

**PLANETARY
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2000781F MKII MLB Operating Procedure

NOTE: To avoid costly test failures and program delays, all users shall completely understand this document before attempting to operate the Lightband for any purpose.

Customers are prohibited from operating the Lightband without reading the User's Manual for Mark II Lightband and completing the Lightband Training Course offered by PSC.

Program Name	
MLB Size (Diameter-Bolts)	
MLB Assembly Number	
MLB Assembly Revision	
MLB Serial Number	
Technician Name	
Quality Assurance Name(s)	

This procedure does not involve any high-energy liquids, solid fuels, or any material with inherently hazardous physical or chemical properties.

TABLE OF CONTENTS

1. REVISION HISTORY	3
2. GLOSSARY	4
3. INTRODUCTION	5
4. WARNINGS.....	9
5. HANDLING PRECAUTIONS	10
6. LIGHTBAND MECHANICAL ATTACHMENT PROCEDURE.....	11
7. STOWING THE LIGHTBAND	14
8. SETTING-FOR-FLIGHT THE LIGHTBAND	24
9. DEPLOYING THE LIGHTBAND	29
10. REMOVING THE LIGHTBAND FROM ADJOINING STRUCTURES	35
11. PREPARING THE MLB TO BE COMPRESSED.....	36
12. HORIZONTAL INTEGRATION (OPTIONAL)	39
13. LIGHTBAND ELECTRICAL VERIFICATION	41
14. BEST PRACTICES AND LESSONS LEARNED.....	42
15. SETUP PICTURES.....	43

1. Revision History

Rev	Issued	Created	Reviewed	Change Description
-	02Nov06	RW	RW	Initial document
A	11May07	RW	RW	Added details and descriptions for latest MKII revision
B	12July07	RW	RW	Changed stow, set for flight, and deploy voltage limits
C	21Aug07	RH	RH	Reduced operating voltages and current, deleted and modified steps, added training verification step, added removal from adjoining structures section
D	15Oct10	RH	WH	<ul style="list-style-type: none"> - Removed "Approving Authorities" section - Updated pictures to reflect current design - Increased weight to compress Lightband - Increased Stow voltage for 38" Lightbands - Added "Best Practices" section
E	15Apr11	RH	WH	<ul style="list-style-type: none"> - Updated Required Materials - Added Sections: Warnings, Handling Precautions, Horizontal Integration, Electrical Verification - Increased stow voltage - Expanded Best Practices section - Added voltage and current recording - Expanded procedures - Added and improved figures and changed numbering
F	12Mar15	CF	WH	<ul style="list-style-type: none"> -Updated Cover Page -Updated Section 2.1 -Updated Figure 1 -Added Figure 2 -Updated Figure 5 -Updated Section 3.2 Required Materials -Updated Section 4 Warnings -Added Section 5 -Added steps 6.1.1 & 6.1.2 -Updated steps 6.1.3 & 6.1.4 -Added step 6.1.5 -Updated steps 6.1.6 & 6.1.7 -Added step 6.1.8 -Updated steps 6.1.9, 6.1.10, 7.1.1, & 7.1.3 -Updated requirement 3 of step 7.1.6 -Updated steps 7.1.8, 7.1.10, & Figure 18 -Added step 7.2.1 -Updated steps 7.2.2 & 7.2.3 -Added step 7.2.7 -Updated step 7.2.8 -Added steps 7.2.9 & 7.2.10 -Updated steps 7.2.11, 7.2.12, & 7.2.13 -Added Figure 19 -Updated Figure 20 & Figure 21 -Updated Table 1: Electrical Parameters now size dependent -Added Figure 23 -Added step 8.1.1 -Updated steps 8.1.2 & 8.1.3 -Added step 8.1.7 -Updated step 8.1.8 -Added step 8.1.9 -Updated steps 8.1.10, 8.1.11, & 8.1.12 -Added Figure 24 -Updated Figure 25 & Figure 26 -Updated Table 2: Decreased first peak current and free-running current, increased time to initially cut power -Updated Figure 28 -Added step 9.1.1 -Updated steps 9.1.2 & 9.1.3 -Added step 9.1.7 -Updated steps 9.1.8 & 9.1.9 -Added step 9.1.11 -Updated steps 9.1.12, 9.1.13, & 9.1.14 -Added Figure 29 -Updated Figure 30 & Figure 31 -Updated Table 3: Decreased first peak current and decreased max motor spin down duration -Added Figure 33 -Added Section 11 -Added note about milliohm meter to Section 13 -Updated Table 4: Tighten allowable motor resistance, decreased maximum resistance through switches. -Updated Tip #1,2,4 in Section 14

2. Glossary

- A (or Amps) – Ampere (SI unit of electric current)
- Atm – Standard atmospheric pressure (unit of pressure)
- C – Celsius (unit of temperature)
- CG – Center of Gravity
- Doc – Document (referring to a PSC internal Document number)
- DOF – Degrees of Freedom
- DMM – Digital Multimeter
- ESD – Electrostatic Discharge
- I – Current (measured in Amps)
- IAW – In accordance with
- in – Inch (unit of length)
- lbf – Pound force (unit of force)
- LCT – Lightband Compression Tool
- LV – Launch Vehicle
- MBA – Motor Bracket Assembly
- Mk II – Mark II a model designation of the Motorized Lightband, the MkII is easily identified as having external motors.
- MLB – Motorized Lightband
- mtr – Motor
- OD – Outer Diameter
- Ohm – SI unit of resistance
- PSC – Planetary Systems Corporation
- QA – Quality Assurance
- R – Resistance (measured in Ohms)
- Rev – Revision
- S – Samples
- Sec – Second (unit of time)
- SHC – Socket Head Cap (fastener)
- SN – Serial Number
- STP – Standard Temperature and Pressure (20°C and 1 Atm)
- SV – Space Vehicle
- TVAC – Thermal Vacuum
- TYP - Typically
- V_{dc} – Voltage Direct Current (measure in Volts)
- W – Watt (SI unit of Power)

