Low Temperature Performance of COTS Electronic Components for Martian Surface Applications

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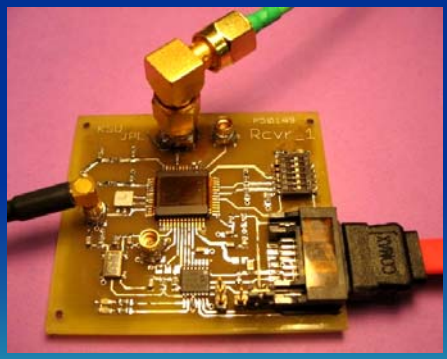
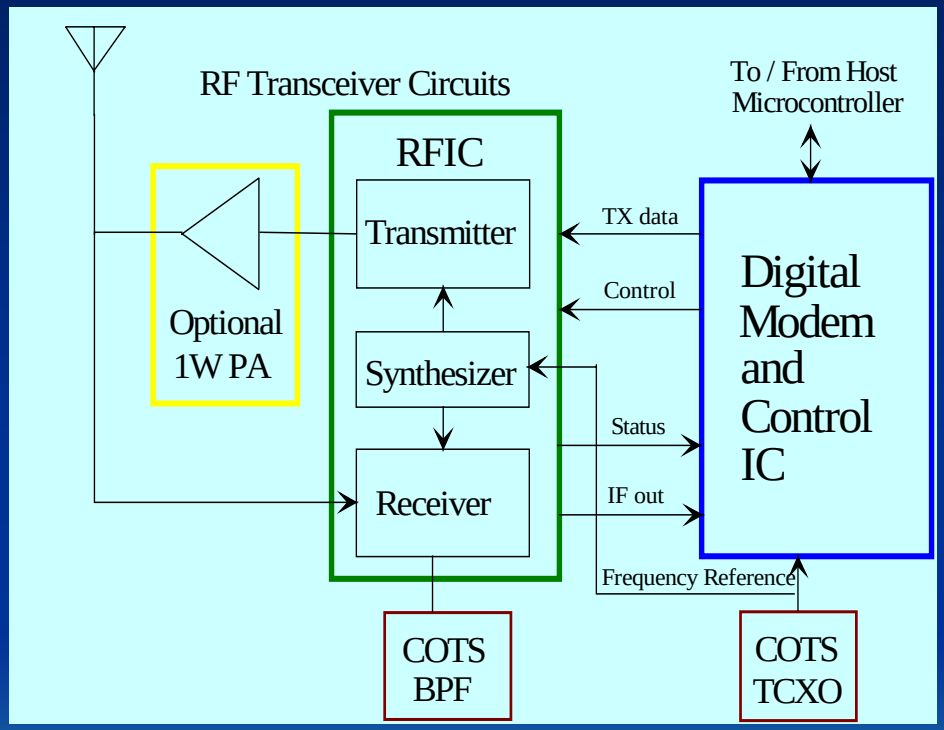
Background and Overview

- This work was carried out as part of the Mars Technology Program's UHF Proximity Microtransceiver development effort
- The microtransceiver will be a PC board form-factor radio with Prox-1 compatibility
- It is being designed for use outside normal warm electronic box (WEB) environments to help reduce mass and volume
- The goal is to work to < -100 C



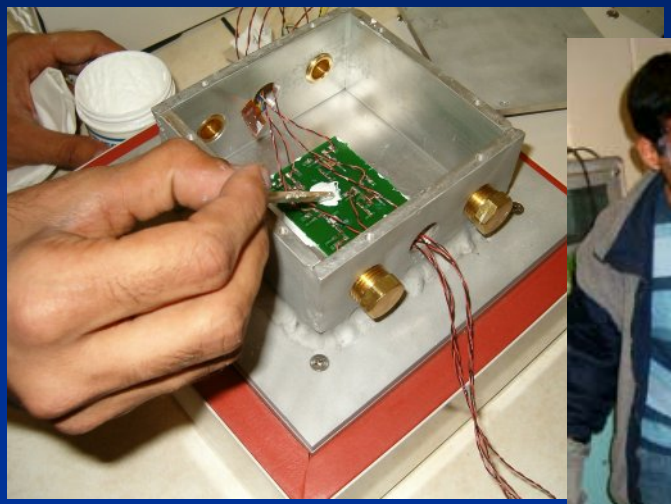
Top-Level Microtransceiver Block Diagram

