

ARISSat-1

Critical Design Review

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AMSAT[®]
Radio Amateur Satellite Corporation



U/v Transponder

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Introduction

- **U/v Transponder and Command Receiver**
 - Requirements
 - Design
 - Safety Considerations
 - Verification
 - Operations
 - Status

Transponder Objectives

- Transponder To Contain:
 - COMM RX at 70 CM
 - COMM TX at 2 Meters w/0.5 Watts Pout
 - Command RX at 70 CM
- Key Features
 - Interface to the SDX at 10.7 MHz
 - Good Transponder Linearity
 - Low Power Consumption
 - Small Size

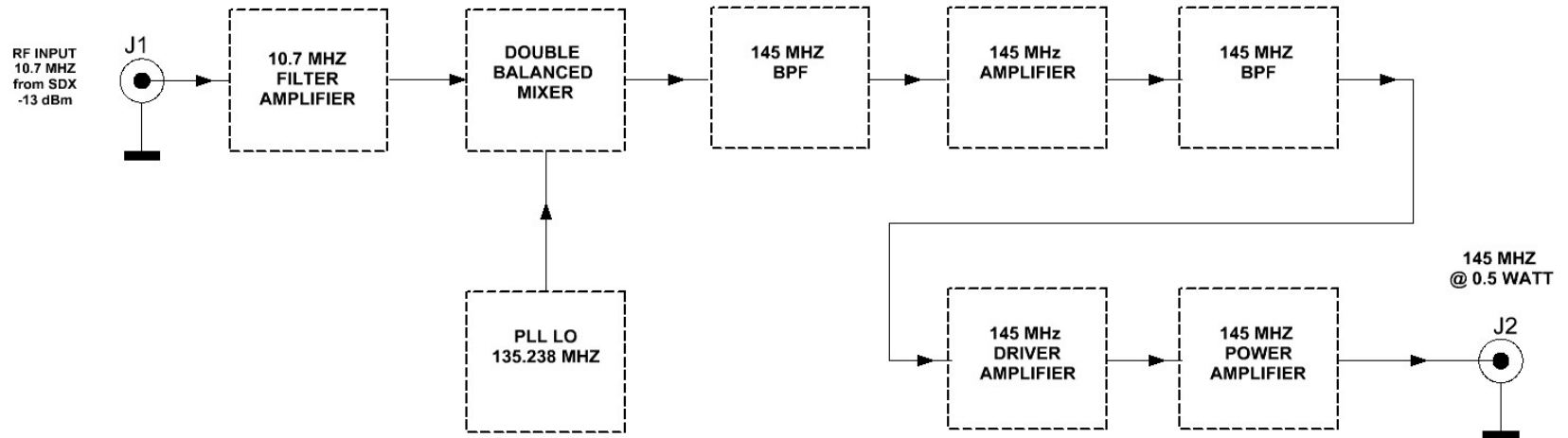
Requirements

- COMM TX - 10.7 MHz to 145.938 MHz Up Converter
 - 10.7 MHz in @ ~ -6 dBm
 - 145.938 MHz out @ 0.5 Watts
 - 8 Vdc in @ 240 mA
- COMM RX - 435.742 MHz to 10.7 MHz Down Converter
 - Noise Figure: 3 dB, Image Rejection: > -90 dB
 - AGC starting at -120 dBm, 10.7 MHz out @ -13 dBm
 - 8 Vdc in at 140 mA
- CMD RX - 435 MHz to Audio
 - Receives 435 MHz command signal through COMM RX
 - Audio out to DTMF decoder

COMM TX Design Strategy

- Use Single Conversion from 10.7 MHz to 145.938 MHz to simplify design
- Reduce Size of Filtering
- Use Phase Lock Loop Local Oscillator
- Include 10.7 MHz Input Filtering