3. Introduction

This document describes the steps required to handle and operate the MKII Motorized Lightband (MLB). Training and certification by Planetary Systems Corp (PSC) are required to operate any Lightband.

Read this entire document before attempting any procedures.

Electrical Verification (Table 1, Table 2 and Table 3) and Motor Bracket Resistance (Table 4) apply only at standard temperature and pressure (STP).

Contact PSC to clarify any ambiguity or to answer any other questions.

3.1 Lightband Description

The Lightband is composed of two separable halves. The Lower Ring contains the Hinged Leaves, Retaining Ring, Motor Bracket Assembly (MBA) and Separation Springs. The Upper Ring, smaller and lighter, contains the accepting groove into which the Leaves engage. The typical orientation is Lower Ring attached to the launch vehicle and Upper Ring attached to the space vehicle. The electrical interface to operate the Lightband is a DB-9 socket connector on the outside of the MBA. See Figure 3 to Figure 5. For more information on the Lightband see PSC Doc “2000785 User’s Manual for MkII Lightband”.

There are three Lightband operations:

Lightband Operation	Description
Stowing	Mechanically locking the Upper and Lower Rings together by forcing the Hinged Leaves to engage the accepting groove in the Upper Ring.
Setting for Flight	Moving internal components of the Motor Bracket Assembly at low voltage to minimize separation time. Verifies proper Lightband operation prior to deploying.
Deploying	Separating the Upper Ring from the Lower Ring.

The Lightband is not ESD sensitive.

