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# Acceptance Testing of the Prototype Electrometer for the SAMPIE Flight Experiment

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# ACCEPTANCE TESTING OF THE PROTOTYPE ELECTROMETER FOR THE SAMPIE FLIGHT EXPERIMENT

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## SUMMARY

The Solar Array Module Plasma Interaction Experiment (SAMPIE) has two key instruments at the heart of its data acquisition capability. One of these, the electrometer, is designed to measure both ion and electron current from most of the samples included in the experiment. The accuracy requirement, specified by the project's Principal Investigator, is for agreement within 10% with a calibrated laboratory instrument. Plasma chamber testing was performed to assess the capabilities of the prototype design. Agreement was determined to be within 2% for electron collection and within 3% for ion collection.

## INTRODUCTION

The Solar Array Module Plasma Interactions Experiment (SAMPIE)<sup>1,2</sup> is an approved NASA flight experiment manifested for shuttle launch in early 1994. The SAMPIE experiment is designed to investigate the interaction of high voltage space power systems with ionospheric plasma. To study the behavior of solar cells, a number of solar cell coupons (representing design technologies of current interest) will be biased to high voltages to measure both arcing and current collection. Additionally, SAMPIE will include experiments to study the basic nature of arcing and current collection.

The measurement of plasma current collection is especially important in view of the fact that the ground potential of large space structures with respect to the ionosphere can differ significantly from that of the plasma. This occurs as a result of current balance. Because of their large mass and low mobility, ions collected by negatively biased surfaces result in a relatively small plasma current density. The lightweight electrons, on the other hand, are readily collected by positively biased surfaces. Ram and wake effects further complicate the picture. Ram ion energy is considerably higher than ambient thermal energy so ion collection is enhanced on ram facing surfaces relative to surfaces which are oblique to plasma flow. The spacecraft will reach equilibrium at whatever potential results in a net collected current of zero. The worst situations occur when the spacecraft power system uses a negative ground. In such a configuration, large surfaces are negative and must collect slow moving ions to balance the current from electron collection which now occurs only from relatively small areas of positive surface. In the worst case, parts of the spacecraft will be biased with respect to the ionosphere to a level very near the maximum voltage used on the solar arrays.

SAMPIE is managed by the Space Experiments Division of NASA's Lewis Research Center<sup>3</sup> with development and fabrication performed by Sverdrup Technology under contract to NASA.

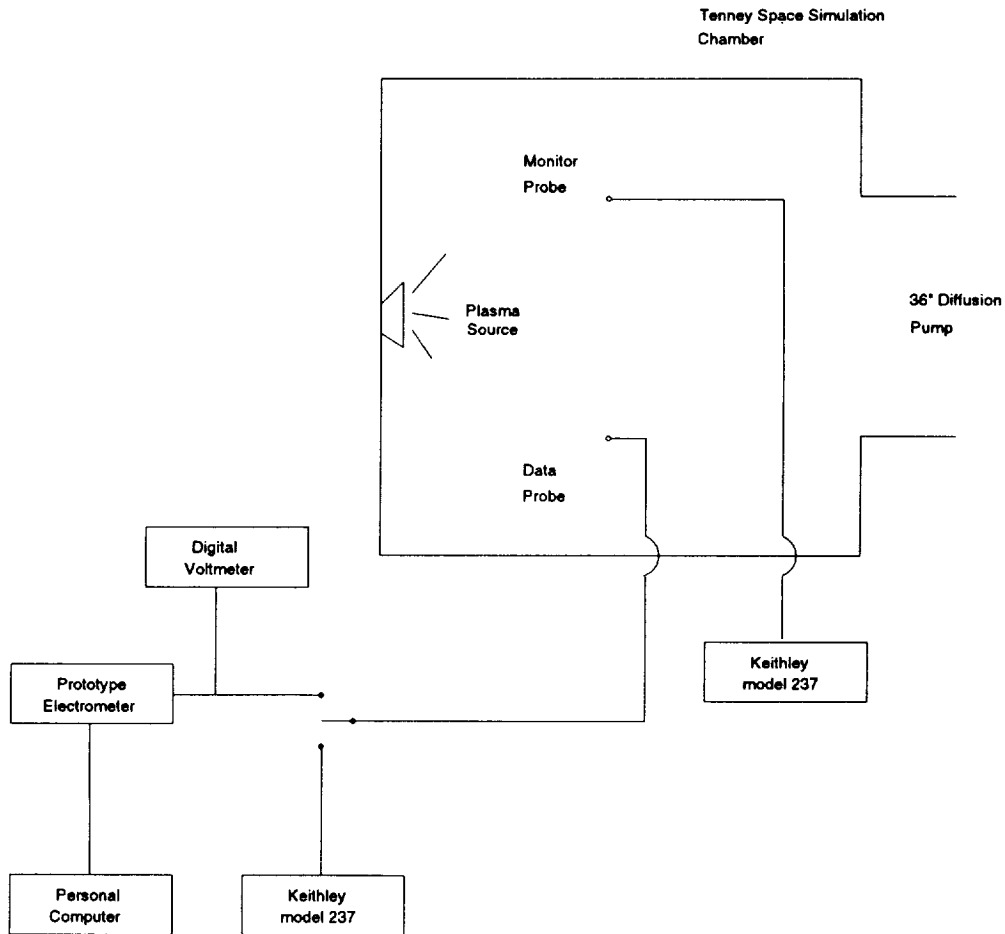
The key instrument in the current collection measurements is the electrometer. The task of the electrical engineering team was to provide capabilities normally found in a large, heavy laboratory instrument on a single circuit card. The design details of the instrument will be reported in the future<sup>4</sup>. Here we discuss the direct comparison of SAMPIE's prototype electrometer with a state of the art laboratory instrument, the Keithley model 237. The acceptance criterion was agreement within 10% over the bias range specified for SAMPIE, -600V to +300V.

## TEST FACILITY AND PROCEDURES

Testing was done in the Plasma Interaction Facility (PIF) at the Lewis Research Center. The plasma chamber used was a Tenney Corporation space simulation chamber offering a cylindrical volume six feet in diameter by six feet long. A thirty six inch diffusion pump provides an initial pumpdown to approximately  $5 \times 10^{-7}$  torr. Plasma is generated by a tungsten filament source with a continuous flow of Argon. Pressure in the tank during operation of the plasma source was approximately  $5 \times 10^{-5}$  torr.

The necessary test is conceptually quite simple. The electrometer to be tested applies a bias voltage to a 3/4" spherical Langmuir probe and measures the resulting collected current. The measurements were made from -600 volts to +300 volts in 25 volt increments. A total of ten complete data sets were taken from each instrument. Data sets were taken alternately from each instrument to help minimize any effects of changing experimental conditions. Alternating the instruments and averaging ten sets of data will smooth random fluctuations. Additional precautions are necessary to account for systematic drifts in plasma density caused by conditions in the plasma source. Filament sources generally degrade as the tungsten evaporates and the resistance slowly increases. The result is a slow increase in filament temperature and a resulting increase in measured plasma density. To account for this, the experimental procedure used two separate Langmuir probes, designated as the data probe and the monitor probe. These probes were located about three feet apart and were positioned so that each was about four feet from the plasma source. Figure 1 shows a schematic representation of the experimental layout.

The prototype electrometer was controlled by a laboratory PC while the Keithley was operated from its front panel controls. A data run began by recording the current measured by the monitor probe. A voltage is programmed into the electrometer which returns the measured current. Every five data points, the monitor probe is read.



**Figure 1 - Block diagram of the Test Facility and layout**

A complication exists in the design of the prototype. The desired test procedure used voltages in 25 volt increments beginning at -600V. While the Keithley has no problem with this, the prototype uses an 8-bit analog to digital conversion which divides the voltage range into 256 equal parts. As a result, the voltages available differ from the desired input by as much as a 1.5 volt. The resulting voltage impressed on the probe by the prototype board was measured with a digital voltmeter. When taking data with the Keithley, the actual voltages provided by the prototype were programmed in. Table I shows these voltages.

**Table I - Nominal vs. Actual bias voltages**

| Volts<br>nominal | Volts<br>Actual | Volts<br>nominal | Volts<br>Actual | Volts<br>nominal | Volts<br>Actual |
|------------------|-----------------|------------------|-----------------|------------------|-----------------|
| -600             | -600.99         | -300             | -298.69         | 25               | 24.35           |
| -575             | -573.45         | -275             | -273.97         | 50               | 49.14           |
| -550             | -548.73         | -250             | -249.20         | 75               | 73.80           |
| -525             | -524.01         | -225             | -224.45         | 100              | 98.35           |
| -500             | -499.26         | -200             | -199.80         | 125              | 125.67          |
| -475             | -474.57         | -175             | -175.08         | 150              | 150.27          |
| -450             | -449.85         | -150             | -150.35         | 175              | 175.14          |
| -425             | -425.09         | -125             | -125.72         | 200              | 199.75          |
| -400             | -400.40         | -100             | -98.51          | 225              | 224.50          |
| -375             | -375.67         | -75              | -73.84          | 250              | 249.23          |
| -350             | -350.98         | -50              | -49.04          | 275              | 274.00          |
| -325             | -323.42         | -25              | -24.30          | 300              | 298.72          |

The correction for source drift was applied by normalizing all collection current values to a monitor probe value of 1 milliamp. An example of a data set for the prototype, shown in table II, illustrates the procedure.

**Table II - Data Set P01**

| Volts<br>Nominal | P01<br>Raw<br>$\mu\text{A}$ | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>$\mu\text{A}$ | Volts<br>Nominal | P01<br>Raw<br>$\mu\text{A}$ | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>$\mu\text{A}$ | Volts<br>Nominal | P01<br>Raw<br>mA | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>mA |
|------------------|-----------------------------|------------------------|-------------------------------------|------------------|-----------------------------|------------------------|-------------------------------------|------------------|------------------|------------------------|--------------------------|
| -600             | 11.20                       | <b>0.715</b>           | 15.66                               | -300             | 5.87                        | <b>0.722</b>           | 8.13                                | 25               | 0.09             | <b>0.729</b>           | 0.12                     |
| -575             | 10.60                       | 0.715                  | 14.83                               | -275             | 5.47                        | 0.725                  | 7.54                                | 50               | 0.19             | 0.729                  | 0.26                     |
| -550             | 10.30                       | 0.715                  | 14.41                               | -250             | 4.96                        | 0.728                  | 6.81                                | 75               | 0.30             | 0.730                  | 0.42                     |
| -525             | 9.56                        | 0.715                  | 13.37                               | -225             | 4.55                        | 0.731                  | 6.22                                | 100              | 0.39             | <b>0.730</b>           | 0.53                     |
| -500             | 9.15                        | <b>0.715</b>           | 12.80                               | -200             | 4.28                        | <b>0.735</b>           | 5.82                                | 125              | 0.48             | 0.731                  | 0.66                     |
| -475             | 8.80                        | 0.715                  | 12.31                               | -175             | 3.80                        | 0.733                  | 5.18                                | 150              | 0.57             | 0.731                  | 0.78                     |
| -450             | 8.56                        | 0.716                  | 11.96                               | -150             | 3.28                        | 0.731                  | 4.49                                | 175              | 0.66             | 0.732                  | 0.90                     |
| -425             | 7.93                        | 0.716                  | 11.08                               | -125             | 2.76                        | 0.729                  | 3.79                                | 200              | 0.73             | <b>0.733</b>           | 1.00                     |
| -400             | 7.55                        | <b>0.716</b>           | 10.54                               | -100             | 2.21                        | <b>0.728</b>           | 3.04                                | 225              | 0.83             | 0.733                  | 1.13                     |
| -375             | 7.04                        | 0.717                  | 9.82                                | -75              | 1.70                        | 0.728                  | 2.34                                | 250              | 0.89             | 0.734                  | 1.21                     |
| -350             | 6.72                        | 0.719                  | 9.35                                | -50              | 1.18                        | 0.728                  | 1.62                                | 275              | 0.99             | 0.735                  | 1.34                     |
| -325             | 6.13                        | 0.721                  | 8.50                                | -25              | 0.09                        | 0.728                  | 0.62                                | 300              | 1.05             | <b>0.735</b>           | 1.43                     |

The values bold italics in the monitor probe column are measured values, the others are interpolated. The correction to the data was made by multiplying the raw data by the inverse of the

monitor probe value, normalizing each point to a monitor value of 1 milliamp. Plasma conditions corresponding to a monitor probe current of 1 milliamp are shown in table III. The procedure effectively normalizes all data to the plasma density indicated.