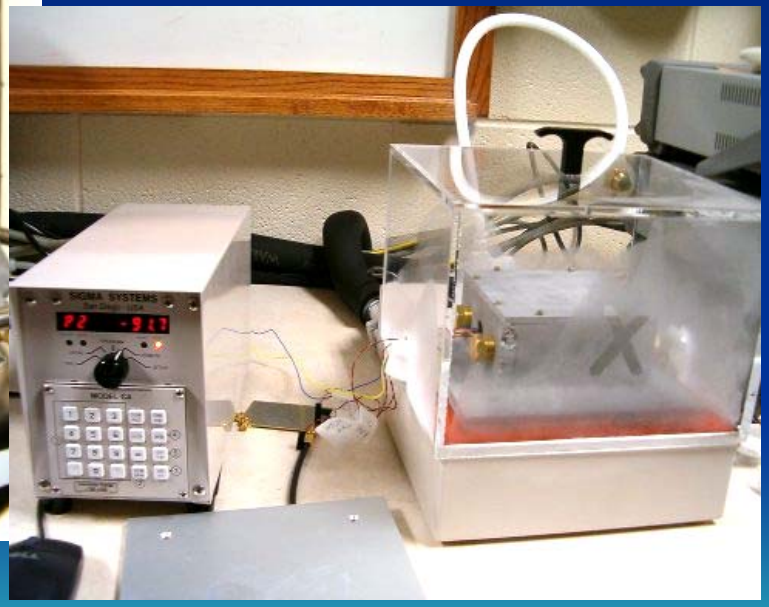


- Design employs a two / three chip solution for 10 mW / 100 mW / 1 Watt output.
- Receiver employs low-risk superhet architecture
- Off-chip components limited to Commercial Off-the-shelf (COTS) IF filter and TCXO
- Components characterized to < –100 C include both COTS parts and the Silicon-on-Sapphire IC process

Experimental Setup

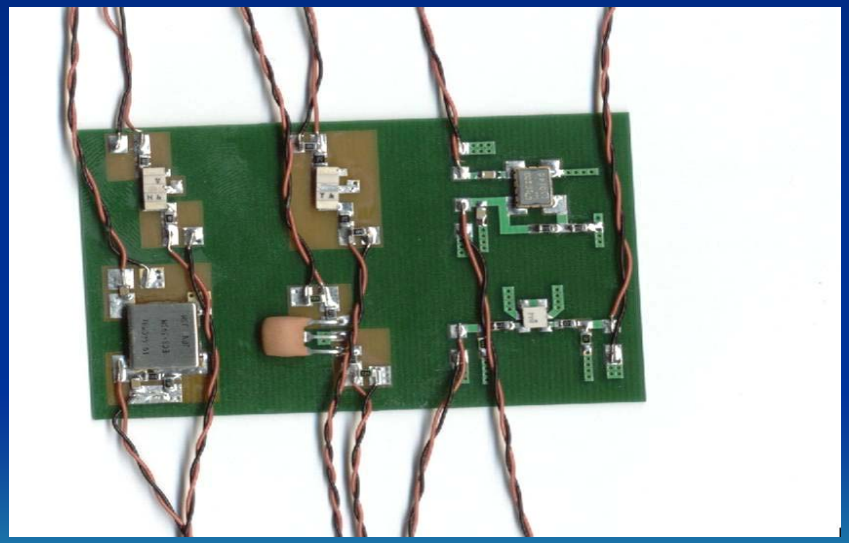
Cryogenic platform uses L-N2 for coolant, dual-probe Sigma-Systems platform, and custom Al test chamber.

