Low Cost, Low Temperature ~~Lab~~ Shop Testing

James Jarvis

APRS World, LLC

www.aprsworld.com

Need

- South Pole field trial of WT10 wind turbine for IRIS / PASSCAL
  - -83°C to -12°C
  - APRS World WT10 wind turbine
    - bearings, seals & cables
  - Web Camera
    - operation
  - Instrumentation
    - operation and accuracy

Traditional Approaches: Thermal Chamber

Pros   Cons

- Fast
- Accura
- Able to

Traditional Approaches:
Field Testing

Pros   **Cons**

- Actual conditions

- Unpredictable

- Expensive

- Slow

Traditional Approaches:
Immersion (dry ice / acetone)

Pros

- Easy

- Liquid
- Solvent compatibility
- Very fast – thermal shocks

"Aldolrxnpic" by Original uploader was E kwan at en.wikipedia - Originally from en.wikipedia; description page is/was here.. Licensed under Public Domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Aldolrxnpic.jpg#/media/File:Aldolrxnpic.jpg

Idea: Ultra Freezer

- Two common ranges:
  - -40°C and -85°C
- Expensive new ($20k)
- Cheap and plentiful used ($1k)
- 120V @ 20A or 240V @ 15A – easy!

Ultra Freezer Pitfalls

- Often sold because they have problems
- Compressors and refrigerant are expensive
- Cascade system means that problem anywhere in system will require multiple compressors and refrigerant charges

Getting Colder: Liquid CO2

- Sublimination point: -78.5°C

- Cheap:$0.08 per pound

- Off the shelf controllers

- Readily available

APRS World's freezers

- Original -85°C worked for a few hours, then died
- Only -40°C freezers available given time and price constraints
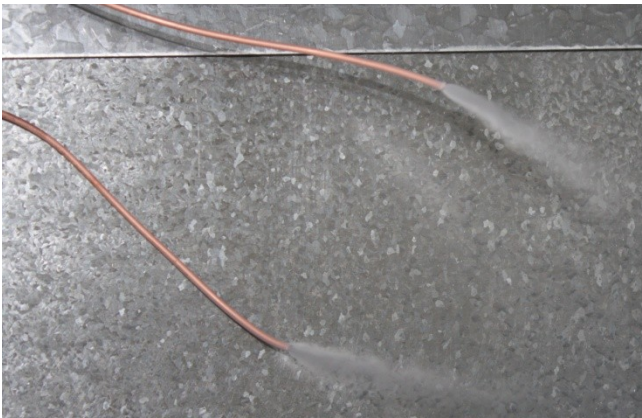
APRS World's Freezer Modifications

- So-Low -40°C Freezer
- Liquid CO2 for sub -40°C operation
- RTD (PT100) instrumentation
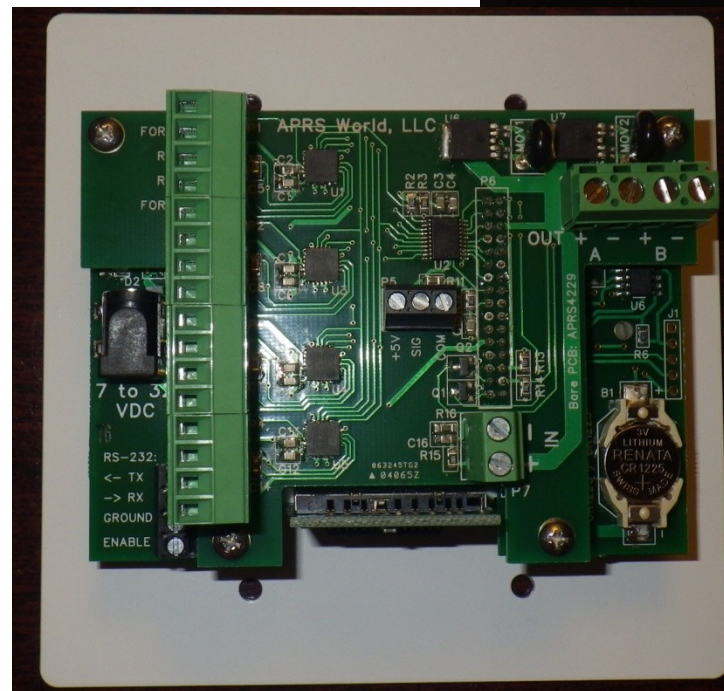- 5cm instrumentation port