**Table III - Plasma Parameters**

|                  |                                 |
|------------------|---------------------------------|
| Electron Density | $2.6 \times 10^5 / \text{cm}^3$ |
| Electron Temp    | 1.72 eV                         |
| Ion Temp         | .193 eV                         |
| Plasma Potential | 4.08 eV                         |

It should be noted that no data was taken for an applied bias of zero volts. This point is unstable for two reasons. First, it lies within the plasma potential, that is, an applied bias of zero means the probe is at earth ground which is different from plasma ground. The probe will therefore be slightly negative with respect to plasma and will tend to collect ions. Second, even though the mean electron temperature is approximately 2 eV, the tail of the maxwellian energy distribution contains a significant number of electrons with sufficient thermal energy to overcome the small bias the probe has with respect to plasma. Electrons which happen to be moving in the right direction will therefore impact the probe and contribute to the current. The interplay of these two currents and the associated electron and ion sheaths appeared to be very unstable. This was checked by setting the Keithley to zero volts and programming the instrument to repeatedly measure and report the current in an infinite loop. The observed result was a reading that fluctuated wildly and apparently randomly. Since this data point is of little interest in any anticipated application of the instrument, it was omitted.

## RESULTS

A total of ten complete data sets were taken. Mean, standard deviation, and standard error were then calculated. Table IV presents a summary of the data from the prototype. Table V gives the same information for the Keithley 237. Table VI shows the mean and standard error for both instruments as well as for the ratio of the two. The raw data from all individual runs is presented in the appendix.

**Table IV - Data summary for the prototype instrument**

| Volts<br>Nominal | Volts<br>Actual | P01<br>$\mu\text{A}$ | P02<br>$\mu\text{A}$ | P03<br>$\mu\text{A}$ | P04<br>$\mu\text{A}$ | P05<br>$\mu\text{A}$ | P06<br>$\mu\text{A}$ | P07<br>$\mu\text{A}$ | P08<br>$\mu\text{A}$ | P09<br>$\mu\text{A}$ | P10<br>$\mu\text{A}$ |
|------------------|-----------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| -600             | -600.99         | 15.66                | 15.42                | 14.86                | 14.97                | 14.64                | 14.02                | 14.10                | 13.36                | 13.57                | 13.11                |
| -575             | -573.45         | 14.83                | 14.71                | 13.93                | 13.99                | 13.50                | 12.94                | 12.67                | 12.82                | 13.13                | 12.38                |
| -550             | -548.73         | 14.41                | 14.11                | 13.13                | 13.22                | 12.77                | 12.65                | 12.38                | 12.36                | 12.35                | 11.72                |
| -525             | -524.01         | 13.37                | 12.86                | 11.86                | 12.57                | 12.14                | 12.06                | 11.62                | 12.09                | 11.65                | 11.15                |
| -500             | -499.26         | 12.80                | 12.52                | 12.20                | 11.69                | 11.62                | 11.68                | 11.24                | 11.55                | 11.13                | 10.82                |
| -475             | -474.57         | 12.31                | 12.31                | 11.72                | 10.92                | 10.91                | 11.09                | 10.76                | 11.18                | 10.87                | 10.41                |
| -450             | -449.85         | 11.96                | 11.87                | 10.99                | 10.58                | 10.30                | 10.40                | 10.38                | 10.73                | 10.26                | 10.08                |
| -425             | -425.09         | 11.08                | 10.92                | 10.16                | 10.10                | 10.18                | 9.81                 | 10.10                | 9.64                 | 9.83                 | 9.43                 |
| -400             | -400.40         | 10.54                | 10.48                | 10.01                | 9.96                 | 9.83                 | 9.58                 | 9.52                 | 9.01                 | 9.22                 | 9.34                 |
| -375             | -375.67         | 9.82                 | 9.88                 | 9.33                 | 9.37                 | 9.02                 | 9.24                 | 8.94                 | 8.85                 | 8.87                 | 8.85                 |
| -350             | -350.98         | 9.35                 | 9.22                 | 8.73                 | 8.72                 | 8.68                 | 8.53                 | 8.44                 | 8.00                 | 8.31                 | 8.28                 |
| -325             | -323.42         | 8.50                 | 8.46                 | 8.10                 | 7.93                 | 8.02                 | 7.91                 | 7.87                 | 7.80                 | 7.97                 | 7.75                 |
| -300             | -298.69         | 8.13                 | 8.24                 | 7.37                 | 7.59                 | 7.49                 | 7.39                 | 7.35                 | 7.23                 | 7.28                 | 6.93                 |
| -275             | -273.97         | 7.54                 | 7.58                 | 7.21                 | 7.20                 | 6.90                 | 6.95                 | 6.87                 | 6.74                 | 6.78                 | 6.64                 |
| -250             | -249.20         | 6.81                 | 6.81                 | 6.59                 | 6.41                 | 6.41                 | 6.32                 | 6.24                 | 6.22                 | 6.19                 | 6.11                 |
| -225             | -224.45         | 6.22                 | 6.11                 | 5.91                 | 5.77                 | 5.85                 | 5.81                 | 5.79                 | 5.70                 | 5.66                 | 5.53                 |
| -200             | -199.80         | 5.82                 | 5.79                 | 5.49                 | 5.47                 | 5.37                 | 5.33                 | 5.23                 | 5.16                 | 5.23                 | 5.11                 |
| -175             | -175.08         | 5.18                 | 5.08                 | 4.88                 | 4.94                 | 4.75                 | 4.83                 | 4.75                 | 4.64                 | 4.63                 | 4.56                 |
| -150             | -150.35         | 4.49                 | 4.48                 | 4.32                 | 4.26                 | 4.24                 | 4.13                 | 4.11                 | 4.14                 | 4.15                 | 4.08                 |
| -125             | -125.72         | 3.79                 | 3.71                 | 3.68                 | 3.49                 | 3.49                 | 3.53                 | 3.41                 | 3.45                 | 3.44                 | 3.42                 |
| -100             | -98.51          | 3.04                 | 3.13                 | 2.97                 | 2.95                 | 2.91                 | 2.91                 | 2.98                 | 2.90                 | 2.90                 | 2.86                 |
| -75              | -73.84          | 2.34                 | 2.42                 | 2.23                 | 2.25                 | 2.26                 | 2.16                 | 2.19                 | 2.16                 | 2.24                 | 2.16                 |
| -50              | -49.04          | 1.62                 | 1.73                 | 1.57                 | 1.57                 | 1.54                 | 1.52                 | 1.55                 | 1.59                 | 1.54                 | 1.51                 |
| -25              | -24.30          | 0.62                 | 0.67                 | 0.69                 | 0.63                 | 0.62                 | 0.67                 | 0.67                 | 0.63                 | 0.69                 | 0.72                 |
|                  |                 | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   |
| 25               | 24.35           | 0.12                 | 0.12                 | 0.13                 | 0.12                 | 0.12                 | 0.13                 | 0.13                 | 0.12                 | 0.13                 | 0.13                 |
| 50               | 49.14           | 0.26                 | 0.27                 | 0.28                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.28                 |
| 75               | 73.80           | 0.42                 | 0.41                 | 0.41                 | 0.41                 | 0.40                 | 0.41                 | 0.41                 | 0.41                 | 0.41                 | 0.41                 |
| 100              | 98.35           | 0.53                 | 0.54                 | 0.53                 | 0.53                 | 0.52                 | 0.53                 | 0.53                 | 0.53                 | 0.54                 | 0.53                 |
| 125              | 125.67          | 0.66                 | 0.67                 | 0.67                 | 0.67                 | 0.66                 | 0.67                 | 0.66                 | 0.66                 | 0.67                 | 0.66                 |
| 150              | 150.27          | 0.78                 | 0.78                 | 0.78                 | 0.78                 | 0.78                 | 0.78                 | 0.77                 | 0.78                 | 0.78                 | 0.78                 |
| 175              | 175.14          | 0.90                 | 0.90                 | 0.89                 | 0.89                 | 0.89                 | 0.88                 | 0.90                 | 0.89                 | 0.90                 | 0.90                 |
| 200              | 199.75          | 1.00                 | 1.01                 | 1.00                 | 1.00                 | 1.00                 | 1.00                 | 1.00                 | 1.00                 | 1.02                 | 0.97                 |
| 225              | 224.50          | 1.13                 | 1.11                 | 1.12                 | 1.12                 | 1.11                 | 1.13                 | 1.07                 | 1.06                 | 1.08                 | 1.07                 |
| 250              | 249.23          | 1.21                 | 1.21                 | 1.17                 | 1.20                 | 1.14                 | 1.20                 | 1.19                 | 1.18                 | 1.24                 | 1.23                 |
| 275              | 274.00          | 1.34                 | 1.34                 | 1.30                 | 1.28                 | 1.30                 | 1.32                 | 1.35                 | 1.35                 | 1.32                 | 1.31                 |
| 300              | 298.72          | 1.43                 | 1.42                 | 1.42                 | 1.41                 | 1.39                 | 1.47                 | 1.45                 | 1.41                 | 1.40                 | 1.41                 |



