Pacsat Alternative Receiver Front End Design

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The following, for consideration, is a proposal for an alternative to the current Pacsat four-receiver configuration that reduces build cost, gains valuable board space and reduces weight without loss of performance.

Background

Pacsat requires four receivers operating on different frequencies within a common frequency range. The receivers share a common antenna, LNA and filtering. The output of the final component in the commonly shared chain must be split into four matching connections without substantial performance losses incorporating impedance matching for the individual receivers. The 1”4 split introduces a minimum 6db loss which must be overcome by the shared LNA.

Pacsat uses OnSemi AX5043 devices as receivers. The AX5043 has an uncommon receiver input requirement as a result of allowing as an option both receive and transmit on the same chip interface. The AX5043 incorporates an internal Class E amplifier which requires an output consisting of a 180-degree phase differential connection. The receiver, using the same connection, expects a 180-degree differential input.

The prototype Pacsat board uses a combination of a center tapped RF transformer as a 1:2 splitter with each output leg feeding a 1:4 transformer to obtain the necessary isolate 180-degree phase differential input to each of the four AX5043 receivers.

Analysis

The basic shared receiver-transmitter interface shown in Attachment 1 is similar to Figure 14 of the AX5043 Datasheet (Page 37). Looking from left to right there are three components, low pass filter, phase balun and transmitter Class E tank. The phase balun consists of a commonly fed inductor-capacitor low pass and high pass filter each feeding a leg of the AX5043 differential input/output. The low and high pass filter introduce a 90-degree phase shift in the opposite direction, the end result being a 180-degree differential connection to the AX5043. The phase balun must be tuned to the center frequency for the device.

Attachment 2, based on Figure 15 of the AX5043 Datasheet (Page 38), shows a configuration where the output of the AX5043 on transmit is taken from the optional PA output (not shown) and the receiver fed through a single ended circuit consisting of a blocking capacitor and the high-low pass balun into the receiver differential input. The AX5043 receiver requires an inductor to ground on each leg of the differential input. One of these conditions is met by the grounded inductor of the high pass filter with an additional inductor attached to the low-pass fed leg to ground.

During the early days of Pacsat development a Jonathan Brandenberg receiver board was modified to test this configuration on a single receiver with no obvious loss in performance. However, no formal performance testing was performed.

Proposal

It is proposed the three-transformer arrangement of the prototype Pacsat board be replaced with a single 1:4 splitter transformer with each output of the transformer forming a single ended input through individual phase baluns to the AX5043 differential receiver input.

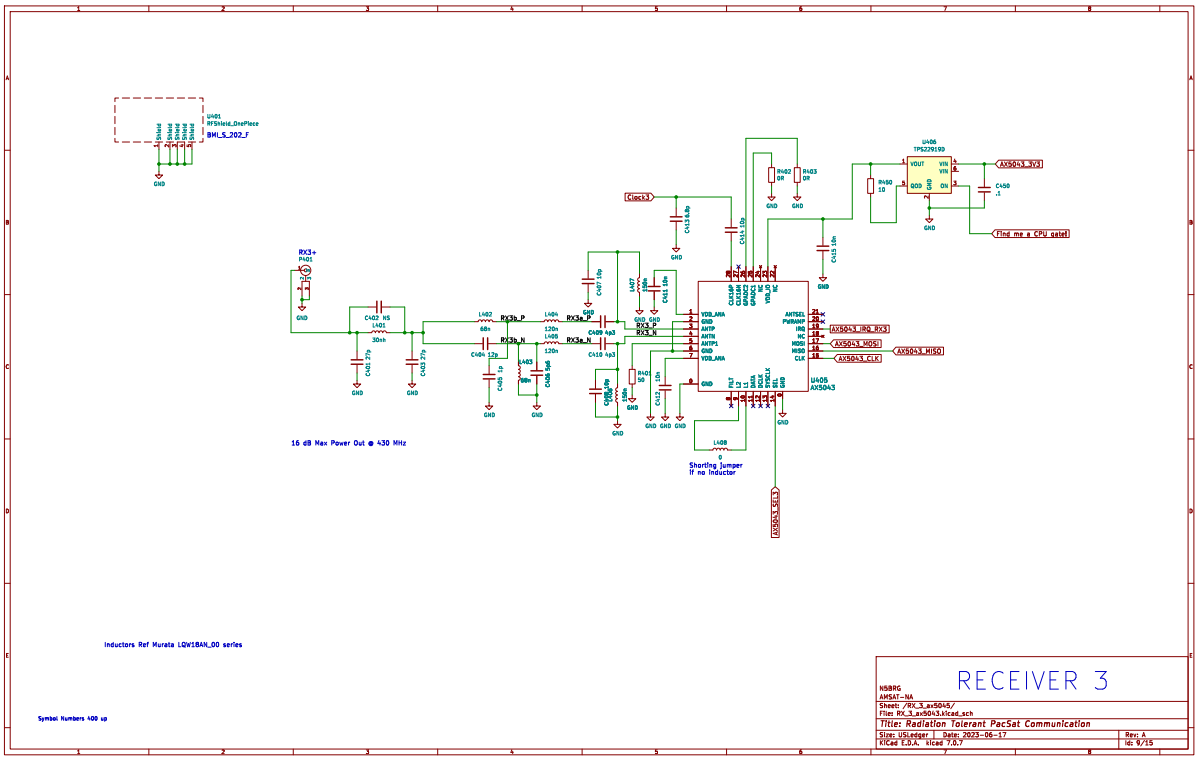
As the necessary components are common inductors and capacitors with no power handling requirements, using this approach will result in eliminating transformer cost in addition to reducing board weight and regaining board space for other features. This approach will require a new board layout requiring increased board area for each receiver.

