Beach 40 DSB voice transceiver for 7 MHz Page 1

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The Beach 40 is a simple yet practical voice transceiver for 40 metres, largely inspired by the pioneering ZL2BMI 80m DSB design of the 1980s. It uses only basic components; simplicity and ease of construction were considered more important than small size or modern techniques. The transceiver attracted great interest when demonstrated on YouTube and has been built around the world.

The Beach 40 can be built in stages from widely available parts. Its low power consumption makes it ideal for portable, SOTA or holiday operation. And the skills learned are those needed to later tackle an SSB project such as the BitX.

Tried and tested, you’re not on your own when you build a Beach 40. Other builders can be contacted through the ‘minimalist QRP’ Yahoo Group (www.groups.yahoo.com/minimalistqrp) in case of any problems.

Even those more operating inclined should consider assembling one. Readers who work 40 other stations on a Beach 40 (or similar DSB transceiver inspired by this article) can claim the ‘Beach 40-40 QRP Award’ free of charge. A distance award is also available. Details at the end of this article.

Circuit Description
The Beach 40 uses just six common transistors and an LM386 audio IC. It features a direct conversion receiver and DSB transmitter with about 1 to 2 watts output. The VFO, buffer, balanced modulator/product detector and low pass filter are shared between transmitter and receiver, minimising the parts used.

Stages are as follows:
VFO and buffer
These stages generate a carrier signal at the operating frequency, as required by both the transmitter and direct conversion receiver. A 7.2 MHz ceramic resonator pulled over a 7.050 to 7.200 MHz range with a series variable capacitor is used. The untuned buffer provides isolation between the oscillator and the rest of the transceiver.

A plastic transistor radio tuning capacitor adjusts the frequency. This can be fiddly to adjust as the whole range is crammed into a half turn of the dial. A potentiometer and power diode used as a varactor provide a fine tuning control, allowing easier resolution of SSB. If you have an air spaced capacitor and vernier reduction drive the fine tuning control can be omitted.

A 7 MHz crystal can be substituted if without a 7.2 MHz ceramic resonator. 7.159 MHz is the most common crystal frequency, though 7.122 MHz crystals are also cheaply available from overseas and are in a more active part of the band. In both cases crystals can be paralleled to provide a wide-swing ‘super VXO’. Actual frequency pulling range depends on series inductance and capacitance along with the crystals’ characteristics. Between 20 and 60 kHz should be possible with careful experimentation with inductor values.

Balanced modulator/product detector
This stage forms the heart of the transceiver. It is effectively a mixer that takes two incoming signals to produce a desired output. On transmit it combines the 7 MHz RF from the VFO with speech audio to produce an RF signal modulated with audio. On receive the process works in reverse, with an incoming 7 MHz signal mixing with the locally generated 7 MHz to produce an
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audio frequency difference. Having both functions in the one stage greatly simplifies construction.

Balanced modulators have surprisingly few components and are powered only by the incoming signals. Ordinary silicon diodes perform well in this circuit. The only other parts needed are an impedance step-up transformer and a potentiometer to set the balance.

Output from the balanced modulator should comprise two side bands and almost no carrier. The balance trim-pot and trimmer capacitor are once-only adjustments to achieve the required balance and carrier suppression.

Operating the balanced modulator in reverse on receive is elegantly simple, without extra switching required. The 7 MHz input from the buffer remains the same. The RF output becomes an RF input, with signals being applied from the antenna via the output filter and receive band pass filter. The audio output is tapped off the same point used for the audio input from the microphone amplifier on transmit.

**Receiver audio amplifier**
A high gain LM386 stage amplifies the very weak audio from the product detector. The extra parts in this circuit increase the gain to such an extent that no other amplification is necessary to drive headphones under normal suburban RF noise levels. Further background on this stage can be found in a Sprat article called ‘Unleashing the LM386’, also available on the web.

**Microphone amplifier**
The microphone amplifier is a simple transistor circuit intended to sufficiently drive the balanced modulator. DC bias is provided for an Electret microphone. However a dynamic microphone could be substituted (with the bias resistor removed) provided that its output is sufficient.

A separate stage for the microphone amplifier is not strictly necessary as the receiver audio amplifier could be reused instead. However, unlike the balanced modulator, this needs complex switching so it is easier to build a dedicated audio stage for transmit.

**RF amplifier/driver/power amplifier**
The 7 MHz DSB output from the balanced modulator is boosted by three broadband RF amplifier stages. These comprise a 2N2222 amplifier, a BD139 driver and another BD139 as the final amplifier with approximately 1 to 2 watts output.