Table V - Data summary for the Kiethley 237

| Volts<br>Nominal | Volts<br>Actual | K01<br>$\mu\text{A}$ | K02<br>$\mu\text{A}$ | K03<br>$\mu\text{A}$ | K04<br>$\mu\text{A}$ | K05<br>$\mu\text{A}$ | K06<br>$\mu\text{A}$ | K07<br>$\mu\text{A}$ | K08<br>$\mu\text{A}$ | K09<br>$\mu\text{A}$ | K10<br>$\mu\text{A}$ |
|------------------|-----------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| -600             | -600.99         | 14.83                | 14.68                | 14.44                | 14.27                | 14.30                | 14.27                | 14.02                | 13.72                | 13.68                | 13.12                |
| -575             | -573.45         | 14.15                | 13.77                | 13.44                | 13.30                | 13.27                | 13.20                | 12.99                | 12.83                | 12.74                | 12.24                |
| -550             | -548.73         | 13.51                | 13.10                | 12.78                | 12.66                | 12.65                | 12.62                | 12.43                | 12.21                | 12.14                | 11.76                |
| -525             | -524.01         | 12.97                | 12.46                | 12.21                | 12.11                | 12.14                | 11.94                | 11.87                | 11.68                | 11.62                | 11.20                |
| -500             | -499.26         | 12.48                | 11.95                | 11.65                | 11.58                | 11.63                | 11.55                | 11.20                | 11.15                | 11.11                | 10.80                |
| -475             | -474.57         | 11.90                | 11.41                | 11.21                | 11.04                | 11.00                | 10.97                | 10.74                | 10.62                | 10.60                | 10.32                |
| -450             | -449.85         | 11.35                | 10.88                | 10.67                | 10.57                | 10.48                | 10.49                | 10.19                | 10.09                | 10.09                | 9.84                 |
| -425             | -425.09         | 10.78                | 10.32                | 10.16                | 10.02                | 9.97                 | 9.90                 | 9.72                 | 9.65                 | 9.57                 | 9.36                 |
| -400             | -400.40         | 10.30                | 9.78                 | 9.69                 | 9.52                 | 9.60                 | 9.48                 | 9.25                 | 9.20                 | 9.15                 | 8.96                 |
| -375             | -375.67         | 9.71                 | 9.24                 | 9.04                 | 9.03                 | 9.01                 | 8.95                 | 8.73                 | 8.68                 | 8.63                 | 8.48                 |
| -350             | -350.98         | 9.14                 | 8.69                 | 8.54                 | 8.50                 | 8.47                 | 8.44                 | 8.26                 | 8.17                 | 8.18                 | 8.00                 |
| -325             | -323.42         | 7.84                 | 8.11                 | 7.98                 | 7.96                 | 7.91                 | 7.86                 | 7.70                 | 7.65                 | 7.64                 | 7.48                 |
| -300             | -298.69         | 7.99                 | 7.61                 | 7.51                 | 7.43                 | 7.42                 | 7.33                 | 7.22                 | 7.16                 | 7.08                 | 7.02                 |
| -275             | -273.97         | 7.41                 | 7.07                 | 6.96                 | 6.91                 | 6.88                 | 6.78                 | 6.74                 | 6.67                 | 6.61                 | 6.54                 |
| -250             | -249.20         | 6.81                 | 6.54                 | 6.42                 | 6.36                 | 6.35                 | 6.26                 | 6.22                 | 6.18                 | 6.07                 | 6.06                 |
| -225             | -224.45         | 6.23                 | 5.99                 | 5.87                 | 5.85                 | 5.82                 | 5.74                 | 5.70                 | 5.68                 | 5.66                 | 5.58                 |
| -200             | -199.80         | 5.70                 | 5.46                 | 5.36                 | 5.34                 | 5.31                 | 5.24                 | 5.22                 | 5.19                 | 5.13                 | 5.08                 |
| -175             | -175.08         | 5.09                 | 4.87                 | 4.79                 | 4.77                 | 4.74                 | 4.68                 | 4.67                 | 4.63                 | 4.59                 | 4.56                 |
| -150             | -150.35         | 4.47                 | 4.28                 | 4.21                 | 4.20                 | 4.17                 | 4.13                 | 4.11                 | 4.09                 | 4.02                 | 4.03                 |
| -125             | -125.72         | 3.86                 | 3.70                 | 3.63                 | 3.61                 | 3.58                 | 3.55                 | 3.54                 | 3.52                 | 3.48                 | 3.45                 |
| -100             | -98.51          | 3.14                 | 3.04                 | 3.03                 | 2.96                 | 2.93                 | 2.89                 | 2.89                 | 2.86                 | 2.84                 | 2.83                 |
| -75              | -73.84          | 2.41                 | 2.32                 | 2.33                 | 2.28                 | 2.25                 | 2.24                 | 2.24                 | 2.21                 | 2.21                 | 2.21                 |
| -50              | -49.04          | 1.61                 | 1.55                 | 1.57                 | 1.53                 | 1.52                 | 1.52                 | 1.52                 | 1.50                 | 1.50                 | 1.51                 |
| -25              | -24.30          | 0.68                 | 0.64                 | 0.65                 | 0.64                 | 0.64                 | 0.64                 | 0.64                 | 0.65                 | 0.66                 | 0.67                 |
|                  |                 | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   | mA                   |
| 25               | 24.35           | 0.12                 | 0.12                 | 0.13                 | 0.12                 | 0.12                 | 0.13                 | 0.13                 | 0.13                 | 0.13                 | 0.13                 |
| 50               | 49.14           | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 | 0.27                 |
| 75               | 73.80           | 0.40                 | 0.40                 | 0.40                 | 0.40                 | 0.40                 | 0.40                 | 0.40                 | 0.40                 | 0.40                 | 0.40                 |
| 100              | 98.35           | 0.53                 | 0.53                 | 0.53                 | 0.53                 | 0.53                 | 0.53                 | 0.53                 | 0.53                 | 0.53                 | 0.53                 |
| 125              | 125.67          | 0.66                 | 0.66                 | 0.66                 | 0.66                 | 0.65                 | 0.66                 | 0.66                 | 0.66                 | 0.66                 | 0.66                 |
| 150              | 150.27          | 0.77                 | 0.77                 | 0.77                 | 0.77                 | 0.77                 | 0.78                 | 0.77                 | 0.77                 | 0.77                 | 0.77                 |
| 175              | 175.14          | 0.88                 | 0.88                 | 0.88                 | 0.88                 | 0.88                 | 0.89                 | 0.88                 | 0.89                 | 0.88                 | 0.88                 |
| 200              | 199.75          | 0.99                 | 0.98                 | 0.99                 | 0.99                 | 0.98                 | 0.99                 | 0.98                 | 0.98                 | 0.99                 | 0.99                 |
| 225              | 224.50          | 1.09                 | 1.09                 | 1.09                 | 1.10                 | 1.09                 | 1.10                 | 1.09                 | 1.10                 | 1.10                 | 1.09                 |
| 250              | 249.23          | 1.19                 | 1.19                 | 1.19                 | 1.19                 | 1.19                 | 1.20                 | 1.19                 | 1.20                 | 1.20                 | 1.20                 |
| 275              | 274.00          | 1.29                 | 1.29                 | 1.29                 | 1.29                 | 1.29                 | 1.30                 | 1.30                 | 1.30                 | 1.30                 | 1.30                 |
| 300              | 298.72          | 1.39                 | 1.38                 | 1.41                 | 1.39                 | 1.39                 | 1.40                 | 1.40                 | 1.40                 | 1.41                 | 1.40                 |

Table VI - Final Statistics

| Volts<br>Nominal | Volts<br>Actual | Prototype       |                   |                     | Kiethley        |                   |                     | Prototype/Kiethley |                   |                     |
|------------------|-----------------|-----------------|-------------------|---------------------|-----------------|-------------------|---------------------|--------------------|-------------------|---------------------|
|                  |                 | Mean<br>$\mu A$ | Standard<br>Error | Fractional<br>Error | Mean<br>$\mu A$ | Standard<br>Error | Fractional<br>Error | Mean               | Standard<br>Error | Fractional<br>Error |
| -600             | -600.99         | 14.37           | 0.276             | 0.019               | 14.13           | 0.162             | 0.011               | 1.017              | 0.023             | 0.022               |
| -575             | -573.45         | 13.49           | 0.269             | 0.020               | 13.19           | 0.170             | 0.013               | 1.022              | 0.024             | 0.024               |
| -550             | -548.73         | 12.91           | 0.263             | 0.020               | 12.59           | 0.157             | 0.012               | 1.026              | 0.025             | 0.024               |
| -525             | -524.01         | 12.14           | 0.205             | 0.017               | 12.02           | 0.153             | 0.013               | 1.010              | 0.021             | 0.021               |
| -500             | -499.26         | 11.72           | 0.196             | 0.017               | 11.51           | 0.151             | 0.013               | 1.019              | 0.022             | 0.021               |
| -475             | -474.57         | 11.25           | 0.206             | 0.018               | 10.98           | 0.144             | 0.013               | 1.024              | 0.023             | 0.022               |
| -450             | -449.85         | 10.75           | 0.209             | 0.019               | 10.46           | 0.140             | 0.013               | 1.028              | 0.024             | 0.024               |
| -425             | -425.09         | 10.12           | 0.165             | 0.016               | 9.94            | 0.129             | 0.013               | 1.018              | 0.021             | 0.021               |
| -400             | -400.40         | 9.75            | 0.162             | 0.017               | 9.49            | 0.122             | 0.013               | 1.027              | 0.022             | 0.021               |
| -375             | -375.67         | 9.22            | 0.122             | 0.013               | 8.95            | 0.112             | 0.013               | 1.030              | 0.019             | 0.018               |
| -350             | -350.98         | 8.63            | 0.131             | 0.015               | 8.44            | 0.102             | 0.012               | 1.022              | 0.020             | 0.019               |
| -325             | -323.42         | 8.03            | 0.081             | 0.010               | 7.81            | 0.061             | 0.008               | 1.028              | 0.013             | 0.013               |
| -300             | -298.69         | 7.50            | 0.127             | 0.017               | 7.38            | 0.090             | 0.012               | 1.017              | 0.021             | 0.021               |
| -275             | -273.97         | 7.04            | 0.104             | 0.015               | 6.86            | 0.080             | 0.012               | 1.027              | 0.019             | 0.019               |
| -250             | -249.20         | 6.41            | 0.080             | 0.012               | 6.33            | 0.072             | 0.011               | 1.013              | 0.017             | 0.017               |
| -225             | -224.45         | 5.84            | 0.065             | 0.011               | 5.81            | 0.060             | 0.010               | 1.004              | 0.015             | 0.015               |
| -200             | -199.80         | 5.40            | 0.078             | 0.014               | 5.30            | 0.057             | 0.011               | 1.018              | 0.018             | 0.018               |
| -175             | -175.08         | 4.83            | 0.064             | 0.013               | 4.74            | 0.049             | 0.010               | 1.018              | 0.017             | 0.017               |
| -150             | -150.35         | 4.24            | 0.047             | 0.011               | 4.17            | 0.042             | 0.010               | 1.017              | 0.015             | 0.015               |
| -125             | -125.72         | 3.54            | 0.042             | 0.012               | 3.59            | 0.037             | 0.010               | 0.986              | 0.016             | 0.016               |
| -100             | -98.51          | 2.95            | 0.025             | 0.008               | 2.94            | 0.032             | 0.011               | 1.004              | 0.014             | 0.014               |
| -75              | -73.84          | 2.24            | 0.027             | 0.012               | 2.27            | 0.021             | 0.009               | 0.987              | 0.015             | 0.015               |
| -50              | -49.04          | 1.57            | 0.020             | 0.013               | 1.53            | 0.011             | 0.007               | 1.026              | 0.015             | 0.015               |
| -25              | -24.30          | 0.66            | 0.011             | 0.017               | 0.65            | 0.004             | 0.006               | 1.015              | 0.018             | 0.018               |
|                  |                 | mA              |                   |                     | mA              |                   |                     |                    |                   |                     |
| 25               | 24.35           | 0.13            | 0.002             | 0.014               | 0.13            | 0.001             | 0.011               | 0.998              | 0.017             | 0.018               |
| 50               | 49.14           | 0.27            | 0.001             | 0.005               | 0.27            | 0.001             | 0.003               | 1.008              | 0.006             | 0.006               |
| 75               | 73.80           | 0.41            | 0.001             | 0.004               | 0.40            | 0.000             | 0.001               | 1.014              | 0.004             | 0.004               |
| 100              | 98.35           | 0.53            | 0.002             | 0.003               | 0.53            | 0.000             | 0.001               | 1.004              | 0.003             | 0.003               |
| 125              | 125.67          | 0.66            | 0.001             | 0.002               | 0.66            | 0.001             | 0.001               | 1.009              | 0.002             | 0.002               |
| 150              | 150.27          | 0.78            | 0.001             | 0.001               | 0.77            | 0.001             | 0.001               | 1.010              | 0.002             | 0.002               |
| 175              | 175.14          | 0.89            | 0.002             | 0.002               | 0.88            | 0.001             | 0.001               | 1.014              | 0.002             | 0.002               |
| 200              | 199.75          | 1.00            | 0.004             | 0.004               | 0.99            | 0.001             | 0.001               | 1.013              | 0.004             | 0.004               |
| 225              | 224.50          | 1.10            | 0.008             | 0.007               | 1.09            | 0.001             | 0.001               | 1.006              | 0.007             | 0.007               |
| 250              | 249.23          | 1.20            | 0.009             | 0.008               | 1.19            | 0.002             | 0.001               | 1.002              | 0.008             | 0.008               |
| 275              | 274.00          | 1.32            | 0.007             | 0.005               | 1.30            | 0.002             | 0.001               | 1.018              | 0.006             | 0.006               |
| 300              | 298.72          | 1.42            | 0.007             | 0.005               | 1.40            | 0.003             | 0.002               | 1.016              | 0.006             | 0.005               |

