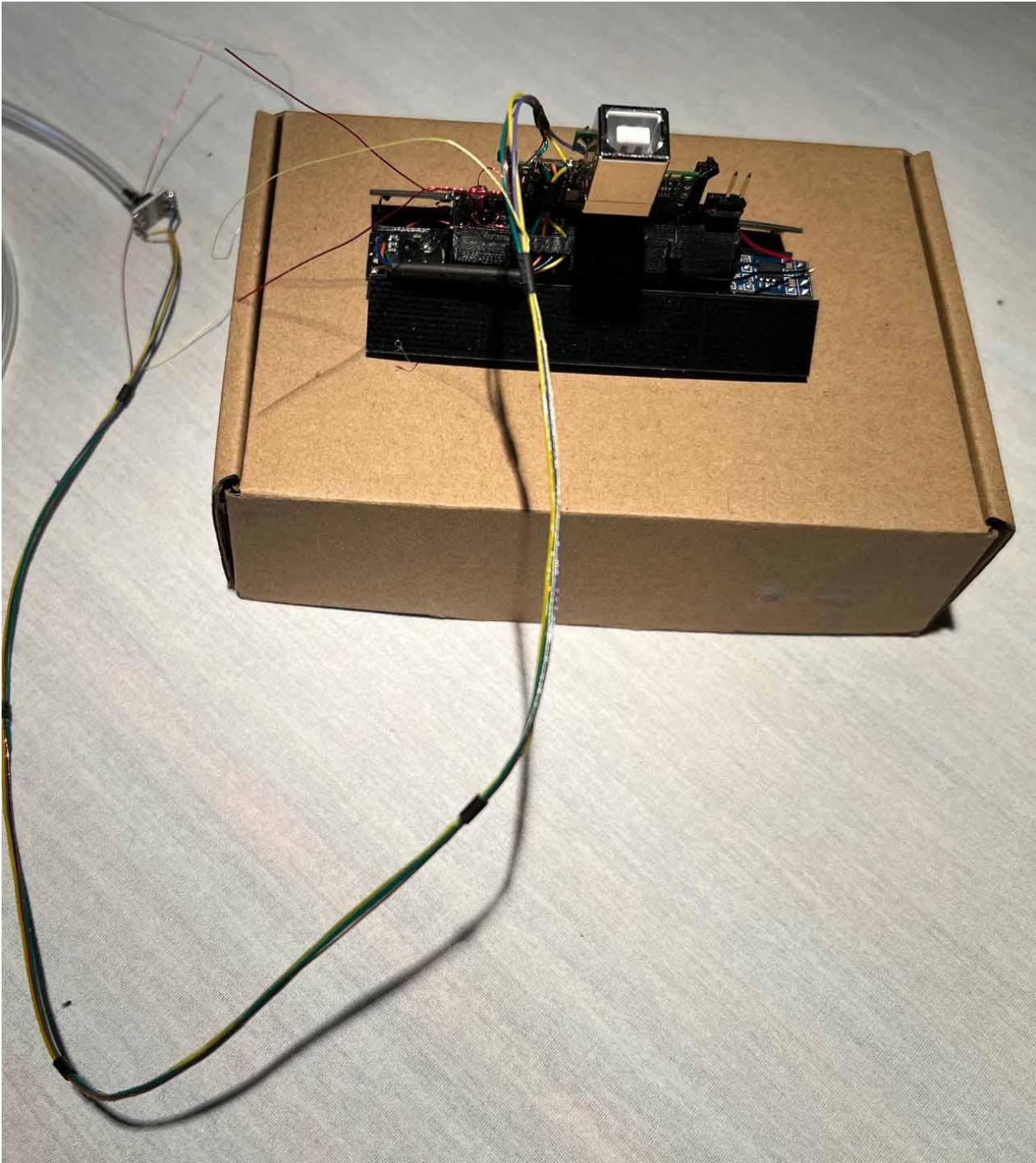