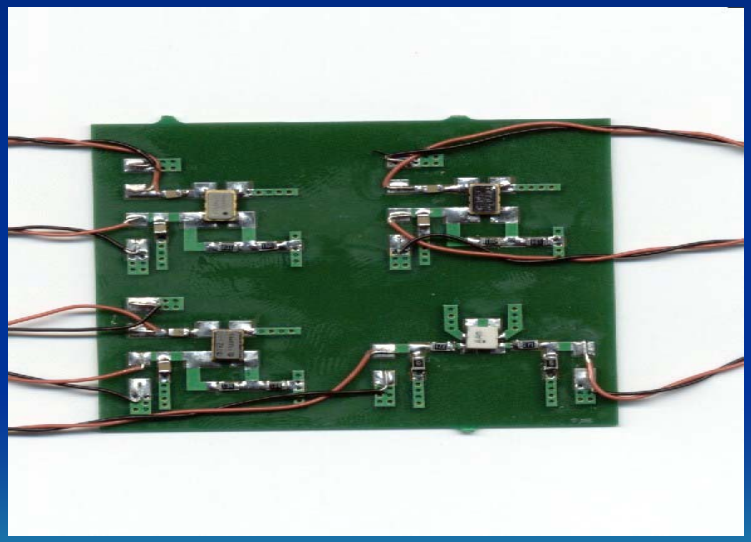




COTS Parts Tested

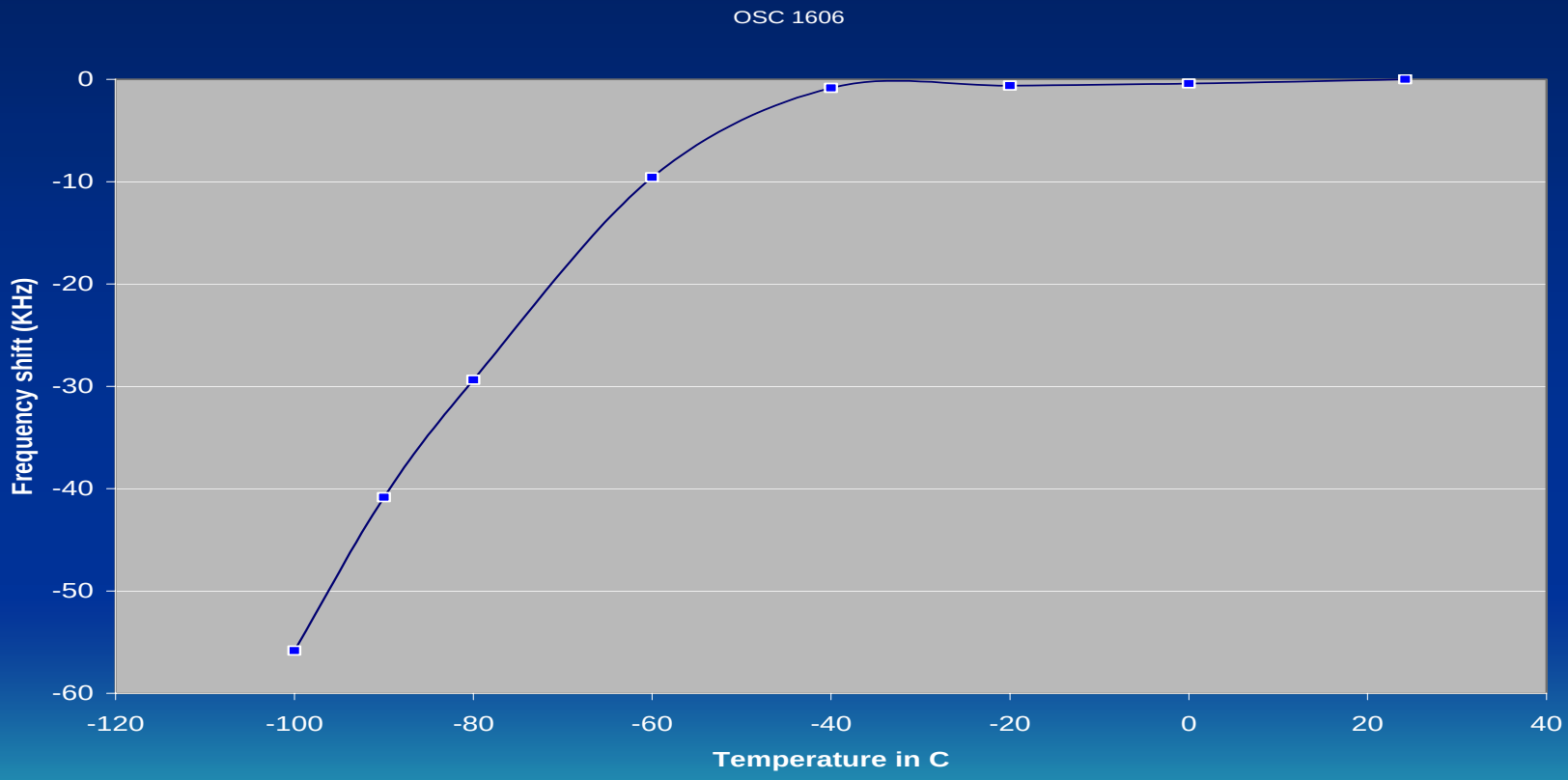
- 5 ceramic filter and 5 TCXOs were tested
- Probe 2 was placed directly on top of circuit boards to provide accurate assessment of device temperature





