APPENDIX A

PROGRAM CODE USED FOR CAMPELL SCIENTIFIC DATA-LOGGERS

A.1 Hatfield Automatic Weather Station

```
;{CR10}
;Programme for monitoring automatic weather station at Hatfield Exp Farm
;Updated on 29/10/96 to include SVP, VP & VPD
;Updated on 7/11/96 to correct Temp & Rain calibrations with manual
    ;station
;Updated 25/11/96 to correct for overestimation of rain - multiplier
    ;changed from .5598 to .4976
;Updated 26/11/96 to correct for SVP, VP & VPD (ie not give rh_frac
    ;as VP
;Updated with recalibration of Pyranometer and Cup anamometer on 4/7/98

* Table 1 Program
  01:  10 Execution Interval (seconds)

1:  Temp (107) (P11)
 1: 1       Reps
 2: 1       In Chan
 3: 1       Excite all reps w/Exchan 1
 4: 1       Loc [ Temp_C    ]
 5: 1       Mult
 6: .17     Offset

2:  Excite-Delay (SE) (P4)
 1: 1       Reps
 2: 5       2500 mV Slow Range
 3: 2       In Chan
 4: 2       Excite all reps w/Exchan 2
 5: 15      Delay (units 0.01 sec)
 6: 2500    mV Excitation
 7: 2       Loc [ RH        ]
 8: .1028   Mult
 9: 1.42    Offset

3:  Pulse (P3)
 1: 1       Reps
 2: 1       Pulse Input Channel
 3: 22      Switch Closure, Output Hz
 4: 3       Loc [ Wind_mps  ]
 5: .8685   Mult
 6: 0       Offset

4:  Volt (Diff) (P2)
 1: 1       Reps
 2: 33      25 mV 50 Hz Rejection Range
 3: 2       In Chan
 4: 4       Loc [ Rad_Wpm2  ]
 5: 99.944  Mult
 6: 0       Offset

5:  Pulse (P3)
 1: 1       Reps
```

2: 2 Pulse Input Channel
3: 2 Switch Closure
4: 5 Loc [Rain_mm]
5: .4976 Mult
6: 0.0 Offset

6: Z=X*F (P37)
1: 2 X Loc [RH]
2: .01 F
3: 7 Z Loc [rh_frac]

7: Saturation Vapor Pressure (P56)
1: 1 Temperature Loc [Temp_C]
2: 8 Loc [SVP]

8: Z=X*Y (P36)
1: 8 X Loc [SVP]
2: 7 Y Loc [rh_frac]
3: 9 Z Loc [VP_kPa]

9: Z=X-Y (P35)
1: 8 X Loc [SVP]
2: 9 Y Loc [VP_kPa]
3: 10 Z Loc [VPD_kPa]

10: Batt Voltage (P10)
1: 6 Loc [Batt_V]

11: If time is (P92)
1: 0000 Minutes (Seconds --) into a
2: 60 Interval (same units as above)
3: 10 Set Output Flag High

12: Real Time (P77)
1: 1220 Year,Day,Hour/Minute (prev day at midnight, 2400 at midnight)

13: Average (P71)
1: 4 Reps
2: 1 Loc [Temp_C]

14: Totalize (P72)
1: 1 Reps
2: 5 Loc [Rain_mm]

15: Average (P71)
1: 3 Reps
2: 8 Loc [SVP]

16: If time is (P92)
1: 0000 Minutes (Seconds --) into a
2: 1440 Interval (same units as above)
3: 10 Set Output Flag High

17: Real Time (P77)
1: 1200 Year,Day (prev day at midnight)

18: Totalize (P72)
1: 1 Reps
2: 5 Loc [Rain_mm]

19: Maximize (P73)
1: 1 Reps
2: 10 Value with Hr-Min
3: 1 Loc [Temp_C]

20: Minimize (P74)
1: 1 Reps
2: 10 Value with Hr-Min
3: 1 Loc [Temp_C]

21: Sample (P70)
1: 1 Reps
2: 6 Loc [Batt_V]

A.2 Mobile Automatic Weather Station at Syferkuil Clementine Orchard

```
;{CR10X}
;SYCALAWS.CSI
;Program drafted to control Mobile AWS on 27 & 28 June 2000
;WIRING:
;  Radiometer (Top): Black to H1; Red to L1
;            (Bot): Blue to H2; Brown to L2
;  Diffuse; to Diff 3
;  HMP 35C:  Orange to H6    Green to L6
;            Black to E1     Yellow to E2
;            Red to V12      Clear + White + Purple to G
;  Cup anemometer:   Red to P1     Green & Black to G
;  Rain Gauge:       White to P2   Black to G
;OUTPUT:
;  Hourly: Code; DOY; Hour; Station_ID; T; RH; Rad (W/m2); Reflect;
;          Diffuse; Wind (m/s); Rain (mm); rh (frac); SVP; VP & VPD (kPa)
;  Daily:  Code; DOY; Hour: Station ID; Tx; Tn; Rad (ave W/m2 for 24hrs)
;          VP (ave kPa); Rain (Tot mm); Wind (m/s); Total Solar

* Table 1 Program
  01:  10Execution Interval (seconds)

1:  Read ID (P117)
 1: 1        Loc [ StationID ]

2:  Z=F (P30)
 1: 1        F
 2: 0        Exponent of 10
 3: 1        Z Loc [ StationID ]

3:  Batt Voltage (P10)
 1: 13       Loc [ V_Batt    ]

4:  Temp (107) (P11)
 1: 1        Reps
 2: 11       SE Channel
 3: 1        Excite all reps w/E1
 4: 2        Loc [ Temp_C    ]
 5: 1        Mult
 6: .08      Offset

5:  Excite-Delay (SE) (P4)
 1: 1        Reps
 2: 5        2500 mV Slow Range
 3: 12       SE Channel
 4: 2        Excite all reps w/Exchan 2
 5: 15       Delay (units 0.01 sec)
 6: 2500     mV Excitation
 7: 3        Loc [ RH        ]
 8: .1026    Mult
 9: 2.0285   Offset

6:  Z=X*F (P37)
 1: 3        X Loc [ RH        ]
 2: .01      F
 3: 9        Z Loc [ rh_frac   ]

7:  Saturation Vapor Pressure (P56)
 1: 2        Temperature Loc [ Temp_C    ]
```

```
 2: 10      Loc [ SVP_kPa   ]

8:  Z=X*Y (P36)
 1: 10      X Loc [ SVP_kPa   ]
 2: 9       Y Loc [ rh_frac   ]
 3: 11      Z Loc [ VP_kPa    ]

9:  Z=X-Y (P35)
 1: 10      X Loc [ SVP_kPa   ]
 2: 11      Y Loc [ VP_kPa    ]
 3: 12      Z Loc [ VPD_kPa   ]

10:  Volt (Diff) (P2)
 1: 1       Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 1       DIFF Channel
 4: 4       Loc [ Rad_Wm2   ]
 5: 56.635   Mult
 6: 0       Offset
;Measures solar radiation and converts to W/m^2

11:  If (X<=>F) (P89)
 1: 4       X Loc [ Rad_Wm2   ]
 2: 4       <
 3: 0       F
 4: 30       Then Do

12:  Z=F (P30)
 1: 0       F
 2: 0       Exponent of 10
 3: 4       Z Loc [ Rad_Wm2   ]

13:  End (P95)
;Eliminates -ve  Radiation values

14:  Z=X (P31)
 1: 4       X Loc [ Rad_Wm2   ]
 2: 14      Z Loc [ TotSolar  ]

15:  Z=X*F (P37)
 1: 14      X Loc [ TotSolar  ]
 2: .00001   F
 3: 14      Z Loc [ TotSolar  ]


16:  Volt (Diff) (P2)
 1: 1       Reps
 2: 25       2500 mV 60 Hz Rejection Range
 3: 2       DIFF Channel
 4: 5       Loc [ Reflect   ]
 5: 51.143   Mult
 6: 0.0     Offset

17:  If (X<=>F) (P89)
 1: 5       X Loc [ Reflect   ]
 2: 4       <
 3: 0       F
 4: 30       Then Do

18:  Z=F (P30)
```

```
 1: 0       F
 2: 0       Exponent of 10
 3: 5       Z Loc [ Reflect   ]

19:  End (P95)

20:  Volt (Diff) (P2)
 1: 1       Reps
 2: 25       2500 mV 60 Hz Rejection Range
 3: 3       DIFF Channel
 4: 6       Loc [ Diffuse   ]
 5: 119.2    Mult
 6: 0       Offset

21:  If (X<=>F) (P89)
 1: 6       X Loc [ Diffuse   ]
 2: 4       <
 3: 0       F
 4: 30       Then Do

22:  Z=F (P30)
 1: 0       F
 2: 0       Exponent of 10
 3: 6       Z Loc [ Diffuse   ]

23:  End (P95)

24:  Pulse (P3)
 1: 1       Reps
 2: 1       Pulse Channel 1
 3: 21       Low Level AC, Output Hz
 4: 7       Loc [ Wind_ms   ]
 5: .75      Mult
 6: .2      Offset
;Measures wind speed

25:  If (X<=>F) (P89)
 1: 7       X Loc [ Wind_ms   ]
 2: 4       <
 3: 0.20001  F
 4: 30       Then Do

26:  Z=F (P30)
 1: 0       F
 2: 0       Exponent of 10
 3: 7       Z Loc [ Wind_ms   ]

27:  End (P95)
;Corrects for wind speed less than 0.2 m/s

28:  Pulse (P3)
 1: 1       Reps
 2: 2       Pulse Channel 2
 3: 2       Switch Closure, All Counts
 4: 8       Loc [ Rain_mm   ]
 5: .2      Mult
 6: 0.0      Offset

29:  If (X<=>F) (P89)
 1: 8       X Loc [ Rain_mm   ]
```

```
 2: 3       >=
 3: 0.2     F
 4: 30      Then Do

30:  If time is (P92)
 1: 0       Minutes (Seconds --) into a
 2: 1       Interval (same units as above)
 3: 10      Set Output Flag High (Flag 0)

31:  Set Active Storage Area (P80)
 1: 1       Final Storage Area 1
 2: 333     Array ID

32:  Real Time (P77)
 1: 1220    Year,Day,Hour/Minute (midnight = 2400)

33:  Totalize (P72)
 1: 1       Reps
 2: 8       Loc [ Rain_mm   ]

34:  End (P95)
;Records rain at 1 min intervals when it is raining

35:  If time is (P92)
 1: 0       Minutes (Seconds --) into a
 2: 60      Interval (same units as above)
 3: 10      Set Output Flag High (Flag 0)

36:  Set Active Storage Area (P80)
 1: 1       Final Storage Area 1
 2: 111     Array ID

37:  Real Time (P77)
 1: 1220    Year,Day,Hour/Minute (midnight = 2400)

38:  Sample (P70)
 1: 1       Reps
 2: 1       Loc [ StationID ]

39:  Sample (P70)
 1: 1       Reps
 2: 13      Loc [ V_Batt    ]

40:  Average (P71)
 1: 6       Reps
 2: 2       Loc [ Temp_C    ]

41:  Totalize (P72)
 1: 1       Reps
 2: 8       Loc [ Rain_mm   ]

42:  Average (P71)
 1: 4       Reps
 2: 9       Loc [ rh_frac   ]

43:  If time is (P92)
 1: 0       Minutes (Seconds --) into a
 2: 1440    Interval (same units as above)
 3: 10      Set Output Flag High (Flag 0)
```

```
44:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 222      Array ID

45:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

46:  Sample (P70)
 1: 1        Reps
 2: 1        Loc [ StationID ]

47:  Maximum (P73)
 1: 1        Reps
 2: 00       Value Only
 3: 2        Loc [ Temp_C    ]

48:  Minimum (P74)
 1: 1        Reps
 2: 00       Time Option
 3: 2        Loc [ Temp_C    ]

49:  Average (P71)
 1: 1        Reps
 2: 4        Loc [ Rad_Wm2   ]

50:  Average (P71)
 1: 1        Reps
 2: 11       Loc [ VP_kPa    ]

51:  Totalize (P72)
 1: 1        Reps
 2: 8        Loc [ Rain_mm   ]

52:  Average (P71)
 1: 1        Reps
 2: 7        Loc [ Wind_ms   ]

53:  Totalize (P72)
 1: 1        Reps
 2: 14       Loc [ TotSolar  ]
```