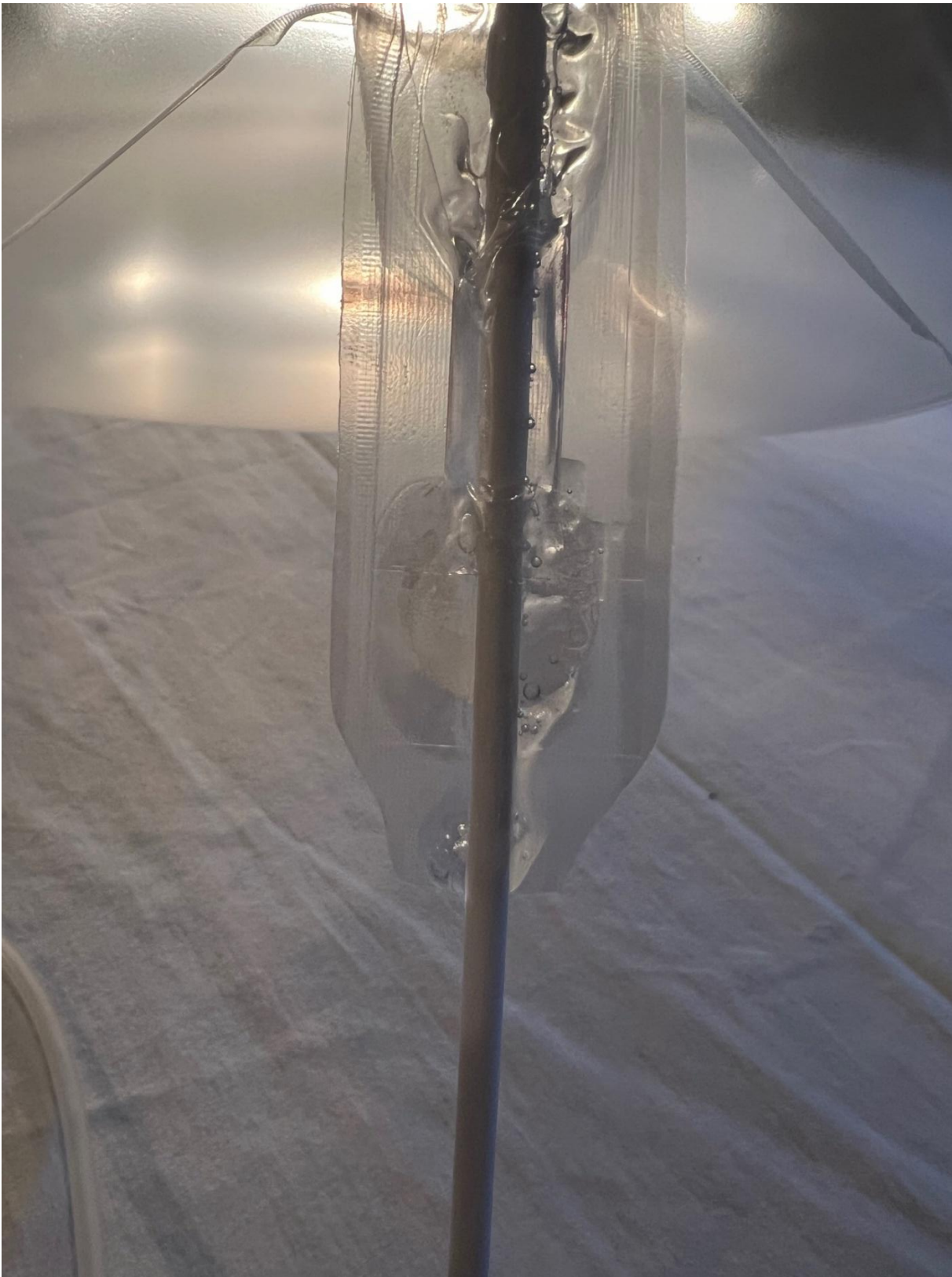


