Iowa High Altitude Balloon Project 20M Beacon

The IHAB-2 beacon is an outgrowth of the beacon for the first IHAB balloon launch. That transmitter was a hurridly thrown together combination of some left over projects, and new oscillator and buffer circuits. It worked, but I was unhappy with it's performance. Improvements were needed in keying characteristics, antenna matching, efficiency, and current consumption. The beacon transmitter described below addresses those concerns.

There are 5 main sections to the beacon, the transmitter, power supply/switch board, and the keyer, and DTMF controller. **Figure 1** is a picture of the beacon's payload tray showing the layout and interconnecting wiring. This tray is one of several in payload container.

Let's start with the transmitter strip, figure 2.   This transmitter began life as a 40M Class E transmitter. David Cripe, NMØS, had been working on a slick little transceiver design and I built one of the prototypes. With his approval I scaled the final, and LPF components for 20M and it worked well. So well in fact, that the final operated at over 80% efficiency and stayed cool during a 2 hour key down test, figure 2 is the schematic. The whole system was tested by operating the whole beacon system for for 6 hours into a dummy load and the transmitter performed flawlessly. At that point it was deemed ready for the flight, or as the famous aircraft designer Burt Rutan likes to say "Mission Capable".

The initial output was 1.6 W into a dummy load with a 12 volts power supply. To save weight a 9 volt lithium battery was used and the output dropped to 1.2 W. it was a good trade off though, as 1.2 was enough, and the lithium eliminated a NiMH battery pack that was much heavier. Two hours into the flight the power drops to 1 W, as determined by bench testing, and it would have stayed at approximately 1W for the duration. That was more than adequate, as shown by the huge number of signal reports on QRPSpots.com, the QRP ARCI web site. and the QSL cards received. As Ed Hare, W1RFI, and I like to say "One watt is a LOT of power." Especially when the antenna is so high.

The final amp is the ubiquitous 2N7000 operating in class E and matching 50 ohms out of the network. FIgure 2 is the schematic of the transmitter. The 74HC02 Quad NOR Gate is a high speed device and is suitable for HF service. In this application it is configured as an oscillator and keyed driver. I was pleased by the keying characteristics. The old trick of running the oscillator constantly, and keying the driver worked very well. Pulling one of the inputs low turns on the gates, switching the output high, so a normally keying electronic keyer, straight key, or bug can be used. The low driver output the dots and dashes prevents the 2N7000 from conducting during that time, allowing it to run cooler. There was no attempt to shape the keying characteristics. At 1W clicks were nonexistant and the slightly hard sound enhances copyability (izzat a word?).

As mentioned above, the final's circuit was scaled from a 40M Class E design by David Cripe, NMØS, and no attempt was made to optimize the values. The calculations are easy, in doubling the frequency, divide the Ls and Cs by 2. While the drain waveform wasn't ideal, the final ran cool and the output after the LPF was clean. It's difficult to see in figure 1, but the 2N7000 was mounted flat side to the copper clad using heat sink compound further enhancing cooling. The flight antenna is a half wave with no counterpoise, and it is neat to see 66' of wire dangling below the payload container at lift off. A half wave was chosen due to it's high feedpoint impedance and less reliance on a counterpoise.

An unusual item in the transmitter is the antenna coupler. I call it "Nick's Coupler", and first saw it on the web site of Nick Kennedy, WA5BDU. It uses one of Diz's FT-114-43 toroids, and is a step up transformer. The transmitter side winding has 4 turns and the antenna side has 32 turns. The rationale for the 1:8 turns ratio is that in practice the impedance at the end of an end fed half wavelength antenna is on the order of 1800 to 5000 ohms (from Steve Yates, AA5TB, web site). So I chose a middle value 3200 ohms to match, and the impedance ratio of 1:64 does that. The -43 mterial provides enough reactance to prevent much loss through the core. I'm sure that the SWR isn't a perfect 1:1, but it's close enough. It may have been better to incorporate a matching network, but who knows what the impedance is at 87000 feet anyway, hi.