APRS World's CO2 Controller Modifications

- Replaced unusual fittings with NPT
- Added solenoid indicator light
- Removed dead backup battery
- Designed and built missing CO2 discharge tube
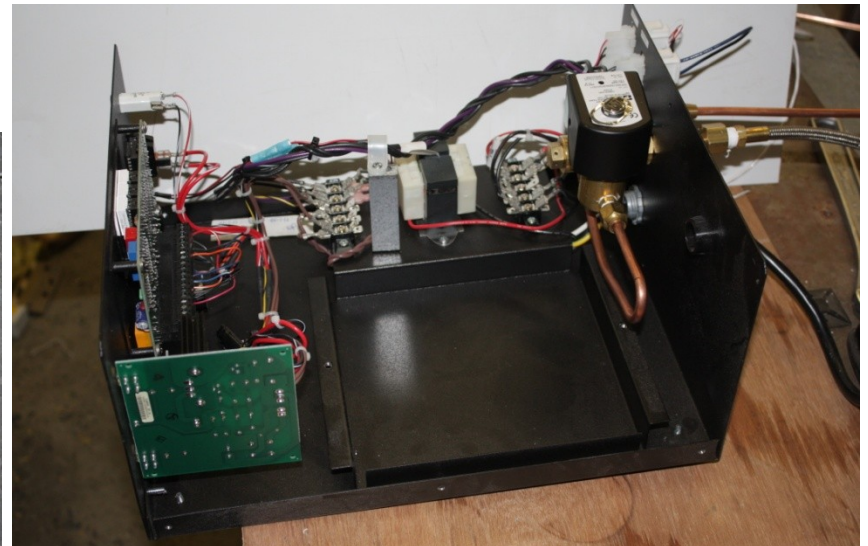
RTD Temperature Instrumentation: ThermokLogger-RTD

- 4 x PT100 or PT1000 RTD 4-wire inputs
- 2 x programmable solid state relay outputs
- SD card logging
- Real time clock
- LCD display
- Optional wireless modems
- RS-232 port

RTD Temperature Instrumentation: ThermokUSB-RTD2

- 2 x PT100 or PT1000 RTD 4-wire inputs
- USB interface
- Modbus or streaming ASCII
- Small (4 x 4.5cm)
- DIN rail mountable
- Open Source
  - hardware
  - firmware
  - software
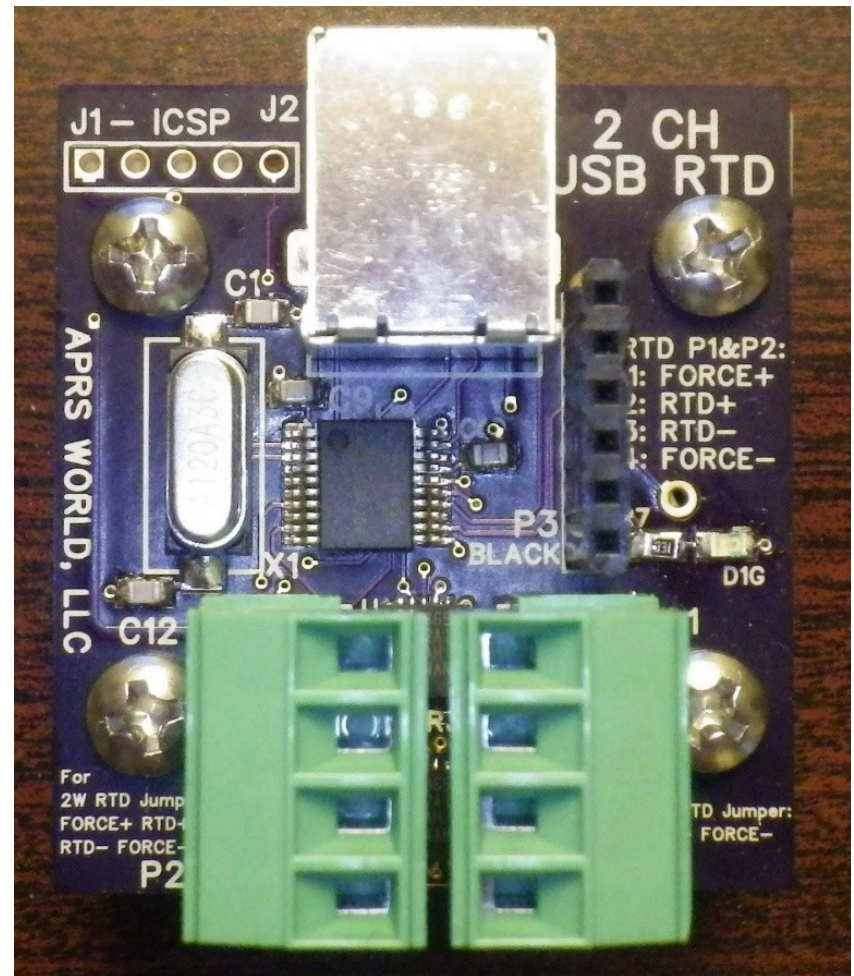
Bearing Friction Testing

