit is preprogrammed, but it should be the last part installed. Before or after installing potentiometer R1, the sidetone volume control, set the slider near mid-scale using an ohmmeter so that the morse code sidetone will be audible during initial check-out. Next, install the remaining parts, preferably in the order indicated on the

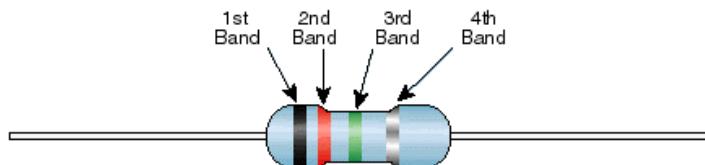
parts list. For the FB2, be sure to keep the connectors, LED's, and switch flush with the board so that proper alignment with the front panel is maintained. Refer to the following figure for information on reading the resistor color codes.

SB1 users will have to construct *two* serial interface cables, one for connection to their PC for message loading and GPS time slot selection, and another for connection to the GPS during synchronized operation. ***The transmit data and receive data connections must be reversed in the cable that connects the SB1 to the GPS. This can be accomplished by building a second cable with the connections reversed, or by inserting a double-male gender changer and a null modem between the SB1/SB2 and the GPS receiver.***

Refer to the SB1 schematic page for pin-out information and a representative photograph of a completed cable. Use the provided DB9 connector, socket contact strip, and colored hook-up wire for the cable. Using side cutters, snip off a three (3) contact section of socket contacts. Strip and tin both ends of each wire before soldering to the connector contacts. If you have access to heatshrink sleeving and a heat gun, add heatshrink sleeving to the solder connections to make the cable more durable.

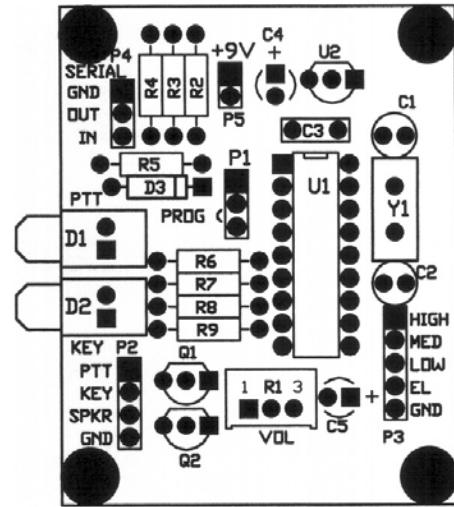
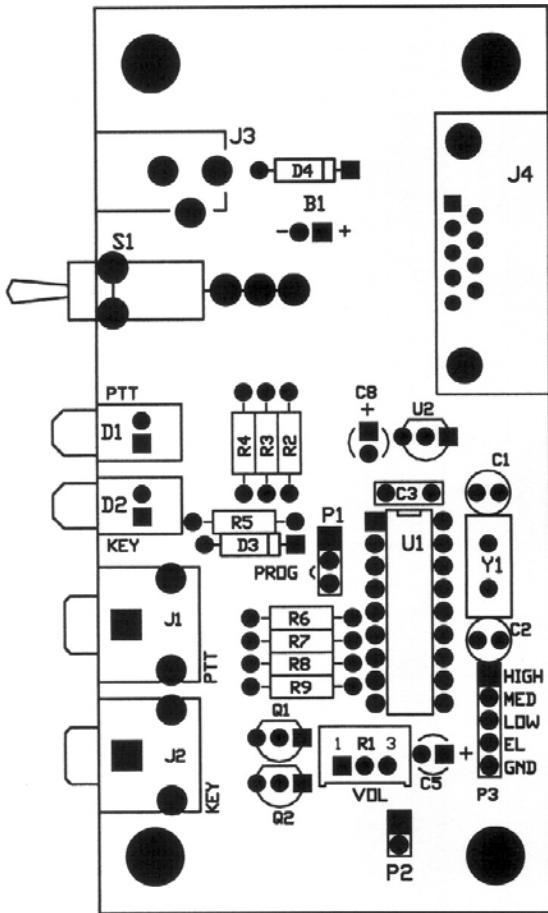
SB2 has the serial DB9 connector mounted directly on the PCB. This connector allows direct connection to a PC for loading your beacon message and selecting your GPS time slots. ***A user supplied double-male gender changer and a null modem are required to connect the SB2 to the GPS receiver.***