Notice that the transmitter is built Manhattan style. While I enjoy making printed circuit boards, Manhattan construction is my choice for quickly building a circuit to test and modify. The IC was a bit of a challenge, but a little DIP board and magnet wire made short work of it. I glued the toroids to the board, as well as together, with hot melt glue because I wanted to assure stability while handling during the launch and when landing. Impacting the ground at somewhere around 1500 fpm can be quite a jolt if the landing site isn't soft ground..

The power supply board (figure 4) is uncomplicated but neccessary. **Figure 3** is the schematic. A p-channel MOSFET performs reverse voltage protection duty. It is connected backwards (source to +) in order to prevent it's internal diode from conducting, and the gate is grounded, turning it on hard. The very low on resistance of some PMOS transistors make them much preferred to the often used diode, IMHO. I first saw this idea used in a project by Paul Alexander, WB9IPA (SK). Paul was a good designer and fine ham and it's an honor to reference his work.

A 2N4403 is used as a switch to shut down the transmitter in case of a malfunction. The base is switched by a command from the ground, and when it's grounded current flows to the tranmitter. In retrospect I could have used a PMOS with a little more current capacity than the 2N4403, but this works well. It is adapted from the well known Vcc keying circuit by W7EL and publicized in EMRFD. A 5 volt regulator powers the EZKeyer, Ramsey DTMF tone decoder, and the toggle on/off flip flop smd board. The two switches neccessary to the keyer operation. So why is there an unused 8 pin dip board? It was a failed expriment and I couldn't remove the board, the super glue was indeed super.

The Keyer is a slightly modified AAØZZ EZKeyer, and it keys the transmitter over and over and over and ... It is loaded with the beacon message, in this case "K6JSS iHAB 2" and some spaces. K6JSS is the QRP ARCI club call and was the call of Harry Blomquist (SK) the founder of QRP ARCI . Craig Johnson, AAØZZ, conveniently provided a beacon mode in the keyer code. In this case the message is stored in memory #2, and is sent by holding holding down the memory button, causing the contents to cycle continously. The SPDT toggle switch performs the same function when aloft.   The large push button switch is the command button. Only the paddle jack is used since is needed for programming, and the others weren't neccessary to the mission.

Control of the transmitter from the ground is accomplished by DTMF tones from a 2M HT. Why is it neccessary to incorporate beacon control in the design? The FCC says so - I think. Reading the regulations leaves me pretty sure, but not positive. Taken together, parts 97.109 Station Control), 201(Auxillary Station), 203 (Beacon Station), and 213 (Telecommand) appear to require the ability to shut down any problematic station within 3 minutes of the problem occurrence, within 50KM (31 miles) of the surface of the Earth. The station can be automatically controlled on 2M and below, and must have a photocopy of the station license, telephone number of the license, and a control operator posted in a conspicous place. So to be safe, I incorporated a shutdown circuit controllable from the ground, and the paperwork is in place on the payload container.

Figure 6 shows the controller schematic and **Figure 5** is a picture of the SMT flip flop board that I produced. The input and output have been slightly modified from Dave Johnson's original circuit. Dave is the owner of DiscoverCircuits.com. and his circuit is used with permission.   If you're a schematic junkie like I am, www.discovercircuits.com is a wonderful place to spend some time browsing.. I added an MMBT3904 at the input and a 2N7002 at the output. The Ramsey Tone Decoder is a good fit for this project, saved much time,and works very well. To effect control of the beacon, an HT on the ground sends a signal with one of the DTMF tones to the airborne HT, and the audio tone then is passed to the tone decoder via the earphione jack on the HT.   The tone decoder performs it's function and sets a corresponding header pin low which triggers the flip flop board. The the flip flop's output stays high until it receives another pulse before going low.   So it toggles on and off as the HT on the ground sends commands, resulting in sending one transmission to turn the beacon off, and another one to turn it back on, if desired. The ability to turn it back on wold be important in the event of an accidental button push of the controlling keypad.