A.3 Lysimeter and tube solarimeter control program Peach Orchard

```
;{CR10}
;TITLE: LYS15MIN
;{CR10}
;Program for monitoring Lysimeter & Tube Solarimeter data
   ;at 15 min intervals from 8th December 1996
;Drafted and installed on 8/12/96

* Table 1 Program
  01:  10Execution Interval (seconds)

1:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 1        In Chan
 4: 1        Loc [ East_mm   ]
 5: 221      Mult
 6: -1440    Offset

2:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 2        In Chan
 4: 2        Loc [ West_mm   ]
 5: 228      Mult
 6: -1520    Offset

3:  Volt (Diff) (P2)
 1: 1        Reps
 2: 35       2500 mV 50 Hz Rejection Range
 3: 3        In Chan
 4: 3        Loc [ ExcitE_V  ]
 5: 0.0055   Mult
 6: 0.0      Offset

4:  Volt (Diff) (P2)
 1: 1        Reps
 2: 35       2500 mV 50 Hz Rejection Range
 3: 4        In Chan
 4: 4        Loc [ ExcitW_V  ]
 5: 0.0054   Mult
 6: 0.0      Offset

5:  Do (P86)
 1: 41       Set Port 1 High

6:  Beginning of Loop (P87)
 1: 0000     Delay
 2: 7        Loop Count

7:  Do (P86)
 1: 72       Pulse Port 2

8:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 6        In Chan
 4: 7     -- Loc [ Sol_1s    ]
 5: 1.0      Mult
```

```
 6: 0.0      Offset

9:  End (P95)

10:  Do (P86)
 1: 51       Set Port 1 Low

11:  Z=X*F (P37)
 1: 7        X Loc [ Sol_1s    ]
 2: 76.802   F
 3: 7        Z Loc [ Sol_1s    ]

12:  Z=X*F (P37)
 1: 8        X Loc [ Sol_2     ]
 2: 69.505   F
 3: 8        Z Loc [ Sol_2     ]

13:  Z=X*F (P37)
 1: 9        X Loc [ Sol_3     ]
 2: 69.605   F
 3: 9        Z Loc [ Sol_3     ]

14:  Z=X*F (P37)
 1: 10       X Loc [ Sol_4mid  ]
 2: 74.879   F
 3: 10       Z Loc [ Sol_4mid  ]

15:  Z=X*F (P37)
 1: 11       X Loc [ Sol_5     ]
 2: 66.019   F
 3: 11       Z Loc [ Sol_5     ]

16:  Z=X*F (P37)
 1: 12       X Loc [ Sol_6     ]
 2: 70.965   F
 3: 12       Z Loc [ Sol_6     ]

17:  Z=X*F (P37)
 1: 13       X Loc [ Sol_7N    ]
 2: 69.087   F
 3: 13       Z Loc [ Sol_7N    ]

18:  Pulse (P3)
 1: 1        Reps
 2: 1        Pulse Input Channel
 3: 02       Switch Closure
 4: 5        Loc [ DrainE_mm ]
 5: 0.0024   Mult
 6: 0.0      Offset

19:  Pulse (P3)
 1: 1        Reps
 2: 2        Pulse Input Channel
 3: 02       Switch Closure
 4: 6        Loc [ DrainW_mm ]
 5: 0.0026   Mult
 6: 0.0      Offset

20:  Batt Voltage (P10)
 1: 14       Loc [ Batt_V    ]
```

21: If time is (P92)
1: 0 Minutes (Seconds --) into a
2: 15 Interval (same units as above)
3: 10 Set Output Flag High

22: Real Time (P77)
1: 1120 Year,Day,Hour/Minute (2400 at midnight)

23: Resolution (P78)
1: 1 high resolution

24: Average (P71)
1: 2 Reps
2: 1 Loc [East_mm]

25: Resolution (P78)
1: 0 low resolution

26: Totalize (P72)
1: 2 Reps
2: 5 Loc [DrainE_mm]

27: Average (P71)
1: 7 Reps
2: 7 Loc [Sol_1s]

28: Sample (P70)
1: 2 Reps
2: 3 Loc [ExcitE_V]

29: Sample (P70)
1: 1 Reps
2: 14 Loc [Batt_V]

A.4 Program to control tube solarimeters & Line Quantum Sensors

```
;{CR10X}
;TITLE: SOLPEN.CSI
; Program for measurement of light penetration of hedgerow plantings.
; Use HMP35C TEMPERATURE & RH PROBE (S/N 636980) wired as follows:
;    Red = + 12V, Yellow (power control) =  E2 ,
;    Green (RH) = SE 11,    Orange (Temp) = SE 12
;    Black (Temp Excitation) = Switched Excitation = E1,
;    Clear + White + Purple = Ground
; Albedo meter in Diff Channel 1 (Top) & 2 (Bottom)
; Diffuse Radiation Pyranometer in Diff channel 3 (Pyran No 1)
; AM416 to Diff Channels 4 & 5
;    Control port C1 is for RES & Control port C2 is for CLK
;    Tube Solarimeters in Sets 1, 2, 3 & 4H1-L1
;    LQS in Sets 4H2-L2, 5, 6 & 7

* Table 1 Program

1:  Temp (107) (P11)
 1: 1        Reps
 2: 11       SE Channel
 3: 1        Excite all reps w/E1
 4: 1        Loc [ AirTemp   ]
 5: 1.0      Mult
 6: 0.08     Offset

2:  Excite-Delay (SE) (P4)
 1: 1        Reps
 2: 5        2500 mV Slow Range
 3: 12       SE Channel
 4: 2        Excite all reps w/Exchan 2
 5: 15       Delay (units 0.01 sec)
 6: 2500     mV Excitation
 7: 2        Loc [ RH        ]
 8: 1.0256   Mult
 9: 2.0285   Offset
; Calibration for HMP35C (S/N 636980) is RH = 2.02852 + 1.02559X
;    where X is RH calculated by instruction P4.

3:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 1        DIFF Channel
 4: 3        Loc [ AlbTop    ]
 5: 56.6352  Mult
 6: 0.0      Offset

4:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 2        DIFF Channel
 4: 4        Loc [ AlbBot    ]
 5: 51.1427  Mult
 6: 0.0      Offset

5:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 3        DIFF Channel
```

```
 4: 5        Loc [ Diffuse   ]
 5: 119.2    Mult
 6: 0.0      Offset

6:  Do (P86)
 1: 41       Set Port 1 High
; Activate AM416 thru' C1 (RES =C1)

7:  Beginning of Loop (P87)
 1: 0        Delay
 2: 7        Loop Count
;7 loops with 2 Diff sensors per set = 7 x 2 = 14

8:  Do (P86)
 1: 72       Pulse Port 2
; Pulses AM416 thru' C2 (CLK = C2)

9:  Step Loop Index (P90)
 1: 2        Step
; Necessary not to over-write readings

10:  Volt (Diff) (P2)
 1: 2        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 4        DIFF Channel
 4: 6     -- Loc [ Sol1      ]
 5: 1        Mult
 6: 0.0      Offset

11:  End (P95)
; Ends loop determining mV readings from sensors
; Readings recorded in Loc 6 to 19 inclusive

12:  Do (P86)
 1: 51       Set Port 1 Low
;Resets AM416 to beginning (Controlled thru' C1)

13:  Z=X*F (P37)
 1: 6        X Loc [ Sol1      ]
 2: 66.681   F
 3: 6        Z Loc [ Sol1      ]

14:  Z=X*F (P37)
 1: 7        X Loc [ Sol2      ]
 2: 65.727   F
 3: 7        Z Loc [ Sol2      ]

15:  Z=X*F (P37)
 1: 8        X Loc [ Sol3      ]
 2: 67.266   F
 3: 8        Z Loc [ Sol3      ]

16:  Z=X*F (P37)
 1: 9        X Loc [ Sol4      ]
 2: 71.336   F
 3: 9        Z Loc [ Sol4      ]

17:  Z=X*F (P37)
 1: 10       X Loc [ Sol5      ]
 2: 65.83    F
```

```
 3: 10      Z Loc [ Sol5     ]

18:  Z=X*F (P37)
 1: 11      X Loc [ Sol6     ]
 2: 65.076  F
 3: 11      Z Loc [ Sol6     ]

19:  Z=X*F (P37)
 1: 12      X Loc [ Sol7     ]
 2: 63.59   F
 3: 12      Z Loc [ Sol7     ]

20:  Z=X*F (P37)
 1: 13      X Loc [ LQS1     ]
 2: 439.062  F
 3: 13      Z Loc [ LQS1     ]

21:  Z=X*F (P37)
 1: 14      X Loc [ LQS2     ]
 2: 311.512  F
 3: 14      Z Loc [ LQS2     ]

22:  Z=X*F (P37)
 1: 15      X Loc [ LQS3     ]
 2: 364.085  F
 3: 15      Z Loc [ LQS3     ]

23:  Z=X*F (P37)
 1: 16      X Loc [ LQS4     ]
 2: 444.295  F
 3: 16      Z Loc [ LQS4     ]

24:  Z=X*F (P37)
 1: 17      X Loc [ LQS5     ]
 2: 405.383  F
 3: 17      Z Loc [ LQS5     ]

25:  Z=X*F (P37)
 1: 18      X Loc [ LQS6     ]
 2: 419.737  F
 3: 18      Z Loc [ LQS6     ]

26:  Z=X*F (P37)
 1: 19      X Loc [ LQS7     ]
 2: 423.338  F
 3: 19      Z Loc [ LQS7     ]

27:  Batt Voltage (P10)
 1: 20      Loc [ Batt_V    ]

28:  If time is (P92)
 1: 0       Minutes (Seconds --) into a
 2: 15      Interval (same units as above)
 3: 10      Set Output Flag High (Flag 0)

29:  Real Time (P77)
 1: 1220    Year,Day,Hour/Minute (midnight = 2400)

30:  Average (P71)
 1: 19      Reps
```

```
 2: 1        Loc [ AirTemp    ]

31:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 1440     Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

32:  Real Time (P77)
 1: 1200     Year,Day (midnight = 2400)

33:  Maximum (P73)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 1        Loc [ AirTemp    ]

34:  Minimum (P74)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 1        Loc [ AirTemp    ]

35:  Maximum (P73)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 2        Loc [ RH         ]

36:  Minimum (P74)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 2        Loc [ RH         ]

37:  Sample (P70)
 1: 1        Reps
 2: 20       Loc [ Batt_V     ]
```