TALARC ALP40J – Design and Construction (Launch in May)



Current State of Construction – Moving from left to right you can see the balloon pressure sensor connected to the cable connected to the payload, the GPS dipole antenna wires, the IR sensor circuit board glued to the 3D printed frame, ¼” Unun toroid, U4B circuit board with USB-B connector, battery connection jumper and MPPT solar battery charger circuit board. The 60” balloon was stretched to 115”. The total mass of the payload is 42.85 grams plus 5.50 grams float, and the balloon and pressure tube has a mass of 78 grams. The estimated float altitude is ~40,000’.

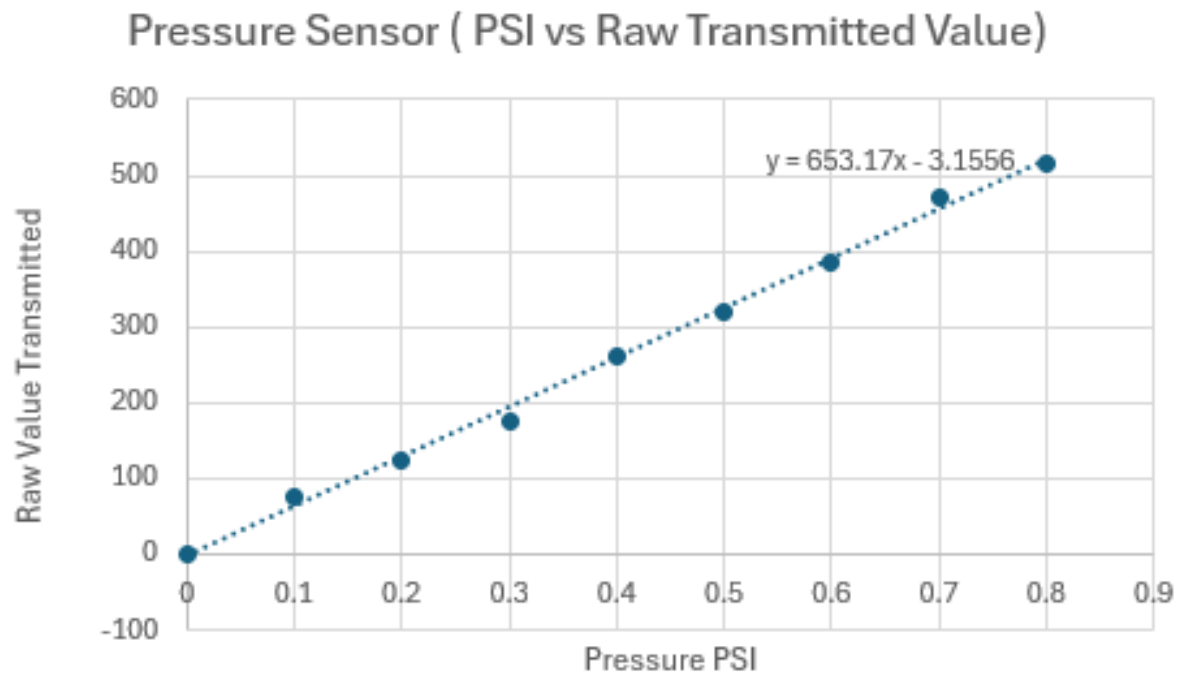
The pressure sensor tube has been inserted into the balloon and glued with UV activated glue.



The pressure sensor has been calibrated at 75 F/24 C, see the chart below. Using the formula $\text{Balloon Pressure (PSI)} = \text{Transmitted Pressure Sensor Value} / 653$ was tested with several different pressures around the expected value of 0.1 psi that resulted in accurate readings.