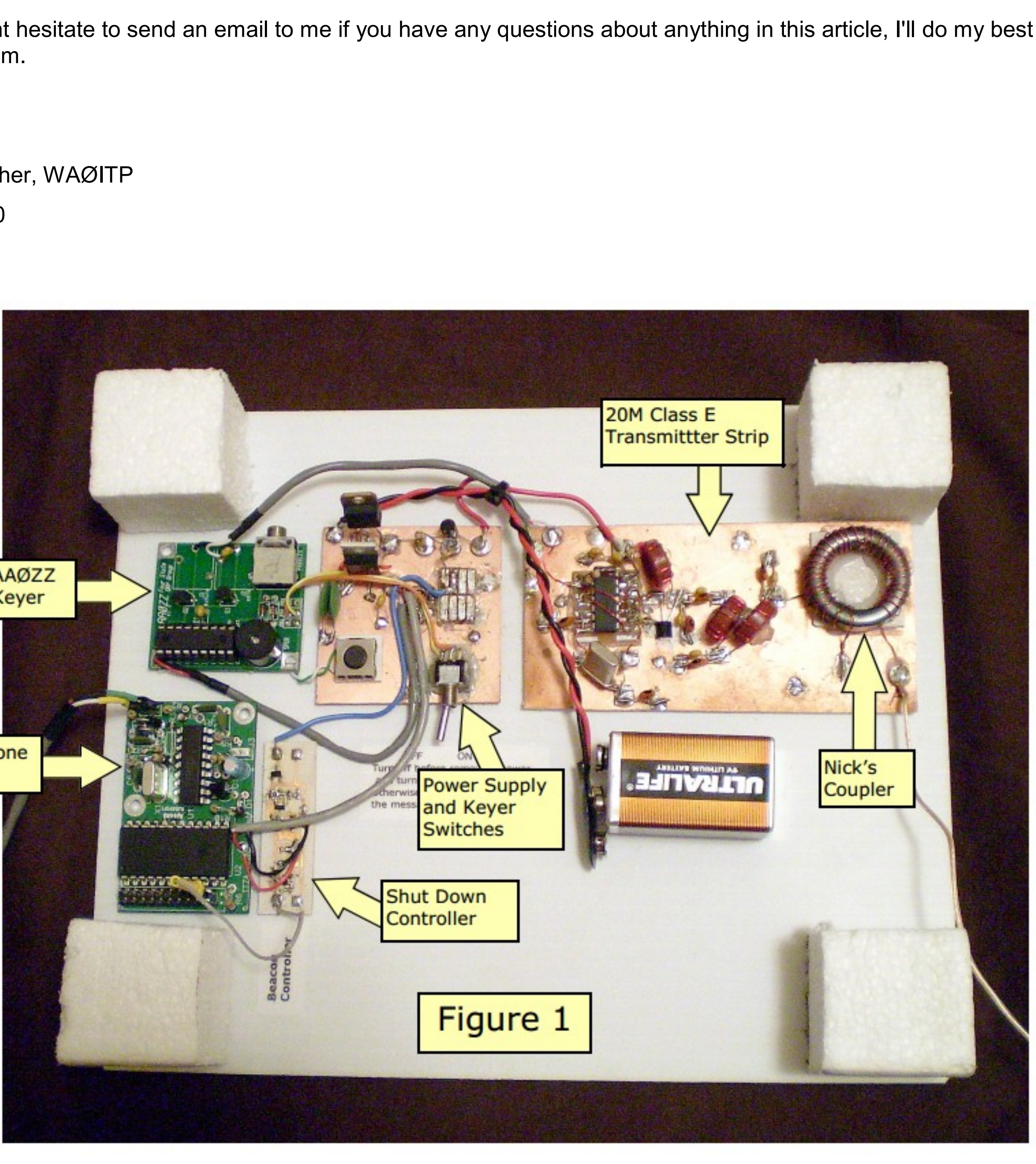
What's in the future? The beacon work is over but the benefits linger on. The beacon will fly again soon, and probably many more times The transmitter design is a good starting place for a small transmitter, and the rock solid performance, small parts count, and good keying make it the logical choice for a good SMT Winter project. By the time you read this it should be on the air. (This is being written on 20Nov2010) Working on this design fired my interest anew in Class E amps. Remembering Dave'spresentation on Class E design at FDIM 2008, I created an Excel spreadsheet using the design formulas he presented. Using the spreadsheet is very easy and the resulting amplifier is easy to build and a rewarding performer. The spreadsheet is found here http://www.wa0itp.com Along the way somewhere during this project, I lost my fear of Class E amplifiers. The subject seemed so intimidating until I read Dave's article in QRP Quarterly, Summer 2009.   I want to thank him for Elmering me through this project. He has the knack of explaining the esoteric to the untrained and making it understandable. That's more than a knack, it's a gift.