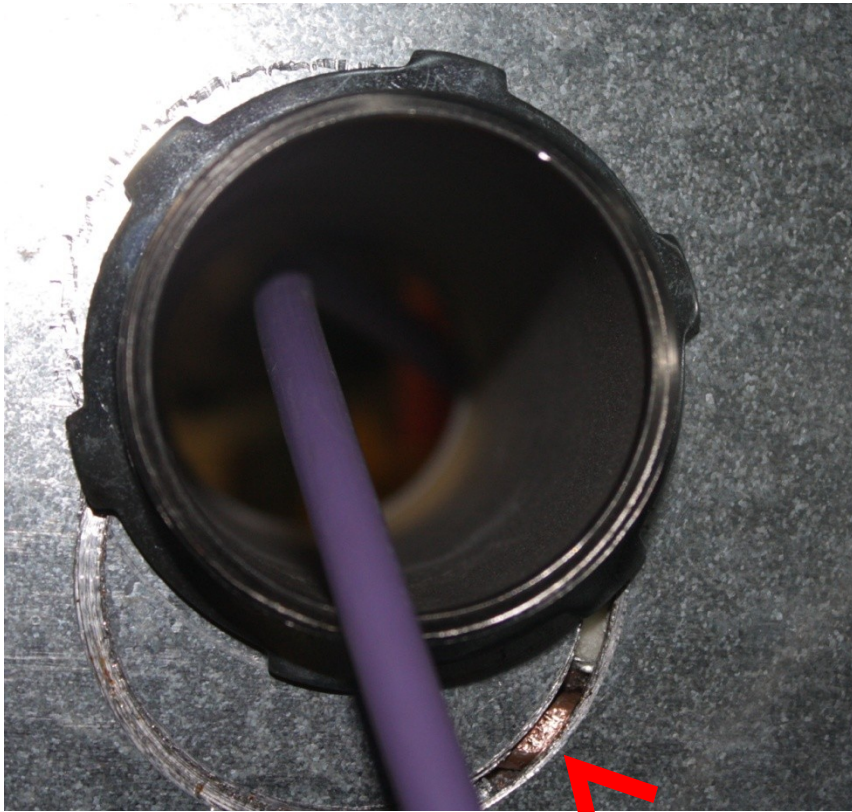- 12-volt cordless drill with drive adapter for WTAPRS

- DC power / energy meter

- Lower power to turn turbine at given RPM => less bearing losses

Instrumentation Port

- 2" SCH 40 Stainless Pipe
- SCH 80 polypropylene pipe cap when not in use
- Also provides CO_2 vent
- Almost a disaster when installing
 - MFG instructions wrong!

Results: Test Setup

- < $2000 able to obtain South Pole cold
- Fast ramps down with CO_2
- Slow ramps with refrigeration
- Stable
- Good remote monitoring