**Transmit/receive switching**
The Beach 40 requires only two things to be switched to go from receive to transmit. These are the power connections (some stages get power only during transmit or receive) and the antenna (via the low pass filter).

A panel-mounted toggle switch is the easiest but for convenience I suggest a double pole double throw relay actuated by earthing one side of its coil through the microphone’s PTT switch.

One relay section switches the antenna/low pass filter between transmitter and receiver stages while the other switches the supply voltage. The ceramic resonator oscillator and buffer are common stages so remain on all the time.

**Low pass filter**
The low pass filter suppresses the significant harmonics that are likely to be on the transmitter’s
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output. It remains in circuit all the time to provide extra out of band rejection on receive.

Obtaining parts
Simple discrete parts are used to ensure reproducibility. They are generally available from suppliers such as Jaycar and Altronics. This includes the plastic dielectric variable capacitor, although an old metal / air-spaced unit can be substituted if available.

7.2 MHz ceramic resonators are rarer but not unobtainable. Suppliers listing them at the time of writing include Wagner Electronics in Sydney and VK5EME MiniKits. Or, as an alternative, use a VXO, with crystals for either 7.159 MHz (available from Rockby) or 7.122 MHz (available from Expanded Spectrum Systems). The latter covers a busier part of the band and can be pulled down by as much as 50 or 60 kHz with a carefully selected series inductance value and a good variable capacitor.

Obtaining the hardware should be equally easy. Use a metal case for good RF shielding. You can buy new but used is cheaper. Computer printer switch boxes are abundant, solidly built and a good size for QRP projects. Or consider a decorative tin, often stocked by op-shops for a few dollars. Salvaged switches, sockets and microphones allow further savings, as does blank printed circuit board material ordered via eBay.

Construction & Testing
Parts are mounted on pieces of blank printed circuit board material. Several pieces of board can be soldered together to form a chassis if desired. Offcuts from another board can be cut into 4 or 5mm squares to provide anchor points for parts that must be insulated from the earthed main board.

Build and test each stage individually to simplify troubleshooting.

Start with the ceramic resonator oscillator and buffer. Its output, as heard on a nearby receiver, should cover 7050 to over 7200 kHz. If it does not tune low enough check the connections of the variable capacitor and that both sections (often labelled ‘O’ and ‘A’ are in parallel. Conversely, if it lacks top end coverage adjust both trimmers (on the rear of the variable capacitor) to minimum and check for any stray capacitance or excessively long leads. This stage should be shielded from the rest of the rig, possibly using printed circuit board material or tin-plate as a partition.

The receiver audio amplifier can be built and tested next. You may wish to mount the LM386 in a socket and/or on a small piece of matrix board to spread out the connections. Or, if game you can simply mount it, upturned dead bug style, hard against the copper side of the board, with pins 2 and 4 bent back to be soldered to it. Apply power and headphones then touch the input with a screwdriver or finger. Hearing clicks and hum is proof that it is working.

The balanced modulator is next. Start by winding the two hole ferrite with enamelled copper wire such as found in old power transformers or available new. Unlike most balanced modulators there
is no need to twist the wires. Instead there is just a primary and secondary winding. Make a note of which side is which (possibly by using longer leads for one side) as connections are critical. Diode polarisation is important and short wires maximise balance. For now set the balance potentiometer to half travel.

By this time you have all three basic building blocks needed for a direct conversion receiver. Yield to temptation to connect and test. Connect the antenna to the balanced modulator/demodulator. Local and DX station should be receivable with headphones. If not troubleshoot with a locally generated signal.

Spend some time tuning around if this is your first direct conversion receiver. Gain will be lower than your black box so you must listen harder. However there will be a pleasing clarity to signals received. The receiver’s main drawback is that it can be overpowered by strong stations at night due to its limited front end filtering. Operating experience is that this is only rarely a problem as most within-VK activity on 40 metres takes place during the day.

Build the transmitter’s microphone amplifier next. Include the bias resistor going to the microphone socket if using an Electret insert. Otherwise leave it out. Apply power to the microphone amplifier, VFO and buffer and attach a wire to the balanced modulator’s output. Bring this near a 7 MHz SSB receiver and speak into the microphone, wearing headphones to prevent audio feedback. Your voice should be clear. Detune the SSB receiver so that a 1 kHz carrier tone is heard and adjust the balanced modulator’s trim-pot for a null, as indicated on the receiver’s signal strength meter. Tweak the trimmer capacitor for an even deeper null, touching up the balance trimpot if necessary. The balanced modulator is doing its job if the carrier is at least 30 or 40 dB below the signal level your voice peaks at.