**Standard EIA Color Code Table 4 Band:  $\pm 2\%$ ,  $\pm 5\%$ , and  $\pm 10\%$**



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	$10^0$	
Brown	1	1	$10^1$	
Red	2	2	$10^2$	$\pm 2\%$
Orange	3	3	$10^3$	
Yellow	4	4	$10^4$	
Green	5	5	$10^5$	
Blue	6	6	$10^6$	
Violet	7	7	$10^7$	
Gray	8	8	$10^8$	
White	9	9	$10^9$	
Gold			$10^{-1}$	$\pm 5\%$
Silver			$10^{-2}$	$\pm 10\%$

Chart Provided By



Synchronized Beacon parts placement: SB2 on the left, SB1 on the right.

(Notes: C8 on SB2 board marking is really C4. The stripe on C4 indicates the + lead. C3 is marked "104". J4 on the SB2 may include mounting hardware that should be removed and discarded. Use caution when connecting to pin headers as no polarization keying is employed. Match stripe on D3/D4 with stripe on PCB silkscreen.)

#### Initial Check Out

The quickest check out for the Synchronized Beacon is to perform the following steps.

1. Connect a speaker to P2.
2. Connect a DC source of 8 to 15 VDC for FB1 or 9 to 15 VDC for FB2. Observe polarity.
3. Observe the factory programmed message on the LED's and from the speaker, "vvv" one time. If an active GPS is connected to the serial interface on the SB1/SB2, the "vvv" message will repeat at the selected time slots (default is 0 seconds after both even and odd minutes).

Note: All "sent" characters activate the green Key LED and generate a sidetone while being sent. A steady Key generated using the Key command and a time delay will illuminate the Key LED and generate a sidetone.

#### Operating a Beacon

Before operating any beacon transmitter on amateur radio frequencies, consult the current FCC regulations, part 97.203, governing beacon stations. A portion of the regulation is provided below as an example of the information provided.

#### 97.203 Beacon Stations

- (a) Any amateur station licensed to a holder of a Technician, Technician Plus, General, Advanced or Amateur Extra Class operator license may be a beacon. A holder of a Technician, Technician Plus, General, Advanced or Amateur Extra Class operator license may be the control operator of a beacon, subject to the privileges of the class of operator license held.
- (b) A beacon must not concurrently transmit on more than 1 channel in the same amateur service frequency band, from the same station location.
- (c) The transmitter power of a beacon must not exceed 100 W.
- (d) A beacon may be automatically controlled while it is transmitting on the 28.20-28.30 MHz, 50.06-50.08 MHz, 144.275-144.300 MHz, 222.05-222.06 MHz, or 432.300-432.400 MHz segments, or on the 33 cm and shorter wavelength bands.

(e) Before establishing an automatically controlled beacon in the National Radio Quiet Zone or before changing the transmitting frequency, transmitter power, antenna height or directivity, the station licensee must give written notification thereof to the Interference Office, National Radio Astronomy Observatory, P.O. Box 2, Green Bank, WV 24944.