CO2 and Refrigeration Fast Ramp
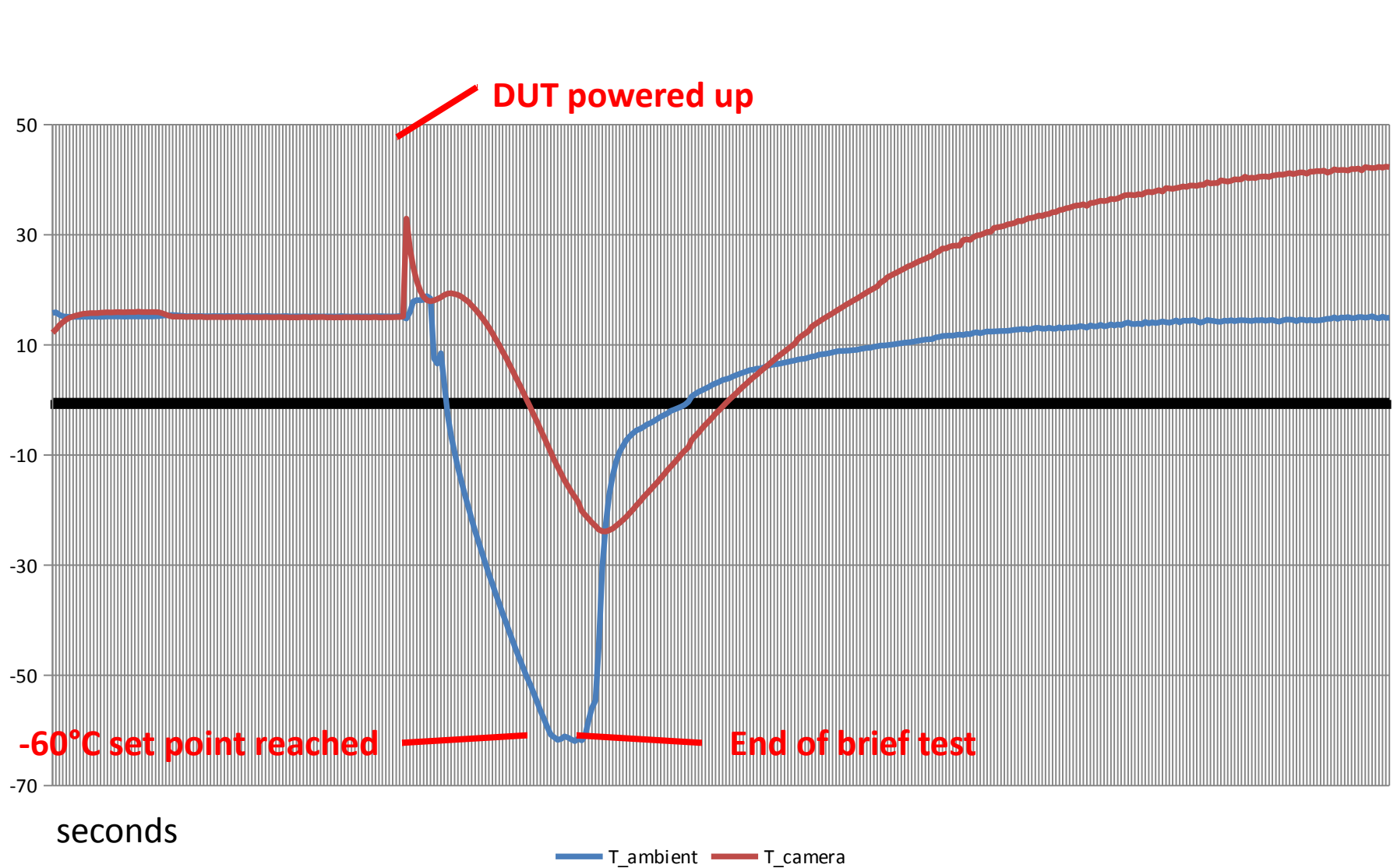
Results: WT10 / WT14

