Relativity Mission
Gravity Probe B

Engineering Test Procedure For

Non-Flight Unit for Payload Verification

SRE Flight Equivalent Unit (SRE FEU)

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SRE FEU Serial Number _____

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1.0 General Description

This document is the Engineering Test procedure for the SQUID READOUT ELECTRONICS Flight Equivalent Unit (SRE FEU). The purpose of this test is to verify the electronic performance of the SRE FEU and to assure that it is satisfactory for use in Payload Verification operations. This is a stand alone test and requires a Test Fixture consisting of a Flight-Equivalent SQUID in a test dewar..

2.0 Reference Documents

SRE FEU Schematics Package

3.0 Test Facilities

LMMS Bldg. 250

4.0 General Requirements

Test will be performed under the environmental conditions existing in LMMS Bldg. 250

4.2 Any red lines to the procedure shall require the approval and initial of the Test Engineer and the Product Assurance Representative.

4.3 In order to expedite test operations, unless specifically noted, the sequence in which major sections or subsections are performed may be altered at the discretion of the Test Technician or Test Engineer.

4.4 QA or their representative shall be notified 24 hours before test procedure operations are initiated.

4.5 Initial and date (_____) the bottom of each page of this procedure to verify that its tasks have been accomplished.

4.6 Serial numbers of test equipment used during this test shall be recorded in the List of Equipment" log sheet.

4.7 Test operators shall read this procedure in its entirety and resolve any apparent ambiguities prior to beginning this test.

5.0 Safety / Security Requirement

5.1 Standard safety practices to ensure safety of personal and prevent damage to equipment shall be observed during performance of this test.

5.2 Ensure that power is removed from cable assemblies before connecting or disconnecting cable connectors.

5.3 Examine all mating connectors before attempting to mate them. Remove any foreign particle. Look for any damaged pins or sockets. Do not force the coupling action if excessive resistance is encountered. Ensure that key ways are aligned.

5.4 Protect all electrical connectors with Connector Savers or plastic caps when the connectors are not mated.

5.5 Special care shall be exercised to prevent damage caused by Electrostatic Discharge when connections are made to the Flight Equivalent SQUID..

6.0 Support Hardware / Test Equipment

6.1 The following support hardware and test equipment will be used and the applicable information for the instruments shall be recorded in the List of Equipment at the appendix. Verify the instruments have valid calibration sticker and record in Table 11.1

Name/ Description	Manufacturer/Model No. Part. No.	Qty Req'd
Flight Equivalent SQUID fixture	SQUID 35C	1
SRE Test Interface Box	N/A	1
Spectrum Analyzer	HP 35665	1
Digital Multimeter	Keithley Model 196; HP –3457A	1
Oscilloscope	LeCroy LC334AL	1

Standard Test Cables	See 6.2 below.	Lot

6.2 An assortment of standard test leads is required to complete the signal connections between test points and meters, etc. The following table lists a number of such leads that might be required.

Description	Vendor Part number	Qty
SMD Microtip* Test Probe, black	Pomona 5144-48-0	2
SMD Microtip* Test Probe, red	Pomona 5144-48-2	2
Micrograbber*/Banana Plug, black	Pomona 5053-36-0	2
Micrograbber*/Banana Plug, red	Pomona 5053-36-2	2
Patch Cord, black	Pomona B-36-0	2
Patch Cord, red	Pomona B-36-2	2
Dbl Banana/BNC cable	Pomona 2BC-BNC-36	2
BNC Cables	Pomona 2249-C-12	4
BNC Cables	Pomona 2249-C-36	4
BNC Cables	Pomona 2249-C-60	4
BNC female to Dbl Banana Adapter	Pomona 1269	4
BNC Tees (f/m/f)	Pomona 3285	2
Stackup Banana plugs	Pomona 1325-0	10

7.0 SRE FEU Cable Installation

7.1 Verify that the power switch on the SRE FEU Power Supply is OFF.

SRE FEU Power Switch OFF ___ Verified

7.2 Install the following cables to the SRE FEU and the FEU SQUID:

SQUID Cable (GTU2-1001-101) connected between SRE FEU connector and connectors on the FEU SQUID Test Fixture as follows:

Cable connector MSX-P3 to test fixture connector M ___ Verified
Cable connector SSX-P4 to test fixture connector S ___ Verified
Cable connector FBX-P2 to test fixture connector FB ___ Verified

BNC Coaxial cable connected between SRE FEU Test Interface Box Preamp Out and Channel 1 input of oscilloscope.