#### **End of Excerpt**

Be considerate in selecting the frequency, timing, and power level for your Synchronized Beacon transmitter. With the Synchronized Beacon, multiple beacons can easily share a single frequency. Contact other beacon operators at interesting geographic locations and offer to synchronize your SB1/SB2 with theirs. Create your own little beacon network. With the Synchronized Beacon, there is room for everyone. For every frequency where there was once only one beacon, there can be many. Everyone does not have to do exactly the same thing, the same way! That is what is so great about amateur radio! Obey the rules, be considerate, and have fun. You are guaranteed to learn a lot in the process. Read and understand the FCC regulations regarding amateur radio beacon operation, as well as amateur agreements on where beacon transmitters should be located. Without special authorization from the FCC, beacon transmitters are only permitted in specific band segments at frequencies above 28 MHz. There is much information available on the internet, and in *The ARRL Operating Manual*.

#### **Selecting a Transmitter**

Select the lowest power transmitter that will serve your needs. Keep in mind the transmitter's duty cycle rating because your Synchronized Beacon will be transmitting its message repeatedly. Monitor both the transmitter and the power supply for signs of overheating before leaving them unattended. Insert more "dead time" using the T and S delay commands or widen your GPS time slots if your transmitter shows signs of overheating. The Synchronized Beacon can key most modern transmitters directly with its open collector Key output. Contact ESS if you need assistance interfacing with the negative voltage present on an older grid-block keyed tube transmitter. If you are keying a transmitter in the semi-break-in mode, set the transmit-receive delay time to minimize wear and tear on the transmit-receive relay. A better method may be to use the PTT output to activate the relay, with user programmable delays inserted as necessary.

#### **Transmitter Power Control Interface**

The outputs of P3 are intended for selecting up to 4 power levels in conjunction with the Expanded Spectrum Systems BA1 Beacon Attenuator, in order to increase the usefulness of radio propagation beacons. Connecting between the transmitter and the antenna, the BA1 is a high power programmable attenuator that works with any HF through 6-meter transmitter and accepts up to 100 watts of RF drive. Synchronized Beacon users can now fully emulate the operation of the International Beacon Project, where the beacon transmits long dashes at 100W, 10W, 1W, and 0.1W while synchronize to the GPS satellite constellation. The H command (also the default state) sets the High output (P3, pin 1) to a TTL 1 and the other outputs to TTL 0 until another power command (M, L, or X) is executed or until the message repeats. This puts the BA1 in the minimum attenuation state. Likewise, the M command sets the Med output (P3, pin 2) to a TTL 1 and the other outputs to TTL 0 until another power command (H, L, or X) is executed or until the message repeats. This puts the BA1 in the -10 dB state. Commands L and X behave in the same manner as H and M, but activate the Low and EL outputs (P3, pins 3 and 4). P3, pin 5 is a ground return for the H, M, L, and X outputs. Of course, the P3 outputs can be used for any control function that can respond to TTL logic levels. For instance, for directional microwave beacons, the P3 outputs can be used to control relays to switch between multiple directional antennas. For users with dual-polarization antennas, the P3 outputs can be used to alternate between polarizations, with the appropriate comments included in the CW message.

#### **Possible Applications**

The Synchronized Beacon is a simple, convenient, and low cost platform with which to begin experimenting with radio propagation, both local and long range. GPS synchronization makes for more productive listening, and allows multiple beacons to share a single channel or frequency. Be sure to check out the Freakin' Beacon, also from ESS, with its rich command set. Send us your applications and your suggestions for new products or improvements to this product. ESS is a small, user focused company dedicated to your enjoyment of amateur radio.

#### **Contacting Expanded Spectrum Systems**

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6807 Oakdale Dr.  
Tampa, FL 33610  
813-620-0062 9a-5p EST  
813-623-6142 FAX  
[www.expandedspectrumsystems.com](http://www.expandedspectrumsystems.com)