A.5 Heat dissipation sensors (HDS) program; 16 Sensors

```
;{CR10}
;HDS16SE.csi

;Program drafted to read 16 Heat Dissipation Sensors using
;    SE Channels 1 to 8 and AM416 multiplexer to SE channels 9 & 10'
;Thermocouple connections:
;    To CR10  => "High" line SE 1 to 8; "Low line AG (8 T/c's)
;    To AM416 => "High" line SET 1 H1 thru to SET 4 H2 (8 T/c's)
;AM416 linked to CR10 thru' SE channel 9 & 10
;    Pulsed thru C4 (CLK) & Reset thru' C5 (RES)
;CR10TCR (Thermistor Reference Temp) connected thru'
;    SE chan 12 (Red lead); Excitation chan 3 (E3, Black lead)
;    & AG (clear lead)
;Two CE8's excited thru' C1 & C2
;Final Draft 19/12/99

* Table 1 Program
            01:         1           Execution Interval (seconds)

1:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 120      Interval (same units as above)
 3: 11       Set Flag 1 High

2:  If Flag/Port (P91)
 1: 21       Do if Flag 1 is Low
 2: 0        Go to end of Program Table

3:  AC Half Bridge (P5)
 1: 1        Reps
 2: 22       7.5 mV 60 Hz Rejection Range
 3: 12       SE Channel
 4: 3        Excite all reps w/Exchan 3
 5: 2000     mV Excitation
 6: 3        Loc [ TCRT      ]
 7: 800      Mult
 8: 0.0      Offset

4:  Polynomial (P55)
 1: 1        Reps
 2: 3        X Loc [ TCRT      ]
 3: 1        F(X) Loc [ RefTemp   ]
 4: -53.46   C0
 5: 90.807   C1
 6: -83.257  C2
 7: 52.283   C3
 8: -16.723  C4
 9: 2.211    C5

5:  Batt Voltage (P10)
 1: 2        Loc [ Battery   ]
;Record Battery voltage

6:  Do (P86)
 1: 45       Set Port 5 High
;Activate AM416 thru' "Control port 5" (Res = C5)
```

```
7:  Beginning of Loop (P87)
 1: 0        Delay
 2: 8        Loop Count
;8 loops with 2 Diff sensors per set = 8 X 2 = 16

8:  Do (P86)
 1: 74       Pulse Port 4
;Pulses AM416 thru' C4 (CLK = C4)

9:  Step Loop Index (P90)
 1: 2        Step
;Necessary not to over-write readings

10:  Thermocouple Temp (DIFF) (P14)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 1        DIFF Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp Loc [ RefTemp    ]
 6: 5     -- Loc [ SoilT_1    ]
 7: 1.0      Mult
 8: 0.0      Offset

11:  End (P95)
;End first round of soil Temp measurements
;Soil Temps recorded in Loc 5 to 20 inclusive.

12:  Do (P86)
 1: 55       Set Port 5 Low
;Resets AM416 to beginning

13:  Do (P86)
 1: 41       Set Port 1 High
;Activate 1st CE8 thru' C1

14:  Do (P86)
 1: 42       Set Port 2 High
; Activates 2nd CE8 thru' C2

15:  Beginning of Loop (P87)
 1: 0        Delay
 2: 2        Loop Count

16:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 50       Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

17:  End (P95)
;Create 1 sec period; i.e. activates two CE8s for 1 sec

18:  Do (P86)
 1: 45       Set Port 5 High
;Activates AM416

19:  Beginning of Loop (P87)
 1: 0        Delay
 2: 8        Loop Count
```

```
20:  Do (P86)
 1: 74       Pulse Port 4

21:  Step Loop Index (P90)
 1: 2        Step

22:  Thermocouple Temp (DIFF) (P14)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 1        DIFF Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp Loc [ RefTemp   ]
 6: 21    -- Loc [ Sec1_1    ]
 7: 1.0      Mult
 8: 0.0      Offset

23:  End (P95)

24:  Do (P86)
 1: 55       Set Port 5 Low
;Resets AM416 to beginning
;Complete 16 measurements of Temp after 1 sec heating
;Measurements recorded in Locs 21 to 36 inclusive

25:  Beginning of Loop (P87)
 1: 0        Delay
 2: 40       Loop Count

26:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 50       Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

27:  End (P95)
;Create 20 sec delay; i.e. continue heating for 20 sec.

28:  Do (P86)
 1: 45       Set Port 5 High
;Activate AM416

29:  Beginning of Loop (P87)
 1: 0        Delay
 2: 8        Loop Count

30:  Do (P86)
 1: 74       Pulse Port 4

31:  Step Loop Index (P90)
 1: 2        Step

32:  Thermocouple Temp (DIFF) (P14)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 1        DIFF Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp Loc [ RefTemp   ]
 6: 37    -- Loc [ Sc20_1    ]
 7: 1.0      Mult
 8: 0.0      Offset
```

```
33:  End (P95)

34:  Do (P86)
 1: 55       Set Port 5 Low
; Resets AM416 to beginning
;End Temp measurements after 21 sec heating
;Results recorded to Locs 37 to 52 inclusive.

35:  Do (P86)
 1: 51       Set Port 1 Low

36:  Do (P86)
 1: 52       Set Port 2 Low
;Deactivates two CE8s.

37:  Beginning of Loop (P87)
 1: 0        Delay
 2: 16       Loop Count

38:  Z=X-Y (P35)
 1: 37    -- X Loc [ Sc20_1    ]
 2: 21    -- Y Loc [ Sec1_1    ]
 3: 53    -- Z Loc [ dT_1      ]

39:  End (P95)
;Calculates dT for 16 sensors and places results in
;Locs 53 to 68 inclusive.

40:  Z=F (P30)
 1: 4.001    F
 2: 0        Exponent of 10
 3: 69       Z Loc [ Psi_1     ]

41:  Z=X^Y (P47)
 1: 53       X Loc [ dT_1      ]
 2: 69       Y Loc [ Psi_1     ]
 3: 69       Z Loc [ Psi_1     ]

42:  Z=X*F (P37)
 1: 69       X Loc [ Psi_1     ]
 2: 20.64    F
 3: 69       Z Loc [ Psi_1     ]
;Calcs Psi for HDS S/N 4391: 20.64*(dT)^4.001

43:  Z=F (P30)
 1: 6.494    F
 2: 0        Exponent of 10
 3: 70       Z Loc [ Psi_2     ]

44:  Z=X^Y (P47)
 1: 54       X Loc [ dT_2      ]
 2: 70       Y Loc [ Psi_2     ]
 3: 70       Z Loc [ Psi_2     ]

45:  Z=X*F (P37)
 1: 70       X Loc [ Psi_2     ]
 2: 14.075   F
 3: 70       Z Loc [ Psi_2     ]
;Calcs Psi for HDS S/N 4364: 14.075*(dT)^6.494
```

```
46:  Z=F (P30)
 1: 6.383    F
 2: 0        Exponent of 10
 3: 71       Z Loc [ Psi_3     ]

47:  Z=X^Y (P47)
 1: 55       X Loc [ dT_3      ]
 2: 71       Y Loc [ Psi_3     ]
 3: 71       Z Loc [ Psi_3     ]

48:  Z=X*F (P37)
 1: 71       X Loc [ Psi_3     ]
 2: 14.036   F
 3: 71       Z Loc [ Psi_3     ]
;Calcs Psi for HDS S/N 4380: 14.036*(dT)^6.383

49:  Z=F (P30)
 1: 4.75     F
 2: 0        Exponent of 10
 3: 72       Z Loc [ Psi_4     ]

50:  Z=X^Y (P47)
 1: 56       X Loc [ dT_4      ]
 2: 72       Y Loc [ Psi_4     ]
 3: 72       Z Loc [ Psi_4     ]

51:  Z=X*F (P37)
 1: 72       X Loc [ Psi_4     ]
 2: 18.077   F
 3: 72       Z Loc [ Psi_4     ]
;Calcs Psi for HDS S/N 4375: 18.077*(dT)^4.75

52:  Z=F (P30)
 1: 6.2479   F
 2: 0        Exponent of 10
 3: 73       Z Loc [ Psi_5     ]

53:  Z=X^Y (P47)
 1: 57       X Loc [ dT_5      ]
 2: 73       Y Loc [ Psi_5     ]
 3: 73       Z Loc [ Psi_5     ]

54:  Z=X*F (P37)
 1: 73       X Loc [ Psi_5     ]
 2: 13.351   F
 3: 73       Z Loc [ Psi_5     ]
;Calcs PSi for HDS S/N 4625: 13.351*(dT)^6.2479

55:  Z=F (P30)
 1: 6.0652   F
 2: 0        Exponent of 10
 3: 74       Z Loc [ Psi_6     ]

56:  Z=X^Y (P47)
 1: 58       X Loc [ dT_6      ]
 2: 74       Y Loc [ Psi_6     ]
 3: 74       Z Loc [ Psi_6     ]

57:  Z=X*F (P37)
```

```
 1: 74       X Loc [ Psi_6     ]
 2: 16.536   F
 3: 74       Z Loc [ Psi_6     ]
;Calcs Psi for HDS S/N 4382: 16.536*(dT)^6.0652

58:  Z=F (P30)
 1: 6.1381   F
 2: 0        Exponent of 10
 3: 75       Z Loc [ Psi_7     ]

59:  Z=X^Y (P47)
 1: 59       X Loc [ dT_7      ]
 2: 75       Y Loc [ Psi_7     ]
 3: 75       Z Loc [ Psi_7     ]

60:  Z=X*F (P37)
 1: 75       X Loc [ Psi_7     ]
 2: 20.341   F
 3: 75       Z Loc [ Psi_7     ]
;Calcs Psi for HDS S/N 4379: 20.341*(dT)^6.1381

61:  Z=F (P30)
 1: 3.4538   F
 2: 0        Exponent of 10
 3: 76       Z Loc [ Psi_8     ]

62:  Z=X^Y (P47)
 1: 60       X Loc [ dT_8      ]
 2: 76       Y Loc [ Psi_8     ]
 3: 76       Z Loc [ Psi_8     ]

63:  Z=X*F (P37)
 1: 76       X Loc [ Psi_8     ]
 2: 21.684   F
 3: 76       Z Loc [ Psi_8     ]
;Calcs Psi for HDS S/N 4377: 21.684*(dT)^3.4538

64:  Z=F (P30)
 1: 5.555    F
 2: 0        Exponent of 10
 3: 77       Z Loc [ Psi_9     ]

65:  Z=X^Y (P47)
 1: 61       X Loc [ dT_9      ]
 2: 77       Y Loc [ Psi_9     ]
 3: 77       Z Loc [ Psi_9     ]

66:  Z=X*F (P37)
 1: 77       X Loc [ Psi_9     ]
 2: 13.81    F
 3: 77       Z Loc [ Psi_9     ]
;Calcs Psi for HDS S/N 4378: 13.81*(dT)^5.555

67:  Z=F (P30)
 1: 3.7574   F
 2: 0        Exponent of 10
 3: 78       Z Loc [ Psi_10    ]

68:  Z=X^Y (P47)
 1: 62       X Loc [ dT_10     ]
```

```
 2: 78       Y Loc [ Psi_10    ]
 3: 78       Z Loc [ Psi_10    ]

69:  Z=X*F (P37)
 1: 78       X Loc [ Psi_10    ]
 2: 36.046   F
 3: 78       Z Loc [ Psi_10    ]
;Calcs Psi for HDS S/N 1334: 36.046*(dT)^3.7574

70:  Z=F (P30)
 1: 3.9514   F
 2: 0        Exponent of 10
 3: 79       Z Loc [ Psi_11    ]

71:  Z=X^Y (P47)
 1: 63       X Loc [ dT_11     ]
 2: 79       Y Loc [ Psi_11    ]
 3: 79       Z Loc [ Psi_11    ]

72:  Z=X*F (P37)
 1: 79       X Loc [ Psi_11    ]
 2: 25.233   F
 3: 79       Z Loc [ Psi_11    ]
;Calcs Psi for HDS S/N 1351: 25.2335*(dT)^3.9514

73:  Z=F (P30)
 1: 3.9807   F
 2: 0        Exponent of 10
 3: 80       Z Loc [ Psi_12    ]

74:  Z=X^Y (P47)
 1: 64       X Loc [ dT_12     ]
 2: 80       Y Loc [ Psi_12    ]
 3: 80       Z Loc [ Psi_12    ]

75:  Z=X*F (P37)
 1: 80       X Loc [ Psi_12    ]
 2: 33.516   F
 3: 80       Z Loc [ Psi_12    ]
;Calcs Psi for HDS S/N 1358: 33.516*(dT)^3.9807

76:  Z=F (P30)
 1: 6.5528   F
 2: 0        Exponent of 10
 3: 81       Z Loc [ Psi_13    ]

77:  Z=X^Y (P47)
 1: 65       X Loc [ dT_13     ]
 2: 81       Y Loc [ Psi_13    ]
 3: 81       Z Loc [ Psi_13    ]

78:  Z=X*F (P37)
 1: 81       X Loc [ Psi_13    ]
 2: 36.177   F
 3: 81       Z Loc [ Psi_13    ]
;Calcs Psi for HDS S/N 4722: 36.177*(dT)^6.5528

79:  Z=F (P30)
 1: 5.6721   F
 2: 0        Exponent of 10
```

```
 3: 82      Z Loc [ Psi_14    ]

80:  Z=X^Y (P47)
 1: 66      X Loc [ dT_14     ]
 2: 82      Y Loc [ Psi_14    ]
 3: 82      Z Loc [ Psi_14    ]

81:  Z=X*F (P37)
 1: 82      X Loc [ Psi_14    ]
 2: 21.948  F
 3: 82      Z Loc [ Psi_14    ]
;Calcs PSi for HDS S/N 4727: 21.948*(dT)^5.6721

82:  Z=F (P30)
 1: 5.703   F
 2: 0       Exponent of 10
 3: 83      Z Loc [ Psi_15    ]

83:  Z=X^Y (P47)
 1: 67      X Loc [ dT_15     ]
 2: 83      Y Loc [ Psi_15    ]
 3: 83      Z Loc [ Psi_15    ]

84:  Z=X*F (P37)
 1: 83      X Loc [ Psi_15    ]
 2: 21.251  F
 3: 83      Z Loc [ Psi_15    ]
;Calcs Psi for HDS S/N 4721: 21.251*(dT)^5.703

85:  Z=F (P30)
 1: 3.6961  F
 2: 0       Exponent of 10
 3: 84      Z Loc [ Psi_16    ]

86:  Z=X^Y (P47)
 1: 68      X Loc [ dT_16     ]
 2: 84      Y Loc [ Psi_16    ]
 3: 84      Z Loc [ Psi_16    ]

87:  Z=X*F (P37)
 1: 84      X Loc [ Psi_16    ]
 2: 15.968  F
 3: 84      Z Loc [ Psi_16    ]
;Calcs Psi for HDS S/N 4234: 15.9687*(dT)^3.6961

88:  Do (P86)
 1: 10      Set Output Flag High

89:  Set Active Storage Area (P80)
 1: 1       Final Storage Area 1
 2: 111     Array ID

90:  Real Time (P77)
 1: 1220    Year,Day,Hour/Minute (midnight = 2400)

91:  Minimize (P74)
 1: 1       Reps
 2: 0       Value Only
 3: 2       Loc [ Battery   ]
```

```
92:  Average (P71)
 1: 1        Reps
 2: 1        Loc [ RefTemp    ]

93:  Sample (P70)
 1: 16       Reps
 2: 69       Loc [ Psi_1      ]

94:  Do (P86)
 1: 10       Set Output Flag High

95:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 222      Array ID

96:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

97:  Sample (P70)
 1: 16       Reps
 2: 53       Loc [ dT_1       ]

98:  Do (P86)
 1: 10       Set Output Flag High

99:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 333      Array ID

100:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

101:  Sample (P70)
 1: 16       Reps
 2: 5        Loc [ SoilT_1    ]

102:  Do (P86)
 1: 21       Set Flag 1 Low

* Table 2 Program
        02:         0.0000              Execution Interval (seconds)

* Table 3  Subroutines

End Program
```