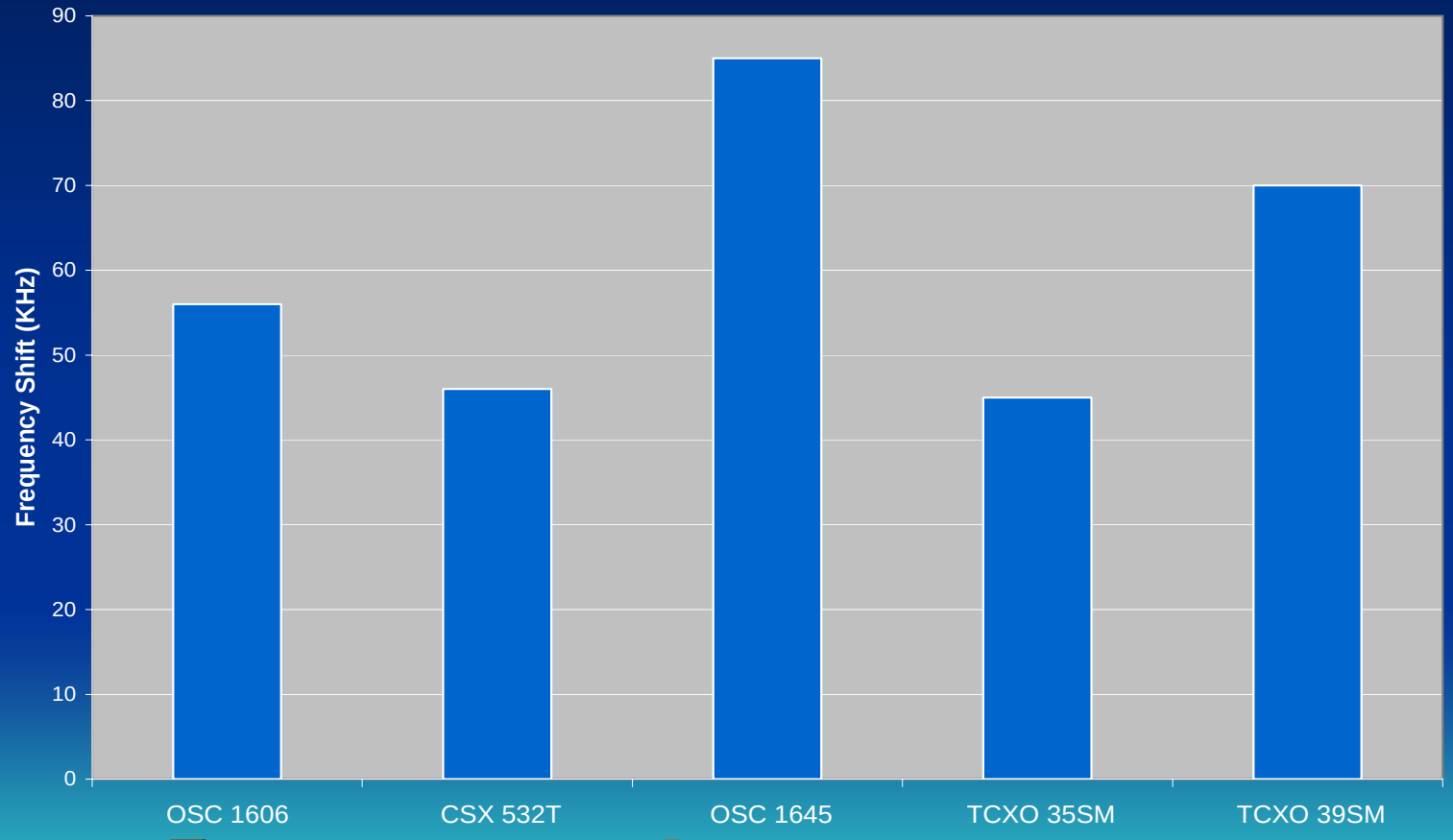
Example TCXO Test Results

NOTE: Freq shift has been scaled to value at 400 MHz PLL output

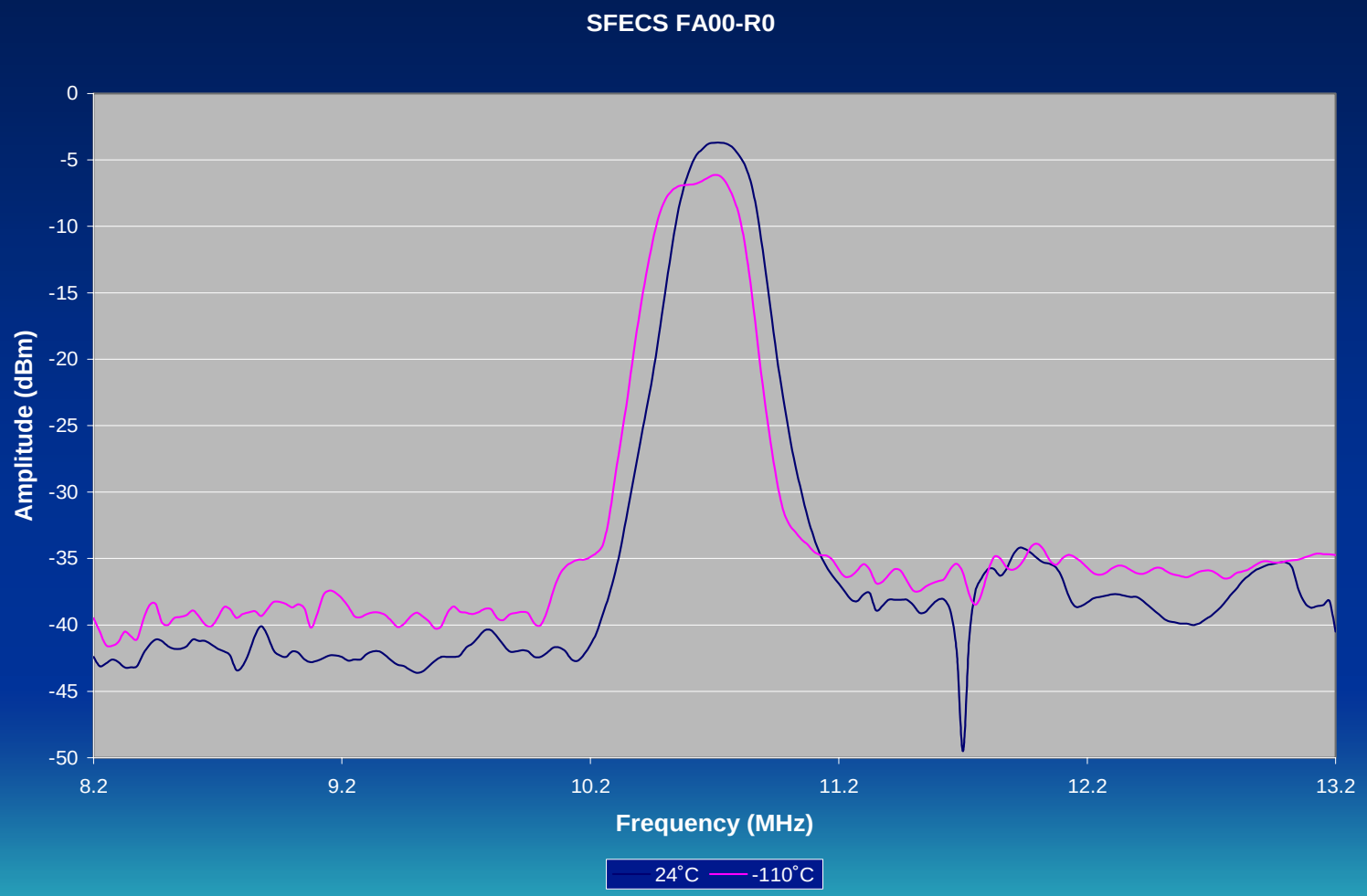


Comparison of TCXOs at –100 C

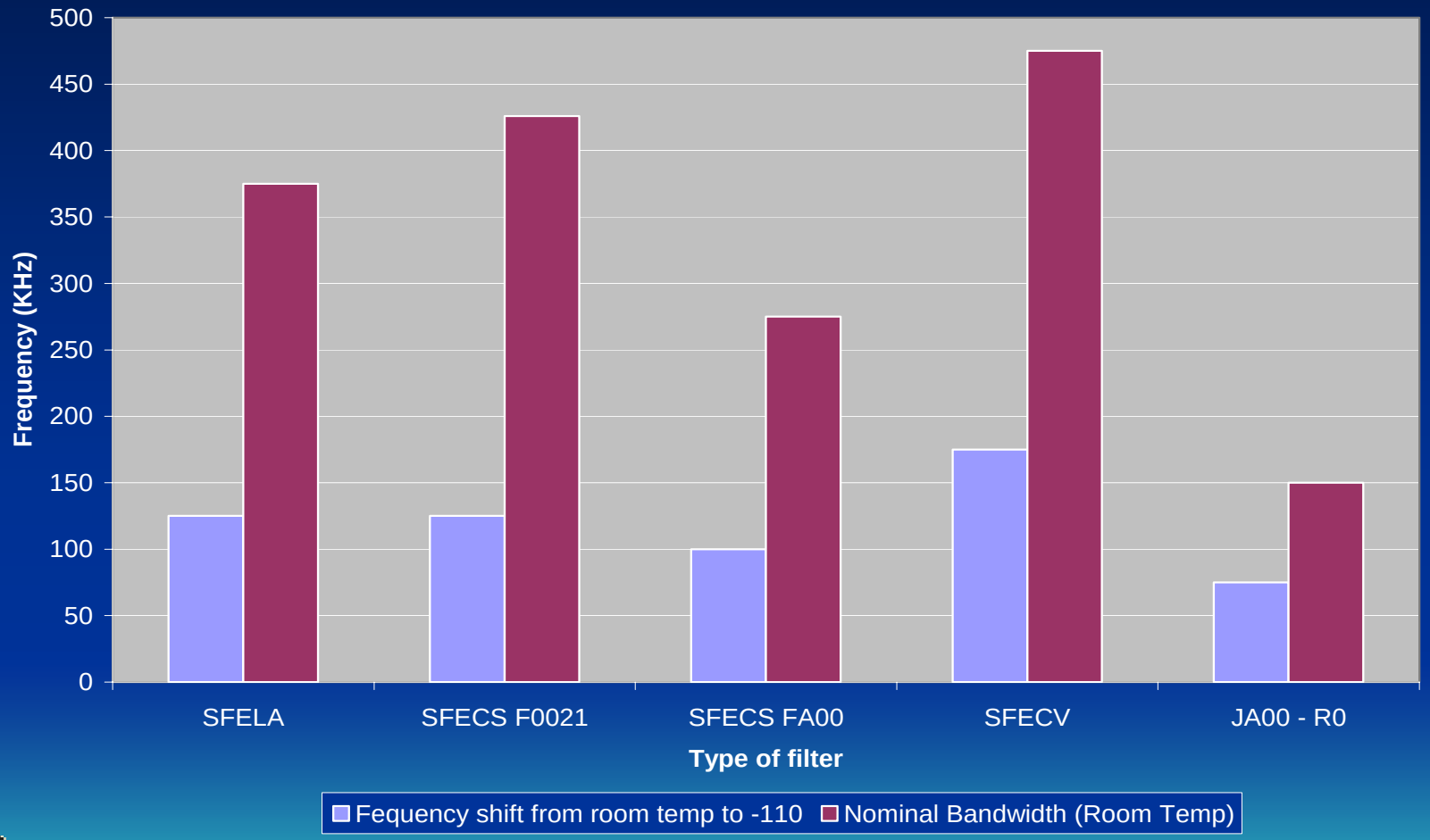
