INSTRUCTION MANUAL

S3497X Psychrometer Software and A3497 TC Psychrometer Cooling Current Interface

Revision: 1/92

Model S3497X Psychrometer Software and Model A3497 Interface
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25 PELTIER THERMOCOUPLE PSYCHROMETER

1. FUNCTION

Instruction 25 measures up to five thermocouple psychrometers (TCP) excited through Campbell Scientific's Model A3497 Psychrometer Cooling Current Interface. Groups of TCPs may be read by using an A3497 for each group of five TCPs and programming Instruction 25 within a Loop.

An option is provided for drying the TCP junction by heating before the cooling current is applied. The heating and cooling current is selectable within the limitation of the CR7 Excitation Card by specifying the excitation voltage.

The results of the measurements: TCP base temperature (°C), the TCP zero (dry-bulb) reading (μV), and a sequence of TCP wet-bulb readings (μV) are stored in Input Storage. The wet-bulb microvolt readins have the zero (dry bulb) reading subtracted (i.e., the wet-bulb depression is stored).

PAR. NO.	DATA TYPE	DESCRIPTION
01:	2	Number of psychrometers per A3497
02:	4	Starting Input Location Destination for measurements
03:	4	Reference temperature location.
04:	2	Option code for base temperature measurement 1= Low wrt ground 2= High wrt ground
05:	2	First measurement Input Card
06:	2	First measurement input channel
07:	2	First heating/cooling Excitation Card
08:	2	First heating/cooling excitation channel
09:	FP	Heating cooling excitation voltage (negative mV)
10:	4	Heating duration time (0.01s)
11:	4	Delay after heating before zero measurement (0.01 s)
12:	4	Cooling duration time (0.01s)
13:	4	Delay after cooling before wet-bulb measurement (0.01s)
14:	4	Delay between wet-bulb measurements (0.01 s)
15:	4	Number of wet-bulb measurements per psychrometer

Input Locations Altered: N_p (N_m +2)
Intermediate Storage: 7
Execution Time (ms):
$80+60N_p + (N_m+1)(300 + 225N_p) + N_mD_m+D_s$

- N_p - Number of TCPs
- N_m - Number of wet-bulb measurements per TCP
- D_m - Parameter 14 in ms
- D_s - Parameters 10+11+12+13 in ms

The excitation voltage for the heating current is specified in Parameter 9. The heating duration (Parameter 10), delay before the zero measurement (Parameter 11), cooling duration (Parameter 12), and the delay before the first wet-bulb measurement (Parameter 13) are all selectable in units of hundredths of a second. The number of wet-bulb readings in the sequence and the time between each reading is specified by Parameters 15 and 14, respectively.

2. TCP MEASUREMENT SEQUENCE

The zero reading and each individual wet-bulb reading are the numerical average of five slow integration differential measurements made on the ± 1.5 mV full scale range. The resolution is 50 nV with an RMS input noise level of 30 nV. Averaging the five measurements reduces the noise level in the reading to 15 nV.

All the TCPs connected to one A3497 Interface are measured sequentially at a rate of approximately 45 ms per TCP; this process is repeated five times, the average formed, the zero reading subtracted, and the result stored in Input Storage. Approximately 60 ms is required for self calibration before each of the five measurement sequences. The time required to complete this five measurement per TCP reading t_r, is thus:

$$t_r = 5(60+45N_p) = 300+225N_p$$

where t_r is in milliseconds and Np is the number of TCPs measured (maximum of five). Thus, five TCPs are read in about 1.4 s while three TCPs require about 1 s.

If zero delay between wet-bulb readings is specified in Parameter 14, the time between recorded readings for a given TCP is equal to t_r.

The time interval between initiating the first measurement and completing the fifth measurement for a given TCP is approximated by

$$t_i = (4)\ (60)\ +45(4N_p+1) = 285+180N_p$$

where t_i is in milliseconds.

3. TCP BASE TEMPERATURE MEASUREMENT

Three wire psychrometers such as those manufactured by J.R.D. Merrill Specialty Equipment* or Wescor, Inc.** provide for a TCP base temperature measurement. The base measurement made by Instruction 25 is identical to the standard CR7 Single-ended Thermocouple Measurement Instruction 13 using an input range of 15 mV, a "slow" integration time (16.6 ms), and a copper-constantan (type T) TC. Since the base temperature TCs are connected to every other single-ended input channel, Parameter 4 may be used to specify whether the first measurement begins on the high or low input.

The base temperature measurement requires a reference junction temperature in order to compute an absolute temperature. This value is obtained using the Panel Temperature Instruction 17. The Input Location Number of the reference temperature is entered in parameter 3. If 0 is entered for Parameter 3, no base temperature measurements are made, and no Input Storage is allocated for these measurements. This option allows for situations where the base temperature TCs are not copper-constantan, and the measurements must be made using Instruction 13.