Please dont hesitate to send an email to me if you have any questions about anything in this article, I'll do my best to answer them.

72

Terry Fletcher, WAØITP

20Nov2010



IHAB 20M Beacon Transmitter

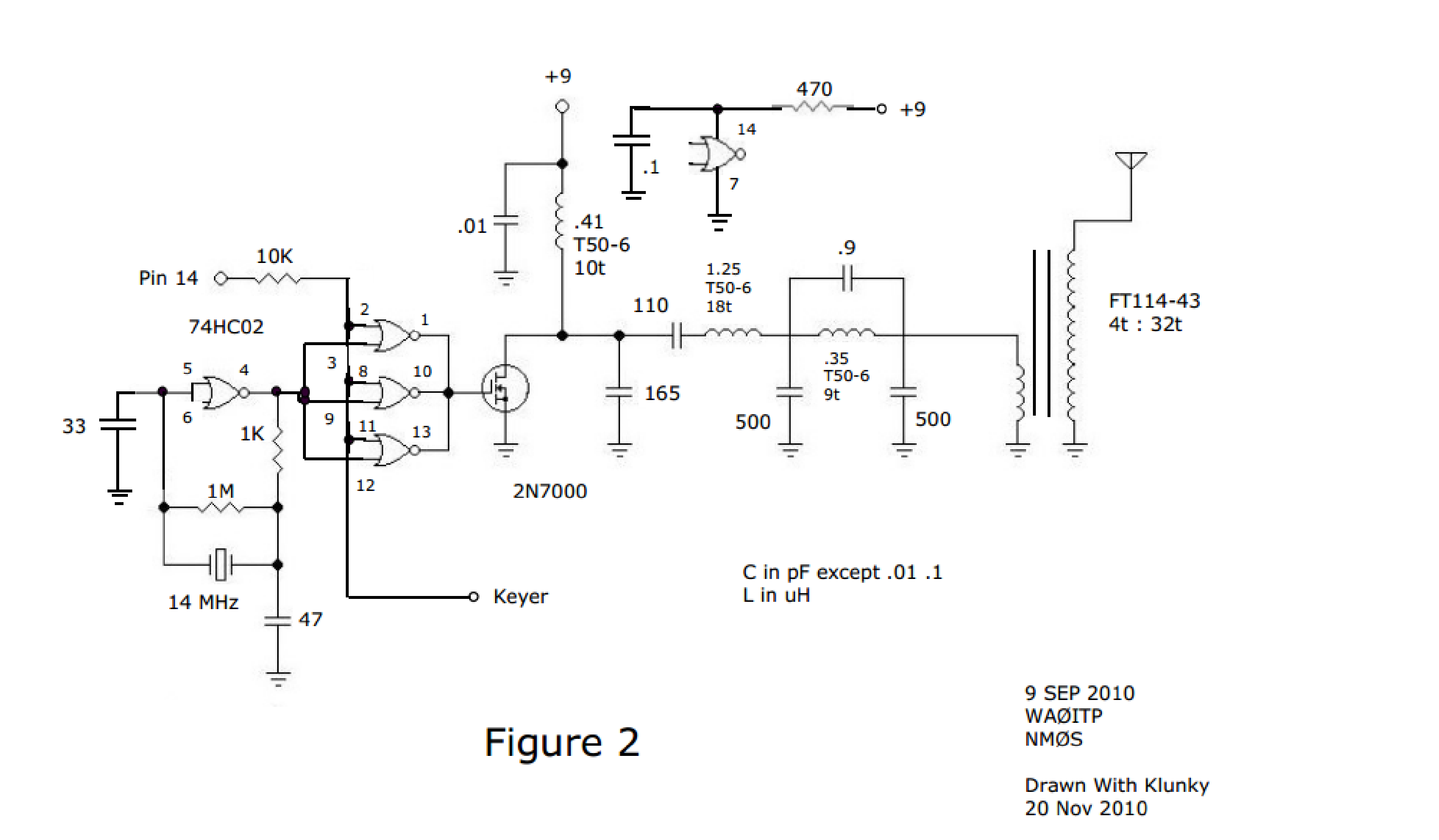