Since the electron and ion current differ by three orders of magnitude, they will be plotted separately. Figure 2 shows the electron current for the two instruments and figure 3 shows the ion current.

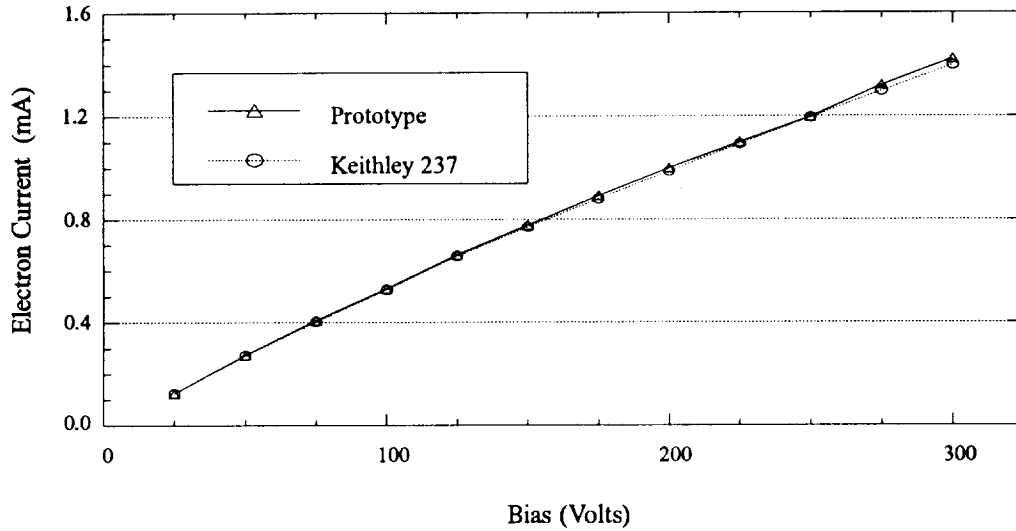


Figure 2 - Electron Current vs Applied Bias

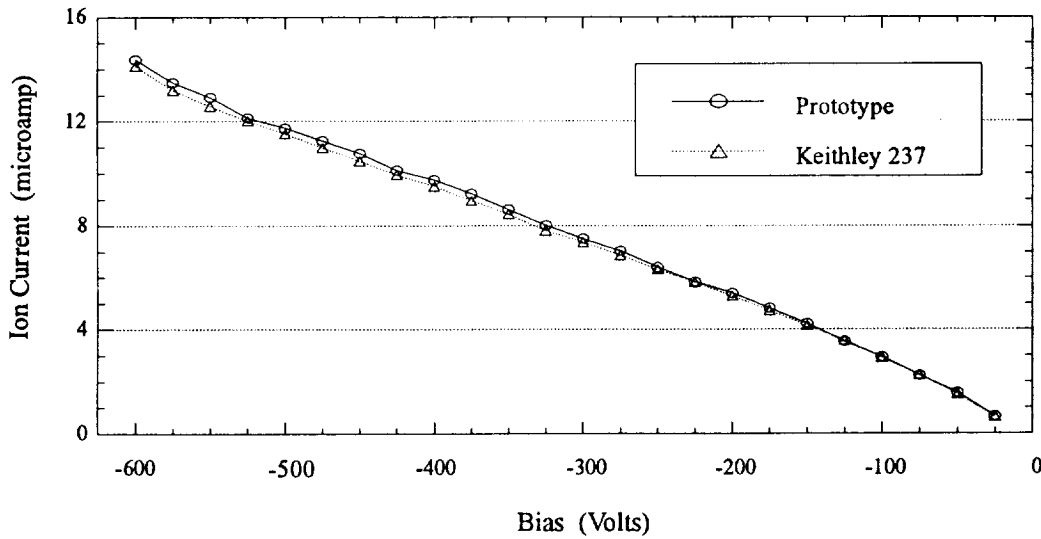
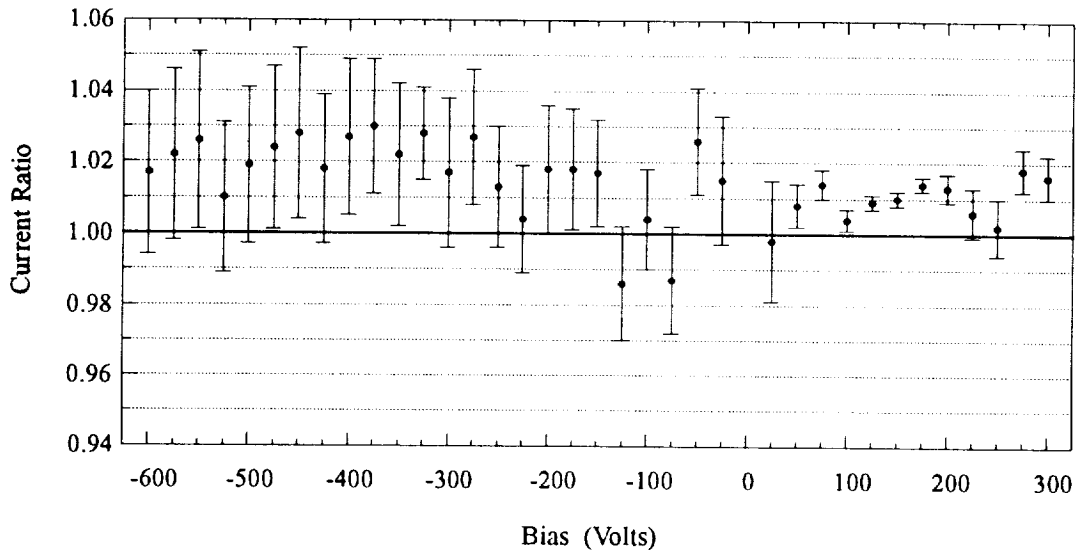


Figure 3 - Ion Current vs Applied Bias

Although standard errors were calculated for the above data, error bars were so small that they produced a cluttered appearance when added to the graphs and were therefore omitted. A more useful comparison is to plot the ratio of the mean currents at each bias voltage. This is displayed in figure 4.



**Figure 4 - Current Ratio (Prototype/Keithley) vs Applied Bias**

The error bars shown indicate the standard error of the mean. The uncertainties for the two data sets was calculated by the spreadsheet used to reduce the data. For each value of applied bias, this value is simply the standard deviation divided by the square root of the number of observations (10). For the final ratio, the fractional error is first calculated as the root-mean-square of the individual fractional errors. The standard error is then the product of the fractional error and the ratio of the means.

## DISCUSSION

As stated above, the requirement for acceptability was for the prototype to agree to within 10% or better with the laboratory instrument. For ion current, agreement is seen to be generally better than 3% and for electron current better than 2%. The results for ion current are believed to be conservative in that a systematic error is apparent in the data which could be eliminated were the experiments to be repeated. Examination of ion currents in tables IV and V show that there is a systematic, almost monotonic drift to lower currents as subsequent runs were taken. This trend is not apparent in electron currents taken at positive voltages which appear to be random from one run to the next. The reason for this is almost certainly related to the manner in which the source drift correction was made. Recall that a separate monitor probe was used to normalize the currents to constant plasma conditions and that this probe was always read at +100 volts. Inherent in such a procedure is the assumption that any change in plasma conditions affects ion and electron densities by the same amount, i.e., that the plasma is always in an overall neutral condition. While it is hard to see how this could not be so, the data can be interpreted as suggesting that a normalization based on electron density does not completely remove changes in ion density. Other possible explanations might involve small differences in the plasma potential for the two bias polarities or the effects of unknown resistances somewhere in the circuits. In any event, this systematic drift is undoubtedly responsible for the larger error bars associated with the ion currents and can reasonably be expected to have influenced the mean values as well. Were the experiments

to be repeated, separate measurements of the monitor probe at +100 volts and at -100 volts would eliminate this difficulty. In any case, the prototype considerably exceeds minimum requirements and SAMPIE's project schedule does not permit time to redo the tests. The final flight model will undergo similar, although not as exhaustive, testing when it is integrated into the SAMPIE package.

#### REFERENCES

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3. Wald, L.W. and Hillard G.B., "The Solar Array Module Plasma Interactions Experiment (SAMPIE): A Shuttle-Based Plasma Interactions Experiment", the Proceedings of the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA August 4-9, Vol 1 p385, 1991.
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## APPENDIX - Raw Data

Data runs for the prototype are designated with a capital P and a sequential number. Runs for the Keithley 237 begin with a K.