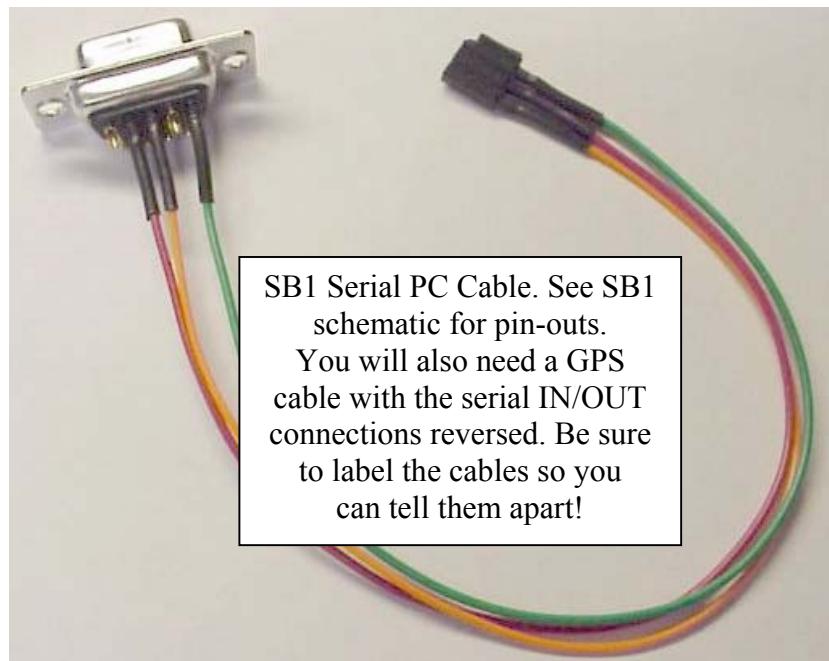
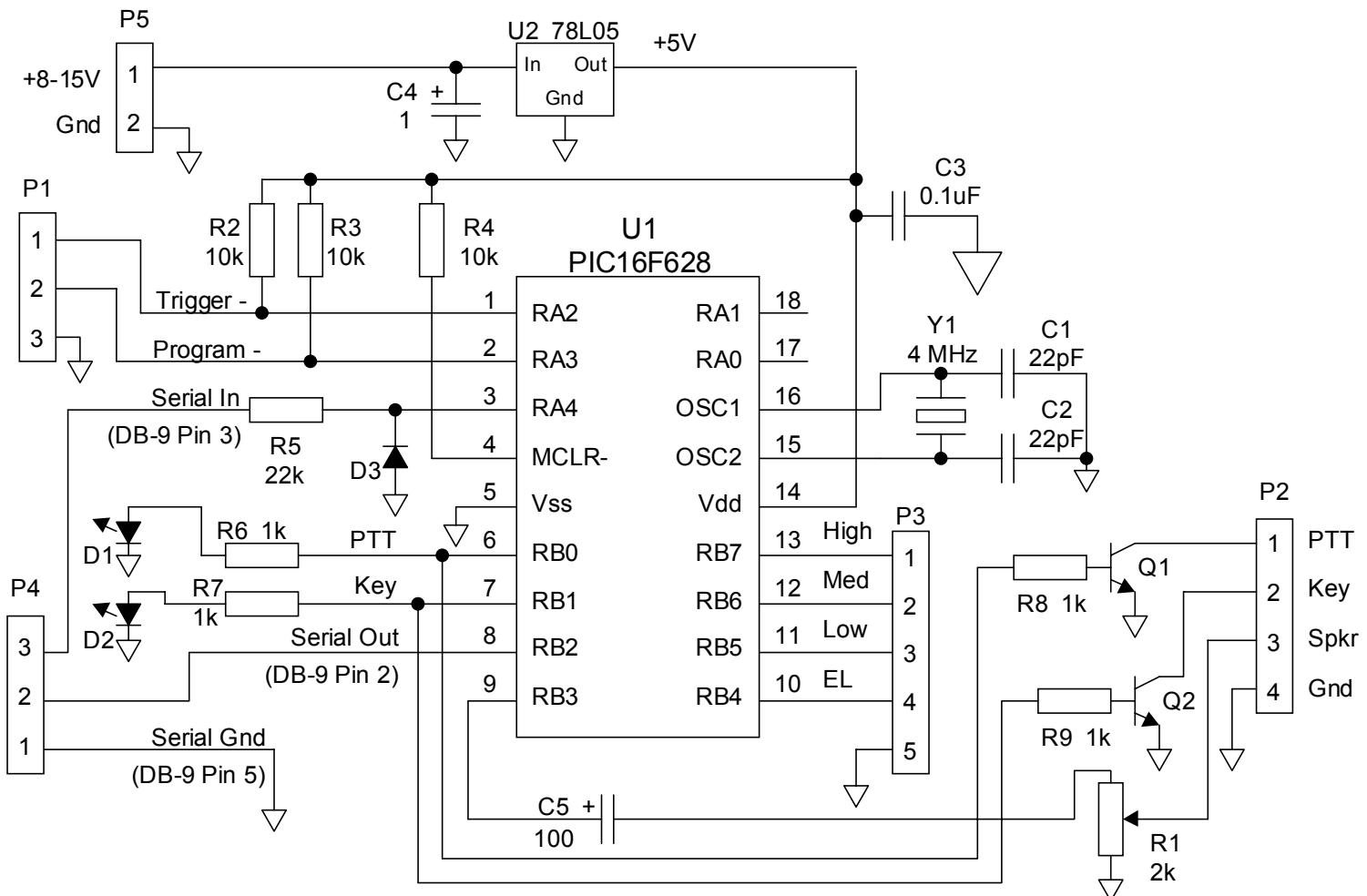
## Parts List: Synchronized Beacon SB1