COMM TX Block Diagram



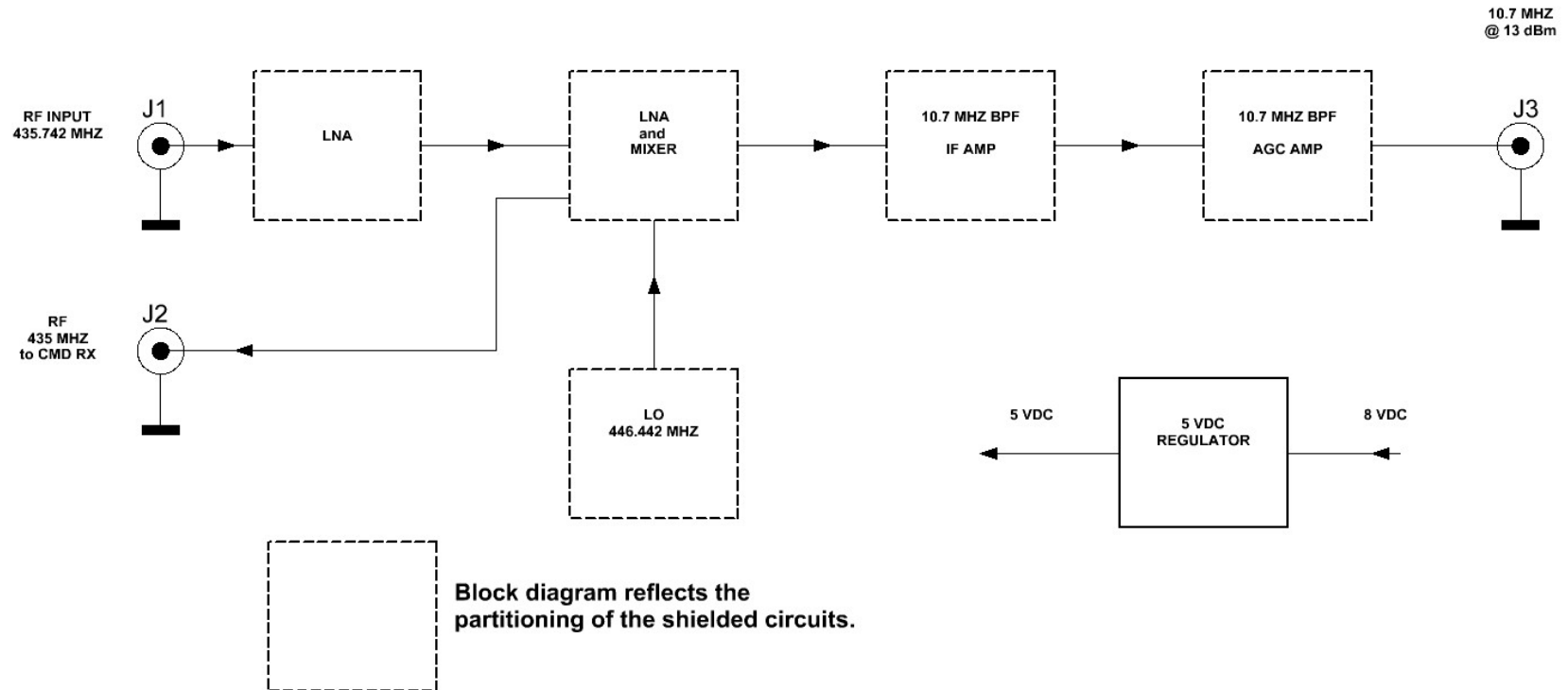
COMM TX PERFORMANCE

- IF Input: 10.7 MHz at ~ -6 dBm
- Power Output: +27 dBm (0.5 watts)
- DC Input Power: +8 Vdc @ 240 mA (1.92 watts)
- Overall Efficiency: 26%
- Frequency Accuracy : +/- 1 PPM (145 Hz at 145 MHz)
- Frequency Stability: +/- 2.5 PPM (-30 to +70C)
- Harmonic Rejection: -40 dBc
- Spurious Rejection: -50 dBc
- PCB Size: 2.35" (60 cm) X 2.8" (71 cm)

COMM RX Design Strategy

- Use Single Conversion (to simplify design)
- Lots of 435 MHz Input Filtering (for good image rejection)
- Low Noise Figure
- Reduce Size of Filtering (Saw vs. Helical)
- Use Phase Lock Loop Local Oscillator
- Include AGC to keep input to SDX constant
- Include 435 MHz output for CMD RX

COMM RX Block Diagram



COMM RX PERFORMANCE

- Input: 435 MHz
- Noise Figure: < 3.5 dB
- Image Rejection: > 90 dB
- AGC Threshold: -120 dBm
- IF Output: 10.7 MHz. at -13 dBm
- DC Input Power: +8 Vdc @ 135 mA (1.08 watts)
- Frequency Accuracy : +/- 1 PPM (435 Hz at 435 MHz)
- Frequency Stability: +/- 2.5 PPM (-30 to +70C)
- PCB Size: 2.35" (60 cm) X 2.8" (71 cm)

CMD RX Requirements

- Input Frequency: 435 to 438 MHz
- Dual Conversion
- Crystal Controlled LO
- Audio Filtering for DTMF Tones
- Receives 70 cm signal from COMM RX
- Noise Figure: 4 dB nominal
- Image Rejection: > -90 dB
- 8 Vdc at less than 20 mA

Verification

- Engineering units have been tested as a stand alone transponder in various laboratory scenarios with and without the SDX interface.

Operations

- As a “linear” U/v transponder, it will receive CW, SSB and FM 70 cm signals from ground stations. The bandwidth of 16 KHz will support many CW signals, up to 5 SSB signals or one FM signal
- It will transmit, the 70 cm received signals to the ground at 145.938 MHz
- At the same time it will also transmit other signals such as a FM signal used for SSTV and voice announcements, a BPSK telemetry channel and the CW beacon signal, all generated in the SDX.
- The CMD RX, with ground commands, will control key satellite functions

Status

- One “full spec” Engineering unit has been completed and has experienced various tests as a stand alone transponder and with the SDX interface.
- Two “flight” units are in process and will be available for environmental and system integration testing by the end of February

Status (continued)

- While the transponder has been tested under laboratory conditions, the environment and system integration testing still remains. As a result, I am recommending the following:
 - Develop a test plan to operate the “full” transponder mode
 - (70 cm input, through the SDX, and 145 MHz output)
 - Exercise the CMD RX command codes and satellite interfaces
 - Develop an environmental test plan for the transponder separate from and before system environmental testing:
 - High temperature (40 degrees C), operational 168 hour burn-in
 - Temperature tests (TBD parameters)
 - Temperature/altitude (TBD parameters)
 - Vibration (TBD parameters)
 - Complete/update the “build” documentation including the requirements documentation as result of the data obtain from the environmental and system tests.

An Engineering Unit