A.6 Heat dissipation sensors (HDS) program; 24 Sensors

```
;{CR10X}
;24HDSPSI.CSI
;Program done to read 24 Heat Dissipation Sensors (HDS)
;thru' AM416 multiplexer & excited thru three CE8s.
;AM416 clocked <pulsed) thru C4 & Reset thru C5.
;CE8s activated thru C1, C2 & C6.

* Table 1 Program
  01:  10Execution Interval (seconds)

1:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 60       Interval (same units as above)
 3: 11       Set Flag 1 High

2:  If Flag/Port (P91)
 1: 21       Do if Flag 1 is Low
 2: 0        Go to end of Program Table

3:  AC Half Bridge (P5)
 1: 1        Reps
 2: 22       7.5 mV 60 Hz Rejection Range
 3: 12       SE Channel
 4: 3        Excite all reps w/Exchan 3
 5: 2000     mV Excitation
 6: 3        Loc [ TCRT      ]
 7: 800      Mult
 8: 0        Offset

4:  Polynomial (P55)
 1: 1        Reps
 2: 3        X Loc [ TCRT      ]
 3: 1        F(X) Loc [ RefTemp   ]
 4: -53.46   C0
 5: 90.807   C1
 6: -83.257  C2
 7: 52.283   C3
 8: -16.723  C4
 9: 2.211    C5

5:  Batt Voltage (P10)
 1: 2        Loc [ Battery   ]

;          MEASUREMENTS FOR 1st 8 T/c's ON CR10X

6:  Thermocouple Temp (SE) (P13)
 1: 8        Reps
 2: 22       7.5 mV 60 Hz Rejection Range
 3: 1        SE Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 5        Loc [ SoilT_1   ]
 7: 1.0      Mult
 8: 0        Offset
;Det Soil T for 1st 8 T/c's: recorded in Locs 5 to 12

7:  Do (P86)
 1: 41       Set Port 1 High
```

```
;Activates 1st CE8 thru C1

8:  Beginning of Loop (P87)
 1: 0       Delay
 2: 2       Loop Count

9:  Excitation with Delay (P22)
 1: 1       Ex Channel
 2: 0       Delay W/Ex (units = 0.01 sec)
 3: 50      Delay After Ex (units = 0.01 sec)
 4: 0       mV Excitation

10:  End (P95)
;Create 1 sec period (2 X 50 X 0.01 = 1 sec)
;       Activates CE8 No 1 for 1 sec

11:  Thermocouple Temp (SE) (P13)
 1: 8       Reps
 2: 22      7.5 mV 60 Hz Rejection Range
 3: 1       SE Channel
 4: 1       Type T (Copper-Constantan)
 5: 1       Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 29      Loc [ Sec1_1    ]
 7: 1       Mult
 8: 0       Offset
;Records Temp after 1 sec heating: Locs 29 to 36 inclusive

12:  Beginning of Loop (P87)
 1: 0       Delay
 2: 40      Loop Count

13:  Excitation with Delay (P22)
 1: 1       Ex Channel
 2: 0       Delay W/Ex (units = 0.01 sec)
 3: 50      Delay After Ex (units = 0.01 sec)
 4: 0       mV Excitation

14:  End (P95)
;Creates 20 sec delay, i.e. continue heating for 20 sec

15:  Thermocouple Temp (SE) (P13)
 1: 8       Reps
 2: 22      7.5 mV 60 Hz Rejection Range
 3: 1       SE Channel
 4: 1       Type T (Copper-Constantan)
 5: 1       Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 53      Loc [ T20s_1    ]
 7: 1       Mult
 8: 0       Offset
;Determine Temp of 1st T/c's after 21 sec heating: Locs 53 to 60 inclusive

16:  Do (P86)
 1: 51      Set Port 1 Low
;Deactivates CE8 No 1
;           COMPLETED MEASUREMENTS FOR 1st 8 T/c's

;           MEASURE SOIL TEMP FOR BALANCE OF T/c's

17:  Do (P86)
 1: 45      Set Port 5 High
```

```
;Actvate AM416 thru' Control port 5 (Res = C5)

18:  Beginning of Loop (P87)
 1: 0        Delay
 2: 8        Loop Count
;8 loops with 2 SE sensors per set: 8 X 2 = 16

19:  Do (P86)
 1: 74       Pulse Port 4
;Pulses AM416 thru' C4 (CLK = C4)

20:  Step Loop Index (P90)
 1: 2        Step
;Necessary not to over-write readings

21:  Thermocouple Temp (SE) (P13)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 9        SE Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 13    -- Loc [ SoilT_9   ]
 7: 1        Mult
 8: 0        Offset

22:  End (P95)
;Ends determ of 16 soil Temp measurements
;Temps recorded in Loc 9 to 24 inclusive.

23:  Do (P86)
 1: 55       Set Port 5 Low
;Resets AM 416 to beginning

;          MEASUREMENTS FOR 2nd GROUP OF T/c's (Heating cycle)

24:  Do (P86)
 1: 42       Set Port 2 High
;Activates 2nd CE8 thru' C2

25:  Beginning of Loop (P87)
 1: 0        Delay
 2: 2        Loop Count

26:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 50       Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

27:  End (P95)
;Create 1 sec period; i.e. activate CE8 No 2 for 1 sec

28:  Do (P86)
 1: 45       Set Port 5 High
;Activates AM416

29:  Beginning of Loop (P87)
 1: 0        Delay
 2: 4        Loop Count
```

```
30:  Do (P86)
 1: 74       Pulse Port 4

31:  Step Loop Index (P90)
 1: 2        Step

32:  Thermocouple Temp (SE) (P13)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 9        SE Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 37    -- Loc [ Sec1_9    ]
 7: 1        Mult
 8: 0        Offset

33:  End (P95)
;Ends 8 T/c measurements after 1 sec heating; Locs 37 to 44 inclusive

34:  Do (P86)
 1: 55       Set Port 5 Low
;Resets AM416

35:  Beginning of Loop (P87)
 1: 0        Delay
 2: 40       Loop Count

36:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 50       Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

37:  End (P95)
;Creates 20 sec delay; i.e. continue heating for 20 sec

38:  Do (P86)
 1: 45       Set Port 5 High
;Activates AM416

39:  Beginning of Loop (P87)
 1: 0        Delay
 2: 4        Loop Count

40:  Do (P86)
 1: 74       Pulse Port 4

41:  Step Loop Index (P90)
 1: 2        Step

42:  Thermocouple Temp (SE) (P13)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 9        SE Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 61    -- Loc [ T20s_9    ]
 7: 1        Mult
 8: 0        Offset
```

```
43:  End (P95)
;Ends Temp measurements after 21 sec heating for 2nd Group of T/c's
;Temp 21 sec (T20s_9) recorded in Locs 61 to 68 inclusive.
;   NNB AM416 is not reset, left at SET 4

44:  Do (P86)
 1: 52       Set Port 2 Low
;Deactivates CE8 No 2

;           MEASUREMENTS FOR 3rd GROUP OF 8 T/c's (Heating cycle)

45:  Do (P86)
 1: 46       Set Port 6 High
;Activates 3rd CE8

46:  Beginning of Loop (P87)
 1: 0        Delay
 2: 2        Loop Count

47:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 50       Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

48:  End (P95)
;Create 1 sec period for 3rd CE8

49:  Beginning of Loop (P87)
 1: 0        Delay
 2: 4        Loop Count

50:  Do (P86)
 1: 74       Pulse Port 4

51:  Step Loop Index (P90)
 1: 2        Step

52:  Thermocouple Temp (SE) (P13)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 9        SE Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp (Deg. C) Loc [ RefTemp    ]
 6: 45    -- Loc [ Sec1_17    ]
 7: 1        Mult
 8: 0        Offset

53:  End (P95)

54:  Do (P86)
 1: 55       Set Port 5 Low
;Resets AM416 to channel 1

55:  Do (P86)
 1: 45       Set Port 5 High
;Activates AM416

56:  Beginning of Loop (P87)
 1: 0        Delay
```

```
 2: 4       Loop Count

57:  Do (P86)
 1: 74      Pulse Port 4

58:  Do (P86)
 1: 74      Pulse Port 4

59:  End (P95)
;Steps AM416 thru 8 channels, i.e. to SET 5

60:  Beginning of Loop (P87)
 1: 0       Delay
 2: 40      Loop Count

61:  Excitation with Delay (P22)
 1: 1       Ex Channel
 2: 0       Delay W/Ex (units = 0.01 sec)
 3: 50      Delay After Ex (units = 0.01 sec)
 4: 0       mV Excitation

62:  End (P95)
;20 sec delay

63:  Beginning of Loop (P87)
 1: 0       Delay
 2: 4       Loop Count

64:  Do (P86)
 1: 74      Pulse Port 4

65:  Step Loop Index (P90)
 1: 2       Step

66:  Thermocouple Temp (SE) (P13)
 1: 2       Reps
 2: 21      2.5 mV 60 Hz Rejection Range
 3: 9       SE Channel
 4: 1       Type T (Copper-Constantan)
 5: 1       Ref Temp (Deg. C) Loc [ RefTemp   ]
 6: 69    -- Loc [ T20s_17   ]
 7: 1       Mult
 8: 0       Offset

67:  End (P95)
;Ends Temp 21 sec measurements for 3rd CE8
; recorded in Locs 69 to 76

68:  Do (P86)
 1: 55      Set Port 5 Low
;Resets AM416 to channel 1

69:  Do (P86)
 1: 56      Set Port 6 Low
;Deactivates CE8 No 3
;          ENDS MEASUREMENTS FOR 3rd GROUP OF T/c's

70:  Beginning of Loop (P87)
 1: 0       Delay
 2: 24      Loop Count
```

```
71:  Z=X-Y (P35)
 1: 53    -- X Loc [ T20s_1    ]
 2: 29    -- Y Loc [ Sec1_1    ]
 3: 77    -- Z Loc [ dT_1      ]
;Calculates dT for 24 sensors and places result in
;Locs 77 to 100 inclusive

72:  End (P95)
;Ends dT calc loop

73:  Z=F (P30)
 1: 3.5268   F
 2: 0        Exponent of 10
 3: 101      Z Loc [ Psi_1     ]

74:  Z=X^Y (P47)
 1: 77       X Loc [ dT_1      ]
 2: 101      Y Loc [ Psi_1     ]
 3: 101      Z Loc [ Psi_1     ]

75:  Z=X*F (P37)