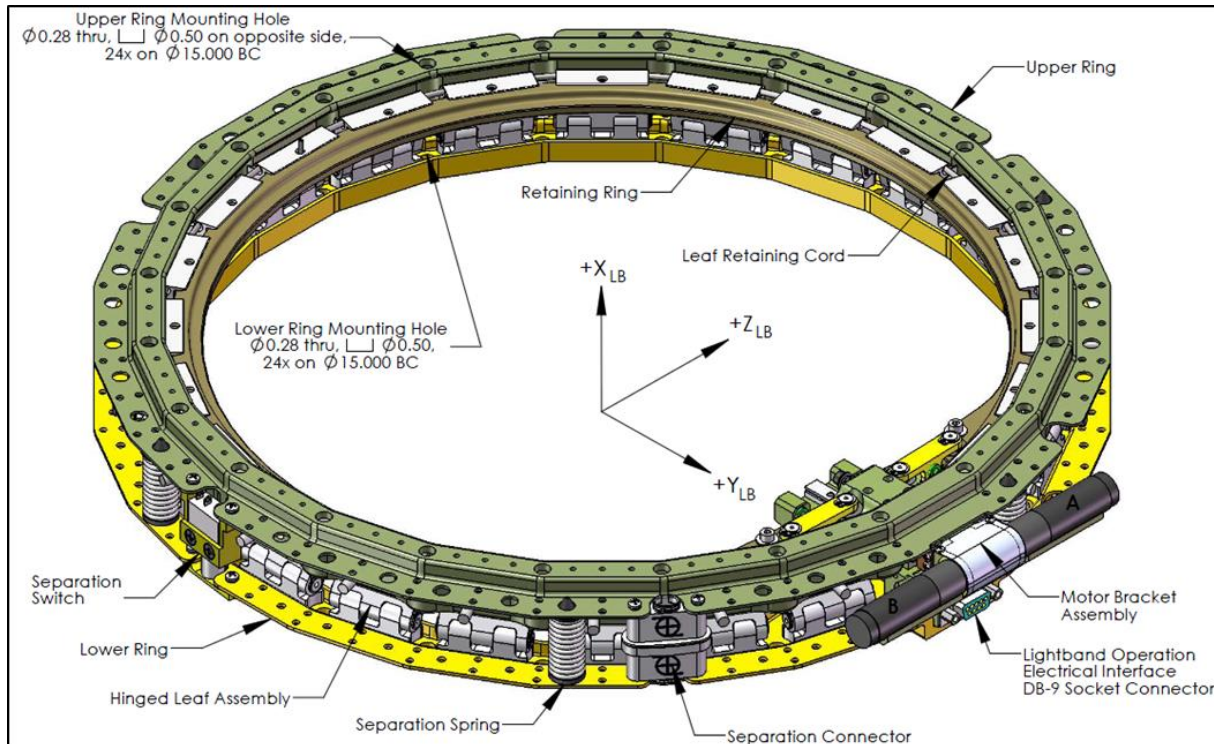


Figure 1: MKII 15.000-24 MLB shown Stowed

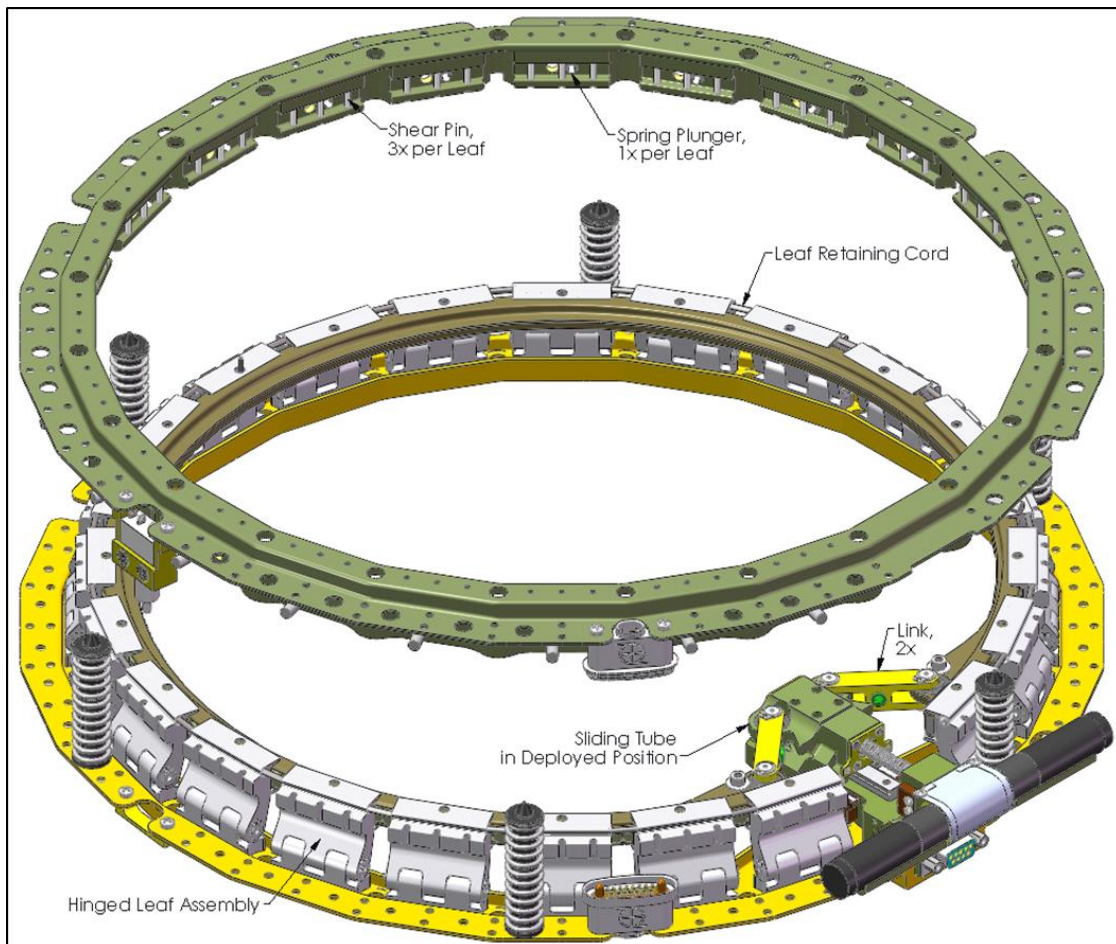


Figure 2: MKII 15.000-24 MLB shown Deployed (also referred to as separated)