BNC Coaxial cable connected between SRE FEU Test Interface Box FLL Out and HP-3457A Digital Multimeter voltage input.

BNC Coaxial cable connected between SRE FEU Test Interface box Demodulator output and the voltage input of a Keithley 196 DVM.

7.3 Record serial number of SQUID cable (GTU2-1001-101) used _____.

8.0 SRE FEU Electronics Setup

1. Turn ON the SRE FEU aft emulator subsystem and then the SRE FEU Power. Also turn on oscilloscope and Keithley and HP DVMs if not already on.

2. Load and run aft emulator program SQUID.exe (Version 1.2).

3. Put the Aft Emulator in the SRE SQUID 1/2 Command Mode and verify on the computer screen.

4. Verify on the Aft Emulator computer screen that the FLL is unlocked. (SQ1 Control = 0000)

5. Set the SQ1 Levels data word to 9321hex.

6. Check that SQ 1 Bias is set to 0000hex with Aft Emulator (verify setting on the computer screen).

7. Adjust SQ 1 Bias using steps of 0100hex or less with Aft Emulator so as to maximize the 409 kHz signal on the oscilloscope

8. Verify SQ1 Offset is set to 8000hex with Aft Emulator (verify on the computer screen).

9. Adjust SQ1 Offset with Aft Emulator so as to maximize the 409 kHz signal on the oscilloscope. Record setting used:

   Offset setting for maximum oscilloscope signal _____

10. Re-adjust SQ 1 Bias using steps of 0100hex or less with Aft Emulator so as to maximize the 409 kHz signal on the oscilloscope and record the final setting

    Bias setting for maximum oscilloscope signal _____

11. Turn the "Mod Level" screwdriver-adjust control on the SRE FEU to the full CW position. Then, turn the control CCW until the oscilloscope signal reaches a maximum. Record the peak-to-peak value of the oscilloscope signal: _____

    Also record the value of the Demodulator output voltage: _____

12. Make changes by increasing the Sq1 offset setting by steps of 0100hex or 0010hex while observing the 409-kHz signal on the oscilloscope and DVM #1 to obtain and record the following (maximum and minimum readings refer to the absolute value of the voltage):

	SQ1 Offset Setting	DVM#1 Reading
a. Prior to changes	_____	_____
b. Next minimum 409-khz signal reading	_____	_____
c. Next maximum 409-khz signal reading	_____	_____
d. Next minimum 409-khz signal reading	_____	_____
e. Next maximum 409-khz signal reading	_____	_____

Now return to the SQ1 Offset setting of line a. above (using steps no larger than 0100hex) and make further changes by decreasing the SQ1 offset setting by steps of 0100hex or 0010hex to obtain and record the following

f. Prior to changes (same value as a)	_____	_____
g. Next minimum 409-khz signal reading	_____	_____
h. Next maximum 409-khz signal reading	_____	_____
i. Next minimum 409-khz signal reading	_____	_____
j. Next maximum 409-khz signal reading	_____	_____

13. Flux lock SQUID 1 by setting the SQ1 Control register to 0002hex on the aft emulator.

14. Set the offset to each of the values "a" through "j" above (using steps no larger than 0100hex) and record the corresponding readings on DVM #2 (connected to FLL out):

Condition	FLL Output Voltage
a.	_____
b.	_____
c.	_____
d.	_____
e.	_____
f.	_____
g.	_____
h.	_____
i.	_____
j.	_____

15. Calculate and record the difference between the voltage readings "a" and "e" above (ignore the sign of the difference):_____

16. Calculate and record the difference between the voltage readings "f" and "j" above (ignore the sign of the difference):_____

17. Record the average of the above two numbers: _____. **This is the Volts per Flux Quantum calibration for Range 1.**

9.0 SRE FEU Set-Up for Noise Tests

9.1 Range 2 Scale Factor

1. Verify that the Bias is properly set for the SQUID being used.

2. Set the preamp gain to 1 and the range to 2 by setting the Aft Emulator Levels register to 9321hex.

3. Connect the FLL Output on the SRE Test Box to the HP-3457A Digital Multimeter.

4. Set the Offset to 8000hex with the Aft Emulator and verify on the compute screen.

5. Close the Flux Lock Loop by setting the Aft Emulator Controls register to 0002hex.

6. Increase or decrease the Offset from 8000hex as required to make the DC voltage at the FLL Output = 0±1 mV. This can usually be achieved by either increasing or decreasing the Offset. Use the method that results in the smaller change from 8000hex. Record this value in Table 10.3.1 below as A1.