 1: 101      X Loc [ Psi_1     ]
 2: -40.043  F
 3: 101      Z Loc [ Psi_1     ]
;Calc  PSi for HDS S/N 1353

76:  Z=F (P30)
 1: 4.4796   F
 2: 0        Exponent of 10
 3: 102      Z Loc [ Psi_2     ]

77:  Z=X^Y (P47)
 1: 78       X Loc [ dT_2      ]
 2: 102      Y Loc [ Psi_2     ]
 3: 102      Z Loc [ Psi_2     ]

78:  Z=X*F (P37)
 1: 102      X Loc [ Psi_2     ]
 2: -21.6616 F
 3: 102      Z Loc [ Psi_2     ]
;Calcs Psi for HDS S/N 1347

79:  Z=F (P30)
 1: 5.3718   F
 2: 0        Exponent of 10
 3: 103      Z Loc [ Psi_3     ]

80:  Z=X^Y (P47)
 1: 79       X Loc [ dT_3      ]
 2: 103      Y Loc [ Psi_3     ]
 3: 103      Z Loc [ Psi_3     ]

81:  Z=X*F (P37)
 1: 103      X Loc [ Psi_3     ]
 2: -16.879  F
 3: 103      Z Loc [ Psi_3     ]
;Calcs Psi for HDS S/N 4724

82:  Z=F (P30)
```

```
 1: 4.1613   F
 2: 0        Exponent of 10
 3: 104      Z Loc [ Psi_4     ]

83:  Z=X^Y (P47)
 1: 80       X Loc [ dT_4      ]
 2: 104      Y Loc [ Psi_4     ]
 3: 104      Z Loc [ Psi_4     ]

84:  Z=X*F (P37)
 1: 104      X Loc [ Psi_4     ]
 2: -14.441  F
 3: 104      Z Loc [ Psi_4     ]
;Calcs Psi for HDS S/N 4725

85:  Z=F (P30)
 1: 6.8064   F
 2: 0        Exponent of 10
 3: 105      Z Loc [ Psi_5     ]

86:  Z=X^Y (P47)
 1: 81       X Loc [ dT_5      ]
 2: 105      Y Loc [ Psi_5     ]
 3: 105      Z Loc [ Psi_5     ]

87:  Z=X*F (P37)
 1: 105      X Loc [ Psi_5     ]
 2: -17.576  F
 3: 105      Z Loc [ Psi_5     ]
;Calcs Psi for HDS S/N 4723

88:  Z=F (P30)
 1: 7.1627   F
 2: 0        Exponent of 10
 3: 106      Z Loc [ Psi_6     ]

89:  Z=X^Y (P47)
 1: 82       X Loc [ dT_6      ]
 2: 106      Y Loc [ Psi_6     ]
 3: 106      Z Loc [ Psi_6     ]

90:  Z=X*F (P37)
 1: 106      X Loc [ Psi_6     ]
 2: -10.032  F
 3: 106      Z Loc [ Psi_6     ]
;Calculates Psi for HDS S/N 4728

91:  Z=F (P30)
 1: 7.4655   F
 2: 0        Exponent of 10
 3: 107      Z Loc [ Psi_7     ]

92:  Z=X^Y (P47)
 1: 83       X Loc [ dT_7      ]
 2: 107      Y Loc [ Psi_7     ]
 3: 107      Z Loc [ Psi_7     ]

93:  Z=X*F (P37)
 1: 107      X Loc [ Psi_7     ]
 2: -11.282  F
```

```
 3: 107      Z Loc [ Psi_7     ]
;Calcs Psi for HDS S/N 4719

94:  Z=F (P30)
 1: 6.3041   F
 2: 0        Exponent of 10
 3: 108      Z Loc [ Psi_8     ]

95:  Z=X^Y (P47)
 1: 84       X Loc [ dT_8      ]
 2: 108      Y Loc [ Psi_8     ]
 3: 108      Z Loc [ Psi_8     ]

96:  Z=X*F (P37)
 1: 108      X Loc [ Psi_8     ]
 2: -22.561  F
 3: 108      Z Loc [ Psi_8     ]
;Calcs Psi for HDS S/N 4720

97:  Z=F (P30)
 1: 5.1654   F
 2: 0        Exponent of 10
 3: 109      Z Loc [ Psi_9     ]

98:  Z=X^Y (P47)
 1: 85       X Loc [ dT_9      ]
 2: 109      Y Loc [ Psi_9     ]
 3: 109      Z Loc [ Psi_9     ]

99:  Z=X*F (P37)
 1: 109      X Loc [ Psi_9     ]
 2: -21.8557 F
 3: 109      Z Loc [ Psi_9     ]
;Calcs Psi for HDS S/N 1329

100:  Z=F (P30)
 1: 2.9517   F
 2: 0        Exponent of 10
 3: 110      Z Loc [ Psi_10    ]

101:  Z=X^Y (P47)
 1: 86       X Loc [ dT_10     ]
 2: 110      Y Loc [ Psi_10    ]
 3: 110      Z Loc [ Psi_10    ]

102:  Z=X*F (P37)
 1: 110      X Loc [ Psi_10    ]
 2: -19.139  F
 3: 110      Z Loc [ Psi_10    ]
;Calcs Psi for HDS S/N 1343

103:  Z=F (P30)
 1: 3.904    F
 2: 0        Exponent of 10
 3: 111      Z Loc [ Psi_11    ]

104:  Z=X^Y (P47)
 1: 87       X Loc [ dT_11     ]
 2: 111      Y Loc [ Psi_11    ]
 3: 111      Z Loc [ Psi_11    ]
```

```
105:  Z=X*F (P37)
 1: 111      X Loc [ Psi_11    ]
 2: -20.2988 F
 3: 111      Z Loc [ Psi_11    ]
;Calcs Psi for HDS S/N 1352

106:  Z=F (P30)
 1: 3.8467   F
 2: 0        Exponent of 10
 3: 112      Z Loc [ Psi_12    ]

107:  Z=X^Y (P47)
 1: 88       X Loc [ dT_12     ]
 2: 112      Y Loc [ Psi_12    ]
 3: 112      Z Loc [ Psi_12    ]

108:  Z=X*F (P37)
 1: 112      X Loc [ Psi_12    ]
 2: -25.316  F
 3: 112      Z Loc [ Psi_12    ]
;Calcs Psi for HDS 4726

109:  Z=F (P30)
 1: 5.297    F
 2: 0        Exponent of 10
 3: 113      Z Loc [ Psi_13    ]

110:  Z=X^Y (P47)
 1: 89       X Loc [ dT_13     ]
 2: 113      Y Loc [ Psi_13    ]
 3: 113      Z Loc [ Psi_13    ]

111:  Z=X*F (P37)
 1: 113      X Loc [ Psi_13    ]
 2: -14.864  F
 3: 113      Z Loc [ Psi_13    ]
;Calcs Psi for HDS S/N 4360

112:  Z=F (P30)
 1: 6.7863   F
 2: 0        Exponent of 10
 3: 114      Z Loc [ Psi_14    ]

113:  Z=X^Y (P47)
 1: 90       X Loc [ dT_14     ]
 2: 114      Y Loc [ Psi_14    ]
 3: 114      Z Loc [ Psi_14    ]

114:  Z=X*F (P37)
 1: 114      X Loc [ Psi_14    ]
 2: -12.595  F
 3: 114      Z Loc [ Psi_14    ]
;Calcs Psi for HDS S/N 4390

115:  Z=F (P30)
 1: 5.3778   F
 2: 0        Exponent of 10
 3: 115      Z Loc [ Psi_15    ]
```

```
116:  Z=X^Y (P47)
 1: 91       X Loc [ dT_15     ]
 2: 115      Y Loc [ Psi_15    ]
 3: 115      Z Loc [ Psi_15    ]

117:  Z=X*F (P37)
 1: 115      X Loc [ Psi_15    ]
 2: -20.325  F
 3: 115      Z Loc [ Psi_15    ]
;Calcs Psi for HDS S/N 4626

118:  Z=F (P30)
 1: 4.1613   F
 2: 0        Exponent of 10
 3: 116      Z Loc [ Psi_16    ]

119:  Z=X^Y (P47)
 1: 92       X Loc [ dT_16     ]
 2: 116      Y Loc [ Psi_16    ]
 3: 116      Z Loc [ Psi_16    ]

120:  Z=X*F (P37)
 1: 116      X Loc [ Psi_16    ]
 2: -25.6447 F
 3: 116      Z Loc [ Psi_16    ]
;Calcs Psi for HDS S/N 1345

121:  Z=F (P30)
 1: 6.0703   F
 2: 0        Exponent of 10
 3: 117      Z Loc [ Psi_17    ]

122:  Z=X^Y (P47)
 1: 93       X Loc [ dT_17     ]
 2: 117      Y Loc [ Psi_17    ]
 3: 117      Z Loc [ Psi_17    ]

123:  Z=X*F (P37)
 1: 117      X Loc [ Psi_17    ]
 2: -16.882  F
 3: 117      Z Loc [ Psi_17    ]
;Calcs Psi for HDS S/N 4367

124:  Z=F (P30)
 1: 5.832    F
 2: 0        Exponent of 10
 3: 118      Z Loc [ Psi_18    ]

125:  Z=X^Y (P47)
 1: 94       X Loc [ dT_18     ]
 2: 118      Y Loc [ Psi_18    ]
 3: 118      Z Loc [ Psi_18    ]

126:  Z=X*F (P37)
 1: 118      X Loc [ Psi_18    ]
 2: -19.189  F
 3: 118      Z Loc [ Psi_18    ]
;Calcs Psi for HDS S/N 4374

127:  Z=F (P30)
```

```
 1: 5.8407   F
 2: 0        Exponent of 10
 3: 119      Z Loc [ Psi_19    ]

128:  Z=X^Y (P47)
 1: 95       X Loc [ dT_19     ]
 2: 119      Y Loc [ Psi_19    ]
 3: 119      Z Loc [ Psi_19    ]

129:  Z=X*F (P37)
 1: 119      X Loc [ Psi_19    ]
 2: -12.842  F
 3: 119      Z Loc [ Psi_19    ]
;Calcs Psi for HDS S/N 4627

130:  Z=F (P30)
 1: 4.9265   F
 2: 0        Exponent of 10
 3: 120      Z Loc [ Psi_20    ]

131:  Z=X^Y (P47)
 1: 96       X Loc [ dT_20     ]
 2: 120      Y Loc [ Psi_20    ]
 3: 120      Z Loc [ Psi_20    ]

132:  Z=X*F (P37)
 1: 120      X Loc [ Psi_20    ]
 2: -16.17   F
 3: 120      Z Loc [ Psi_20    ]
;Calcs Psi for HDS S/N 4381

133:  Z=F (P30)
 1: 1        F
 2: 0        Exponent of 10
 3: 121      Z Loc [ Psi_21    ]
;Psi for "Psi_21"

134:  Z=F (P30)
 1: 5.8008   F
 2: 0        Exponent of 10
 3: 122      Z Loc [ Psi_22    ]

135:  Z=X^Y (P47)
 1: 98       X Loc [ dT_22     ]
 2: 122      Y Loc [ Psi_22    ]
 3: 122      Z Loc [ Psi_22    ]

136:  Z=X*F (P37)
 1: 122      X Loc [ Psi_22    ]
 2: -16.268  F
 3: 122      Z Loc [ Psi_22    ]
;Calcs Psi for HDS S/N 4365

137:  Z=F (P30)
 1: 4.9347   F
 2: 0        Exponent of 10
 3: 123      Z Loc [ Psi_23    ]

138:  Z=X^Y (P47)
 1: 99       X Loc [ dT_23     ]
```

```
 2: 123      Y Loc [ Psi_23    ]
 3: 123      Z Loc [ Psi_23    ]

139:  Z=X*F (P37)
 1: 123      X Loc [ Psi_23    ]
 2: -16.016  F
 3: 123      Z Loc [ Psi_23    ]
;Calcs Psi for HDS S/N 4628

140:  Z=F (P30)
 1: 5.4848   F
 2: 0        Exponent of 10
 3: 124      Z Loc [ Psi_24    ]

141:  Z=X^Y (P47)
 1: 100      X Loc [ dT_24     ]
 2: 124      Y Loc [ Psi_24    ]
 3: 124      Z Loc [ Psi_24    ]

142:  Z=X*F (P37)
 1: 124      X Loc [ Psi_24    ]
 2: -19.324  F
 3: 124      Z Loc [ Psi_24    ]

143:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

144:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 111      Array ID

145:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

146:  Minimize (P74)
 1: 1        Reps
 2: 0        Value Only
 3: 2        Loc [ Battery   ]

147:  Average (P71)
 1: 1        Reps
 2: 1        Loc [ RefTemp   ]

148:  Sample (P70)
 1: 24       Reps
 2: 101      Loc [ Psi_1     ]

149:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

150:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 222      Array ID

151:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

152:  Sample (P70)
 1: 24       Reps
 2: 77       Loc [ dT_1      ]
```