### Data Set P01

| Volts   | P01           | Monitor     | Drift         | Volts   | P01           | Monitor     | Drift         | Volts   | P01         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 11.20         | 0.716       | 15.66         | -300    | 5.87          | 0.722       | 8.13          | 25      | 0.09        | 0.729       | 0.12        |
| -575    | 10.60         | 0.715       | 14.83         | -275    | 5.47          | 0.725       | 7.54          | 50      | 0.19        | 0.729       | 0.26        |
| -550    | 10.30         | 0.715       | 14.41         | -250    | 4.96          | 0.728       | 6.81          | 75      | 0.30        | 0.730       | 0.42        |
| -525    | 9.56          | 0.715       | 13.37         | -225    | 4.55          | 0.731       | 6.22          | 100     | 0.39        | 0.730       | 0.53        |
| -500    | 9.15          | 0.716       | 12.80         | -200    | 4.28          | 0.735       | 5.82          | 125     | 0.48        | 0.731       | 0.66        |
| -475    | 8.80          | 0.715       | 12.31         | -175    | 3.80          | 0.733       | 5.18          | 150     | 0.57        | 0.731       | 0.78        |
| -450    | 8.56          | 0.716       | 11.96         | -150    | 3.28          | 0.731       | 4.49          | 175     | 0.66        | 0.732       | 0.90        |
| -425    | 7.93          | 0.716       | 11.08         | -125    | 2.76          | 0.729       | 3.79          | 200     | 0.73        | 0.733       | 1.00        |
| -400    | 7.55          | 0.716       | 10.54         | -100    | 2.21          | 0.728       | 3.04          | 225     | 0.83        | 0.733       | 1.13        |
| -375    | 7.04          | 0.717       | 9.82          | -75     | 1.70          | 0.728       | 2.34          | 250     | 0.89        | 0.734       | 1.21        |
| -350    | 6.72          | 0.719       | 9.35          | -50     | 1.18          | 0.728       | 1.62          | 275     | 0.99        | 0.735       | 1.34        |
| -325    | 6.13          | 0.721       | 8.50          | -25     | 0.09          | 0.728       | 0.62          | 300     | 1.05        | 0.735       | 1.43        |

### Data Set P02

| Volts   | P02           | Monitor     | Drift         | Volts   | P02           | Monitor     | Drift         | Volts   | P02         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 11.50         | 0.746       | 15.42         | -300    | 6.33          | 0.768       | 8.24          | 25      | 0.09        | 0.794       | 0.12        |
| -575    | 11.00         | 0.748       | 14.71         | -275    | 5.83          | 0.769       | 7.58          | 50      | 0.22        | 0.798       | 0.27        |
| -550    | 10.60         | 0.751       | 14.11         | -250    | 5.25          | 0.771       | 6.81          | 75      | 0.33        | 0.803       | 0.41        |
| -525    | 9.68          | 0.753       | 12.86         | -225    | 4.72          | 0.773       | 6.11          | 100     | 0.44        | 0.808       | 0.54        |
| -500    | 9.45          | 0.755       | 12.52         | -200    | 4.48          | 0.774       | 5.79          | 125     | 0.54        | 0.808       | 0.67        |
| -475    | 9.33          | 0.758       | 12.31         | -175    | 3.94          | 0.775       | 5.08          | 150     | 0.63        | 0.808       | 0.78        |
| -450    | 9.03          | 0.761       | 11.87         | -150    | 3.48          | 0.776       | 4.48          | 175     | 0.73        | 0.808       | 0.90        |
| -425    | 8.33          | 0.763       | 10.92         | -125    | 2.88          | 0.777       | 3.71          | 200     | 0.82        | 0.808       | 1.01        |
| -400    | 8.01          | 0.764       | 10.48         | -100    | 2.44          | 0.78        | 3.13          | 225     | 0.90        | 0.81        | 1.11        |
| -375    | 7.56          | 0.765       | 9.88          | -75     | 1.89          | 0.78        | 2.42          | 250     | 0.99        | 0.813       | 1.21        |
| -350    | 7.06          | 0.766       | 9.22          | -50     | 1.35          | 0.78        | 1.73          | 275     | 1.09        | 0.816       | 1.34        |
| -325    | 6.49          | 0.767       | 8.46          | -25     | 0.531         | 0.79        | 0.67          | 300     | 1.16        | 0.818       | 1.42        |

### Data Set P03

| Volts   | P03           | Monitor     | Drift         | Volts   | P03           | Monitor     | Drift         | Volts   | P03         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 13.00         | 0.876       | 14.86         | -300    | 6.49          | 0.881       | 7.37          | 25      | 0.11        | 0.889       | 0.13        |
| -575    | 12.20         | 0.876       | 13.93         | -275    | 6.36          | 0.882       | 7.21          | 50      | 0.25        | 0.89        | 0.28        |
| -550    | 11.50         | 0.876       | 13.13         | -250    | 5.81          | 0.882       | 6.59          | 75      | 0.36        | 0.891       | 0.41        |
| -525    | 10.40         | 0.877       | 11.86         | -225    | 5.22          | 0.883       | 5.91          | 100     | 0.47        | 0.892       | 0.53        |
| -500    | 10.70         | 0.877       | 12.20         | -200    | 4.85          | 0.884       | 5.49          | 125     | 0.60        | 0.893       | 0.67        |
| -475    | 10.30         | 0.879       | 11.72         | -175    | 4.31          | 0.884       | 4.88          | 150     | 0.70        | 0.893       | 0.78        |
| -450    | 9.68          | 0.881       | 10.99         | -150    | 3.82          | 0.885       | 4.32          | 175     | 0.80        | 0.894       | 0.89        |
| -425    | 8.97          | 0.883       | 10.16         | -125    | 3.26          | 0.886       | 3.68          | 200     | 0.89        | 0.895       | 1.00        |
| -400    | 8.86          | 0.885       | 10.01         | -100    | 2.63          | 0.887       | 2.97          | 225     | 1.00        | 0.896       | 1.12        |
| -375    | 8.25          | 0.884       | 9.33          | -75     | 1.98          | 0.887       | 2.23          | 250     | 1.05        | 0.897       | 1.17        |
| -350    | 7.71          | 0.883       | 8.73          | -50     | 1.39          | 0.887       | 1.57          | 275     | 1.17        | 0.898       | 1.30        |
| -325    | 7.14          | 0.882       | 8.10          | -25     | 0.61          | 0.888       | 0.69          | 300     | 1.28        | 0.899       | 1.42        |

### Data Set P04

| Volts   | P04           | Monitor     | Drift         | Volts   | P04           | Monitor     | Drift         | Volts   | P04         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 13.70         | 0.916       | 14.97         | -300    | 7.00          | 0.922       | 7.59          | 25      | 0.11        | 0.929       | 0.12        |
| -575    | 12.80         | 0.915       | 13.99         | -275    | 6.65          | 0.923       | 7.20          | 50      | 0.25        | 0.93        | 0.27        |
| -550    | 12.10         | 0.915       | 13.22         | -250    | 5.92          | 0.924       | 6.41          | 75      | 0.38        | 0.931       | 0.41        |
| -525    | 11.50         | 0.915       | 12.57         | -225    | 5.34          | 0.925       | 5.77          | 100     | 0.49        | 0.931       | 0.53        |
| -500    | 10.70         | 0.915       | 11.69         | -200    | 5.06          | 0.925       | 5.47          | 125     | 0.62        | 0.932       | 0.67        |
| -475    | 10.00         | 0.916       | 10.92         | -175    | 4.57          | 0.925       | 4.94          | 150     | 0.73        | 0.933       | 0.78        |
| -450    | 9.70          | 0.917       | 10.58         | -150    | 3.94          | 0.925       | 4.26          | 175     | 0.83        | 0.934       | 0.89        |
| -425    | 9.27          | 0.918       | 10.10         | -125    | 3.23          | 0.925       | 3.49          | 200     | 0.94        | 0.935       | 1.00        |
| -400    | 9.15          | 0.919       | 9.96          | -100    | 2.73          | 0.925       | 2.95          | 225     | 1.05        | 0.936       | 1.12        |
| -375    | 8.62          | 0.92        | 9.37          | -75     | 2.08          | 0.926       | 2.25          | 250     | 1.12        | 0.937       | 1.20        |
| -350    | 8.03          | 0.921       | 8.72          | -50     | 1.46          | 0.927       | 1.57          | 275     | 1.20        | 0.938       | 1.28        |
| -325    | 7.31          | 0.922       | 7.93          | -25     | 0.59          | 0.928       | 0.63          | 300     | 1.32        | 0.938       | 1.41        |



### Data Set P05

| Volts   | P05           | Monitor     | Drift         | Volts   | P05           | Monitor     | Drift         | Volts   | P05         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 14.10         | 0.963       | 14.64         | -300    | 7.19          | 0.96        | 7.49          | 25      | 0.12        | 0.964       | 0.12        |
| -575    | 13.00         | 0.963       | 13.50         | -275    | 6.62          | 0.96        | 6.90          | 50      | 0.26        | 0.965       | 0.27        |
| -550    | 12.30         | 0.963       | 12.77         | -250    | 6.15          | 0.96        | 6.41          | 75      | 0.39        | 0.966       | 0.40        |
| -525    | 11.70         | 0.964       | 12.14         | -225    | 5.61          | 0.959       | 5.85          | 100     | 0.50        | 0.966       | 0.52        |
| -500    | 11.20         | 0.964       | 11.62         | -200    | 5.15          | 0.959       | 5.37          | 125     | 0.64        | 0.967       | 0.66        |
| -475    | 10.50         | 0.962       | 10.91         | -175    | 4.56          | 0.959       | 4.75          | 150     | 0.75        | 0.968       | 0.78        |
| -450    | 9.90          | 0.961       | 10.30         | -150    | 4.07          | 0.959       | 4.24          | 175     | 0.86        | 0.968       | 0.89        |
| -425    | 9.74          | 0.957       | 10.18         | -125    | 3.35          | 0.96        | 3.49          | 200     | 0.97        | 0.969       | 1.00        |
| -400    | 9.39          | 0.955       | 9.83          | -100    | 2.79          | 0.96        | 2.91          | 225     | 1.08        | 0.97        | 1.11        |
| -375    | 8.62          | 0.956       | 9.02          | -75     | 2.17          | 0.961       | 2.26          | 250     | 1.11        | 0.971       | 1.14        |
| -350    | 8.32          | 0.958       | 8.68          | -50     | 1.48          | 0.962       | 1.54          | 275     | 1.26        | 0.971       | 1.30        |
| -325    | 7.69          | 0.959       | 8.02          | -25     | 0.60          | 0.963       | 0.62          | 300     | 1.35        | 0.972       | 1.39        |