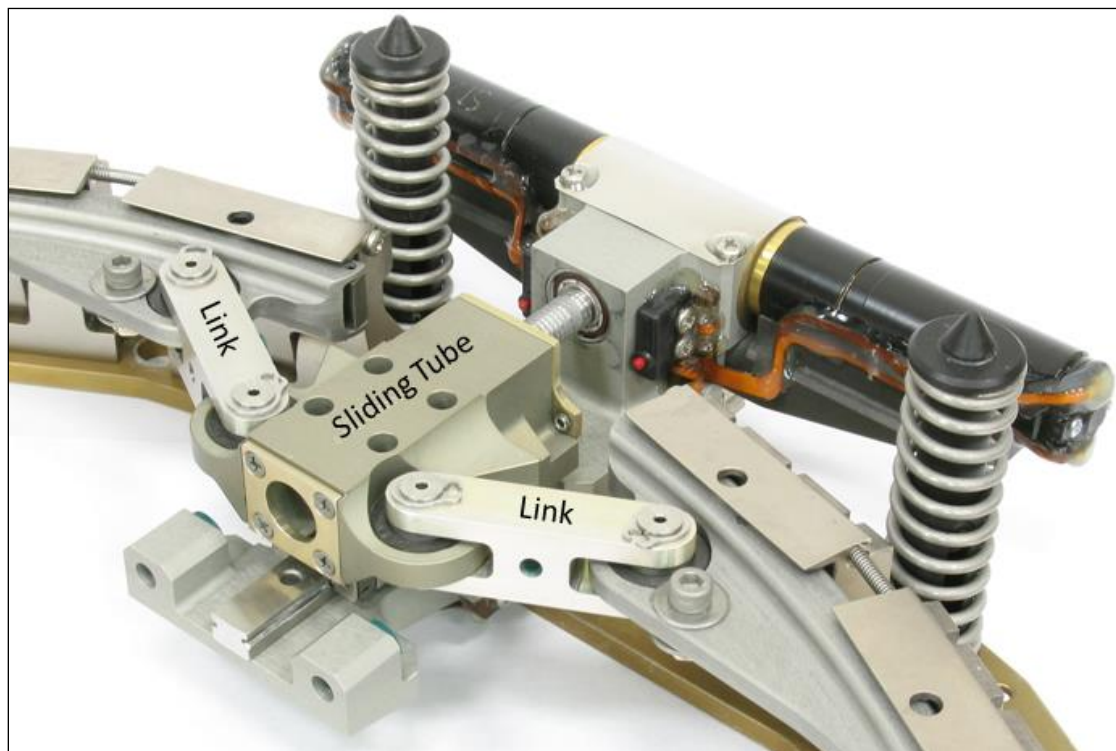


Figure 3: Motor Bracket Assembly

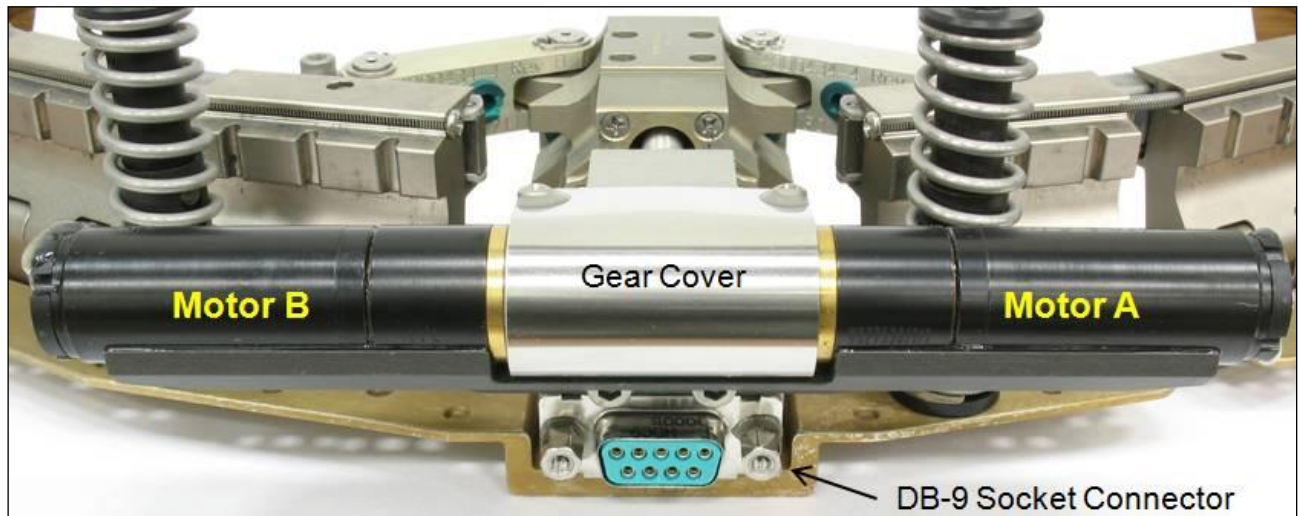


Figure 4: Motor Bracket Assembly

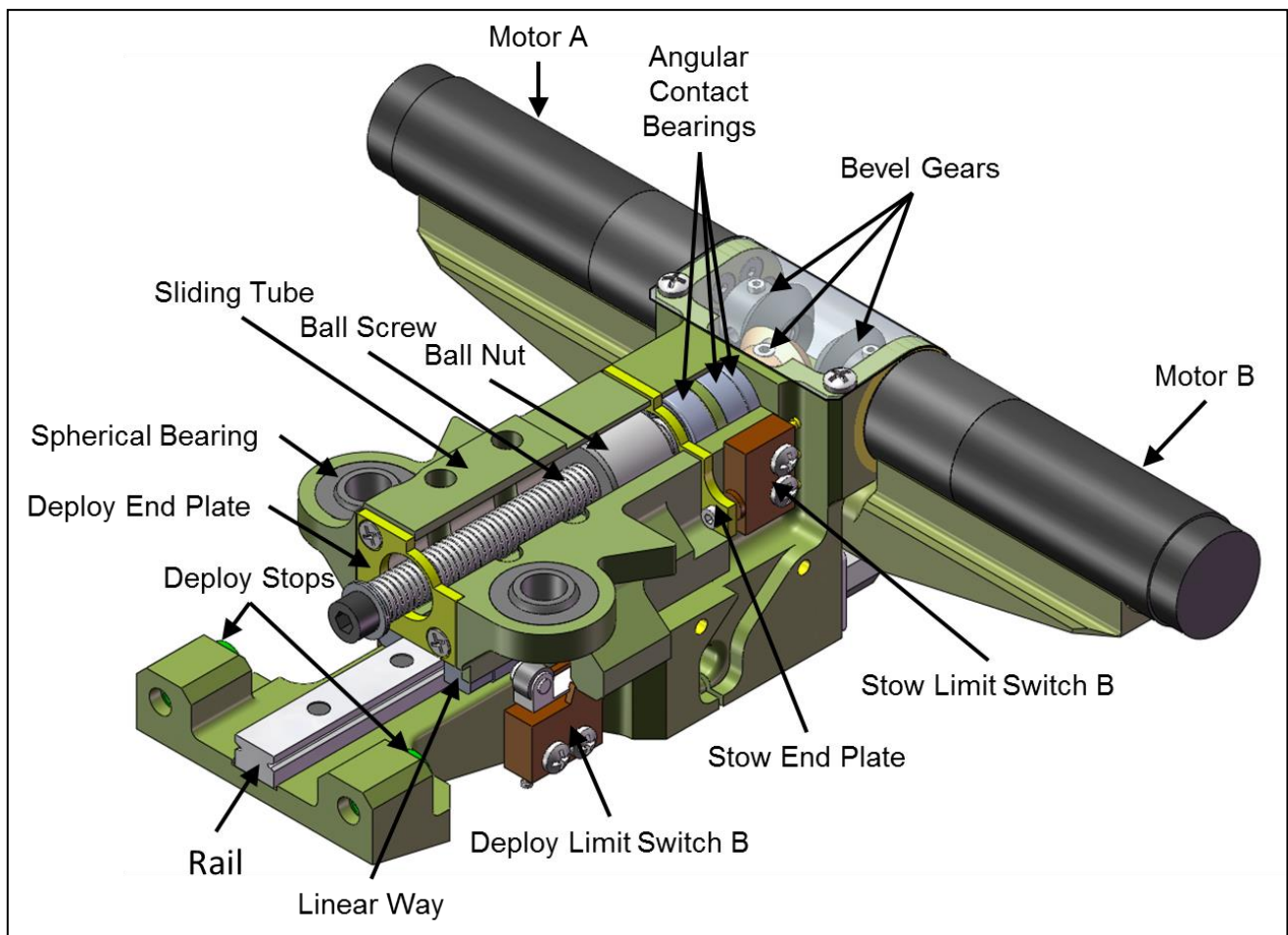


Figure 5: Motor Bracket Assembly (shown stowed)

3.2 Required Materials

Qty	Item	Make & Model Typically Used by PSC
1	Power source, 32 VDC, 6.5 A	-
12	Patch cords (to connect Lightband to power source, minimum 3.5A per line)	Pomona, Banana to Banana, 18AWG
AR	Ability to compress Lightband (payload, weights, compression fixture)	-
1	Oscilloscope, 4 channel (Isolated channels preferred but not required)	Tektronix TDS 2014B
2	Current probes for oscilloscope, 0.05 - 4.0 A range	Tektronix A622
1	Adjustable timer relay with trigger, 0.5 - 1.5 sec in 0.1 sec increments	Macromatic TD-78122
1	Trigger switch (minimum 7A & 32V)	-
2	10 ohm power resistor, ≥ 100 W, used to simulate Lightband motor	Dale HL-100-06Z-10R00-J-J
1	Digital Multimeter (DMM) with leads	Fluke 73III or 77IV (or equivalent)
1	DB-9 pin breakout cable to connect to Lightband	-
1	DB-9 socket breakout cable for Test Circuit	-
1	Adjoining structure for Upper Ring	PSC 2000741
1	Adjoining structure for Lower Ring	PSC 2000741
AR	0.25 inch SHC fasteners (to attach Lower and Upper Rings to adjoining structure)	-
AR	<0.50 inch OD washers (to attach Lower and Upper Rings to adjoining structure)	-
AR	¼-28 Nuts (if applicable, to attach Lower and Upper Rings to adjoining structure)	-
1	3/16 inch hex key (minimum 1.5 inch shank length)	-
1	Torque wrench (with appropriate fitting), 100-115 in*lb range	Sturtevant Richmond CCM-150I
1	Small tweezers to aide in screw handling	-
1	Caliper with inside jaws to measure Lightband height or go/no-go gage	PSC 2002486
1	Thermometer	Fluke 52II (or equivalent)
AR	Isopropanol	-
AR	Lint Free Wipes	-

4. Warnings

Violating any of the below shall void PSC Document 1001015 MLB Warranty.

1. ALL technicians completing this procedure shall be trained directly by PSC and given authority to operate their specific Lightband(s) via PSC Document 2000750 Lightband Training Record.