Quantity	Item/Designation	Label-Value	Attributes	Vendor	PN
1	1	PCB	2-layer, PTH, SS, SM		
2	C1, C2	22pF	CY200D100H31	Digi-Key	BC1005CT-ND
1	C3	.1uF 50V		Digi-Key	BC1101CT-ND
1	C4	1uF		Digi-Key	P2105-ND
1	C5	100uF 10V		Digi-Key	P5517-ND
1	D1	Red LED	PCB Mount, Chicago Miniature Lamp, 5300H5LC	Digi-Key	L20031-ND
1	D2	Green LED	PCB Mount, Chicago Miniature Lamp, 5300H5LC	Digi-Key	L20035-ND
1	D3	1N4148	Axial leads	Digi-Key	1N4148DICT-ND
2	P1, P4	Connector	Molex 22-28-4030	Digi-Key	WM6403-ND
1	P2	Connector	Molex 22-28-4040	Digi-Key	WM6404-ND
1	P3	Connector	Molex 22-28-4050	Digi-Key	WM6405-ND
1	P5	Connector	Molex 22-28-4020	Digi-Key	WM6402-ND
1	Jumper	Jumper	Amp 881545-2	Digi-Key	A26242-ND
2	Q1, Q2	PN2222A	TO-92	Digi-Key	PN2222A-ND
1	R1	2k var		Digi-Key	CT94W202-ND
3	R2, R3, R4	10k	.25W	Digi-Key	10KQBK-ND
1	R5	22k	.25W	Digi-Key	22kQBK-ND
4	R6, R7, R8, R9	1k	.25W	Digi-Key	1KQBK-ND
1	U1	PIC16F628	DIP18	Digi-Key	PIC16F628-04/P-ND
1	U2	78L05	TO-92	Digi-Key	NJM78L05A-ND
1	XU1	Socket, machined	DIP18	Digi-Key	A403AE-ND
1	Y1	Crystal, 4.00 MHz		Digi-Key	CTX006-ND
1 FT	Wire	Red hook-up wire (to DB9 pin 2)			
1 FT	Wire	Orange hook-up wire (to DB9 pin 3)			
1 FT	Wire	Green hook-up wire (to DB9 pin 5)			
1	DB9F	DB9F serial connector		Digi-Key	209F-ND
0.5	Socket Strip	Break-off socket strip, approx. 18 contacts.		Digi-Key	929974-01-36-ND