### Data Set P06

| Volts   | P06           | Monitor     | Drift         | Volts   | P06           | Monitor     | Drift         | Volts   | P06         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 14.30         | 1.02        | 14.02         | -300    | 7.54          | 1.02        | 7.39          | 25      | 0.13        | 1.02        | 0.13        |
| -575    | 13.20         | 1.02        | 12.94         | -275    | 7.09          | 1.02        | 6.95          | 50      | 0.28        | 1.02        | 0.27        |
| -550    | 12.90         | 1.02        | 12.65         | -250    | 6.45          | 1.02        | 6.32          | 75      | 0.42        | 1.02        | 0.41        |
| -525    | 12.30         | 1.02        | 12.06         | -225    | 5.93          | 1.02        | 5.81          | 100     | 0.54        | 1.03        | 0.53        |
| -500    | 11.80         | 1.01        | 11.68         | -200    | 5.44          | 1.02        | 5.33          | 125     | 0.69        | 1.03        | 0.67        |
| -475    | 11.20         | 1.01        | 11.09         | -175    | 4.93          | 1.02        | 4.83          | 150     | 0.80        | 1.03        | 0.78        |
| -450    | 10.50         | 1.01        | 10.40         | -150    | 4.21          | 1.02        | 4.13          | 175     | 0.91        | 1.03        | 0.88        |
| -425    | 9.91          | 1.01        | 9.81          | -125    | 3.60          | 1.02        | 3.53          | 200     | 1.03        | 1.03        | 1.00        |
| -400    | 9.68          | 1.01        | 9.58          | -100    | 2.97          | 1.02        | 2.91          | 225     | 1.16        | 1.03        | 1.13        |
| -375    | 9.33          | 1.01        | 9.24          | -75     | 2.20          | 1.02        | 2.16          | 250     | 1.24        | 1.03        | 1.20        |
| -350    | 8.62          | 1.01        | 8.53          | -50     | 1.55          | 1.02        | 1.52          | 275     | 1.36        | 1.03        | 1.32        |
| -325    | 7.99          | 1.01        | 7.91          | -25     | 0.68          | 1.02        | 0.67          | 300     | 1.51        | 1.03        | 1.47        |

### Data Set P07

| Volts   | P07           | Monitor     | Drift         | Volts   | P07           | Monitor     | Drift         | Volts   | P07         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 14.80         | 1.05        | 14.10         | -300    | 7.79          | 1.06        | 7.35          | 25      | 0.14        | 1.06        | 0.13        |
| -575    | 13.30         | 1.05        | 12.67         | -275    | 7.28          | 1.06        | 6.87          | 50      | 0.29        | 1.06        | 0.27        |
| -550    | 13.00         | 1.05        | 12.38         | -250    | 6.61          | 1.06        | 6.24          | 75      | 0.43        | 1.06        | 0.41        |
| -525    | 12.20         | 1.05        | 11.62         | -225    | 6.14          | 1.06        | 5.79          | 100     | 0.57        | 1.07        | 0.53        |
| -500    | 11.80         | 1.05        | 11.24         | -200    | 5.54          | 1.06        | 5.23          | 125     | 0.71        | 1.07        | 0.66        |
| -475    | 11.30         | 1.05        | 10.76         | -175    | 5.04          | 1.06        | 4.75          | 150     | 0.83        | 1.07        | 0.77        |
| -450    | 10.90         | 1.05        | 10.38         | -150    | 4.36          | 1.06        | 4.11          | 175     | 0.96        | 1.07        | 0.90        |
| -425    | 10.60         | 1.05        | 10.10         | -125    | 3.61          | 1.06        | 3.41          | 200     | 1.07        | 1.07        | 1.00        |
| -400    | 10.00         | 1.05        | 9.52          | -100    | 3.16          | 1.06        | 2.98          | 225     | 1.15        | 1.07        | 1.07        |
| -375    | 9.39          | 1.05        | 8.94          | -75     | 2.32          | 1.06        | 2.19          | 250     | 1.27        | 1.07        | 1.19        |
| -350    | 8.86          | 1.05        | 8.44          | -50     | 1.64          | 1.06        | 1.55          | 275     | 1.44        | 1.07        | 1.35        |
| -325    | 8.26          | 1.05        | 7.87          | -25     | 0.71          | 1.06        | 0.67          | 300     | 1.55        | 1.07        | 1.45        |

### Data Set P08

| Volts   | P08           | Monitor     | Drift         | Volts   | P08           | Monitor     | Drift         | Volts   | P08         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 14.70         | 1.10        | 13.36         | -300    | 8.03          | 1.11        | 7.23          | 25      | 0.14        | 1.12        | 0.12        |
| -575    | 14.10         | 1.10        | 12.82         | -275    | 7.48          | 1.11        | 6.74          | 50      | 0.31        | 1.12        | 0.27        |
| -550    | 13.60         | 1.10        | 12.36         | -250    | 6.90          | 1.11        | 6.22          | 75      | 0.46        | 1.12        | 0.41        |
| -525    | 13.30         | 1.10        | 12.09         | -225    | 6.33          | 1.11        | 5.70          | 100     | 0.59        | 1.12        | 0.53        |
| -500    | 12.70         | 1.10        | 11.55         | -200    | 5.73          | 1.11        | 5.16          | 125     | 0.74        | 1.12        | 0.66        |
| -475    | 12.30         | 1.10        | 11.18         | -175    | 5.15          | 1.11        | 4.64          | 150     | 0.87        | 1.12        | 0.78        |
| -450    | 11.80         | 1.10        | 10.73         | -150    | 4.60          | 1.11        | 4.14          | 175     | 0.99        | 1.12        | 0.89        |
| -425    | 10.60         | 1.10        | 9.64          | -125    | 3.83          | 1.11        | 3.45          | 200     | 1.13        | 1.13        | 1.00        |
| -400    | 9.91          | 1.10        | 9.01          | -100    | 3.22          | 1.11        | 2.90          | 225     | 1.20        | 1.13        | 1.06        |
| -375    | 9.74          | 1.10        | 8.85          | -75     | 2.40          | 1.11        | 2.16          | 250     | 1.33        | 1.13        | 1.18        |
| -350    | 8.80          | 1.10        | 8.00          | -50     | 1.76          | 1.11        | 1.59          | 275     | 1.52        | 1.13        | 1.35        |
| -325    | 8.58          | 1.10        | 7.80          | -25     | 0.70          | 1.11        | 0.63          | 300     | 1.59        | 1.13        | 1.41        |

### Data Set P09

| Volts   | P09           | Monitor     | Drift         | Volts   | P09           | Monitor     | Drift         | Volts   | P09         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 15.60         | 1.15        | 13.57         | -300    | 8.37          | 1.15        | 7.28          | 25      | 0.15        | 1.16        | 0.13        |
| -575    | 15.10         | 1.15        | 13.13         | -275    | 7.80          | 1.15        | 6.78          | 50      | 0.32        | 1.16        | 0.27        |
| -550    | 14.20         | 1.15        | 12.35         | -250    | 7.12          | 1.15        | 6.19          | 75      | 0.47        | 1.16        | 0.41        |
| -525    | 13.40         | 1.15        | 11.65         | -225    | 6.51          | 1.15        | 5.66          | 100     | 0.62        | 1.16        | 0.54        |
| -500    | 12.80         | 1.15        | 11.13         | -200    | 6.02          | 1.15        | 5.23          | 125     | 0.78        | 1.16        | 0.67        |
| -475    | 12.50         | 1.15        | 10.87         | -175    | 5.32          | 1.15        | 4.63          | 150     | 0.91        | 1.16        | 0.78        |
| -450    | 11.80         | 1.15        | 10.26         | -150    | 4.77          | 1.15        | 4.15          | 175     | 1.04        | 1.16        | 0.90        |
| -425    | 11.30         | 1.15        | 9.83          | -125    | 3.96          | 1.15        | 3.44          | 200     | 1.19        | 1.17        | 1.02        |
| -400    | 10.60         | 1.15        | 9.22          | -100    | 3.34          | 1.15        | 2.90          | 225     | 1.26        | 1.17        | 1.08        |
| -375    | 10.20         | 1.15        | 8.87          | -75     | 2.58          | 1.15        | 2.24          | 250     | 1.45        | 1.17        | 1.24        |
| -350    | 9.56          | 1.15        | 8.31          | -50     | 1.77          | 1.15        | 1.54          | 275     | 1.55        | 1.17        | 1.32        |
| -325    | 9.17          | 1.15        | 7.97          | -25     | 0.80          | 1.15        | 0.69          | 300     | 1.64        | 1.17        | 1.40        |

### Data Set P10

| Volts   | P10           | Monitor     | Drift         | Volts   | P10           | Monitor     | Drift         | Volts   | P10         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 16.00         | 1.22        | 13.11         | -300    | 8.52          | 1.23        | 6.93          | 25      | 0.17        | 1.23        | 0.13        |
| -575    | 15.10         | 1.22        | 12.38         | -275    | 8.17          | 1.23        | 6.64          | 50      | 0.34        | 1.23        | 0.28        |
| -550    | 14.30         | 1.22        | 11.72         | -250    | 7.51          | 1.23        | 6.11          | 75      | 0.51        | 1.23        | 0.41        |
| -525    | 13.60         | 1.22        | 11.15         | -225    | 6.80          | 1.23        | 5.53          | 100     | 0.66        | 1.24        | 0.53        |
| -500    | 13.20         | 1.22        | 10.82         | -200    | 6.28          | 1.23        | 5.11          | 125     | 0.82        | 1.24        | 0.66        |
| -475    | 12.70         | 1.22        | 10.41         | -175    | 5.61          | 1.23        | 4.56          | 150     | 0.96        | 1.24        | 0.78        |
| -450    | 12.30         | 1.22        | 10.08         | -150    | 5.02          | 1.23        | 4.08          | 175     | 1.11        | 1.24        | 0.90        |
| -425    | 11.50         | 1.22        | 9.43          | -125    | 4.21          | 1.23        | 3.42          | 200     | 1.20        | 1.24        | 0.97        |
| -400    | 11.40         | 1.22        | 9.34          | -100    | 3.52          | 1.23        | 2.86          | 225     | 1.33        | 1.24        | 1.07        |
| -375    | 10.80         | 1.22        | 8.85          | -75     | 2.66          | 1.23        | 2.16          | 250     | 1.52        | 1.24        | 1.23        |
| -350    | 10.10         | 1.22        | 8.28          | -50     | 1.86          | 1.23        | 1.51          | 275     | 1.62        | 1.24        | 1.31        |
| -325    | 9.46          | 1.22        | 7.75          | -25     | 0.89          | 1.23        | 0.72          | 300     | 1.75        | 1.24        | 1.41        |