Freq shift has been scaled to value at 400 MHz PLL output



Example Filter Test Results

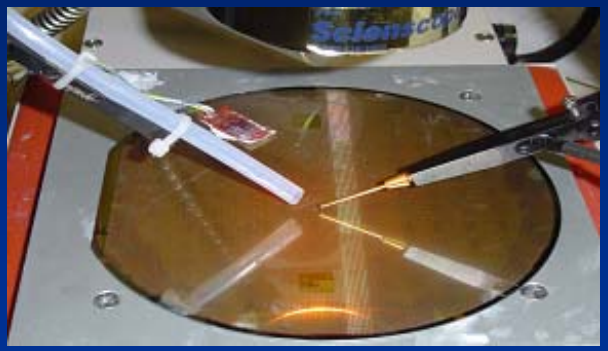


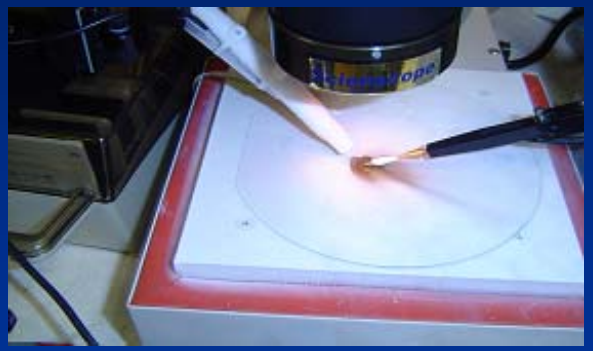
Comparison of Frequency Shift vs Bandwidths