2. The Lightband shall only be operated using this procedure. This procedure shall be filled out for every operation of the Lightband. Steps shall not be skipped or modified.
3. If a Lightband ever fails to operate correctly, PSC shall be contacted immediately for recommendations and troubleshooting techniques. Another operation shall not be attempted without first understanding the cause of the initial failure.
4. ALL bolts shall be used when attaching the Lightband to adjoining structures. Bolts shall not be omitted from any bolt hole in the Lightband.
5. With the Upper Ring not present, the Lightband shall never be powered in the stow direction. This would cause damage by repeatedly slamming the ball nut against a hard stop at high speed and force.
6. During operations, objects shall not be placed and left in-between the Lightband flanges which may inhibit the Lightband from properly stowing. The tolerance on the pre-stowed Lightband height is NOT the same as the stowed tolerance. Common potential objects include wiring harnesses and height gages.
7. The Upper Ring shall be physically separated from the Lower Ring after every deployment. A stow operation shall not be attempted without first inspecting the Lightband.
8. BOTH motors shall always be powered when operating the Lightband.
9. The Lightband shall only be stowed within the temperature range of 10-32°C (50-90°F)

5. Handling Precautions

There are several areas of the Lightband that shall not be touched or allowed to contact other objects.

5.1 Lower Ring

1. Do not touch the portion of the Hinged Leaves that engage the Upper Ring. Do not wipe off the grease during cleaning. See Figure 6.
2. Do not touch the ball screw. Be especially careful when installing fasteners immediately next to the Motor Bracket Assembly. See Figure 7.
3. Do not grab the motors. Do not use the motors to rotate the Lightband.
4. Do not allow the motors to hit or rub against anything. This is especially crucial when rotating the Lower Ring. See Figure 8.