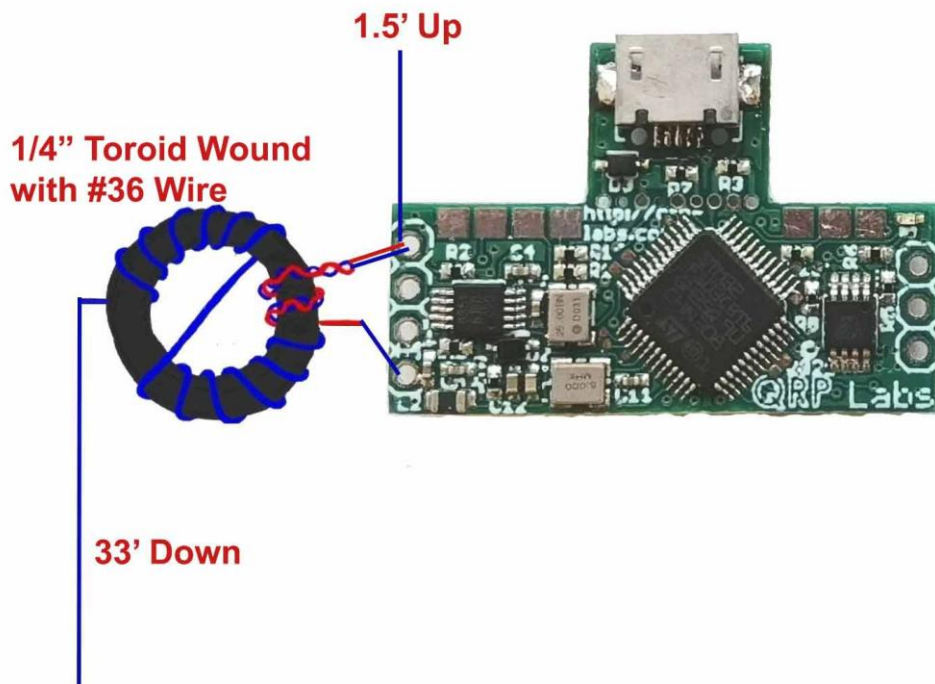
Pressure vs Raw Value Transmitted

0	0	0
0.059619141	0.1	74
0.099902344	0.2	124
0.140991211	0.3	175
0.209472656	0.4	260
0.257006836	0.5	319
0.309375	0.6	384
0.379467773	0.7	471
OVER 512 Bit:	0.8	516



Experiments and Data to be Collected

- U4B PCB Temperature
- Battery and Compartment Temperature
- IR Temperature Sensor Pointed Toward Earth
- Balloon Pressure
- MPPT Solar Charging Circuit
- Lithium Battery Viability
- 20m End Fed Antenna VSWR Tested at 1.5:1
- CW Transmissions Reverse Beacon Net



Antenna Construction schematics above and Rudi, K7RAW, installing the Unun toroid below





Honeywell ABP Series Pressure Sensor



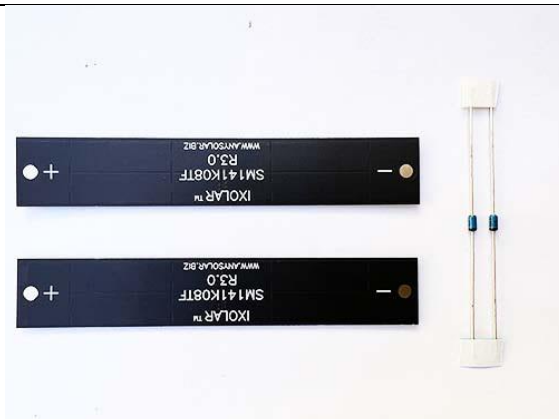
MPPT Solar Charger



IR temperature sensor, TBP-I2C-H04



TLI-1550A/Z2/T



Solar Panels and Diodes

Decode of Standard Information and Telemetry

TALARC ALP40-J Information and Telemetry

WSPR Slot 0 (2-minute transmission)

Date/Time
 Callsign Transmitted
 Grid Square 4
 Reception Frequency
 Received SNR
 Frequency Drift
 Transmitter Power
 Reporter Callsign/Grid Square 6
 Range/Azimuth