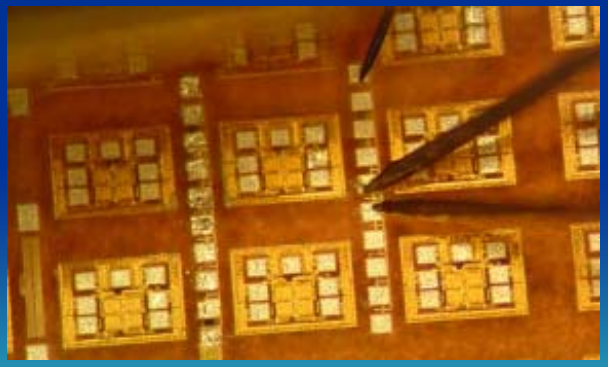


IC Process Testing

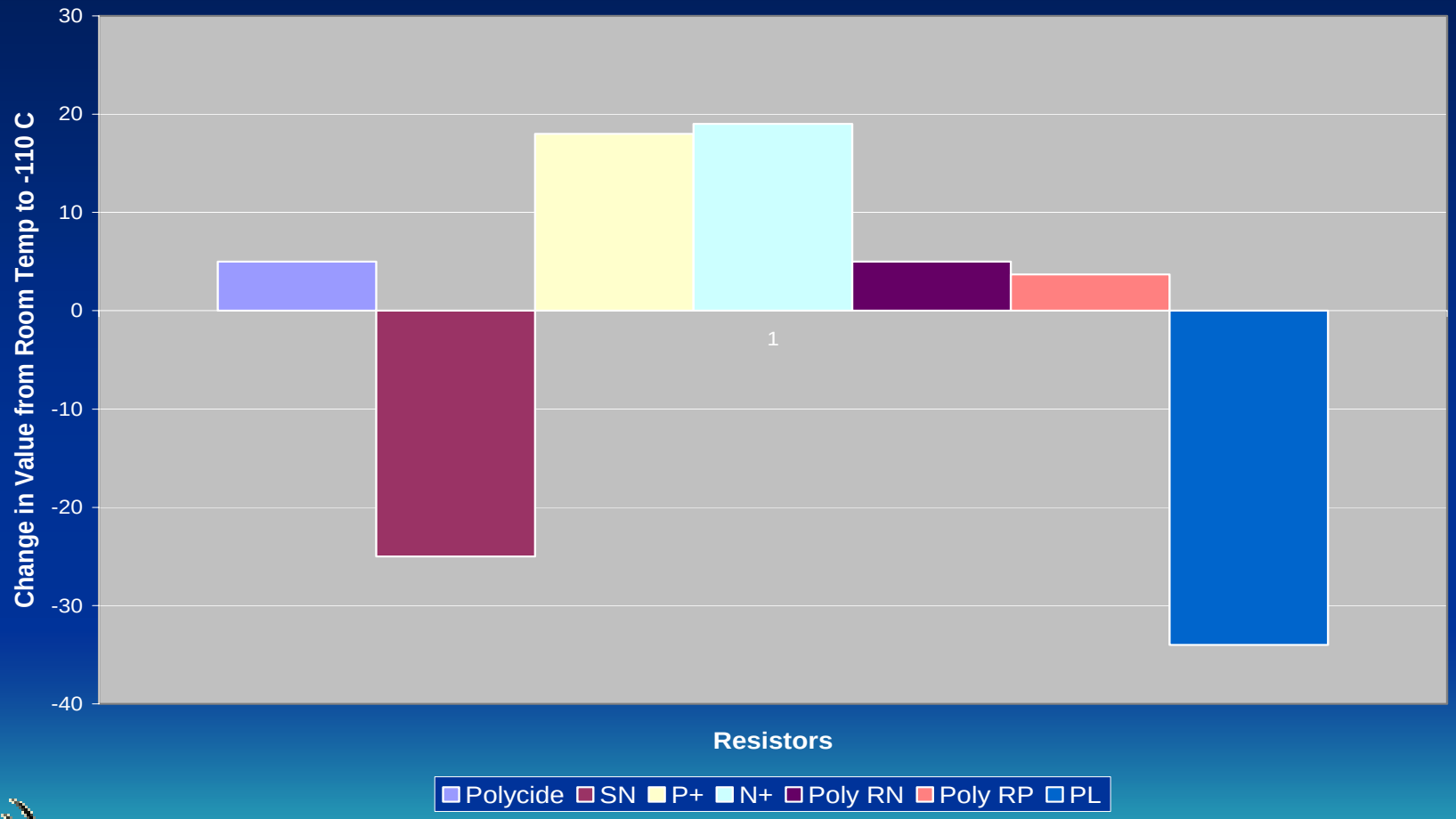
Cannot cover the semiconductor wafer like filters and TCXO because of probe issues.