### Data Set K01

| Volts   | K01           | Monitor     | Drift         | Volts   | K01           | Monitor     | Drift         | Volts   | K01         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 10.90         | 0.735       | 14.83         | -300    | 5.87          | 0.735       | 7.99          | 25      | 0.09        | 0.737       | 0.12        |
| -575    | 10.40         | 0.735       | 14.15         | -275    | 5.46          | 0.737       | 7.41          | 50      | 0.20        | 0.737       | 0.27        |
| -550    | 9.93          | 0.735       | 13.51         | -250    | 5.03          | 0.739       | 6.81          | 75      | 0.30        | 0.738       | 0.40        |
| -525    | 9.53          | 0.735       | 12.97         | -225    | 4.62          | 0.741       | 6.23          | 100     | 0.39        | 0.738       | 0.53        |
| -500    | 9.17          | 0.735       | 12.48         | -200    | 4.23          | 0.742       | 5.70          | 125     | 0.49        | 0.739       | 0.66        |
| -475    | 8.75          | 0.735       | 11.90         | -175    | 3.77          | 0.741       | 5.09          | 150     | 0.57        | 0.739       | 0.77        |
| -450    | 8.34          | 0.735       | 11.35         | -150    | 3.31          | 0.74        | 4.47          | 175     | 0.65        | 0.74        | 0.88        |
| -425    | 7.92          | 0.735       | 10.78         | -125    | 2.85          | 0.739       | 3.86          | 200     | 0.73        | 0.74        | 0.99        |
| -400    | 7.57          | 0.735       | 10.30         | -100    | 2.32          | 0.738       | 3.14          | 225     | 0.81        | 0.741       | 1.09        |
| -375    | 7.14          | 0.735       | 9.71          | -75     | 1.78          | 0.738       | 2.41          | 250     | 0.88        | 0.741       | 1.19        |
| -350    | 6.72          | 0.735       | 9.14          | -50     | 1.19          | 0.737       | 1.61          | 275     | 0.96        | 0.742       | 1.29        |
| -325    | 6.26          | 0.798       | 7.84          | -25     | 0.50          | 0.736       | 0.68          | 300     | 1.03        | 0.743       | 1.39        |

### Data Set K02

| Volts   | K02           | Monitor     | Drift         | Volts   | K02           | Monitor     | Drift         | Volts   | K02         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 12.10         | 0.824       | 14.68         | -300    | 6.49          | 0.853       | 7.61          | 25      | 0.11        | 0.865       | 0.12        |
| -575    | 11.40         | 0.828       | 13.77         | -275    | 6.04          | 0.854       | 7.07          | 50      | 0.23        | 0.866       | 0.27        |
| -550    | 10.90         | 0.832       | 13.10         | -250    | 5.59          | 0.855       | 6.54          | 75      | 0.35        | 0.867       | 0.40        |
| -525    | 10.40         | 0.835       | 12.46         | -225    | 5.13          | 0.856       | 5.99          | 100     | 0.46        | 0.868       | 0.53        |
| -500    | 10.00         | 0.837       | 11.95         | -200    | 4.68          | 0.857       | 5.46          | 125     | 0.57        | 0.869       | 0.66        |
| -475    | 9.57          | 0.839       | 11.41         | -175    | 4.18          | 0.858       | 4.87          | 150     | 0.67        | 0.87        | 0.77        |
| -450    | 9.15          | 0.841       | 10.88         | -150    | 3.68          | 0.859       | 4.28          | 175     | 0.76        | 0.871       | 0.88        |
| -425    | 8.70          | 0.843       | 10.32         | -125    | 3.18          | 0.86        | 3.70          | 200     | 0.86        | 0.872       | 0.98        |
| -400    | 8.26          | 0.845       | 9.78          | -100    | 2.62          | 0.861       | 3.04          | 225     | 0.95        | 0.873       | 1.09        |
| -375    | 7.83          | 0.847       | 9.24          | -75     | 2.00          | 0.862       | 2.32          | 250     | 1.04        | 0.874       | 1.19        |
| -350    | 7.38          | 0.849       | 8.69          | -50     | 1.34          | 0.863       | 1.55          | 275     | 1.13        | 0.875       | 1.29        |
| -325    | 6.90          | 0.851       | 8.11          | -25     | 0.56          | 0.864       | 0.64          | 300     | 1.21        | 0.876       | 1.38        |

### Data Set K03

| Volts   | K03           | Monitor     | Drift         | Volts   | K03           | Monitor     | Drift         | Volts   | K03         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 13.00         | 0.9         | 14.44         | -300    | 6.72          | 0.895       | 7.51          | 25      | 0.12        | 0.91        | 0.13        |
| -575    | 12.10         | 0.9         | 13.44         | -275    | 6.24          | 0.896       | 6.96          | 50      | 0.24        | 0.91        | 0.27        |
| -550    | 11.50         | 0.9         | 12.78         | -250    | 5.76          | 0.897       | 6.42          | 75      | 0.37        | 0.91        | 0.40        |
| -525    | 11.00         | 0.901       | 12.21         | -225    | 5.27          | 0.898       | 5.87          | 100     | 0.48        | 0.91        | 0.53        |
| -500    | 10.50         | 0.901       | 11.65         | -200    | 4.81          | 0.898       | 5.36          | 125     | 0.60        | 0.911       | 0.66        |
| -475    | 10.10         | 0.901       | 11.21         | -175    | 4.30          | 0.898       | 4.79          | 150     | 0.70        | 0.912       | 0.77        |
| -450    | 9.62          | 0.902       | 10.67         | -150    | 3.78          | 0.898       | 4.21          | 175     | 0.80        | 0.912       | 0.88        |
| -425    | 9.16          | 0.902       | 10.16         | -125    | 3.26          | 0.898       | 3.63          | 200     | 0.90        | 0.913       | 0.99        |
| -400    | 8.74          | 0.902       | 9.69          | -100    | 2.72          | 0.898       | 3.03          | 225     | 1.00        | 0.914       | 1.09        |
| -375    | 8.14          | 0.9         | 9.04          | -75     | 2.09          | 0.898       | 2.33          | 250     | 1.09        | 0.915       | 1.19        |
| -350    | 7.67          | 0.898       | 8.54          | -50     | 1.41          | 0.899       | 1.57          | 275     | 1.18        | 0.916       | 1.29        |
| -325    | 7.15          | 0.896       | 7.98          | -25     | 0.59          | 0.9         | 0.65          | 300     | 1.29        | 0.917       | 1.41        |

### Data Set K04

| Volts   | K04           | Monitor     | Drift         | Volts   | K04           | Monitor     | Drift         | Volts   | K04         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 13.40         | 0.939       | 14.27         | -300    | 7.04          | 0.948       | 7.43          | 25      | 0.12        | 0.956       | 0.12        |
| -575    | 12.50         | 0.94        | 13.30         | -275    | 6.55          | 0.948       | 6.91          | 50      | 0.26        | 0.956       | 0.27        |
| -550    | 11.90         | 0.94        | 12.66         | -250    | 6.04          | 0.949       | 6.36          | 75      | 0.39        | 0.957       | 0.40        |
| -525    | 11.40         | 0.941       | 12.11         | -225    | 5.55          | 0.949       | 5.85          | 100     | 0.51        | 0.958       | 0.53        |
| -500    | 10.90         | 0.941       | 11.58         | -200    | 5.07          | 0.95        | 5.34          | 125     | 0.63        | 0.959       | 0.66        |
| -475    | 10.40         | 0.942       | 11.04         | -175    | 4.54          | 0.951       | 4.77          | 150     | 0.74        | 0.96        | 0.77        |
| -450    | 9.97          | 0.943       | 10.57         | -150    | 3.99          | 0.951       | 4.20          | 175     | 0.85        | 0.962       | 0.88        |
| -425    | 9.46          | 0.944       | 10.02         | -125    | 3.44          | 0.952       | 3.61          | 200     | 0.95        | 0.964       | 0.99        |
| -400    | 8.99          | 0.944       | 9.52          | -100    | 2.82          | 0.952       | 2.96          | 225     | 1.06        | 0.965       | 1.10        |
| -375    | 8.53          | 0.945       | 9.03          | -75     | 2.17          | 0.953       | 2.28          | 250     | 1.15        | 0.966       | 1.19        |
| -350    | 8.04          | 0.946       | 8.50          | -50     | 1.46          | 0.954       | 1.53          | 275     | 1.25        | 0.967       | 1.29        |
| -325    | 7.54          | 0.947       | 7.96          | -25     | 0.62          | 0.954       | 0.64          | 300     | 1.35        | 0.968       | 1.39        |

### Data Set K05

| Volts   | K05           | Monitor     | Drift         | Volts   | K05           | Monitor     | Drift         | Volts   | K05         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 13.90         | 0.972       | 14.30         | -300    | 7.23          | 0.975       | 7.42          | 25      | 0.12        | 0.983       | 0.12        |
| -575    | 12.90         | 0.972       | 13.27         | -275    | 6.71          | 0.976       | 6.88          | 50      | 0.27        | 0.985       | 0.27        |
| -550    | 12.30         | 0.972       | 12.65         | -250    | 6.20          | 0.977       | 6.35          | 75      | 0.40        | 0.986       | 0.40        |
| -525    | 11.80         | 0.972       | 12.14         | -225    | 5.69          | 0.978       | 5.82          | 100     | 0.52        | 0.988       | 0.53        |
| -500    | 11.30         | 0.972       | 11.63         | -200    | 5.19          | 0.978       | 5.31          | 125     | 0.65        | 0.988       | 0.65        |
| -475    | 10.70         | 0.973       | 11.00         | -175    | 4.64          | 0.979       | 4.74          | 150     | 0.76        | 0.988       | 0.77        |
| -450    | 10.20         | 0.973       | 10.48         | -150    | 4.08          | 0.979       | 4.17          | 175     | 0.87        | 0.988       | 0.88        |
| -425    | 9.71          | 0.974       | 9.97          | -125    | 3.51          | 0.98        | 3.58          | 200     | 0.97        | 0.988       | 0.98        |
| -400    | 9.35          | 0.974       | 9.60          | -100    | 2.87          | 0.98        | 2.93          | 225     | 1.08        | 0.989       | 1.09        |
| -375    | 8.78          | 0.974       | 9.01          | -75     | 2.21          | 0.981       | 2.25          | 250     | 1.18        | 0.99        | 1.19        |
| -350    | 8.26          | 0.975       | 8.47          | -50     | 1.49          | 0.981       | 1.52          | 275     | 1.28        | 0.991       | 1.29        |
| -325    | 7.71          | 0.975       | 7.91          | -25     | 0.63          | 0.982       | 0.64          | 300     | 1.38        | 0.992       | 1.39        |

### Data Set K06

| Volts   | K06           | Monitor     | Drift         | Volts   | K06           | Monitor     | Drift         | Volts   | K06         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 14.70         | 1.03        | 14.27         | -300    | 7.62          | 1.04        | 7.33          | 25      | 0.13        | 1.04        | 0.13        |
| -575    | 13.60         | 1.03        | 13.20         | -275    | 7.05          | 1.04        | 6.78          | 50      | 0.28        | 1.04        | 0.27        |
| -550    | 13.00         | 1.03        | 12.62         | -250    | 6.51          | 1.04        | 6.26          | 75      | 0.42        | 1.04        | 0.40        |
| -525    | 12.30         | 1.03        | 11.94         | -225    | 5.97          | 1.04        | 5.74          | 100     | 0.55        | 1.04        | 0.53        |
| -500    | 11.90         | 1.03        | 11.55         | -200    | 5.45          | 1.04        | 5.24          | 125     | 0.69        | 1.04        | 0.66        |
| -475    | 11.30         | 1.03        | 10.97         | -175    | 4.87          | 1.04        | 4.68          | 150     | 0.81        | 1.04        | 0.78        |
| -450    | 10.80         | 1.03        | 10.49         | -150    | 4.29          | 1.04        | 4.13          | 175     | 0.92        | 1.04        | 0.89        |
| -425    | 10.20         | 1.03        | 9.90          | -125    | 3.69          | 1.04        | 3.55          | 200     | 1.04        | 1.05        | 0.99        |
| -400    | 9.76          | 1.03        | 9.48          | -100    | 3.01          | 1.04        | 2.89          | 225     | 1.15        | 1.05        | 1.10        |
| -375    | 9.22          | 1.03        | 8.95          | -75     | 2.33          | 1.04        | 2.24          | 250     | 1.26        | 1.05        | 1.20        |
| -350    | 8.69          | 1.03        | 8.44          | -50     | 1.58          | 1.04        | 1.52          | 275     | 1.37        | 1.05        | 1.30        |
| -325    | 8.10          | 1.03        | 7.86          | -25     | 0.67          | 1.04        | 0.64          | 300     | 1.47        | 1.05        | 1.40        |