Figure 2

Power Supply and Switch Board

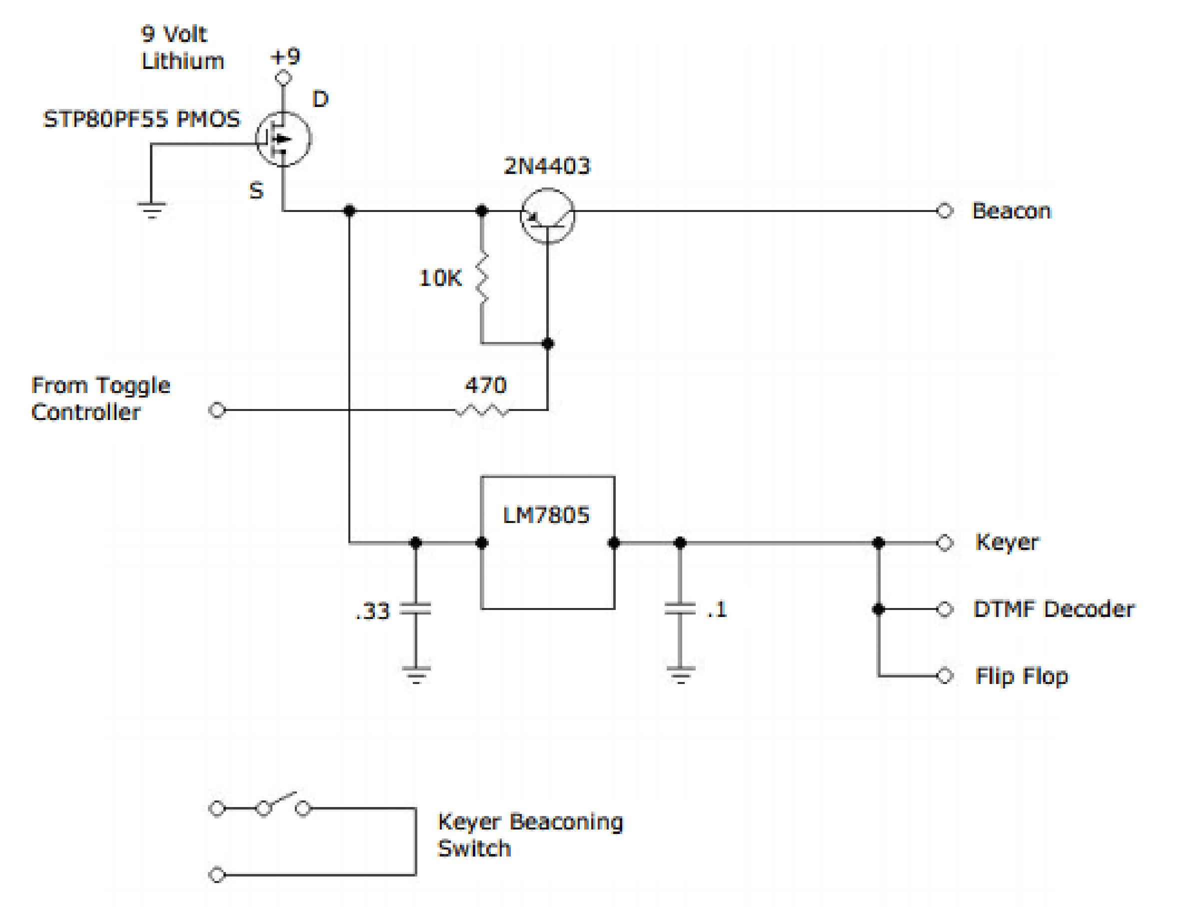
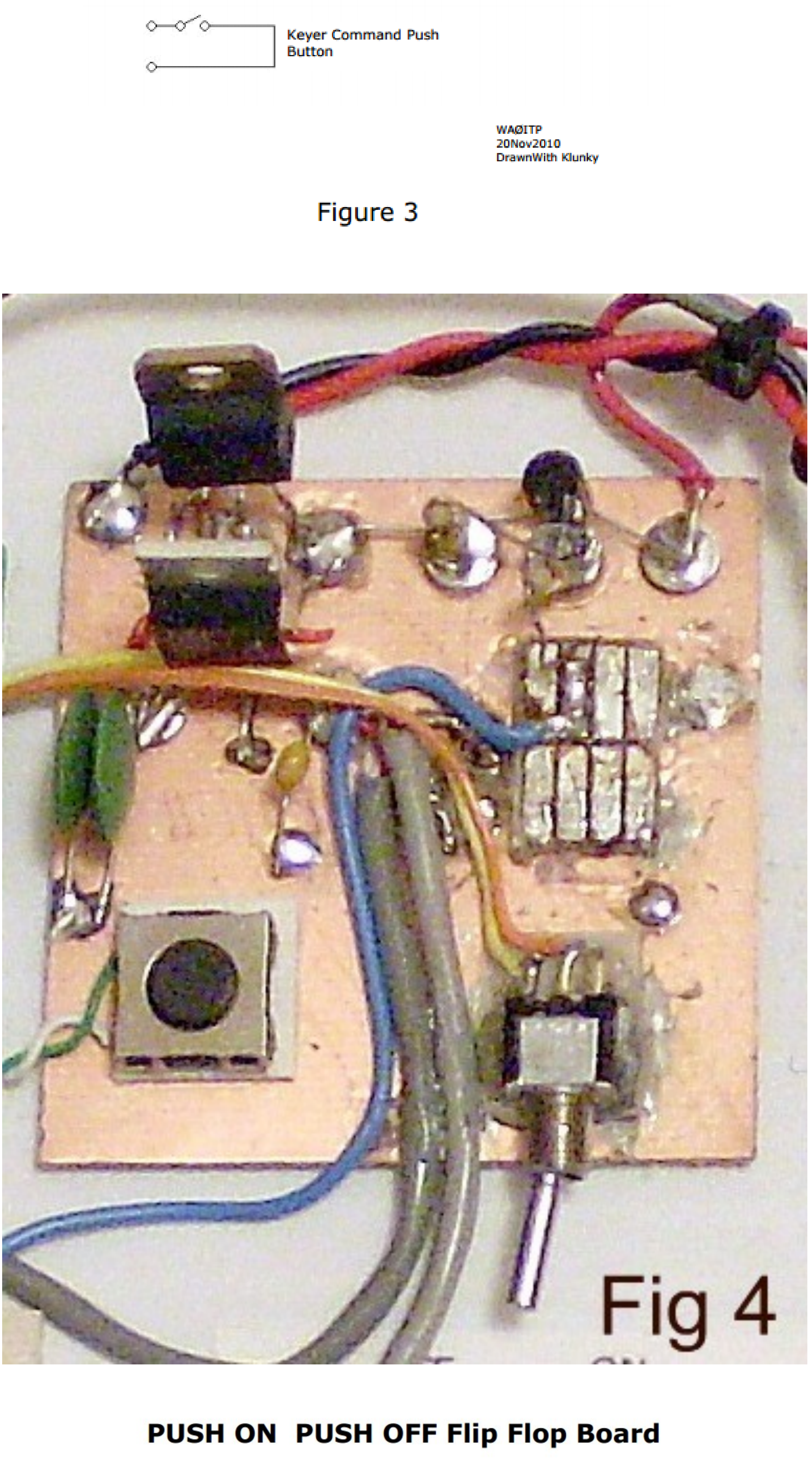