153: Do (P86)
1: 10 Set Output Flag High (Flag 0)

154: Set Active Storage Area (P80)
1: 1 Final Storage Area 1
2: 333 Array ID

155: Real Time (P77)
1: 1220 Year,Day,Hour/Minute (midnight = 2400)

156: Sample (P70)
1: 24 Reps
2: 5 Loc [SoilT_1]

A.7 Heat dissipation sensors (HDS) program; 28 Sensors

```
;{CR10X}
;HDS28CIT.CSI
;Program drafted to read 28 Heat Dissipation Sensors (HDS)
;thru' AM416 multiplexer & excited thru' four CE8s.
;CR10TCR (Thermistor Reference Temperature) connected thru'
;   SE channel 12 (Red lead): Excitation channel 3 (E3, Black lead)
;   & AG (clear lead)
;AM416 clocked <pulsed) thru C5 & Reset thru C6.
;CE8s activated thru C1, C2, C3, & C4.
;OUTPUT: RefT, SoilT, dT & Psi on the Hour.
;Drafted: Begun 19/11/99

* Table 1 Program
          01:        1          Execution Interval (seconds)

1:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 120      Interval (same units as above)
 3: 11       Set Flag 1 High

2:  If Flag/Port (P91)
 1: 21       Do if Flag 1 is Low
 2: 0        Go to end of Program Table

3:  AC Half Bridge (P5)
 1: 1        Reps
 2: 22       7.5 mV 60 Hz Rejection Range
 3: 12       SE Channel
 4: 3        Excite all reps w/Exchan 3
 5: 2000     mV Excitation
 6: 3        Loc [ TCRT      ]
 7: 800      Mult
 8: 0        Offset

4:  Polynomial (P55)
 1: 1        Reps
 2: 3        X Loc [ TCRT      ]
 3: 1        F(X) Loc [ RefTemp    ]
 4: -53.46   C0
 5: 90.807   C1
 6: -83.257  C2
 7: 52.283   C3
 8: -16.723  C4
 9: 2.211    C5

5:  Batt Voltage (P10)
 1: 2        Loc [ Battery    ]

6:  Do (P86)
 1: 46       Set Port 6 High
;Activate AM416 thru' Control Port 6 (Res = C6)

7:  Beginning of Loop (P87)
 1: 0        Delay
 2: 14       Loop Count
;14 loops with 2 Diff sensors per set: 14 X 2 = 28

8:  Do (P86)
```

```
 1: 75       Pulse Port 5
;Pulses AM416 thru" C5 (CLK = C5)

9:  Step Loop Index (P90)
 1: 2        Step
;Necessary not to over-write readings

10:  Thermocouple Temp (DIFF) (P14)
 1: 2        Reps
 2: 21       2.5 mV 60 Hz Rejection Range
 3: 1        DIFF Channel
 4: 1        Type T (Copper-Constantan)
 5: 1        Ref Temp Loc [ RefTemp    ]
 6: 5     -- Loc [ SoilT_1    ]
 7: 1        Mult
 8: 0        Offset

11:  End (P95)
;Ends first round of 28 soil Temp measurements
;Temps recorded in Loc 5 to 32 inclusive.

12:  Do (P86)
 1: 56       Set Port 6 Low
;Resets AM416 to beginning

13:  Do (P86)
 1: 41       Set Port 1 High
;Activates 1st CE8 thru' C1

14:  Do (P86)
 1: 42       Set Port 2 High
;Activates 2nd CE8 thru' C2

15:  Do (P86)
 1: 43       Set Port 3 High
;Activates 3rd CE8 thru' C3

16:  Do (P86)
 1: 44       Set Port 4 High
;Activates 4th CE8 thru' C4

17:  Beginning of Loop (P87)
 1: 0        Delay
 2: 2        Loop Count

18:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 50       Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

19:  End (P95)
;Create 1 sec period (2 X 50 X 0.01 = 1 sec);
;       i.e. activate CE8's for 1 sec

20:  Do (P86)
 1: 46       Set Port 6 High
;Activates AM416

21:  Beginning of Loop (P87)
```

```
 1: 0       Delay
 2: 14      Loop Count

22:  Do (P86)
 1: 75      Pulse Port 5

23:  Step Loop Index (P90)
 1: 2       Step

24:  Thermocouple Temp (DIFF) (P14)
 1: 2       Reps
 2: 21      2.5 mV 60 Hz Rejection Range
 3: 1       DIFF Channel
 4: 1       Type T (Copper-Constantan)
 5: 1       Ref Temp Loc [ RefTemp   ]
 6: 33    -- Loc [ Sec1_1    ]
 7: 1.0     Mult
 8: 0       Offset

25:  End (P95)

26:  Do (P86)
 1: 56      Set Port 6 Low
;Complete 28 measurements of Temp after 1 sec heating
;Measurements recorded in Locs 33 to 60 inclusive.

27:  Beginning of Loop (P87)
 1: 0       Delay
 2: 40      Loop Count

28:  Excitation with Delay (P22)
 1: 1       Ex Channel
 2: 0       Delay W/Ex (units = 0.01 sec)
 3: 50      Delay After Ex (units = 0.01 sec)
 4: 0       mV Excitation

29:  End (P95)
;Creates 20 sec delay; i.e. continue heating for 20 sec

30:  Do (P86)
 1: 46      Set Port 6 High

31:  Beginning of Loop (P87)
 1: 0       Delay
 2: 14      Loop Count

32:  Do (P86)
 1: 75      Pulse Port 5

33:  Step Loop Index (P90)
 1: 2       Step

34:  Thermocouple Temp (DIFF) (P14)
 1: 2       Reps
 2: 21      2.5 mV 60 Hz Rejection Range
 3: 1       DIFF Channel
 4: 1       Type T (Copper-Constantan)
 5: 1       Ref Temp Loc [ RefTemp   ]
 6: 61    -- Loc [ T20s_1    ]
 7: 1.0     Mult
```

```
 8: 0.0      Offset

35:  End (P95)

36:  Do (P86)
 1: 56       Set Port 6 Low
;Ends Temp measurements after 21 sec heating & resets AM416
;Temp 21 sec (T20s_X) recorded in Locs 61 to 88 inclusive.

37:  Do (P86)
 1: 51       Set Port 1 Low
;Deactivates CE8 No 1

38:  Do (P86)
 1: 52       Set Port 2 Low
;Deactivates CE8 No 2

39:  Do (P86)
 1: 53       Set Port 3 Low
;Deactivates CE8 No 3

40:  Do (P86)
 1: 54       Set Port 4 Low
;Deactivates CE8 No 4

41:  Beginning of Loop (P87)
 1: 0        Delay
 2: 28       Loop Count

42:  Z=X-Y (P35)
 1: 61    -- X Loc [ T20s_1    ]
 2: 33    -- Y Loc [ Sec1_1    ]
 3: 89    -- Z Loc [ dT_1      ]
;Calculates dT for 28 sensors and places result in
;   Locs 89 to 116 inclusive

43:  End (P95)
;Ends dT calc loop

44:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

45:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 111      Array ID

46:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

47:  Minimize (P74)
 1: 1        Reps
 2: 0        Value Only
 3: 2        Loc [ Battery    ]

48:  Average (P71)
 1: 1        Reps
 2: 1        Loc [ RefTemp    ]

49:  Sample (P70)
 1: 28       Reps
```

```
 2: 5        Loc [ SoilT_1    ]

50:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

51:  Set Active Storage Area (P80)
 1: 1        Final Storage Area 1
 2: 222      Array ID

52:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

53:  Sample (P70)
 1: 28       Reps
 2: 89       Loc [ dT_1       ]

54:  Do (P86)
 1: 21       Set Flag 1 Low

* Table 2 Program
            02:         0.0000              Execution Interval (seconds)

* Table 3  Subroutines

End Program
```

A.8 TDR cable length measurement for 28 TDR probes in Clementine Orchard

```
;{CR10X}
;CLEMTDRD.CSI
; Program drafted to measure cable lengths of 28 TDR probes
;   having different lengths.
; Drafted 28/11/99
; SDM1502 Cable Tester DIP switch set at 0000 to give address of 00
; Level 1 SDMX50 coaxial multiplexer MSD = 0 & LSD = 1 to give
;          address of 01
; Level 2 SDMX50 coaxial multiplexers (three off) MSD = 0 & LSD = 2 to
;          give address of 02
; Four probes with cable length of 16ft connected at Level 1
; Eight probes with length of 20 ft connected to Box 6, Level 2
;          via channel 6 in Level 1 Mux
; Eight probes with length of 24 ft connected to Box 7, Level 2
;          via channel 7 in Level 1 Mux
; Eight probes with length of 29 ft connected to Box 8, Level 2
;          via channel 8 in level 1 Mux
; Program activated thru flag 1.

* Table 1 Program
  01: 10 Execution Interval (seconds)

1:  If Flag/Port (P91)
 1: 11       Do if Flag 1 is High
 2: 30       Then Do

2:  Do (P86)
 1: 44       Set Port 4 High

3:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 500      Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

4:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 98       Manual MUX Address Advance
 3: .3       Probe Length (meters)
 4: 0.0      Cable Length (meters)
 5: 7104     MMMP  Mux & Probe Selection
 6: 1        Loc [ W1_06_1   ]
 7: 1        Mult
 8: 0        Offset
;Measure Probes for site W1

5:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 98       Manual MUX Address Advance
 3: .3       Probe Length (meters)
 4: 0.0      Cable Length (meters)
 5: 6104     MMMP  Mux & Probe Selection
 6: 5        Loc [ W2_06_2   ]
 7: 1.0      Mult
 8: 0.0      Offset

6:  TDR Measurement (P100)
 1: 00       SDM1502 Address
```

```
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 1004    MMMP  Mux & Probe Selection
 6: 9       Loc [ W3_06_3   ]
 7: 1.0     Mult
 8: 0.0     Offset

7:  TDR Measurement (P100)
 1: 00      SDM1502 Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 6504    MMMP  Mux & Probe Selection
 6: 13      Loc [ C4_06_4   ]
 7: 1.0     Mult
 8: 0.0     Offset


8:  TDR Measurement (P100)
 1: 00      SDM1502 Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 7504    MMMP  Mux & Probe Selection
 6: 17      Loc [ E5_06_5   ]
 7: 1.0     Mult
 8: 0.0     Offset

9:  TDR Measurement (P100)
 1: 00      SDM1502 Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 8104    MMMP  Mux & Probe Selection
 6: 21      Loc [ E6_06_6   ]
 7: 1.0     Mult
 8: 0.0     Offset

10:  TDR Measurement (P100)
 1: 00      SDM1502 Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 8504    MMMP  Mux & Probe Selection
 6: 25      Loc [ E7_06_7   ]
 7: 1.0     Mult
 8: 0.0     Offset

11:  Do (P86)
 1: 54      Set Port 4 Low

12:  Batt Voltage (P10)
 1: 29      Loc [ V_batt    ]

13:  Do (P86)
 1: 10      Set Output Flag High (Flag 0)

14:  Real Time (P77)
 1: 1220    Year,Day,Hour/Minute (midnight = 2400)
```

```
15:  Sample (P70)
 1: 29       Reps
 2: 1        Loc [ W1_06_1   ]

16:  Do (P86)
 1: 21       Set Flag 1 Low

17:  End (P95)
```

A.9 TDR cable length measurement for 40 TDR probes in Peach Orchard

```
;{CR10X}
;HATTDRd.CSI
; Program drafted to measure cable lengths of 40 CS605 TDR probes
; having different lengths
; Drafted 20/10/99
; SDM1502 Cable Tester DIP switch set at 0000 togive address of 00
; Level 1 SDMX50 coaxial multiplexer MSD = 0 & LSD = 1 to give address 01
; Level 2 SDMX50 coaxial multiplexers (five off) MSD = 0 & LSD = 2
;          to give address of 02

* Table 1 Program
  01:  10Execution Interval (seconds)

1:  If Flag/Port (P91)
 1: 15       Do if Flag 5 is High
 2: 30       Then Do

2:  Do (P86)
 1: 44       Set Port 4 High

3:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 500      Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

4:  TDR Measurement (P100)
 1: 00       SDM Address
 2: 98       Manual MUX Address Advance
 3: .3       Probe Length (meters)
 4: 0.0      Cable Length (meters)
 5: 1441     MMMP Mux & Probe Selection
 6: 1        Loc [ S1_06____ ]
 7: 0.1138   Mult
 8: -0.1758  Offset

5:  TDR Measurement (P100)
 1: 00       SDM Address
 2: 98       Manual MUX Address Advance
 3: .3       Probe Length (meters)
 4: 0.0      Cable Length (meters)
 5: 1331     MMMP Mux & Probe Selection
 6: 2        Loc [ S1_26     ]
 7: 0.1138   Mult
 8: -0.1758  Offset

6:  TDR Measurement (P100)
 1: 00       SDM Address
 2: 98       Manual MUX Address Advance
 3: .3       Probe Length (meters)
 4: 0.0      Cable Length (meters)
 5: 1221     MMMP Mux & Probe Selection
 6: 3        Loc [ S1_56     ]
 7: 0.1138   Mult
 8: -0.1758  Offset

7:  TDR Measurement (P100)
 1: 00       SDM Address
```

2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 1111 MMMP Mux & Probe Selection
6: 4 Loc [S1_86]
7: 0.1138 Mult
8: -0.1758 Offset

8: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 1881 MMMP Mux & Probe Selection
6: 5 Loc [S3_06]
7: 0.1138 Mult
8: -0.1758 Offset

9: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 1771 MMMP Mux & Probe Selection
6: 6 Loc [S3_26]
7: 0.1138 Mult
8: -0.1758 Offset

10: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 1661 MMMP Mux & Probe Selection
6: 7 Loc [S3_56]
7: 0.1138 Mult
8: -0.1758 Offset

11: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 1551 MMMP Mux & Probe Selection
6: 8 Loc [S3_86]
7: 0.1138 Mult
8: -0.1758 Offset

12: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 2441 MMMP Mux & Probe Selection
6: 9 Loc [S5_06]
7: 0.1138 Mult
8: -0.1758 Offset

13: TDR Measurement (P100)
1: 00 SDM Address

2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 2331 MMMP Mux & Probe Selection
6: 10 Loc [S5_26]
7: 0.1138 Mult
8: -0.1758 Offset

14: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 2221 MMMP Mux & Probe Selection
6: 11 Loc [S5_56]
7: 0.1138 Mult
8: -0.1758 Offset

15: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 2111 MMMP Mux & Probe Selection
6: 12 Loc [S5_86]
7: 0.1138 Mult
8: -0.1758 Offset

16: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 2881 MMMP Mux & Probe Selection
6: 13 Loc [S7_06]
7: 0.1138 Mult
8: -0.1758 Offset

17: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 2771 MMMP Mux & Probe Selection
6: 14 Loc [S7_26]
7: 0.1138 Mult
8: -0.1758 Offset

18: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 3441 MMMP Mux & Probe Selection
6: 15 Loc [S7_56]
7: 0.1138 Mult
8: -0.1758 Offset

19: TDR Measurement (P100)
1: 00 SDM Address

```
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 3331    MMMP Mux & Probe Selection
 6: 16      Loc [ S7_86    ]
 7: 0.1138  Mult
 8: -0.1758 Offset

20: TDR Measurement (P100)
 1: 00      SDM Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 2661    MMMP Mux & Probe Selection
 6: 17      Loc [ S9_06    ]
 7: 0.1138  Mult
 8: -0.1758 Offset

21: TDR Measurement (P100)
 1: 00      SDM Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 2551    MMMP Mux & Probe Selection
 6: 18      Loc [ S9_26    ]
 7: 0.1138  Mult
 8: -0.1758 Offset

22: TDR Measurement (P100)
 1: 00      SDM Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 3221    MMMP Mux & Probe Selection
 6: 19      Loc [ S9_56    ]
 7: 0.1138  Mult
 8: -0.1758 Offset

23: TDR Measurement (P100)
 1: 00      SDM Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 3111    MMMP Mux & Probe Selection
 6: 20      Loc [ S9_86    ]
 7: 0.1138  Mult
 8: -0.1758 Offset

24: TDR Measurement (P100)
 1: 00      SDM Address
 2: 98      Manual MUX Address Advance
 3: .3      Probe Length (meters)
 4: 0.0     Cable Length (meters)
 5: 4221    MMMP Mux & Probe Selection
 6: 21      Loc [ N1_06    ]
 7: 0.1138  Mult
 8: -0.1758 Offset

25: TDR Measurement (P100)
 1: 00      SDM Address
```