### Data Set K07

| Volts   | K07           | Monitor     | Drift         | Volts   | K07           | Monitor     | Drift         | Volts   | K07         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 15.00         | 1.07        | 14.02         | -300    | 7.80          | 1.08        | 7.22          | 25      | 0.14        | 1.08        | 0.13        |
| -575    | 13.90         | 1.07        | 12.99         | -275    | 7.28          | 1.08        | 6.74          | 50      | 0.30        | 1.08        | 0.27        |
| -550    | 13.30         | 1.07        | 12.43         | -250    | 6.72          | 1.08        | 6.22          | 75      | 0.44        | 1.09        | 0.40        |
| -525    | 12.70         | 1.07        | 11.87         | -225    | 6.16          | 1.08        | 5.70          | 100     | 0.58        | 1.09        | 0.53        |
| -500    | 12.10         | 1.08        | 11.20         | -200    | 5.64          | 1.08        | 5.22          | 125     | 0.72        | 1.09        | 0.66        |
| -475    | 11.60         | 1.08        | 10.74         | -175    | 5.04          | 1.08        | 4.67          | 150     | 0.84        | 1.09        | 0.77        |
| -450    | 11.00         | 1.08        | 10.19         | -150    | 4.44          | 1.08        | 4.11          | 175     | 0.96        | 1.09        | 0.88        |
| -425    | 10.50         | 1.08        | 9.72          | -125    | 3.82          | 1.08        | 3.54          | 200     | 1.08        | 1.1         | 0.98        |
| -400    | 9.99          | 1.08        | 9.25          | -100    | 3.12          | 1.08        | 2.89          | 225     | 1.20        | 1.1         | 1.09        |
| -375    | 9.43          | 1.08        | 8.73          | -75     | 2.42          | 1.08        | 2.24          | 250     | 1.31        | 1.1         | 1.19        |
| -350    | 8.92          | 1.08        | 8.26          | -50     | 1.64          | 1.08        | 1.52          | 275     | 1.43        | 1.1         | 1.30        |
| -325    | 8.32          | 1.08        | 7.70          | -25     | 0.70          | 1.08        | 0.64          | 300     | 1.54        | 1.1         | 1.40        |

### Data Set K08

| Volts   | K08           | Monitor     | Drift         | Volts   | K08           | Monitor     | Drift         | Volts   | K08         | Monitor     | Drift       |
|---------|---------------|-------------|---------------|---------|---------------|-------------|---------------|---------|-------------|-------------|-------------|
| Nominal | Raw           | Probe       | Corrected     | Nominal | Raw           | Probe       | Corrected     | Nominal | Raw         | Probe       | Corrected   |
|         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\mu\text{A}$ | $\text{mA}$ | $\mu\text{A}$ |         | $\text{mA}$ | $\text{mA}$ | $\text{mA}$ |
| -600    | 15.50         | 1.13        | 13.72         | -300    | 8.09          | 1.13        | 7.16          | 25      | 0.15        | 1.14        | 0.13        |
| -575    | 14.50         | 1.13        | 12.83         | -275    | 7.54          | 1.13        | 6.67          | 50      | 0.31        | 1.14        | 0.27        |
| -550    | 13.80         | 1.13        | 12.21         | -250    | 6.98          | 1.13        | 6.18          | 75      | 0.46        | 1.14        | 0.40        |
| -525    | 13.20         | 1.13        | 11.68         | -225    | 6.42          | 1.13        | 5.68          | 100     | 0.60        | 1.14        | 0.53        |
| -500    | 12.60         | 1.13        | 11.15         | -200    | 5.86          | 1.13        | 5.19          | 125     | 0.75        | 1.14        | 0.66        |
| -475    | 12.00         | 1.13        | 10.62         | -175    | 5.23          | 1.13        | 4.63          | 150     | 0.88        | 1.14        | 0.77        |
| -450    | 11.40         | 1.13        | 10.09         | -150    | 4.62          | 1.13        | 4.09          | 175     | 1.01        | 1.14        | 0.89        |
| -425    | 10.90         | 1.13        | 9.65          | -125    | 3.98          | 1.13        | 3.52          | 200     | 1.13        | 1.15        | 0.98        |
| -400    | 10.40         | 1.13        | 9.20          | -100    | 3.26          | 1.14        | 2.86          | 225     | 1.26        | 1.15        | 1.10        |
| -375    | 9.81          | 1.13        | 8.68          | -75     | 2.52          | 1.14        | 2.21          | 250     | 1.38        | 1.15        | 1.20        |
| -350    | 9.23          | 1.13        | 8.17          | -50     | 1.71          | 1.14        | 1.50          | 275     | 1.49        | 1.15        | 1.30        |
| -325    | 8.64          | 1.13        | 7.65          | -25     | 0.74          | 1.14        | 0.65          | 300     | 1.61        | 1.15        | 1.40        |

### Data Set K09

| Volts<br>Nominal | K09<br>Raw<br>$\mu\text{A}$ | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>$\mu\text{A}$ | Volts<br>Nominal | K09<br>Raw<br>$\mu\text{A}$ | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>$\mu\text{A}$ | Volts<br>Nominal | K09<br>Raw<br>mA | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>mA |
|------------------|-----------------------------|------------------------|-------------------------------------|------------------|-----------------------------|------------------------|-------------------------------------|------------------|------------------|------------------------|--------------------------|
| -600             | 16.00                       | 1.17                   | 13.68                               | -300             | 8.36                        | 1.18                   | 7.08                                | 25               | 0.16             | 1.21                   | 0.13                     |
| -575             | 14.90                       | 1.17                   | 12.74                               | -275             | 7.80                        | 1.18                   | 6.61                                | 50               | 0.33             | 1.21                   | 0.27                     |
| -550             | 14.20                       | 1.17                   | 12.14                               | -250             | 7.22                        | 1.19                   | 6.07                                | 75               | 0.49             | 1.21                   | 0.40                     |
| -525             | 13.60                       | 1.17                   | 11.62                               | -225             | 6.74                        | 1.19                   | 5.66                                | 100              | 0.64             | 1.21                   | 0.53                     |
| -500             | 13.00                       | 1.17                   | 11.11                               | -200             | 6.16                        | 1.2                    | 5.13                                | 125              | 0.80             | 1.21                   | 0.66                     |
| -475             | 12.40                       | 1.17                   | 10.60                               | -175             | 5.51                        | 1.2                    | 4.59                                | 150              | 0.94             | 1.21                   | 0.77                     |
| -450             | 11.80                       | 1.17                   | 10.09                               | -150             | 4.86                        | 1.21                   | 4.02                                | 175              | 1.07             | 1.22                   | 0.88                     |
| -425             | 11.20                       | 1.17                   | 9.57                                | -125             | 4.21                        | 1.21                   | 3.48                                | 200              | 1.21             | 1.22                   | 0.99                     |
| -400             | 10.70                       | 1.17                   | 9.15                                | -100             | 3.44                        | 1.21                   | 2.84                                | 225              | 1.34             | 1.22                   | 1.10                     |
| -375             | 10.10                       | 1.17                   | 8.63                                | -75              | 2.67                        | 1.21                   | 2.21                                | 250              | 1.47             | 1.22                   | 1.20                     |
| -350             | 9.57                        | 1.17                   | 8.18                                | -50              | 1.82                        | 1.21                   | 1.50                                | 275              | 1.59             | 1.22                   | 1.30                     |
| -325             | 8.94                        | 1.17                   | 7.64                                | -25              | 0.80                        | 1.21                   | 0.66                                | 300              | 1.72             | 1.22                   | 1.41                     |

### Data Set K10

| Volts<br>Nominal | K10<br>Raw<br>$\mu\text{A}$ | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>$\mu\text{A}$ | Volts<br>Nominal | K10<br>Raw<br>$\mu\text{A}$ | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>$\mu\text{A}$ | Volts<br>Nominal | K10<br>Raw<br>mA | Monitor<br>Probe<br>mA | Drift<br>Corrected<br>mA |
|------------------|-----------------------------|------------------------|-------------------------------------|------------------|-----------------------------|------------------------|-------------------------------------|------------------|------------------|------------------------|--------------------------|
| -600             | 16.40                       | 1.25                   | 13.12                               | -300             | 8.77                        | 1.25                   | 7.02                                | 25               | 0.17             | 1.26                   | 0.13                     |
| -575             | 15.30                       | 1.25                   | 12.24                               | -275             | 8.18                        | 1.25                   | 6.54                                | 50               | 0.35             | 1.26                   | 0.27                     |
| -550             | 14.70                       | 1.25                   | 11.76                               | -250             | 7.57                        | 1.25                   | 6.06                                | 75               | 0.51             | 1.26                   | 0.40                     |
| -525             | 14.00                       | 1.25                   | 11.20                               | -225             | 6.97                        | 1.25                   | 5.58                                | 100              | 0.67             | 1.26                   | 0.53                     |
| -500             | 13.50                       | 1.25                   | 10.80                               | -200             | 6.35                        | 1.25                   | 5.08                                | 125              | 0.83             | 1.26                   | 0.66                     |
| -475             | 12.90                       | 1.25                   | 10.32                               | -175             | 5.70                        | 1.25                   | 4.56                                | 150              | 0.98             | 1.26                   | 0.77                     |
| -450             | 12.30                       | 1.25                   | 9.84                                | -150             | 5.04                        | 1.25                   | 4.03                                | 175              | 1.12             | 1.27                   | 0.88                     |
| -425             | 11.70                       | 1.25                   | 9.36                                | -125             | 4.35                        | 1.26                   | 3.45                                | 200              | 1.26             | 1.27                   | 0.99                     |
| -400             | 11.20                       | 1.25                   | 8.96                                | -100             | 3.57                        | 1.26                   | 2.83                                | 225              | 1.39             | 1.27                   | 1.09                     |
| -375             | 10.60                       | 1.25                   | 8.48                                | -75              | 2.78                        | 1.26                   | 2.21                                | 250              | 1.52             | 1.27                   | 1.20                     |
| -350             | 10.00                       | 1.25                   | 8.00                                | -50              | 1.90                        | 1.26                   | 1.51                                | 275              | 1.65             | 1.27                   | 1.30                     |
| -325             | 9.35                        | 1.25                   | 7.48                                | -25              | 0.84                        | 1.26                   | 0.67                                | 300              | 1.78             | 1.27                   | 1.40                     |





# REPORT DOCUMENTATION PAGE

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