Differential i2c adapter board on Raspberry Pi 3B+ for testing of CAT5 shielded cable link to remote RM3100. 5V power from Pi carried on one cable pair to remote differential i2c board with 3.3V LDO regulator for RM3100 power. Small board in upper left is Pi RTC.



Working purpose built local/remote boards for Pi. Left is a KD0EAG design; right is adaptation as PiHAT by HAMSCI. Both have socket for local RM3100 as well as 9808 precision temp sensor, 9815 differential i2c interface, 3.3V LDO regulator and configuration jumpers. Small board in upper left is Pi RTC.



Current consumption and associated voltage drop at the remote end of 120 feet of CAT5E solid #24 conductor cable.

Raspberry Pi 3B+ host, with SparkFun Pi Quiic Hat, Pi 9615 differential I2C bus extenders, PNI 3100 sensor on KD0EAG 0.0.10 remote board.

Tektronix DC-50MHz current probe and Tek DPO2024 oscilloscope. JM 04/26/2020



Ch1: 5mA / div, CH2: VDA/B voltage response to remote current transients during I2C data transaction; DC coupled 50mV/div. Kemet 220uf 6.3V Tantalum Poly cap, 70mohm ESR, VDA/B to ground on remote board. Voltage drop consistent with ~ 3.3ohm resistance of 120ft of paralleled #24 twisted pair.

Current consumption and associated voltage drop at the remote end of 120 feet of CAT5E solid #24 conductor cable.

Raspberry Pi 3B+ host, with SparkFun Pi Quiic Hat, Pi 9615 differential I2C bus extenders, PNI 3100 sensor on KD0EAG 0.0.10 remote board.

Tektronix DC-50MHz current probe and Tek DPO2024 oscilloscope. JM 04/26/2020



Same as previous slide except channel 3 remote SLC trace moved for better viewing of ch1 and 2. No 220uF bypass at remote end. The bypass cap in the previous slide is needed to buffer transient current drawn by remote 9615 for driving the CAT5 transmission line pair.

100KHz i2c bus signals at the end of 400 feet of CAT5E solid #24 conductor cable

Raspberry Pi 3B+ host, with SparkFun Pi Quiic Hat, Pi 9615 differential I2C bus extenders, PNI 3100 sensor on KD0EAG 0.0.10 remote board. Tek DPO2024 oscilloscope. JM 04/26/2020



Lower three traces zoomed to 400ns/div. CH1 & CH2 (Blue and yellow trace): differential SDA signal input to 9615; CH4 (green trace): SDC signal at output of 9615. Note no overshoot transients or ringing; well behaved matched transmission line behavior.

Weatherproof polycarbonate box housing for first outdoor tests 400 feet from structures, power lines, roads



RM3100 on KD0EAG 0.0.10 board with CAT5 pigtail lead to waterproof connector replacing original connector on board. North arrow of RM3100 board points to the left. Long axis of box is N-S line. Closed box sat on an 8x8x16 concrete block on leveled ground in a shaded woodlot.

JennyJump above ground RM3100 24 hour recording 07/04/2020



RM3100 sensor temperature



RM3100 traces significantly different from the Jenny Jump FGM station magnetometer.

X and Z traces show strong positive correlation with the RM3100 temperature record while the Y traces appears to show a weaker negative correlation with temperature.

Inconsistent correlation makes simple post recording correction impractical.

Hillsdale, NY, above ground RM3100 24 hour recording 08/30/2020



Fredericksburg Intermagnet.org 08/30/2020



RM3100 sensor temperature

RM3100 shows a significant difference from FGM Fredericksburg, VA, Intermagnet.org data

X and Z traces show strong positive correlation with the RM3100 temperature but Y trace shows little effect with reasonably close time course to Fredericksburg plus some local noise.

Inconsistent correlation makes simple post recording correction impractical; some form of temperature control is necessary for useful and consistent data.

Housings for 'constant temperature' below ground operation of RM3100



1 ¼ inch common PVC water pipe with Plastruct angle stock glued to inside of pipe as positioning guide rails for KD0EAG / HAMSCI 0.0.10 version local/remote board.

After board is secured, the open end will be sealed with a 1 ¼ inch cap using silicone rubber for a serviceable environmental seal. North arrow on RM3100 board points toward open end of pipe which will be the bottom of the pipe when installed vertically. The board Z sensor becomes the new X (X=-Z); the X sensor is the new Z (Z=X) and the Y sensor remains Y. A closed cell foam pad holds the assembly against the alignment rails. A CAT5 pigtail cable runs from the board to the waterproof RJ connector at the top of the assembly.

Housings for 'constant temperature' below ground operation of RM3100 (2)





Magnetometer 20 inches under soil surface in a garden auger bored hole. Red stripe just visible on elbow is the North-South alignment line.

The Uonecn waterproof RJ connector turned out to have an unreliable shield connection and was replaced with a Cerrxian Cnlinko which was both easier to install in the PVC plug fitting and had better splash protection.

Housings for 'constant temperature' below ground operation of RM3100 (3)



Dual RM3100 magnetometer for comparative evaluation. Alignment tray fixture made from 1 ¼ inch PVC lathe turned to fit inside 1 ½ inch pipe, then cut in half. Plastruct U channel glued in place to hold and position two KD0EAG boards. Right board connected via CAT5 pigtail to water proof connector; left board connected to right with ground, +3.3v, SLC, SDA . Temperature sensors on both boards, i2C addresses configured for 2-RM3100 and 2-9808 sensors.



Alignment and holding fixture inserted in 1 1/2 inch PVC pipe housing. Plastic foam blocks will hold the fixture against the inside pipe wall with a couple of dots of epoxy to secure the assembly longitudinally.

As noted on photo, plastic foam blocks will hold tray fixture against opposite wall of 1 $\frac{1}{2}$ inch pipe with some dots of epoxy securing the tray longitudinally.

Tray will be inset to provide enough clearance for the 1 ½ inch PVC plug which seals the bottom end of the assembly.

4 or 5 packets of desiccant are also included to absorb any condensate from from entrained air at time of sealing.

Housings for 'constant temperature' below ground operation of RM3100 (4)



Single RM3100 on current local/remote PiHAT board version. Plastruct U channel rails provide alignment. This is the Jenny Jump RM3100 currently in operation.



Fully assembled Jenny Jump magnetometer with circular bubble level accurate to 1 degree for vertical alignment and waterproof Cerrxian RJ connector.

In-Ground RM3100 Magnetometer, 24 Hour UTC Recording, Hillsdale, NY, March 14, 2021





RM3100 cycle count 800, average 35, 1 per second, followed by 60 second sliding average. Comparison plots (light blue) from Fredericksburg, VA, Intermagnet.org.

Vertical scales adjusted for equal nT increments. Smallest division on RM3100 plots 10nT.

Temperature variation over the 24 hour logging period 0.25 degrees C.

Noise band of RM3100 plots <5nT pp