2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4111 MMMP Mux & Probe Selection
6: 22 Loc [N1_26]
7: 0.1138 Mult
8: -0.1758 Offset

26: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 3661 MMMP Mux & Probe Selection
6: 23 Loc [N1_56]
7: 0.1138 Mult
8: -0.1758 Offset

27: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 3551 MMMP Mux & Probe Selection
6: 24 Loc [N1_86]
7: 0.1138 Mult
8: -0.1758 Offset

28: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4441 MMMP Mux & Probe Selection
6: 25 Loc [N3_06]
7: 0.1138 Mult
8: -0.1758 Offset

29: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4331 MMMP Mux & Probe Selection
6: 26 Loc [N3_26]
7: 0.1138 Mult
8: -0.1758 Offset

30: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 3881 MMMP Mux & Probe Selection
6: 27 Loc [N3_56]
7: 0.1138 Mult
8: -0.1758 Offset

31: TDR Measurement (P100)
1: 00 SDM Address

2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 3771 MMMP Mux & Probe Selection
6: 28 Loc [N3_86]
7: 0.1138 Mult
8: -0.1758 Offset

32: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4881 MMMP Mux & Probe Selection
6: 29 Loc [N5_06]
7: 0.1138 Mult
8: -0.1758 Offset

33: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4771 MMMP Mux & Probe Selection
6: 30 Loc [N5_26]
7: 0.1138 Mult
8: -0.1758 Offset

34: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4661 MMMP Mux & Probe Selection
6: 31 Loc [N5_56]
7: 0.1138 Mult
8: -0.1758 Offset

35: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 4551 MMMP Mux & Probe Selection
6: 32 Loc [N5_86]
7: 0.1138 Mult
8: -0.1758 Offset

36: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5441 MMMP Mux & Probe Selection
6: 33 Loc [N7_06]
7: 0.1138 Mult
8: -0.1758 Offset

37: TDR Measurement (P100)
1: 00 SDM Address

2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5331 MMMP Mux & Probe Selection
6: 34 Loc [N7_26]
7: 0.1138 Mult
8: -0.1758 Offset

38: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5221 MMMP Mux & Probe Selection
6: 35 Loc [N7_56]
7: 0.1138 Mult
8: -0.1758 Offset

39: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5111 MMMP Mux & Probe Selection
6: 36 Loc [N7_86]
7: 0.1138 Mult
8: -0.1758 Offset

40: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5881 MMMP Mux & Probe Selection
6: 37 Loc [N9_06]
7: 0.1138 Mult
8: -0.1758 Offset

41: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5771 MMMP Mux & Probe Selection
6: 38 Loc [N9_26]
7: 0.1138 Mult
8: -0.1758 Offset

42: TDR Measurement (P100)
1: 00 SDM Address
2: 98 Manual MUX Address Advance
3: .3 Probe Length (meters)
4: 0.0 Cable Length (meters)
5: 5661 MMMP Mux & Probe Selection
6: 39 Loc [N9_56]
7: 0.1138 Mult
8: -0.1758 Offset

43: TDR Measurement (P100)
1: 00 SDM Address

```
 2: 98       Manual MUX Address Advance
 3: .3       Probe Length (meters)
 4: 0.0      Cable Length (meters)
 5: 5551     MMMP Mux & Probe Selection
 6: 40       Loc [ N9_86     ]
 7: 0.1138   Mult
 8: -0.1758  Offset

44:  Do (P86)
 1: 54       Set Port 4 Low

45:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

46:  Real Time (P77)
 1: 110      Day,Hour/Minute (midnight = 0000)

47:  Sample (P70)
 1: 41       Reps
 2: 1        Loc [ S1_06____ ]

48:  Do (P86)
 1: 25       Set Flag 5 Low

49:  End (P95)
```

A.10 TDR Water Content measurement for 28 TDR probes in Clementine Orchard

```
;{CR10X}
;CLEMTDRD.CSI
; Program drafted to measure Water Content of 28 TDR probes
;   having different lengths.
; Drafted 28/11/99
; SDM1502 Cable Tester DIP switch set at 0000 to give address of 00
; Level 1 SDMX50 coaxial multiplexer MSD = 0 & LSD = 1 to give
;          address of 01
; Level 2 SDMX50 coaxial multiplexers (three off) MSD = 0 & LSD = 2 to
;          give address of 02
; Four probes with cable length of 16ft connected at Level 1
; Eight probes with length of 20 ft connected to Box 6, Level 2
;          via channel 6 in Level 1 Mux
; Eight probes with length of 24 ft connected to Box 7, Level 2
;          via channel 7 in Level 1 Mux
; Eight probes with length of 29 ft connected to Box 8, Level 2
;          via channel 8 in level 1 Mux
; Program activated thru flag 1.

* Table 1 Program
  01:  10Execution Interval (seconds)

1:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 120      Interval (same units as above)
 3: 11       Set Flag 1 High

2:  If Flag/Port (P91)
 1: 11       Do if Flag 1 is High
 2: 30       Then Do

3:  Do (P86)
 1: 44       Set Port 4 High

4:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 500      Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

5:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 19.0     Cable Length (meters)
 5: 7104     MMMP  Mux & Probe Selection
 6: 1        Loc [ W1_06_1   ]
 7: 0.1138   Mult
 8: -0.1758  Offset
;Measure Probes for site W1

6:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 18.1     Cable Length (meters)
 5: 6104     MMMP  Mux & Probe Selection
 6: 5        Loc [ W2_06_2   ]
```

```
 7: 0.1138   Mult
 8: -0.1758  Offset
;Measures Probes for site W2

7:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 10.1     Cable Length (meters)
 5: 1004     MMMP  Mux & Probe Selection
 6: 9        Loc [ W3_06_3   ]
 7: 0.1138   Mult
 8: -0.1758  Offset
;Measures Probes for site W3

8:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 18.1     Cable Length (meters)
 5: 6504     MMMP  Mux & Probe Selection
 6: 13       Loc [ C4_06_4   ]
 7: 0.1138   Mult
 8: -0.1758  Offset
;Measures Probes for site C4

9:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 19.0     Cable Length (meters)
 5: 7504     MMMP  Mux & Probe Selection
 6: 17       Loc [ E5_06_5   ]
 7: 0.1138   Mult
 8: -0.1758  Offset

10:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 21.1     Cable Length (meters)
 5: 8104     MMMP  Mux & Probe Selection
 6: 21       Loc [ E6_06_6   ]
 7: 0.1138   Mult
 8: -0.1758  Offset

11:  TDR Measurement (P100)
 1: 00       SDM1502 Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 21.1     Cable Length (meters)
 5: 8504     MMMP  Mux & Probe Selection
 6: 25       Loc [ E7_06_7   ]
 7: 0.1138   Mult
 8: -0.1758  Offset

12:  Do (P86)
 1: 54       Set Port 4 Low

13:  Batt Voltage (P10)
```

```
 1: 29       Loc [ V_batt    ]

14:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

15:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

16:  Sample (P70)
 1: 29       Reps
 2: 1        Loc [ W1_06_1   ]

17:  Do (P86)
 1: 21       Set Flag 1 Low

18:  End (P95)
```

A.11 TDR Water Content measurement for 40 TDR probes in Peach Orchard

```
;{CR10X}
;HATTDRw.CSI
; Program drafted to measure water content of 40 CS605 TDR probes
; having different lenghts
; Drafted 21/10/99
; SDM1502 Cable Tester DIP switch set at 0000 togive address of 00
; Level 1 SDMX50 coaxial multiplexer MSD = 0 & LSD = 1 to give address 01
; Level 2 SDMX50 coaxial multiplexers (five off) MSD = 0 & LSD = 2
;          to give address of 02

* Table 1 Program
01:  10              Execution Interval (seconds)

1:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 240      Interval (same units as above)
 3: 30       Then Do

2:  Do (P86)
 1: 44       Set Port 4 High

3:  Excitation with Delay (P22)
 1: 1        Ex Channel
 2: 0        Delay W/Ex (units = 0.01 sec)
 3: 500      Delay After Ex (units = 0.01 sec)
 4: 0        mV Excitation

4:  TDR Measurement (P100)
 1: 00       SDM Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 13.6     Cable Length (meters)
 5: 1441     MMMP Mux & Probe Selection
 6: 1        Loc [ S1_06____ ]
 7: 0.1138   Mult
 8: -0.1758  Offset

5:  TDR Measurement (P100)
 1: 00       SDM Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 14.6     Cable Length (meters)
 5: 1331     MMMP Mux & Probe Selection
 6: 2        Loc [ S1_26     ]
 7: 0.1138   Mult
 8: -0.1758  Offset

6:  TDR Measurement (P100)
 1: 00       SDM Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 15.8     Cable Length (meters)
 5: 1221     MMMP Mux & Probe Selection
 6: 3        Loc [ S1_56     ]
 7: 0.1138   Mult
 8: -0.1758  Offset

7:  TDR Measurement (P100)
```

1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 17.4 Cable Length (meters)
5: 1111 MMMP Mux & Probe Selection
6: 4 Loc [S1_86]
7: 0.1138 Mult
8: -0.1758 Offset

8: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 12.5 Cable Length (meters)
5: 1881 MMMP Mux & Probe Selection
6: 5 Loc [S3_06]
7: 0.1138 Mult
8: -0.1758 Offset

9: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 13.6 Cable Length (meters)
5: 1771 MMMP Mux & Probe Selection
6: 6 Loc [S3_26]
7: 0.1138 Mult
8: -0.1758 Offset

10: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 14.6 Cable Length (meters)
5: 1661 MMMP Mux & Probe Selection
6: 7 Loc [S3_56]
7: 0.1138 Mult
8: -0.1758 Offset

11: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 15.8 Cable Length (meters)
5: 1551 MMMP Mux & Probe Selection
6: 8 Loc [S3_86]
7: 0.1138 Mult
8: -0.1758 Offset

12: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 11.4 Cable Length (meters)
5: 2441 MMMP Mux & Probe Selection
6: 9 Loc [S5_06]
7: 0.1138 Mult
8: -0.1758 Offset

13: TDR Measurement (P100)

1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 12.5 Cable Length (meters)
5: 2331 MMMP Mux & Probe Selection
6: 10 Loc [S5_26]
7: 0.1138 Mult
8: -0.1758 Offset

14: TDR Measurement (P100)
1: 00 SDM Address
2: 4008 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 13.5 Cable Length (meters)
5: 2221 MMMP Mux & Probe Selection
6: 11 Loc [S5_56]
7: 0.1138 Mult
8: -0.1758 Offset

15: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 14.6 Cable Length (meters)
5: 2111 MMMP Mux & Probe Selection
6: 12 Loc [S5_86]
7: 0.1138 Mult
8: -0.1758 Offset

16: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 9.9 Cable Length (meters)
5: 2881 MMMP Mux & Probe Selection
6: 13 Loc [S7_06]
7: 0.1138 Mult
8: -0.1758 Offset

17: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 11.4 Cable Length (meters)
5: 2771 MMMP Mux & Probe Selection
6: 14 Loc [S7_26]
7: 0.1138 Mult
8: -0.1758 Offset

18: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 12.4 Cable Length (meters)
5: 3441 MMMP Mux & Probe Selection
6: 15 Loc [S7_56]
7: 0.1138 Mult
8: -0.1758 Offset

19: TDR Measurement (P100)

1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 13.6 Cable Length (meters)
5: 3331 MMMP Mux & Probe Selection
6: 16 Loc [S7_86]
7: 0.1138 Mult
8: -0.1758 Offset

20: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 9.9 Cable Length (meters)
5: 2661 MMMP Mux & Probe Selection
6: 17 Loc [S9_06]
7: 0.1138 Mult
8: -0.1758 Offset

21: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 9.9 Cable Length (meters)
5: 2551 MMMP Mux & Probe Selection
6: 18 Loc [S9_26]
7: 0.1138 Mult
8: -0.1758 Offset

22: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 11.4 Cable Length (meters)
5: 3221 MMMP Mux & Probe Selection
6: 19 Loc [S9_56]
7: 0.1138 Mult
8: -0.1758 Offset

23: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 12.4 Cable Length (meters)
5: 3111 MMMP Mux & Probe Selection
6: 20 Loc [S9_86]
7: 0.1138 Mult
8: -0.1758 Offset

24: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 14.6 Cable Length (meters)
5: 4221 MMMP Mux & Probe Selection
6: 21 Loc [N1_06]
7: 0.1138 Mult
8: -0.1758 Offset

25: TDR Measurement (P100)

1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 14.5 Cable Length (meters)
5: 4111 MMMP Mux & Probe Selection
6: 22 Loc [N1_26]
7: 0.1138 Mult
8: -0.1758 Offset

26: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 11.3 Cable Length (meters)
5: 3661 MMMP Mux & Probe Selection
6: 23 Loc [N1_56]
7: 0.1138 Mult
8: -0.1758 Offset