Three stages follow, amplifying the transmitted signal to 1 to 2 watts. The pre-driver and driver use a broadband output coil wound on a similar two hole ferrite to that used in the balanced modulator. In this case though wires are twisted together before being wound. Polarity is again important. The coil in the output of the final amplifier stage is easier – just one piece of wire threaded through a cylindrical 6 hole ferrite bead. Finally add a heat sink to the final BD139 stage. This can be a 2 or 3 cm square of aluminium bent into a U screwed to the transistor.

Test each amplifier stage as it is built. The DSB output should get successively stronger but remain undistorted. A diode RF indicator or milliwatt RF power meter is a useful tool for these tests.

The output from the final amplifier is fed to a normally open contact of a 12 volt DPDT relay. The common contact of this switch section goes to the antenna (via the filter discussed next) while the normally closed contact is wired to the receiver input connection on the balanced modulator/product detector. The other section of the transmit receive relay controls the power; the common connection is 12 volts all the time, the normally open is 12 volts only on transmit (eg microphone amplifier and transmit RF amplifier stages) while the normally closed section goes to the receiver’s audio amplifier. The relay is actuated, and the rig set to transmit, by grounding one side of its coil through the PTT switch in the microphone.

Filtering is provided by a low pass filter. To cut down on coil winding it uses pre-wound 1uH RF chokes. Use mica or polystyrene capacitors if available. Otherwise disc ceramic types can be used but introduce a small loss. The filter is permanently in the antenna connection to work on both transmit and receive.
Testing
The receiver should still work after all the other stages have been added. If not check the wiring around the relay and that the required stages are getting power and RF.

Connect an RF power meter on a 5 or 10 watt scale, key up and speak loudly into the microphone. The power should rise to one or two watts on voice peaks and fall almost nothing between words. If not try re-tweaking the balanced modulator’s null potentiometer to null out the carrier. If this doesn’t work the driver or final amplifier stages may be oscillating or there may be RF feedback. Thin, peaky or distorted audio as heard on a nearby receiver is a good tell tale. Improve shielding and decoupling until the distortion goes away.

Operation and results
Use is simple. Connect to a full sized antenna, tune in and talk. Because the same local oscillator is used for the transmitter and receiver, the transmitter is automatically on frequency when received signals are properly tuned in. At this point you’ll be thankful for including the fine tuning control.

The Beach 40 is no DX machine due to its broad receiver and low power. However stations contacted have reported good transmit audio and many quality contacts over hundreds or even thousands of kilometres should be made. Its current consumption is also very low, making it particularly suitable for portable operating.

Beach 40-40 QRP Award
An award is available to anyone who works at least 40 different stations on 40 metres with a Beach 40 DSB QRP transceiver (or similar). It is free to any Lo-Key reader worldwide. The following simple rules apply:

1. Contacts will be initiated, made and concluded on a Beach 40 QRP DSB transceiver (or similar home brew transceiver project inspired by it) constructed after September 2012.
2. Valid contacts must be made within a 12 month period but can be from multiple locations (eg home and portable locations). Stations contacted must have heard enough of your signal to correctly receive your call sign, signal report and name without assistance.
3. Email a photo of your transceiver plus a log of at least 40 valid contacts (Word, Excel or text document only) with your application. Logs shall list date, UTC, station worked, signal report given, signal report received, name and location for each contact. Identify the furthest contact and give its distance for the distance record (see below).
4. We’ll generally accept your log extract as correct; there is no need to submit QSL cards or other proof.
5. Award recipients will be listed in Lo-Key. Certificates will be sent by email as an A4 pdf document. We may also use submitted photographs in Lo Key and on the Club’s website.

Beach 40 QRP Distance Award
QRP DSB can go surprisingly far on 40 metres. How long? This is what we are seeking to establish with the Beach 40 Distance record. Tell us the furthest you’ve worked on a Beach 40 (or similar DSB transceiver inspired by it). As before, stations contacted must have heard enough of your signal to correctly receive your call sign, signal report and name without assistance. Email a photo of your transceiver and details (ie date, UTC, station, reports exchanged and distance) with your application.

Apply for the distance record at the same time as the Beach 40-40 Award, before or after. Claim again if you work a further station (no limit on number of claims). Claims submitted will be
published in Lo-Key. The applicant working the furthest distance up to October 31, 2014 will receive a certificate as an A4 pdf document (printable at Officeworks or similar if a hard copy is desired).

**Beach 40 x 2 contacts**
Resolving DSB on a direct conversion receiver is hard work. Its even harder if it’s a 2 way QRP contact between two Beach 40s (or similar). Let us know if you achieve this feat along with the distance covered.