Figure 3



PUSH ON PUSH OFF Flip Flop Board

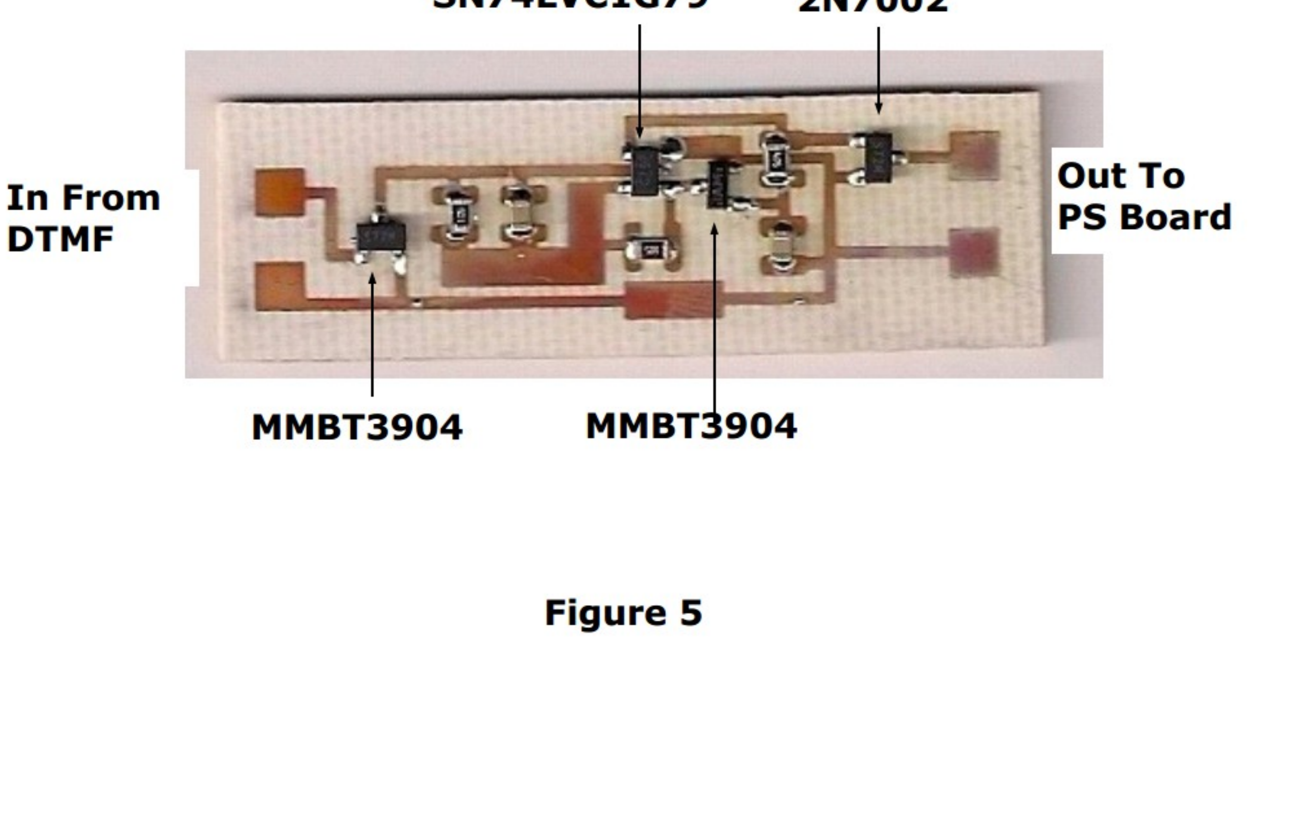