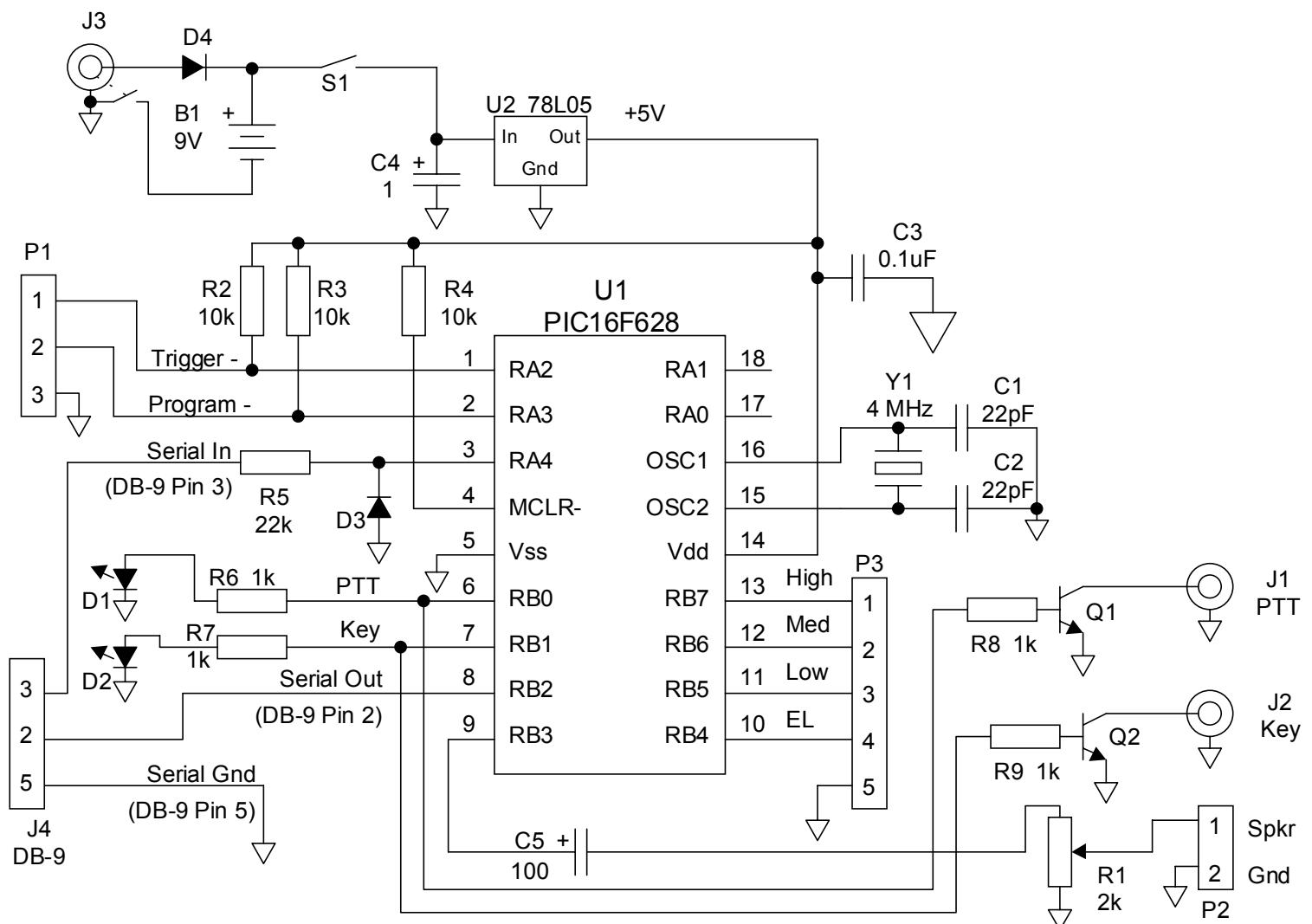
## Parts List: Synchronized Beacon SB2

Quantity	Item/Designation	Label-Value	Attributes	Vendor	PN
1	1	PCB	2-layer, PTH, SS, SM		
2	C1, C2	22pF	CY200D100H31	Digi-Key	BC1005CT-ND
1	C3	.1uF 50V		Digi-Key	BC1101CT-ND
1	C4	1uF	(PCB label shows as C8)	Digi-Key	P2105-ND
1	C5	100uF 10V		Digi-Key	P5517-ND
1	D1	Red LED	PCB Mount, Chicago Miniature Lamp, 5300H5LC	Digi-Key	L20031-ND
1	D2	Green LED	PCB Mount, Chicago Miniature Lamp, 5300H5LC	Digi-Key	L20035-ND
2	D3, D4	1N4148	Axial leads	Digi-Key	1N4148DICT-ND
2	J1,J2	Stereo, .125", threaded, with nut	PCB Mount, CUI Stack, SJ-3543	Digi-Key	CP-3543-ND
1	J3	Power Jack, 2mm	PCB Mount, CUI Stack, PJ-102A	Digi-Key	CP-102A-ND
1	J4	DB-9 Connector	Amp '745781-2	Digi-Key	A23291-ND