5.2 Upper Ring

1. Do not touch the leaf groove. Do not remove grease from the groove when cleaning. See Figure 6.
2. Do not touch the spring plungers. Do not allow the spring plungers to contact or bump against anything. See Figure 9.

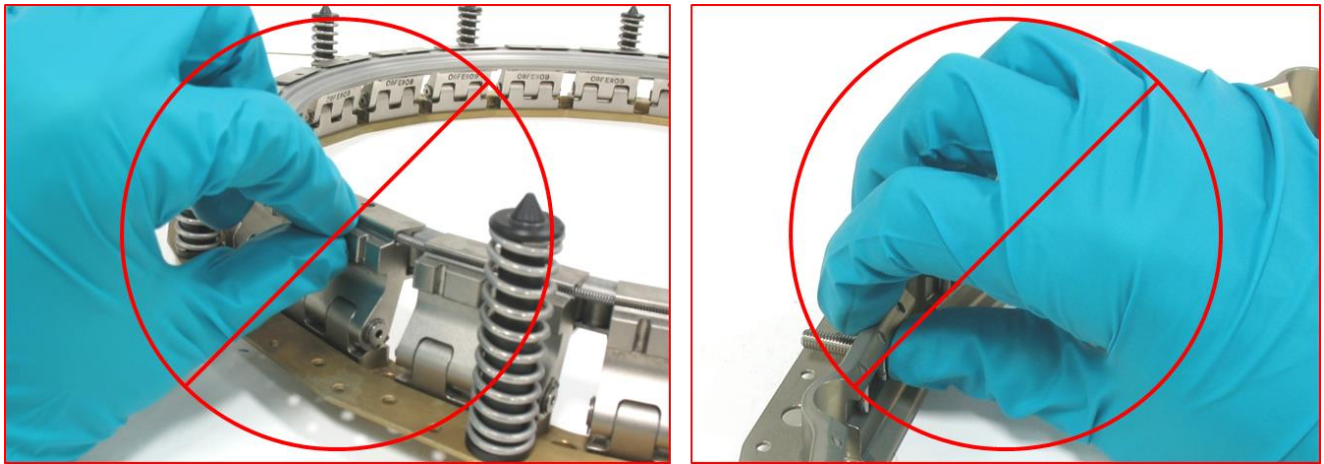


Figure 6: Do NOT touch leaf lip or corresponding groove in Upper Ring.