Figure 5

IHAB Beacon Controller

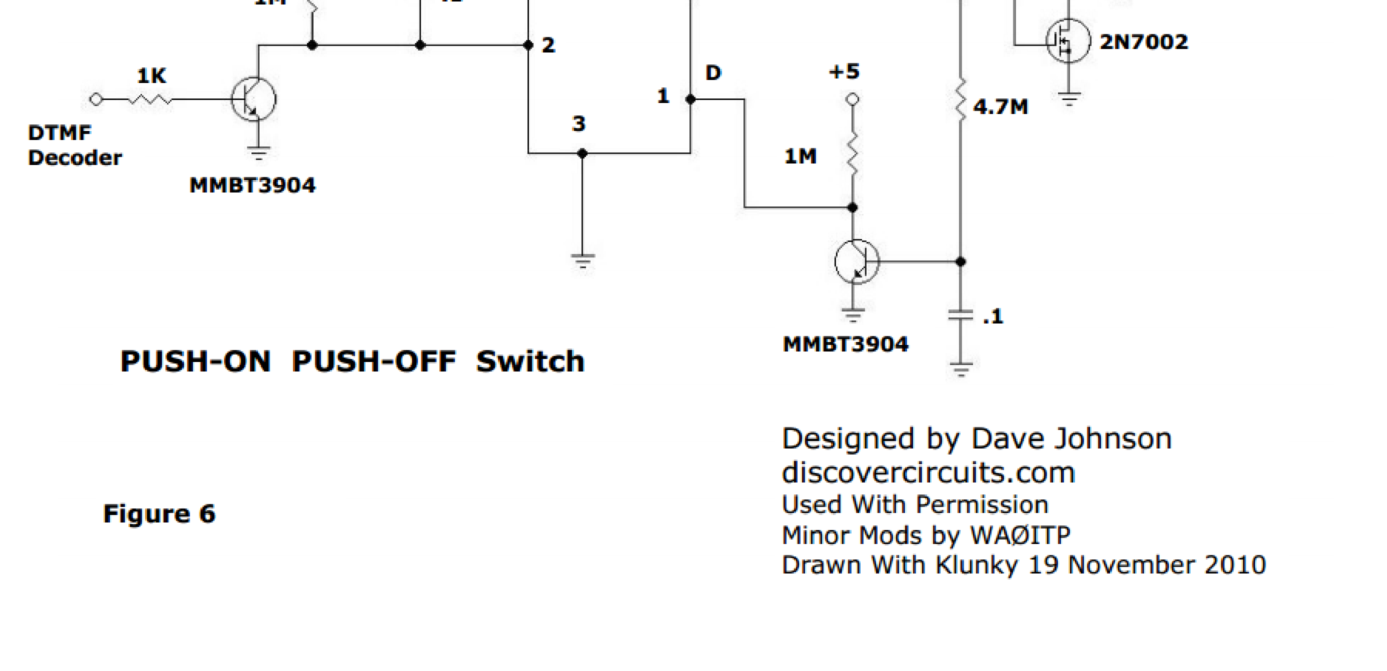


Figure 6