- Bearings
  - Molykote 33 grease works great!
  - Standard low drag seals are okay
  - No short term ball clearance issues
- Drop (output) cable "Carol Super Vu-Tron Supreme"
  - not bendable at "winter" temperatures
  - installable at "summer" temperatures
- Blades (glass filled nylon)
  - gets stiffer as it gets colder
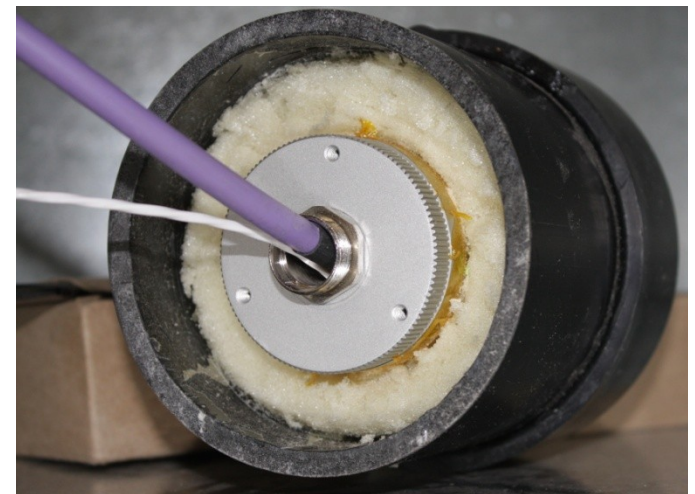 - good!
  - field tested in Antarctica
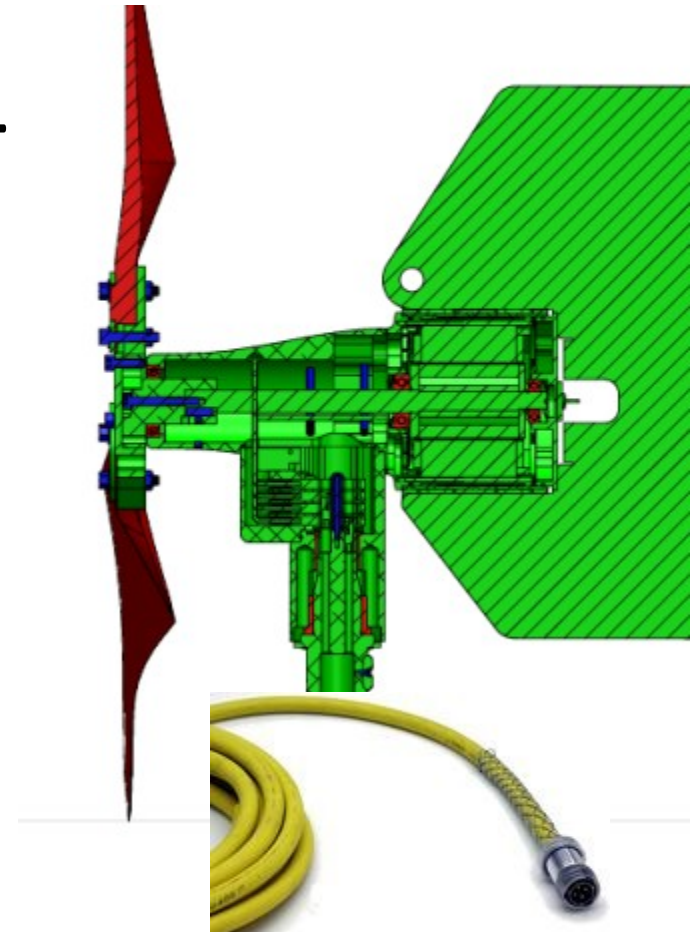
Results: Pelican Cooler

- 2 watts waste heat keeps cooler interior 20°C above outdoor ambient
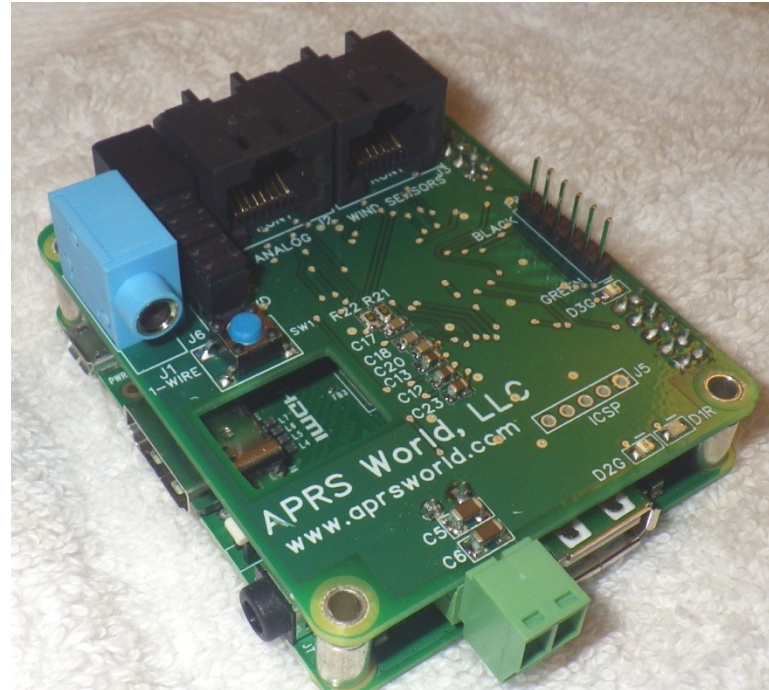- Not bad for $250 MSRP COTS!

Results: IP Camera

- Vivotek IP8364 rated to -20°C
- Mechanical IR cut filter expected to be a problem
- Polyurethane insulated ABS sleeve developed
- Camera interior stays ~30°C above ambient

Results: Pi Camera / Weather Station

- IP Camera
- Weather Station
- Wireless or 802.15.4 POE
- ~1 watts
- IP67 enclosure
- Linux based
- Open source
- Wide DC input voltage

Questions and Comments?

- James Jarvis
    - APRS World, LLC
    - jj@aprsworld.com
    - 507.454.2727

Information on our products:

http://www.aprsworld.com/