7. If the FLL Output was zeroed by increasing the Offset, set the Offset to A1+4000hex by increasing the most significant nibble by 4.

8. If the FLL Output was zeroed by decreasing the Offset, set the Offset to A1-4000hex by decreasing the most significant nibble by 4.

9. Reset the FLL by setting the Aft Emulator Controls register to 0000hex and then setting it to 0002hex.

10. Set the Offset back to value A1 and verify on the screen.

11. Measure the DC voltage at the FLL Output using the HP-3457A voltmeter. This is the Range 2 Scale Factor in volt/flux quanta. Record this value in Table 10.3.1 below.

Table 10.3.1		
Measurement	Measured Value	Pass/Fail
Offset A1 from step 6		NA
Range 2 Scale Factor		NA

9.2 FLL Output Noise

1. Connect the HP-3457A Digital Multimeter and Channel 1 of the HP-35665A Signal Analyzer to the FLL Output on the SRE Test Box.

2. Set the preamp gain to 1 and the range to 2 by setting the Aft Emulator Levels register to 9321hex.

3. Close the Flux Lock Loop by setting the Aft Emulator Controls register to 0002hex or by pressing the appropriate Function Key on the computer keyboard.

4. Set the Offset to 8000hex and then adjust as required to reduce the FLL Output to 0±0.01 volts as read on the Digital Multimeter.

5. Set up the HP-35665A Signal Analyzer to measure the noise bandwidth with the following settings:

Inst Mode - FFT ANALYSIS
Meas Data - PWR SPEC CHANNEL 1
Input - CH 1 AUTO RANGE
Freq - FULL SPAN
Avg - On, then NUMBER AVERAGES = 20, ENTER
Scale - AUTOSCALE ON

6. Start the measurement by pressing the Start button on the Signal Analyzer.

7. After the measurement stops, use the cursor to locate the flat midband section of the noise spectrum on the HP-35665A screen. This is usually between 1 and 10 KHz. Move the cursor slowly to position the it vertically in the middle of the data.

8. Read the voltage from the top of the screen and record it in Table 10.4.1 below. This is the noise voltage in μVrms/√Hz.

9. Enter the Range 2 Scale Factor from Table 10.3.1 in Table 10.4.1 below.

10. Divide the voltage from step 8 by the Range 2 Scale Factor to calculate the noise in μphi0/√Hz. Record this result in Table 10.4.1. It should be < 7 $\mu\Phi_0$ /√Hz.

Table 10.4.1

Measurement	Lower Limit	Upper Limit	Measured Value	Pass/ Fail
Noise Voltage	NA	NA		NA
Range 2 Scale Factor	NA	NA		NA
Calibrated Noise	None	7 $\mu\Phi_0/\sqrt{Hz}$		

9.3 Shutdown

Set the SQ1 offset to 8000 using steps no larger than 0100hex. Make certain that the SQUID is not flux locked by setting the SQ1 Control register to 0000hex if it is not already at that setting. Set the SQ 1 Bias to 0000hex by steps no larger than 0100hex. Turn off the SRE FEU power supply.

10.0 Completion of Procedure

The results obtained in the performance of this test procedure are acceptable.

Test Technician _____ Date_____

Test Engineer_____ Date_____

REE_____ Date_____

IPT Leader_____ Date_____

This is to certify that the information obtained under this test procedure is as represented and the documentation is completed and correct.

Product Assurance_____ Date_____

11.0 Appendix

11.1 List of Equipment

Make copies of the "List of Equipment" Table as required below.

Name/ Description	Manufacturer/Model No.	Serial #	Cal. Due
Flight Equivalent SQUID	SQUID 35C		
SRE Test Interface Box	N/A		
Spectrum Analyzer	HP 35665		
Digital Multimeter	HP 3457A		
Digital Multimeter	Keithley Model 196		
Oscilloscope	LeCroy LC334AL		
Standard Test Cables	See 6.2 below.		