HF/UHF TRANSPONDER

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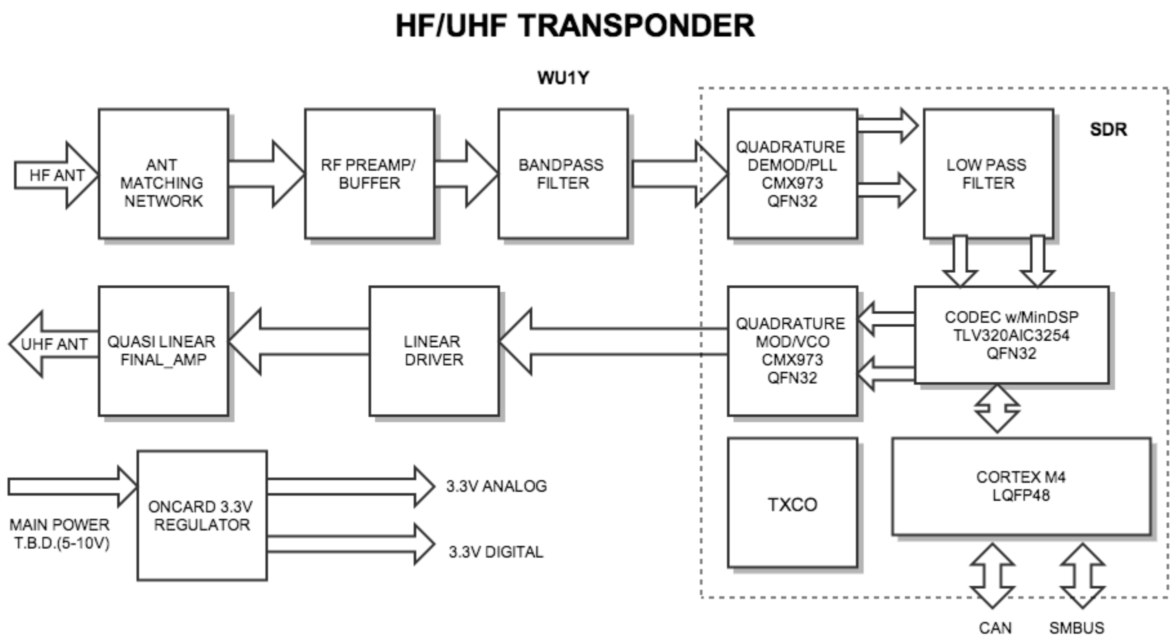
This paper provides a preliminary description of an HF/UHF Transponder suitable for HF/PSK31 to UHF/FM operation aboard a cubesat (or other satellite). The design fits within a cubesat kit card sized envelope. It can also fit within a smaller form factor of (3.5 in x 3.5 in).



Please refer to the block diagram. The proposed design is basically divided into three sections. These are the receive front end, the Software Defined Radio (SDR), and the transmit chain.

Receive Front End

The antenna is assumed to be an untuned monopole of approximately 35 cm or more. The antenna matching network transforms the expected high impedance of this antenna at 10 meters while also providing some hi-pass and low-pass filtering to reduce interference from ground based AM and FM broadcast stations and onboard VHF/UHF/L/S band transmitters.

The filter is followed by an RF amplifier which also provides buffering to stabilize the impedance driving the bandpass filter. The bandpass filter is a relatively high Q filter that restricts inputs to the SDR to the desired portion of the 10M band, centered around approximately 28.120 under all temperature conditions.

SDR RECEIVE

The front end feeds an integrated quadrature demodulator. This chip performs mixing of the RF input with a quadrature LO resulting in analog baseband I and Q signals. Note that the CMX973 provides both a modulator and demodulator in the same package. However, we are using the receive block from one chip and the transmit from a second chip because of incompatible frequencies for full duplex operation in this application. Unused functions on each chip are disabled. The ‘973 receive block has an internal variable gain amplifier on the RF input and variable gain amplifiers on both of the quadrature outputs. This allows easy implementation of AGC and quadrature balancing.

Each of the quadrature outputs then passes through a low pass filter which attenuates the out-of-band energy prior to conversion to digital. Although each of the quadrature stages have differential outputs, the performance may be better in a single ended configuration which eliminates mismatch between outputs and reduces parts count. Single ended operation also allows use of the uncommitted amplifiers in the package eliminating another active part.

The low-pass filtered quadrature outputs are then fed into the 320AIC3254 codec. This is a very flexible device with several features well suited to the SDR application. These include programmable miniDSP’s on inputs and outputs and programmable gain amplifiers. The baseline will use a 48KHz sample rate. The mini-dsp will be used to filter the input to the desired bandwidth so that simple decimation can be used by the DSP. Since it will operate in quadrature, bandwidths up to 48KHz can be supported. Digital inputs are passed to the microcontroller over the serial codec interface.

All further receive functions are performed in the digital domain. These are further described in a separate document. For the primary PSK31 function we perform translation of the desired 3100 Hz channel to baseband, demodulation to a real audio baseband and pre-emphasis. The flexibility of the SDR approach allows virtually any type of modulation to be handled.

SDR Transmit

The transmit audio digital baseband is transformed by a software modulator to FM I/Q. For a 5K deviation with 3000 Hz audio this signal will occupy about 16K of bandwidth.

The digital I/Q baseband is transformed by the codec to I/Q analog basebands. These are mixed by the quadrature modulator to provide a nominal 0dBm output rf. This will have a bandwidth of approximately 16K in the FM mode.

The SDR can also insert a pilot carrier, CW beacon, and/or PSK telemetry channel into the uplinked signal. In addition the SDR can generate higher speed AFSK or FSK for operation in high power mode. Alternatively, the SDR can generate QPSK and other modulations that require more linear operation for use with lower power operation.

Transmitter

The RF output of the modulator is fed to a linear driver amplifier providing on the order of 10dB of gain. This is then fed to the final amplifier which can provide up to 36dBM of output power at

>50% efficiency for FM, and near linear operation at lower power levels. The baseline RF device is an RFM RF6886. The output stages have provision for low-pass filtering to remove harmonics resulting from the non-linear operation at higher power levels.

Power Supply

To accommodate the widest range of input voltage while permitting the use of advanced RF devices, system power is converted to 3.3 volt levels using switching regulator. This directly supplies the output stages. An LDO is used to supply a quieter analog voltage rail for the lower signal level sections. The switching regulator can be bypassed in systems that can supply 3.3 - 3.6V power.