4. INPUT AND A3497 INTERFACE CONNECTIONS

TCPs manufactured by both Merrill Specialty Equipment and Wescor, Inc. are wired identically. Figure 1 shows the TCP connections to both the A3497 and CR7. Table 1 gives color coding for both a Merrill and Wescor screened psychrometer. Note that: TCP temperatures are lower than the base temperature (e.g., at wet-bulb) result in positive readings.

Connect low side of each TCP to the A3497 with a wire inserted into the low input terminal for the respective TCP. Instruction 25 automatically advances to the next excitation channel each time a new A3497 is encountered within a Loop. Use the next available excitation channel for each additional A3497 wired to the CR7.

> **NOTE**: All A3497s measured within a loop must excite the same number of TCPs.

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Table 1. TCP Color Coding for Wescor and Merrill Psychrometers

CR7	Wescor Model PST-55	Merrill Model 74
Hi	Red	White
Lo	Black	Blue
Ground	Blue	Red

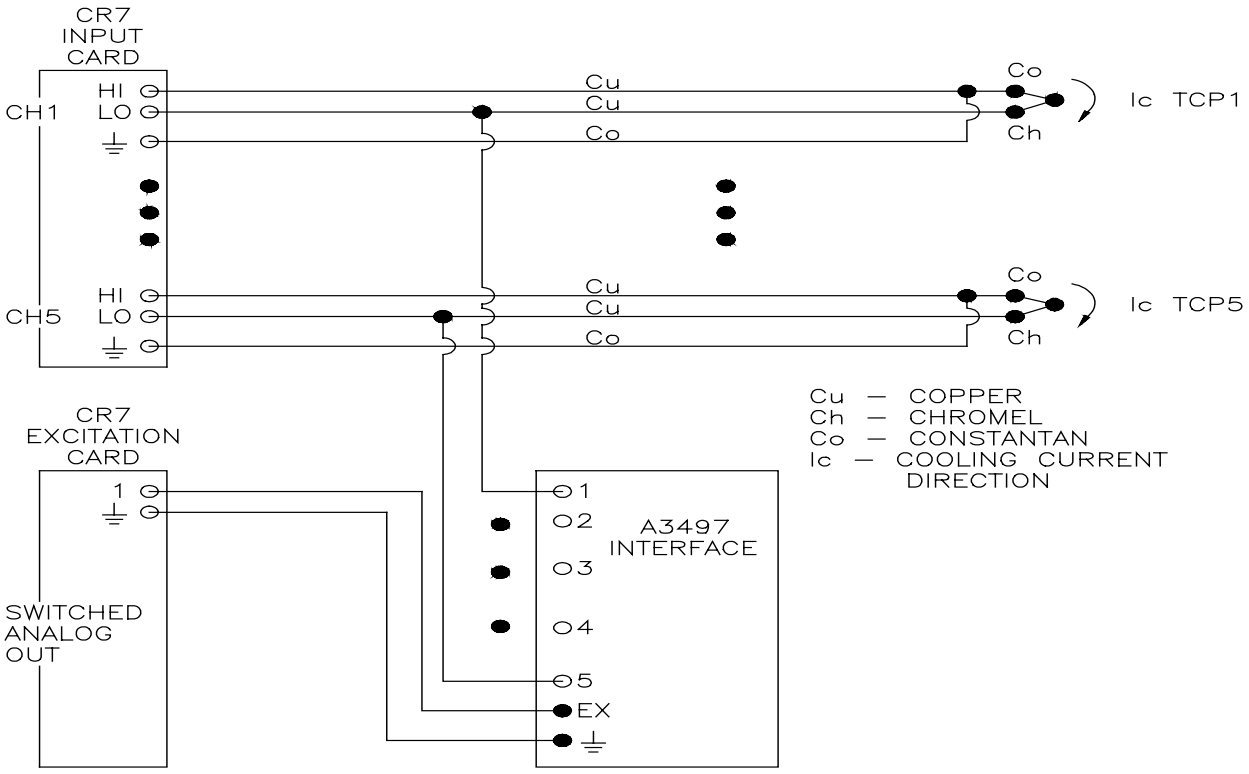

Figure 1. Connection to CR7 using the A3497 Psychrometer Cooling Current Interface

5. THE A3497 INTERFACE AND CURRENT CALCULATION

Figure 2 is a schematic of the A3497 Interface. The A3497 performs several functions. The switched analog output is held at ground through a 10K resistor preventing leakage of current through the TCP junction when the analog output is disabled. The leakage current is typically a negligible 2nA but can be as high as 30nA. In addition, the low leakage diodes isolate the TCPs from each other when excited through a common analog output. The use of parallel diodes with opposing polarity permits both heating and cooling current through the TCP. Finally, the 249 ohm resistors determine the current values for a given excitation voltage.

