7.4 EXPLANATORY NOTES ON DATA-LOGGER

7.4.1 INTRODUCTION

Data-logger has been used to measure strain on mainframe. Four slots (bearing numbers 2, 3, 4, 5) are available for measuring strain. Each slot has ten channels (00-09). Address of each channel is given by ESCC where E is 0 for mainframe i.e. if accessory is installed in the mainframe and 1-7 for extender i.e. if accessory is installed in extender. S is slot of mainframe or extender where accessory is installed. S is 2, 3, 4, 5 depending upon slot number. CC is the channel number of accessory (00-09)

7.4.2 STRAIN MEASUREMENT

The wheatstone bridge circuit is the fundamental strain measuring circuit and implemented into the design of the HP 44717 A through HP 44720A strain gauge accessories.

The strains have been measured by 1/4 bridge arrangement i.e. quarter bridge arrangement i.e. there is only one active element (gauge) in the wheatstone bridge circuit. (Ref. Fig. 7.8).

Fig. 7.8 WHEAT-STONE BRIDGE CIRCUIT
VS : Bridge Excitation Voltage

V_{OUT} : Bridge Output Voltage

- Bridge excitation Voltage of 5V has been applied for 350 ohm bridge arrangement.

Strain is computed by the relation

\[ e = -4 \frac{V_r}{GF} (1 + 2 \frac{V_r}{V_{OUT}/VS}) \]

where \( V_r = [\frac{V_{OUT}/VS}{VS} \text{ strained} - \frac{V_{OUT}/VS}{VS} \text{ unstrained}] \)

GF is gauge factor

A twisted shield cable has been used while connecting the strain gauges to the bridge completion channels to ensure the most accurate measurement.

The strain is measured by executing the following steps:

(i) Declare a reference array or variable to store unstrained reference readings.

(ii) Declare an array or variable to store strained readings.

(iii) Measure the unstrained reference (s) and store reading (s) into array or variable declared in step (i)

iv) Apply load on the specimen.

(v) Measure the strain and store reading (s) into array or variable declared in step (ii)

When two strain gauges are connected to channel 00 and 01 of slot 2, then strains are measured by executing the following program:

```
REAL ST200, ST201
REAL QST200(10),QST 201(10)
USE 600
CONF MEAS STRUN, 200, INTO ST200
CONF MEAS STRUN, 201, INTO ST201
APPLY LOAD 1
CONF MEAS STRQ, 200, REF ST 200, GF 2E-6, INTO QST200(0)
CONF MEAS STRQ, 201, REF ST201, GF 2E-6, INTO QST201(0)
APPLY LOAD 2
CONF MEAS STRQ,200,REF ST200,GF 2E-6,INTO QST200(1)
CONF MEAS STRQ,201,REF ST201,GF 2E-6,INTO QST201(1)
```
If the gauge factor is expressed with an exponent of -6 i.e. GF 2E-6, then the calculated strain is micro strain.

For results in micro strain, multiply the calculated or measured strain by 10^6.

Tensile strain is +ve and compressive strain is -ve.

The variables are:

- **ST200**: Name of variable to store unstrained reference reading on channel 200
- **QST200 (10)**: Name of array to store measurement readings for various loads on channel 200
- **USE 600**: Slot containing voltmeter that performs the measurement
- **STRUN**: Measurement function i.e. unstrained reference
- **200**: Channel on which measurement is performed
- **STRQ**: Measurement function i.e. 1/4 bridge strain
- **REF ST200**: Reference variable representing the reference reading
- **GF 2E-06**: Number representing the Gauge factor

The actual strain is given by the following equation: 

\[ \epsilon_{\text{actual}} = \epsilon_{\text{measured}} \times (1 + R1/Rg) \]

where \( Rg \) is resistance of strain gauge (which is 350 ohm in our case) and \( R1 \) is resistance of leadwire.

The leadwire resistance is determined using leadwire resistance diagnostic.

### 7.4.3 LEADWIRE RESISTANCE DIAGNOSTIC

The leadwire resistance diagnostic accessed through internal channels 17, 18 and 19 enables to determine the resistance of the leadwire from the strain gauge to bridge completion channel terminals.
The bridge completion channels on which this diagnostic can be performed are 7, 8 and 9.

The leadwire resistance is given by

\[ R_{\text{leadwire}} = \frac{V_{\text{leadwire}} \times R}{V_{\text{lower}} + V_{\text{out}} - V_{\text{leadwire}}} \]

The procedure to determine leadwire resistance is explained in the following steps:

1. Connect the bridge excitation voltage (\( \pm \) VS) to the terminal module. Set the voltage to 5.0 V
2. Connect the 1/4 bridge arrangement to bridge completion channel 7.
3. Hold the specimen in a constant (preferably unstrained) condition throughout the procedure.
4. Measure the voltage on the lower leg of the internal bridge by closing internal channel 16 and the volts tree relay (channel 91) assuming that a relay strain gauge multiplexer is used and is installed in slot 2 of the mainframe by executing the following program:

```
REAL VLOWER, VOUT, VLDWIRE
USE 600
CONF DCV
CLOSE 216, 291
TRIG SGL
CHREAD 600, INTO VLOWER
OPEN 216, 291
```

5. Measure bridge output voltage (\( V_{\text{out}} \)) and store the reading by executing the following:

```
MEAS DCV 207, INTO VOUT
```

6. Measure voltage on the leadwire (\( V_{\text{leadwire}} \)) for the strain gauge on channel 7 by closing the internal channel 17 and the volts tree relay (channel 91) by executing the following:

```
CLOSE 217, 219
TPIG SGL
CHREAD 600, INTO VLDWIRE
```

7. Following the measurement, open channels 17 and 91.

```
OPEN 217, 291
```
Leadwire resistance is measured by executing the following program:

```plaintext
REAL RLDWIRE
LET RLDWIRE = VLDWIRE x R / ( VLOWER + VOUT - VLDWIRE)
VREAD RLDWIRE
```

R is the resistance of strain gauge used i.e. 350 ohm

The complete program to measure leadwire resistance is listed below:

```plaintext
REAL VLOWER, VOUT, VLDWIRE
USE 600
CONF DCV
CLOSE 216, 291
TRIG SGL
CHREAD 600, INTO VLOWER
OPEN 216, 291
MEAS DCV 207, INTO VOUT
CLOSE 217, 291
TRIG SGL
CHREAD 600, INTO VLDWIRE
OPEN 217, 291
REAL RLDWIRE
LET RLDWIRE = VLDWIRE x 350 / (VLOWER + VOUT - VLDWIRE)
VREAD RLDWIRE
```

The leadwire resistance was recorded as $1.1835 \times 10^3$ Ohm

$\epsilon_{\text{actual}} = 1.0000034 \epsilon_{\text{measured}}$