27: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 12.4 Cable Length (meters)
5: 3551 MMMP Mux & Probe Selection
6: 24 Loc [N1_86]
7: 0.1138 Mult
8: -0.1758 Offset

28: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 14.5 Cable Length (meters)
5: 4441 MMMP Mux & Probe Selection
6: 25 Loc [N3_06]
7: 0.1138 Mult
8: -0.1758 Offset

29: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 16.0 Cable Length (meters)
5: 4331 MMMP Mux & Probe Selection
6: 26 Loc [N3_26]
7: 0.1138 Mult
8: -0.1758 Offset

30: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 12.4 Cable Length (meters)
5: 3881 MMMP Mux & Probe Selection
6: 27 Loc [N3_56]
7: 0.1138 Mult
8: -0.1758 Offset

31: TDR Measurement (P100)

1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 13.6 Cable Length (meters)
5: 3771 MMMP Mux & Probe Selection
6: 28 Loc [N3_86]
7: 0.1138 Mult
8: -0.1758 Offset

32: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 16.1 Cable Length (meters)
5: 4881 MMMP Mux & Probe Selection
6: 29 Loc [N5_06]
7: 0.1138 Mult
8: -0.1758 Offset

33: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 17.2 Cable Length (meters)
5: 4771 MMMP Mux & Probe Selection
6: 30 Loc [N5_26]
7: 0.1138 Mult
8: -0.1758 Offset

34: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 18.4 Cable Length (meters)
5: 4661 MMMP Mux & Probe Selection
6: 31 Loc [N5_56]
7: 0.1138 Mult
8: -0.1758 Offset

35: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 19.4 Cable Length (meters)
5: 4551 MMMP Mux & Probe Selection
6: 32 Loc [N5_86]
7: 0.1138 Mult
8: -0.1758 Offset

36: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 17.2 Cable Length (meters)
5: 5441 MMMP Mux & Probe Selection
6: 33 Loc [N7_06]
7: 0.1138 Mult
8: -0.1758 Offset

37: TDR Measurement (P100)

1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 18.3 Cable Length (meters)
5: 5331 MMMP Mux & Probe Selection
6: 34 Loc [N7_26]
7: 0.1138 Mult
8: -0.1758 Offset

38: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 19.3 Cable Length (meters)
5: 5221 MMMP Mux & Probe Selection
6: 35 Loc [N7_56]
7: 0.1138 Mult
8: -0.1758 Offset

39: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 20.4 Cable Length (meters)
5: 5111 MMMP Mux & Probe Selection
6: 36 Loc [N7_86]
7: 0.1138 Mult
8: -0.1758 Offset

40: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 18.4 Cable Length (meters)
5: 5881 MMMP Mux & Probe Selection
6: 37 Loc [N9_06]
7: 0.1138 Mult
8: -0.1758 Offset

41: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 19.4 Cable Length (meters)
5: 5771 MMMP Mux & Probe Selection
6: 38 Loc [N9_26]
7: 0.1138 Mult
8: -0.1758 Offset

42: TDR Measurement (P100)
1: 00 SDM Address
2: 4080 La/L with Probe Correction in mm
3: .3 Probe Length (meters)
4: 20.6 Cable Length (meters)
5: 5661 MMMP Mux & Probe Selection
6: 39 Loc [N9_56]
7: 0.1138 Mult
8: -0.1758 Offset

43: TDR Measurement (P100)

```
 1: 00       SDM Address
 2: 4080     La/L with Probe Correction in mm
 3: .3       Probe Length (meters)
 4: 22.0     Cable Length (meters)
 5: 5551     MMMP Mux & Probe Selection
 6: 40       Loc [ N9_86     ]
 7: 0.1138   Mult
 8: -0.1758  Offset

44:  Do (P86)
 1: 54       Set Port 4 Low

45:  Do (P86)
 1: 10       Set Output Flag High (Flag 0)

46:  Real Time (P77)
 1: 110      Day,Hour/Minute (midnight = 0000)

47:  Sample (P70)
 1: 41       Reps
 2: 1        Loc [ S1_06____ ]

48:  End (P95
```

A.12 Mobile Weather station & light penetration of hedge-rows

```
;{CR10X}
;TITLE: SOLWETH.CSI
; Program for measurement weather for mobile weather station
;     when measuring light penetration of hedgerow plantings.
; Use HMP35C TEMPERATURE & RH PROBE (S/N 636980) wired as follows:
;     Red = + 12V, Yellow (power control) =  E2 ,
;     Green (RH) = SE 12,     Orange (Temp) = SE 11
;     Black (Temp Excitation) = Switched Excitation = E1,
;     Clear + White + Purple = Ground
; Albedo meter in Diff Channel 1 (Top) & 2 (Bottom)
; Diffuse Radiation Pyranometer in Diff channel 3 (Pyran No 1)


*Table 1 Program
          01:        10.0       Execution Interval (seconds)

1:  Temp (107) (P11)
 1: 1        Reps
 2: 11       SE Channel
 3: 1        Excite all reps w/E1
 4: 1        Loc [ AirTemp   ]
 5: 1.0      Mult
 6: 0.08     Offset

2:  Excite-Delay (SE) (P4)
 1: 1        Reps
 2: 5        2500 mV Slow Range
 3: 12       SE Channel
 4: 2        Excite all reps w/Exchan 2
 5: 15       Delay (units 0.01 sec)
 6: 2500     mV Excitation
 7: 2        Loc [ RH        ]
 8: 0.1026   Mult
 9: 2.0285   Offset
; Calibration for HMP35C (S/N 636980) is RH = 2.02852 + 1.02559X
;     where X is RH calculated by instruction P4.

3:  Z=X*F (P37)
 1: 2        X Loc [ RH        ]
 2: .01      F
 3: 7        Z Loc [ rh_frac   ]

4:  Saturation Vapor Pressure (P56)
 1: 1        Temperature Loc [ AirTemp   ]
 2: 8        Loc [ SVP       ]

5:  Z=X*Y (P36)
 1: 8        X Loc [ SVP       ]
 2: 7        Y Loc [ rh_frac   ]
 3: 9        Z Loc [ VP_kPa    ]

6:  Z=X-Y (P35)
 1: 8        X Loc [ SVP       ]
 2: 9        Y Loc [ VP_kPa    ]
 3: 10       Z Loc [ VPD_kPa   ]

7:  Volt (Diff) (P2)
 1: 1        Reps
```

```
 2: 33       25 mV 50 Hz Rejection Range
 3: 1        DIFF Channel
 4: 3        Loc [ AlbTop    ]
 5: 56.6352  Mult
 6: 0.0      Offset

 8:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 2        DIFF Channel
 4: 4        Loc [ AlbBot    ]
 5: 51.1427  Mult
 6: 0.0      Offset

 9:  Volt (Diff) (P2)
 1: 1        Reps
 2: 33       25 mV 50 Hz Rejection Range
 3: 3        DIFF Channel
 4: 5        Loc [ Diffuse   ]
 5: 119.2    Mult
 6: 0.0      Offset

10:  Batt Voltage (P10)
 1: 6        Loc [ Batt_V    ]

11:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 15       Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

12:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

13:  Average (P71)
 1: 10       Reps
 2: 1        Loc [ AirTemp   ]

14:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 1440     Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

15:  Real Time (P77)
 1: 1200     Year,Day (midnight = 2400)

16:  Maximum (P73)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 1        Loc [ AirTemp   ]

17:  Minimum (P74)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 1        Loc [ AirTemp   ]

18:  Maximum (P73)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 2        Loc [ RH        ]
```

```
19:  Minimum (P74)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 2        Loc [ RH        ]

20:  Maximize (P73)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 10       Loc [ VPD_kPa   ]

21:  Minimize (P74)
 1: 1        Reps
 2: 10       Value with Hr-Min
 3: 10       Loc [ VPD_kPa   ]

22:  Sample (P70)
 1: 1        Reps
 2: 6        Loc [ Batt_V    ]

* Table 2 Program
            02:         0.0000              Execution Interval (seconds)

* Table 3  Subroutines

End Program
```

A.13 Programme to calibrate seven tube solarimeters

```
;{CR10X}
;TITLE: SOLCAL00.CSI
; Program for calibrating 7 tube solarimeters
; & 7 Line Quantum Sensors (LQS)
; Use Eppley in Diff Channel 3 as Standard
; Use AM416 in Diff Channel 4 & 5, Pulsed thru'

* Table 1 Program
        01:     10.00           Execution Interval (seconds)

1:  Do (P86)
 1: 41      Set Port 1 High

2:  Beginning of Loop (P87)
 1: 0       Delay
 2: 6       Loop Count

3:  Do (P86)
 1: 72      Pulse Port 2

4:  Step Loop Index (P90)
 1: 2       Step

5:  Volt (Diff) (P2)
 1: 2       Reps
 2: 33      25 mV 50 Hz Rejection Range
 3: 4       DIFF Channel
 4: 6    -- Loc [ Sol1     ]
 5: 1       Mult
 6: 0       Offset

6:  End (P95)

7:  Do (P86)
 1: 51      Set Port 1 Low

8:  Volt (Diff) (P2)
 1: 2       Reps
 2: 33      25 mV 50 Hz Rejection Range
 3: 1       DIFF Channel
 4: 18      Loc [ LQS6     ]
 5: 1       Mult
 6: 0       Offset

9:  Volt (Diff) (P2)
 1: 1       Reps
 2: 33      25 mV 50 Hz Rejection Range
 3: 3       DIFF Channel
 4: 20      Loc [ Epply    ]
 5: 115     Mult
 6: .58     Offset

10:  If (X<=>F) (P89)
 1: 20      X Loc [ Epply    ]
 2: 3       >=
 3: 700     F
 4: 30      Then Do
```

```
11:  Z=X+F (P34)
 1: 20       X Loc [ Epply     ]
 2: -0.58    F
 3: 20       Z Loc [ Epply     ]

12:  Z=X*F (P37)
 1: 20       X Loc [ Epply     ]
 2: 1.07113  F
 3: 20       Z Loc [ Epply     ]

13:  Z=X+F (P34)
 1: 20       X Loc [ Epply     ]
 2: 0.58     F
 3: 20       Z Loc [ Epply     ]

14:  End (P95)

15:  Z=X*F (P37)
 1: 6        X Loc [ Sol1      ]
 2: 66.681   F
 3: 6        Z Loc [ Sol1      ]

16:  Z=X*F (P37)
 1: 7        X Loc [ Sol2      ]
 2: 66.98    F
 3: 7        Z Loc [ Sol2      ]

17:  Z=X*F (P37)
 1: 8        X Loc [ Sol3      ]
 2: 67.266   F
 3: 8        Z Loc [ Sol3      ]

18:  Z=X*F (P37)
 1: 9        X Loc [ Sol4      ]
 2: 71.336   F
 3: 9        Z Loc [ Sol4      ]

19:  Z=X*F (P37)
 1: 10       X Loc [ Sol5      ]
 2: 65.83    F
 3: 10       Z Loc [ Sol5      ]

20:  Z=X*F (P37)
 1: 11       X Loc [ Sol6      ]
 2: 65.076   F
 3: 11       Z Loc [ Sol6      ]

21:  Z=X*F (P37)
 1: 12       X Loc [ Sol7      ]
 2: 63.59    F
 3: 12       Z Loc [ Sol7      ]

22:  Z=X*F (P37)
 1: 13       X Loc [ LQS1      ]
 2: 439.06   F
 3: 13       Z Loc [ LQS1      ]

23:  Z=X*F (P37)
 1: 14       X Loc [ LQS2      ]
 2: 311.51   F
```

```
 3: 14       Z Loc [ LQS2      ]

24:  Z=X*F (P37)
 1: 15       X Loc [ LQS3      ]
 2: 364.08   F
 3: 15       Z Loc [ LQS3      ]

25:  Z=X*F (P37)
 1: 16       X Loc [ LQS4      ]
 2: 444.3    F
 3: 16       Z Loc [ LQS4      ]

26:  Z=X*F (P37)
 1: 17       X Loc [ LQS5      ]
 2: 405.38   F
 3: 17       Z Loc [ LQS5      ]

27:  Z=X*F (P37)
 1: 18       X Loc [ LQS6      ]
 2: 419.74   F
 3: 18       Z Loc [ LQS6      ]

28:  Z=X*F (P37)
 1: 19       X Loc [ LQS7      ]
 2: 423.34   F
 3: 19       Z Loc [ LQS7      ]

29:  Batt Voltage (P10)
 1: 1        Loc [ V_Batt    ]

30:  If time is (P92)
 1: 0        Minutes (Seconds --) into a
 2: 10       Interval (same units as above)
 3: 10       Set Output Flag High (Flag 0)

31:  Real Time (P77)
 1: 1220     Year,Day,Hour/Minute (midnight = 2400)

32:  Average (P71)
 1: 15       Reps
 2: 6        Loc [ Sol1      ]

33:  Sample (P70)
 1: 1        Reps
 2: 1        Loc [ V_Batt    ]


* Table 2 Program
            02:         0.0000              Execution Interval (seconds)

* Table 3  Subroutines

End Program
```