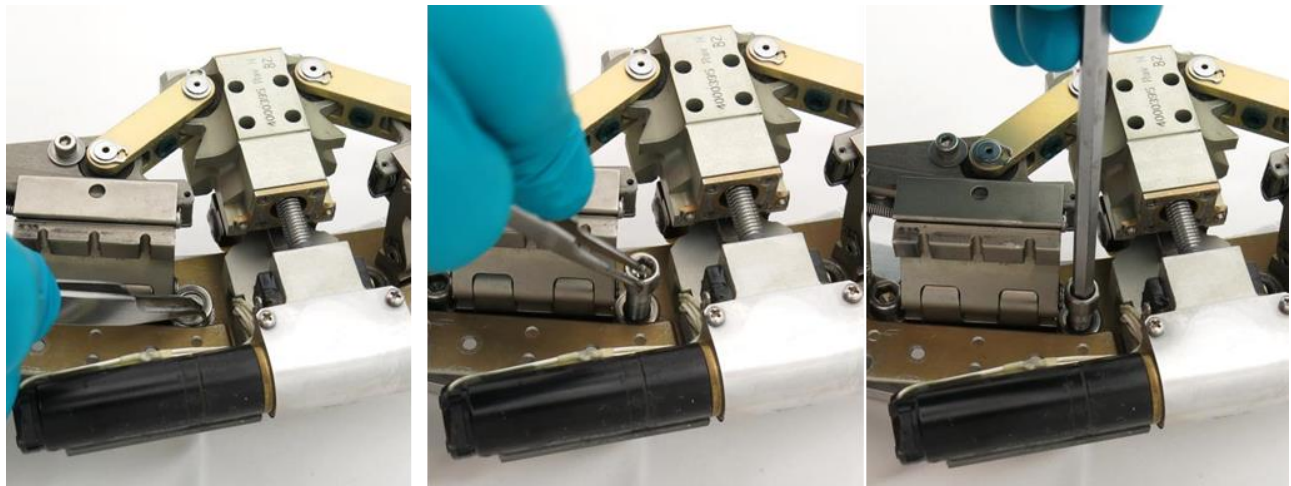


Figure 7: Installing fasteners immediately adjacent the MBA

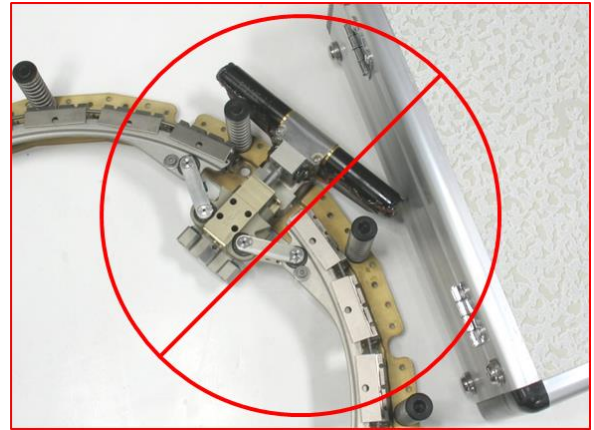
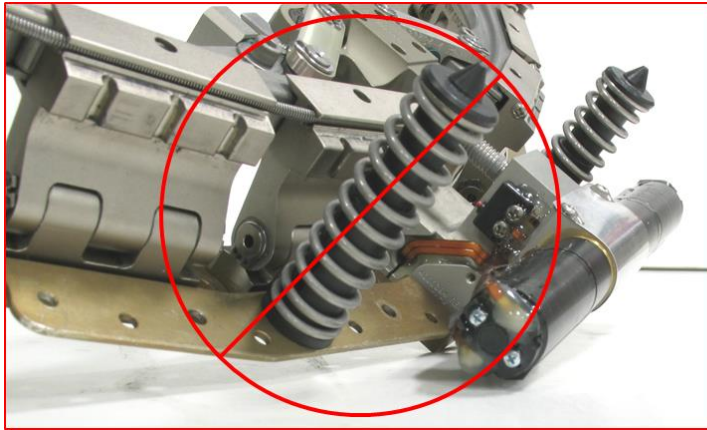


Figure 8: Do NOT allow motors to contact the table or any other objects.

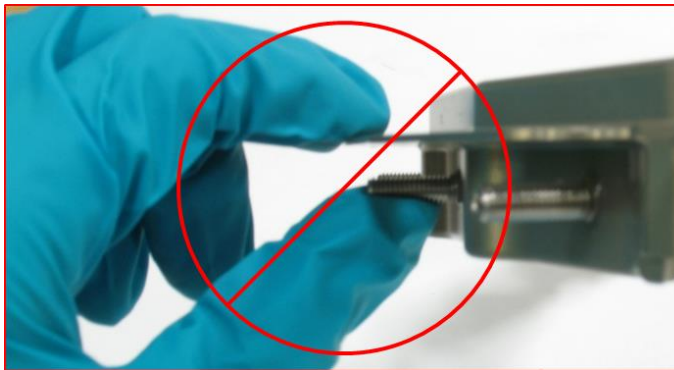


Figure 9: Do NOT touch spring plungers or allow them to contact the table.

6. Lightband Mechanical Attachment Procedure

6.1 Attaching Upper and Lower Rings to Adjoining Structures

Step	Procedure	Date, Time & Initials	
		Tech.	QA
6.1.1	Ensure the SN on the Upper Ring corresponds to the SN on the Lower Ring. Record the following: PSC Assy Part Number: _____ PSC Assy Revision: _____ SN: _____ (This can be found on both the Upper and Lower Rings of the MLB)		
6.1.2	Only PSC trained personnel may operate the Lightband. Verify that the completed training authorizes the operation of this specific Lightband assembly number, revision and serial number.		
6.1.3	The Lightband is designed to accommodate 0.25 inch socket head cap screws and small pattern washers (< 0.50 inch OD). See Section 14. Have ready the required tools and hardware necessary to attach the Lightband to both upper and lower adjoining structures.		
6.1.4	Verify that both mating surfaces are flat per the User's Manual for Mark II Lightband (PSC Doc 2000785).		
6.1.5	Clean mating surfaces with Isopropanol and lint free wipes.		

Step	Procedure	Date, Time & Initials	
		Tech.	QA
6.1.6	<p>Lower ring attachment to adjoining structure for a MLB 15.000-24 only. All other sizes skip to step 6.1.7.</p> <p>The spacing between Leaves is tight and requires a unique attachment procedure. Elevate the Lower Ring off the table to allow all fasteners to hang out the bottom. Place the washer on the Lower Ring prior to inserting the screw. If the screw head rubs, push on each adjacent Leaf Pin to move it out of the way slightly. If the adjoining structure has through holes place the Lower Ring on the structure allowing all fasteners to drop in the holes. If the adjoining structure has threaded holes the fasteners must be inserted gradually. Work around the Lightband, turning each screw a few turns at a time until hand tight. Take care to prevent the screw heads from jamming up into the Leaf Pins. Do not contact the Lightband with the wrench. See Figure 10 to Figure 13. Skip to step 6.1.8.</p> <p>See Section 14 for method of eliminating this tight fit. If using reduced head diameter SHC fasteners skip this step and adjoin Lightband to structure per step 6.1.7.</p>		
6.1.7	<p>Lower ring attachment to adjoining structure for all Lightbands except the MLB 15.000-24 (unless using reduced head fasteners).</p> <p>Place the Lower Ring on the adjoining structure. Insert fasteners and washers through mounting holes. It is often easier to place the washer on the Lower Ring prior to inserting the screw. Tighten fasteners until hand tight. Do not contact the Lightband with the wrench. See Figure 11 & Figure 13.</p>		
6.1.8	<p>Torque all fasteners on the Lower Ring</p> <p>Minimum allowable torque is 70in*lb. PSC typically torques 100-115 in*lb.</p>		
6.1.9	<p>Attach Upper Ring to adjoining structure by inserting fasteners and washers through the counterbores. Tighten fasteners until hand tight. Do not contact the Lightband with the wrench. See Figure 13.</p>		
6.1.10	<p>Torque all fasteners on the Upper Ring.</p> <p>Minimum allowable torque is 70in*lb. PSC typically torques 100-115 in*lb.</p>		