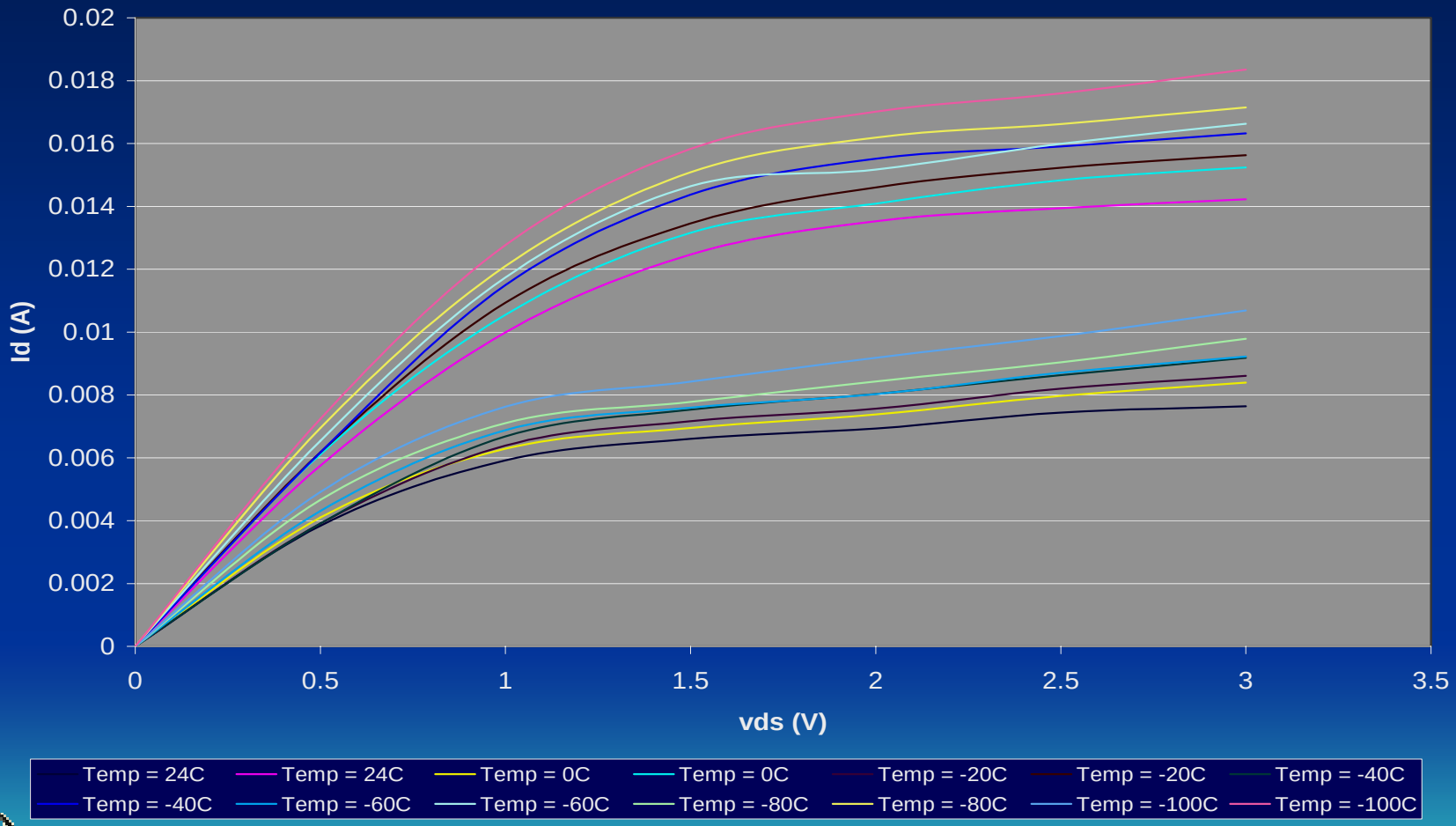




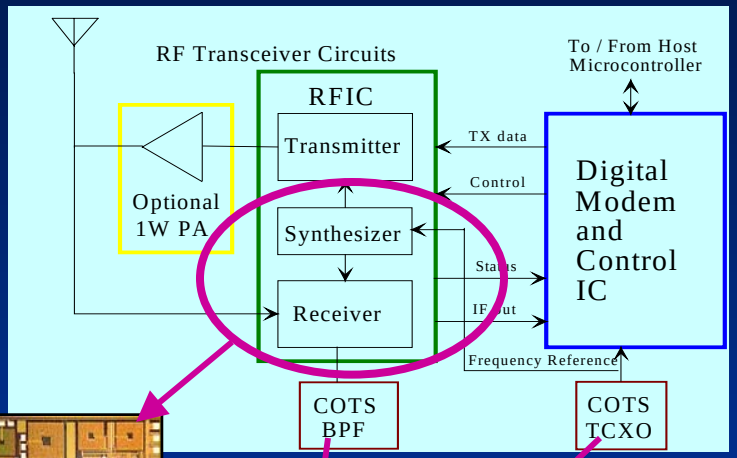
Resistor Percent Change at –100C



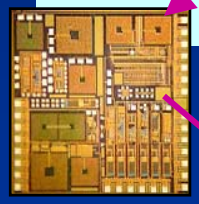
Example MOSFET Results



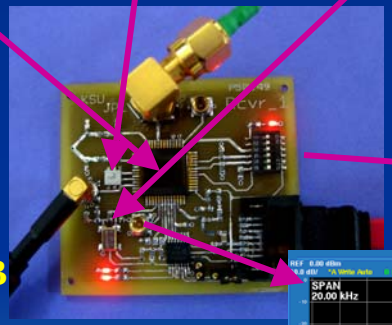
Fab1 Receiver RFIC Testing



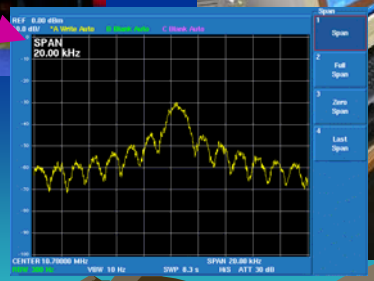
- Fab-1 die includes all major receiver blocks
- Use of high-side injection keeps signal in IF filter center at all temperatures
- Bias circuits designed to minimize gain change over temperature
- Low temperature testing shows nominal behavior to < –100C with low parametric drift



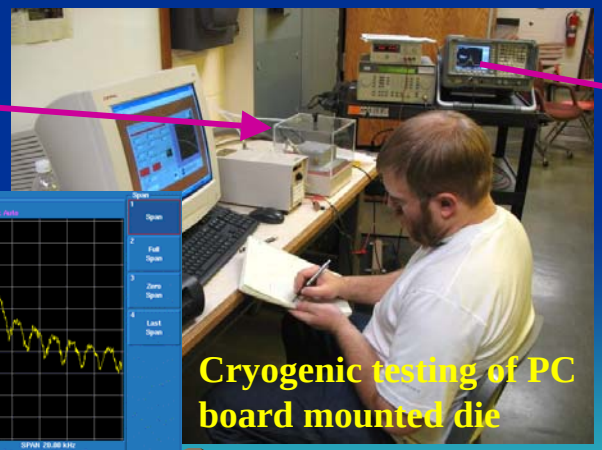
Fab1 die



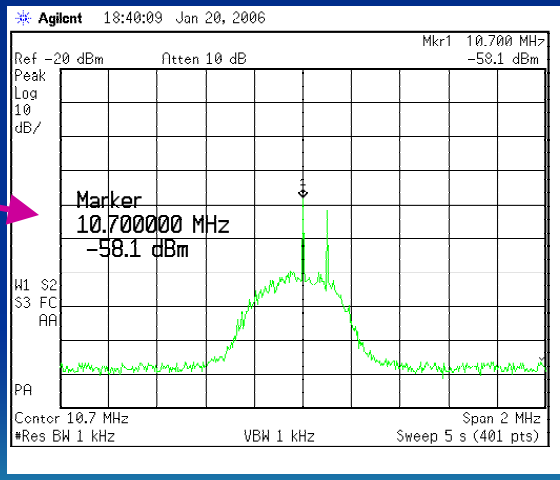
Packaged die on PCB