1	P1	Connector	Molex 22-28-4030	Digi-Key	WM6403-ND
2	P2, XB1	Connector	Molex 22-28-4020	Digi-Key	WM6402-ND
1	P3	Connector	Molex 22-28-4050	Digi-Key	WM6405-ND
1	Jumper	Jumper	Amp 881545-2	Digi-Key	A26242-ND
2	Q1, Q2	PN2222A	TO-92	Digi-Key	PN2222A-ND
1	R1	2k var		Digi-Key	CT94W202-ND
3	R2, R3, R4	10k	.25W	Digi-Key	10KQBK-ND
1	R5	22k	.25W	Digi-Key	22kQBK-ND
4	R6, R7, R8, R9	1k	.25W	Digi-Key	1KQBK-ND
1	S1	SPDT, on-on	PCB Mount, C&K, 7101MD9AV2BE	Digi-Key	CKN1059-ND
1	U1	PIC16F628	DIP18	Digi-Key	PIC16F628-04/P-ND
1	U2	78L05	TO-92	Digi-Key	NJM78L05A-ND
1	XU1	Socket, machined	DIP18	Digi-Key	A403AE-ND
1	Y1	Crystal, 4.00 MHz		Digi-Key	CTX006-ND
0.5	Socket Strip	Break-off socket strip, approx. 18 contacts.		Digi-Key	929974-01-36-ND