WSPR Slot 1 (2-minute transmission)

Date/Time
 Grid Square 4 + 2
 Altitude
 Speed
 PCB Supply Voltage
 PCB Temperature
 Sun Angle (Calculated from Grid Square 6)

Decode of Extended Telemetry

TALARC ALP40-J Generic Extended Telemetry is decoded from “Big Number” transmitted **WSPR Slot 2 (2-minute transmission)** as follows:

As an Example, Let Big Number = 12592724704

Solar Panel Voltage (6)	Battery Temperature (7)	IR Sensor Temperature (7)
0 1 0 1 1 1	0 1 1 1 0 1 0	0 1 0 1 0 1 1
23	58	43

Balloon Pressure Sensor (9)	Altitude Least Sig 0-99 (5)	CPU Reset Flag (1)
0 1 1 1 0 1 0 1 1	1 0 0 0 0	0
235	16	0

Solar Panel Voltage (Volts) = MOD(INT(BigNumber/2/32/512/128/128),64)=23 → Lookup in Table= 3.95 Volts

Battery Temperature (Kelvin)* = MOD(INT(BigNumber /2/32/512/128),128) + 200 = 258K

IR Sensor Temperature (Kelvin)* = MOD(INT(BigNumber/2/32/512),128) + 200 = 243K

Balloon Pressure Sensor (PSI) = MOD(INT(BigNumber/2/32),512) * 0.0008056640625 = 0.189331055

Altitude Least Significant 0 – 99 +/-1.5 meters (M) = MOD(INT(BigNumber/2),32)

U4B Reset Flag (T/F)** = MOD(BigNumber,2)

*Note: Temperature range 200K (-73°C or -99°F) to 327K (54°C or 129°F)

**Note: If TRUE, CPU has been reset in the past 24 hours

Value	Volts	Value	Volts
0	2.80	32	4.40
1	2.85	33	4.45
2	2.90	34	4.50
3	2.95	35	4.55
4	3.00	36	4.60
5	3.05	37	4.65
6	3.10	38	4.70
7	3.15	39	4.75
8	3.20	40	4.80
9	3.25	41	4.85
10	3.30	42	4.90
11	3.35	43	4.95
12	3.40	44	5.00
13	3.45	45	5.05
14	3.50	46	5.10
15	3.55	47	5.15
16	3.60	48	5.20
17	3.65	49	5.25
18	3.70	50	5.30
19	3.75	51	5.35
20	3.80	52	5.40
21	3.85	53	5.45
22	3.90	54	5.50
23	3.95	55	5.55
24	4.00	56	5.60
25	4.05	57	5.65
26	4.10	58	5.70
27	4.15	59	5.75
28	4.20	60	5.80
29	4.25	61	5.85
30	4.30	62	5.90
31	4.35	63	5.95

Software

Standard QRP Labs U4B BASIC programming was used. Program follows use at your own risk.

TALARC Balloon AP40-J Flight Code

Configuration

KB7HTA-17 – 20 Meters – CH 394 – WSPR 14.097140 – CW 14.022000 – Start Minute 06/08 – 1st & 3rd 1?9

Variables

Letter	Initial	Description
S	1	Battery Set Point S = 6 (> 3.9 V), S = 3 (3.7 – 3.9 V), S = 2 (3.4 – 3.7 V) S = 1 (< 3.4 V)