Spectrum of 1-bit ADC output (1.5 ksps QPSK)



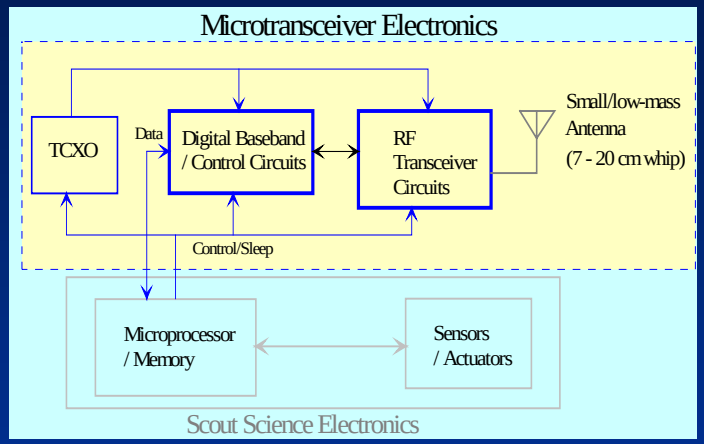
Cryogenic testing of PC board mounted die

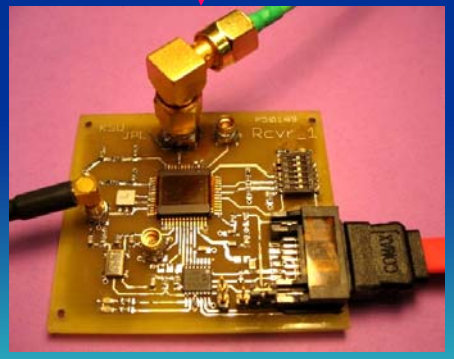


IF filter output from +25 C to –100 C with –100 dBm unmodulated carrier.
(reference harmonic spur visible to right)

Summary

- This project targets a UHF proximity microtransceiver module for aerobots, microrovers, penetrators and small network landers.
- Circuits are being designed for use outside warm box.





- COTS IF filters and TCXOs were characterized before design began
- System and circuit architectures employ measured temperature effects
- First prototype receiver circuits show excellent temperature performance to < -100 C ☺