# Synchronized Beacon SB1 Schematic

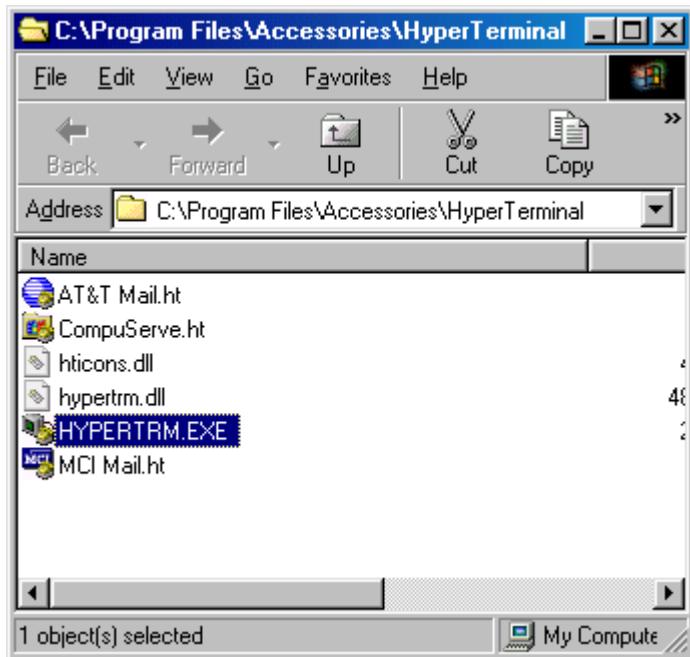


# Synchronized Beacon SB2 Schematic

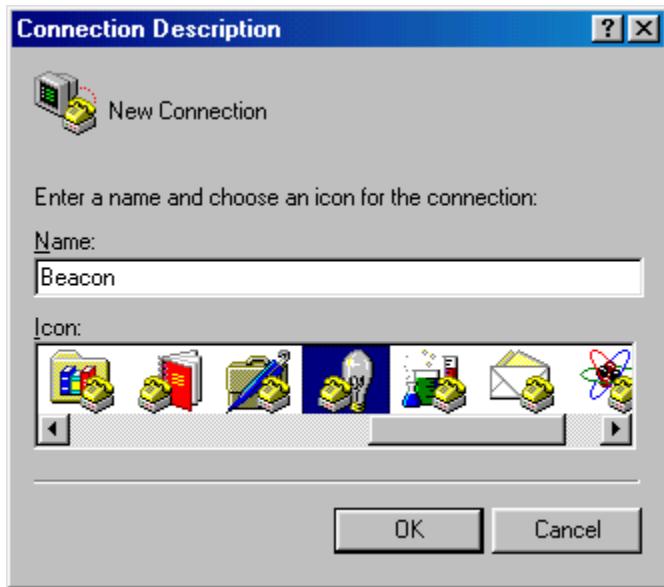


## HyperTerminal Setup:

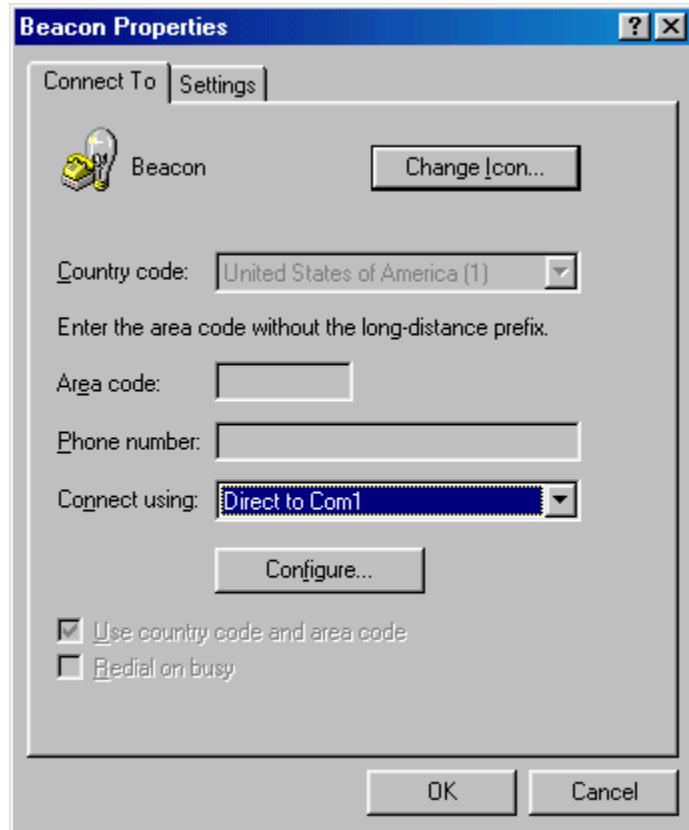
Start HyperTerminal.



Enter a name for the new connection, and pick an icon.



File\Properties.



Configure: 9600b, 8 bits, No parity, 1 stop bit, no flow control.