H	3800	This is the battery "High" set point in millivolts.
L	3600	This is the battery "Low" set point in millivolts.
V	3400	This is the battery "Very Low" set point in millivolts.
O	273	This holds the battery compartment temperature in Kelvin after the "BCT" subroutine is RUN
F	0	Flag for alternating Battery and PCB temperature, and TELEX Slot 3 and CW CQ.
G	0	GPS Start second(s) Reset
J	0	GPS End second(s) Running
E	0	Next Day Flag
M	2500	Below this altitude in meters, send a CW report with latitude, longitude and battery voltage
N	0	Most recent GPS lock time
Y	0	This variable holds the result of reading the solar panel voltage after the diodes but before the Lithium battery charging circuit. There is a 10K Ohm divider network to cut the voltage in half to keep the voltage within the voltage range of the ADC. The full scale 12- bit ADC reading would be 4096 representing 3.3 Volts. The software multiplies this number by 2 to restore the full range of voltages 0 – 6.6, lost due to the voltage divider.
I	0	Internal Balloon Pressure 0 - 512
P	0	This holds the 29.180 Bit Big Number for extended telemetry slot 2
R	0	CPU Reset in Last 24 Hours
Z	0	IR Sensor Temperature
A	?	Temporary Variable
B	?	Temporary Variable
C	?	Temporary Variable
D	?	Temporary Variable

LET CH = 394

sssLET HP = 1

LET S = 1

LET I = 0

LET N = 0

LET P = 0

LET R = 1

LET E = 0

LET Z = 0

LET H = 3800

LET L = 3600

LET V = 3400

LET O = 273

LET F = 0

LET G = 1

LET J = 0

LET M = 2500

GPS 300

/ Check GPS to make sure it is working

RUN "QLOCK"

/ Flash LED 10 time and leave LED on if no lock --- Abort launch

LET G = VAL "#2.1TM"

/ Let G be the initial time in hours

LET G = G * 60 + VAL "#3.2TM"

/ G converted to minutes

```

LET G = G * 60 + VAL "#5.2TM"      / G converted to seconds
10 GPS 200
RUN "BSPS"                          / Set battery set point
IF R = 1
RUN "ADAY"
ENDIF
OUT 19 0
SLEEP 10 5
OUT 19 1
RUN "QBCT"
RUN "PAC2"
TELE
TELEC P
IF F = 0
CW 0 14022000 12 0 "CQ KB7HTA KB7HTA BALLOON #M6 #AT #BT"
ENDIF
IF AT < M      ←Sends Latitude Longitude and battery voltage if below the value of M (2500 meters) on
2m
CW 0 146585000 12 0 "KB7HTA #LT #LN #LT #LN #BT"
ENDIF
GOTO 10
END
~

```

BSPS – Determine the Battery Set Point S = 6 (> 3.8 V), S = 3 (3.6 – 3.8 V), S = 2 (3.4 – 3.6 V) S = 1 (< 3.4 V). The variable S specifies the number of times a WSPR transmission is made each hour. Use the Battery Set Point to determine how often to send WSPR transmissions by introducing CPU sleep cycles.

```

LET S = 1
IF BT > V
  LET S = 2
ENDIF
IF BT > L
  LET S = 3
ENDIF
IF BT > H
  LET S = 6
ENDIF
IF S = 1
  LET A = 5
  RUN "SLPX"
ENDIF
IF S = 2
  LET A = 2
  RUN "SLPX"
ENDIF
IF S = 3
  LET A = 1

```

```
RUN "SLPX"  
ENDIF  
~
```

SLPX – Sleep for the number of transmission cycle(s) determined by the variable A.

```
OUT 19 0  
FOR X = 1 TO A  
  SLEEP 10 5  
NEXT  
OUT 19 1  
~
```

QBCT – Determine If **B**attery **C**ompartmen**T** Temperature or IR Sensor Temperature Needs to be Read and Substituted for U4B Temperature. A value of 2 K was added to 'O' and 'Z' the value stored in the system variable TT to take care of round error between the encoding done by PAC2 and the encoding done on system variable.

```
IF F > 0  
  RUN "BCT"  
  LET TT = O + 2  
  LET F = 0  
ELSE  
  RUN "RIRT"  
  LET TT = Z + 2  
  LET F = 1  
ENDIF  
~
```