Calculators to determine the component values for the phase baluns can be found on the internet. The values for the components in the AX5043 Datasheet indicate they are designed for reference frequency of 169mhz. However, when values are calculated for 169mhz using several available calculators, the values do not match those in the AX5043 Datasheet. Therefore, some work is needed to resolve this difference. It would be easy to construct a small board using calculated components to test the phase output as verification.

It is also assumed that the phase balun for each of the four receivers will be set to a common center frequency unless testing indicates a wide variation in output phase requiring separate phase balun component values for each receiver.

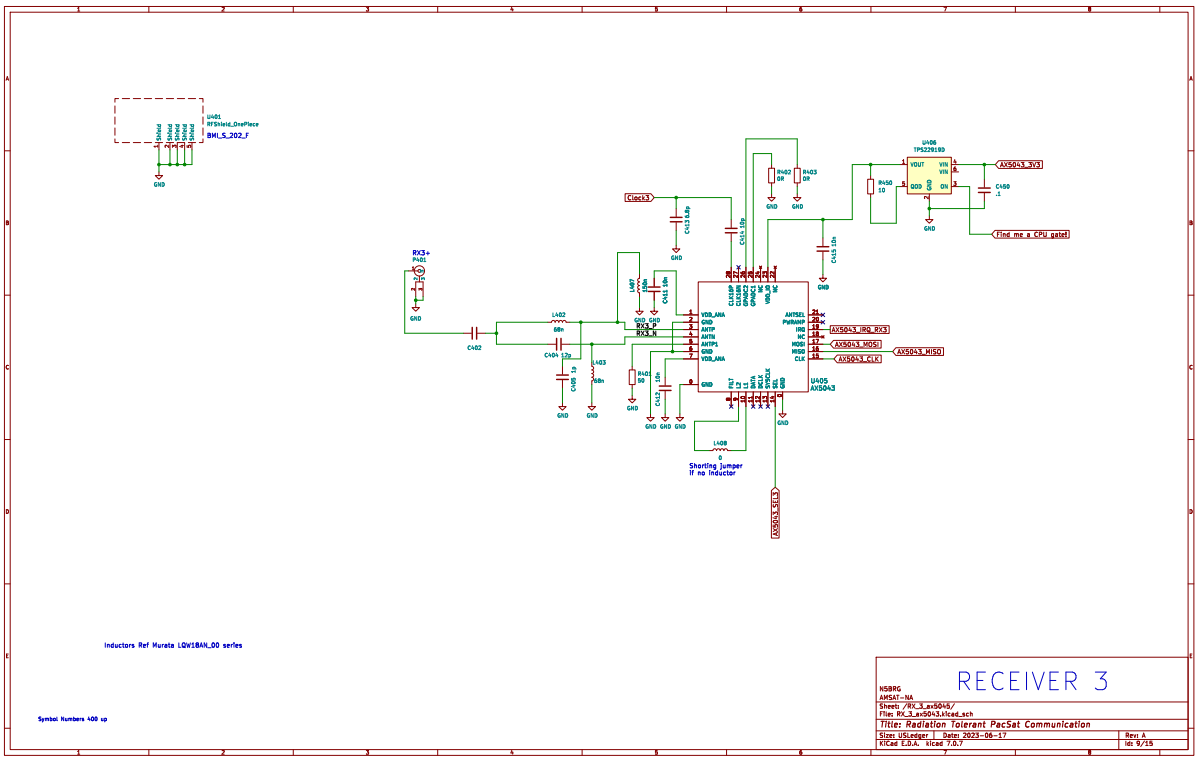
If proof of concept testing is desired, the LaunchPad board could be redone to accommodate two receivers using a 1:2 splitter which would result in a 3db signal loss rather than the 6db loss incurred by a 1:4 splitter. To emulate the performance of a four-receiver configuration a 3db attenuator would be added to the receive path prior to the splitter. The bandpass filter and LNA from the Pacsat prototype board should be included for full path testing.

Attachment 1



Common transmit and receive using AX503 differential connections.

Attachment 2



Single ended receiver with transmit component removed.