> **NOTE:** To obtain the proper direction for the cooling current (Figure 1), a negative excitation voltage must be applied.

The sign of the entry for Parameter 9 is for the cooling current. The instruction uses the same voltage but reverses the polarity when applying the heating voltage. The voltage (mV) required to produce a desired current I, (mA) is given by

$$V = I(249+R_S) +700$$

where R_S is the combined resistance of the TCP junction and constantan lead length, typically around 15 ohms for one meter TCPs. Longer TCP lead lengths can have substantial resistance since 24 awg constantan is around 2.4 ohms per meter.

The total current required is $(I)(N_p)$ where N_p is the number of TCPs connected to the A3497. This value is limited by the available excitation current; i.e., 25 mA at ±5 V, 50 mA at ±2 V. For example, a current of 8 mA for five TCPs is possible because 40 mA are delivered at an excitation voltage of 2.81 volts, but 10 mA per TCP requires a total of 50 mA at 3.34 V. The latter pushes the limitation of the excitation. When in doubt, measure the current supplied by inserting a milliamp meter between the analog port and the Ex terminal of the A3497. Use a duration time sufficient to ensure proper meter response.

6. OUTPUT FORMAT

Instruction 25 stores all readings from a given TCP sequentially in Input Storage. The base temperature is first, followed by the zero reading, and then the sequence of wet-bulb readings with the zero reading subtracted. The series of readings from the next TCP then follows, etc. The number of Input Storage locations allocated must be based upon the number of TCPs excited by one A3497 Interface and the number of wet-bulb readings per TCP. When the Loop Instruction is used, the readings from each A3497's TCPs use the same Input Storage. The readings associated with a given A3497 must be transferred to Final Storage before progressing to the next A3497.

All the readings associated with one A3497 can be transferred to Final Storage using a single Sample Instruction (#70) and the appropriate number of "repetitions." However, this technique results in the reading from all the TCPs being blocked together in one Output Array. By setting the Output Flag and using a Sample Instruction for each TCP associated with the A3497, the readings for each TCP are blocked into their own Output Array and contain their own unique Output Array ID. An example of this latter type of output is shown in Table 2.

7. EXAMPLE

The following program example was used to generate the data shown in Table 2. Four Model PST-55 Wescor and four Model 74 Merrill TCPs were read using two A3497 Interfaces. The program makes use of the Loop Instruction. The following criteria were used:

1. Number of wet-bulb readings per TCP - 29
2. Heating/cooling current - 4.5 mA (-1900 mV)
3. Heating duration - 5 s
4. Delay after heating - 15 s
5. Cooling duration - 15 s
6. Delay after cooling - 0 s
7. Delay between wet-bulb measurements - 0 s
8. Input Storage (31 locations per TCP):
   - First TCP Loc 2 - Loc 32
   - Second TCP Loc 33 - Loc 63
   - Third TCP Loc 64 - Loc 94
   - Fourth TCP Loc 95 - Loc 125
9. Input Card - 1
10. First measurement channel - 1
11. Excitation Card - 1
12. First excitation channel - 1

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```
01:        P      17  Panel Temperature
  01:      1          IN Card
  02:      1          Loc [:Panel T  ]

02:        P      87  Beginning of Loop
  01:      0          Delay
  02:      2          Loop Count

03:        P      25  Thermocouple Psychrometer
  01:      4          Psychrometers per A3497
  02:      2          Loc:[:TCP 1 #1 ]
  03:      1          Ref Temp Loc Panel T
  04:      2          2=Measure HI WRT GND,
                      1=LO
  05:      1          IN Card
  06:      1          IN Chan
  07:      1          EX Card
  08:      1          EX Chan
  09:  -1900          mv Excitation
  10:   1500          Heating (time units=.01sec)
  11:   1500          Delay before 0 measurement
  12:   1500          Cooling duration
  13:      0          Delay before wet bulb meas.
  14:      0          Delay between wet bulb meas.
  15:     29          Wet bulb measm'ts per psychr.