BCT – Read and Convert the **B**attery **C**ompartmen**T** Temperature to Kelvin. The resulting temperatures seem to be 7 K higher than they should be, so 7 is subtracted from the value before leaving the subroutine

```
LET A = INA 5  
DELAY 1  
LET A = INA 5  
LET B = A * 806  
LET C = 3300000 - B  
LET D = C / ( B / 10000 )  
LET O = ( D / 38 ) + ( D / 39 )  
LET O = ( O / 2 ) - 7  
~
```

FLASH – This program is used to send the number of light flashes specified by the variable A.

```
FOR X = 1 TO A  
OUT 19 0  
DELAY 1000  
OUT 19 1  
DELAY 1000
```

NEXT

~

QLOCK – This program determines if the balloon has a GPS lock. If there is a lock it turns off the LED, otherwise it flashes the LED 10 times and leaves it lit.

```
IF GL = 0
LET A = 10
RUN "FLASH"
OUT 19 1
ELSE
OUT 19 0
ENDIF
```

~

RIRT – Read the IR Temperature Sensor

```
LET Z = 0
FOR X = 1 TO 5
  LET D = I2CR 117 7 3
  LET D = D % 65536
  LET Z = Z + D
NEXT
LET Z = 2 * Z / 500
```

~

RSPV – Read the solar panel voltage after the diodes.

```
FOR X = 1 TO 5
LET Y = Y + INA 7
DELAY 10
NEXT
LET A = 0
LET Y = Y / 5
LET Y = Y * 1000 / 4096
LET Y = Y * 3300 / 10000
LET Y = Y * 2
IF Y > 280
  LET Y = (Y - 280) / 5
ELSE
  LET Y = 0
ENDIF
```

~

PAC2 – Package extended telemetry SLOT 2, IR sensor temperature (K), battery compartment temperature (K) and last two LS Digits of the balloon's altitude.

```
LET P = 0
RUN "RSPV"
```

```

LET P = Y * 128
RUN "BCT"
LET P = ( P + ( O - 200 ) ) * 128
RUN "RIRT"
LET P = ( P + ( Z - 200 ) ) * 512
LET I = 0
FOR X = 1 TO 5
LET I = I + INA 0
NEXT
LET I = I / 5
IF I < 335
  LET I = 0
ELSE
  LET I = I - 335
ENDIF
LET P = ( P + I ) * 32
LET A = AT + 100000 / add 100k to altitude make sure string has 6 digits for next setp
LET B = VAL "#5.2VA"
LET A = ( B * 32 + 25 ) / 100 / grab the last 2 digits of altitude
LET P = ( P + A ) * 2
LET P = P + R
~

```

ADAY – Has a day passed since a system reset

```

LET A = 0
LET B = 0
LET J = VAL "#2.1TM" / Let J be the end time in hours
LET J = J * 60 + VAL "#3.2TM" / J converted to minutes
LET J = J * 60 + VAL "#5.2TM" / J converted to seconds
IF J < G
LET E = 1
ELSE
LET A = 1
ENDIF
LET B = A + E
IF B = 2
LET R = 0
ENDIF
~

```

Balloon Mass Analysis

3D ABS Print w/SP Mount:	4.55 grams
Solar Battery Charger:	0.70 grams
IR Temperature Sens:	2.38 grams
Pressure Sensor:	0.66 grams
Battery Temp Sensor:	0.01 grams
Wires for Pressure Sensor:	1.10 grams

U4B Tracker:	1.80 grams
Solar Panels x 2:	6.16 grams
Battery:	21.85 grams
End Fed Antenna Top: silicone	0.20 grams -- #34-gauge copper wire 18" with 6# fishing line and
Miscellaneous:	2.29 grams
Payload Mass:	41.70 grams
End Fed Antenna Bot:	1.15 grams -- #36-gauge copper wire 16' 7.2"
Total Payload:	42.85 grams
Float:	5.50 grams -- +/- 0.5 grams
Neck Weight:	48.35 grams