04:        P      86  Do
  01:     10          Set high Flag 0 (output)

05:        P      70  Sample
  01:     31          Reps
  02:      2          Loc TCP 1 #1

06:        P      86  Do
  01:     10          Set high Flag 0 (output)

07:        P      70  Sample
  01:     31          Reps
  02:     33          Loc TCP 2 #1

08:        P      86  Do
  01:     10          Set high Flag 0 (output)

09:        P      70  Sample
  01:     31          Reps
  02:     64          Loc TCP 3 #1

10:        P      86  Do
  01:     10          Set high Flag 0 (output)
```

```
11:         P         70  Sample
  01:       31        Reps
  02:       95        Loc TCP 4 #1

12:         P         95  End

13:         P             End Table 1
```

Table 2. Example Output

Wescor

.1 molal NaCl (4.62 Bars)

01+0107.	02+24.90	03-0.310	04+3.370	05+3.064	06+2.985	07+2.980	08+2.945
09+2.916	10+2.936	11+2.891	12+2.842	13+2.837	14+2.792	15+2.773	16+2.812
17+2.753	18+2.753	19+2.709	20+2.713	21+2.679	22+2.684	23+2.694	24+2.674
25+2.669	26+2.664	27+2.674	28+2.620	29+2.664	30+2.644	31+2.674	32+2.679

.5 molal NaCl (22.81 Bars)

01+0109.	02+24.90	03-0.039	04+10.88	05+10.47	06+10.26	07+10.16	08+10.10
09+10.02	10+09.94	11+09.85	12+09.79	13+09.73	14+09.64	15+09.60	16+09.56
17+09.50	18+09.42	19+09.32	20+09.26	21+09.12	22+09.03	23+08.90	24+08.77
25+08.61	26+08.34	27+08.04	28+07.57	29+6.912	30+5.876	31+4.377	32+2.541

1.0 molal NaCl (46.4 Bars)

01+0111.	02+24.89	03-0.157	04+21.30	05+21.07	06+20.87	07+20.57	08+20.24
09+19.48	10+16.96	11+6.804	12+0.108	13-0.039	14-0.044	15-0.074	16-0.059
17-0.078	18-0.074	19-0.098	20-0.064	21-0.088	22-0.078	23-0.064	24-0.098
25-0.078	26-0.074	27-0.098	28-0.034	29-0.054	30-0.044	31-0.019	32-0.039

1.5 molal NaCl (71.34 Bars)

01+0113	02+24.89	03-0.024	04+31.97	05+26.27	06+4.914	07+0.088	08+0.004
09-0.019	10+0.004	11-0.024	12-0.024	13-0.039	14+0.004	15-0.039	16-0.009
17-0.034	18-0.024	19-0.024	20-0.059	21-0.044	22-0.069	23-0.074	24-0.074
25-0.064	26-0.078	27-0.054	28-0.054	29-0.059	30-0.049	31-0.054	32-0.049

Merrill

.1 molal NaCl (4.62 Bars)

01+0107.	02+24.91	03-1.731	04+2.748	05+2.467	06+2.398	07+2.407	08+2.368
09+2.343	10+2.338	11+2.304	12+2.328	13+2.309	14+2.324	15+2.319	16+2.284
17+2.289	18+2.264	19+2.299	20+2.279	21+2.294	22+2.294	23+2.284	24+2.309
25+2.274	26+2.289	27+2.294	28+2.284	29+2.264	30+2.269	31+2.269	32+2.269

.5 molal NaCl (22.81 Bars)

01+0109.	02+24.90	03-2.210	04+09.83	05+09.79	06+09.80	07+09.83	08+09.84
09+09.85	10+09.81	11+09.83	12+09.84	13+09.83	14+09.80	15+09.79	16+09.77
17+09.79	18+19.75	19+09.72	20+09.67	21+19.60	22+19.57	23+09.50	24+09.41
25+09.27	26+09.14	27+08.98	28+08.74	29+08.37	30+07.90	31+07.18	32+6.212

1.0 molal NaCl (46.4 Bars)

01+0111.	02+24.91	03+0.000	04+21.62	05+21.22	06+21.03	07+20.88	08+20.71
09+20.55	10+20.34	11+20.13	12+19.83	13+19.37	14+18.50	15+16.17	16+07.71
17+0.863	18+0.202	19+0.093	20+0.083	21+0.098	22+0.083	23+0.0064	24+0.093
25+0.059	26+0.044	27+0.064	28+0.069	29+0.083	30+0.059	31+0.074	32+0.064

1.5 molal NaCl (71.34 Bars)

01+0113.	02+24.89	03+0.044	04+29.52	05+28.66	06+27.25	07+22.46	08+6.187
09+0.370	10+0.143	11+0.128	12+0.128	13+0.123	14+0.152	15+0.143	16+0.113
17+0.138	18+0.118	19+0.133	20+0.167	21+0.157	22+0.202	23+0.217	24+0.226
25+0.207	26+0.231	27+0.241	28+0.261	29+0.251	30+0.226	31+0.251	32+0.256

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