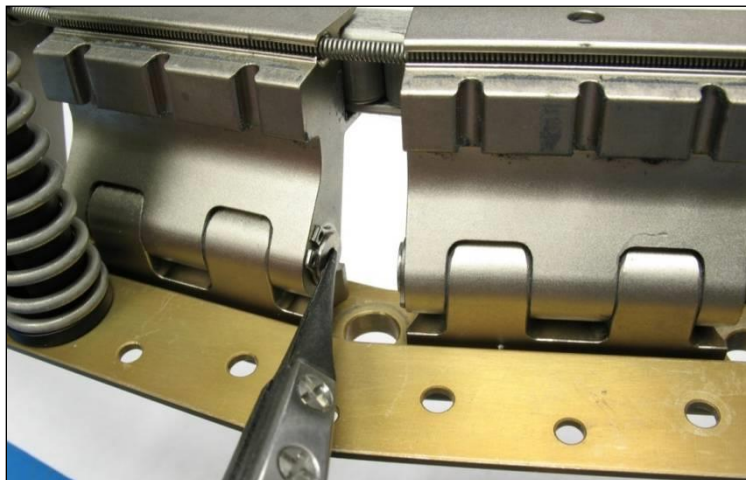


Figure 10: Pushing leaf pin to side to make room for SHC screw (15.000-24 only).

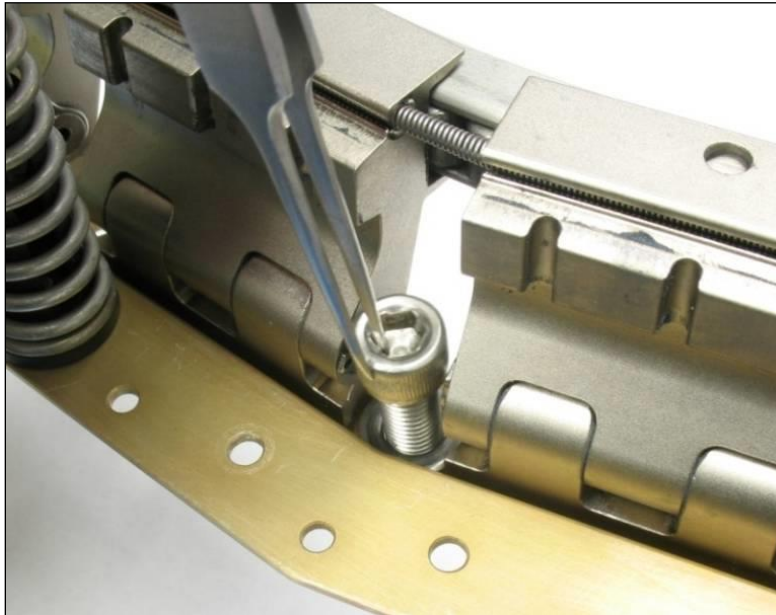


Figure 11: Inserting a SHC screw between Leaves on Lower Ring.



Figure 12: SHC screw and washer inserted between Leaves on elevated Lower Ring.

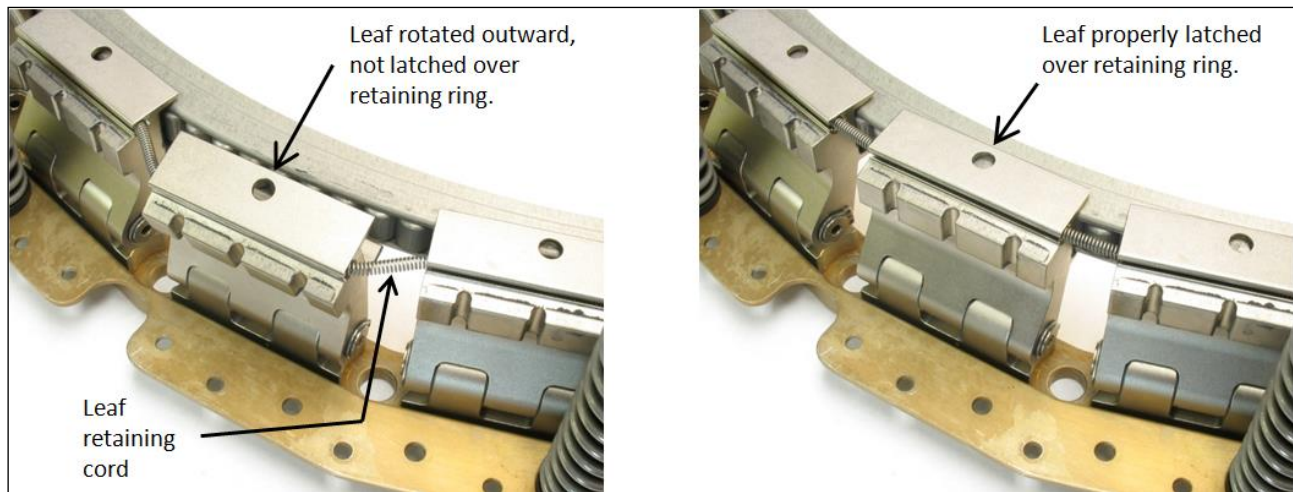


Figure 13: Separated Lightband halves attached to adjoining structures.

7. Stowing the Lightband

7.1 Preparing the Lightband to be Stowed

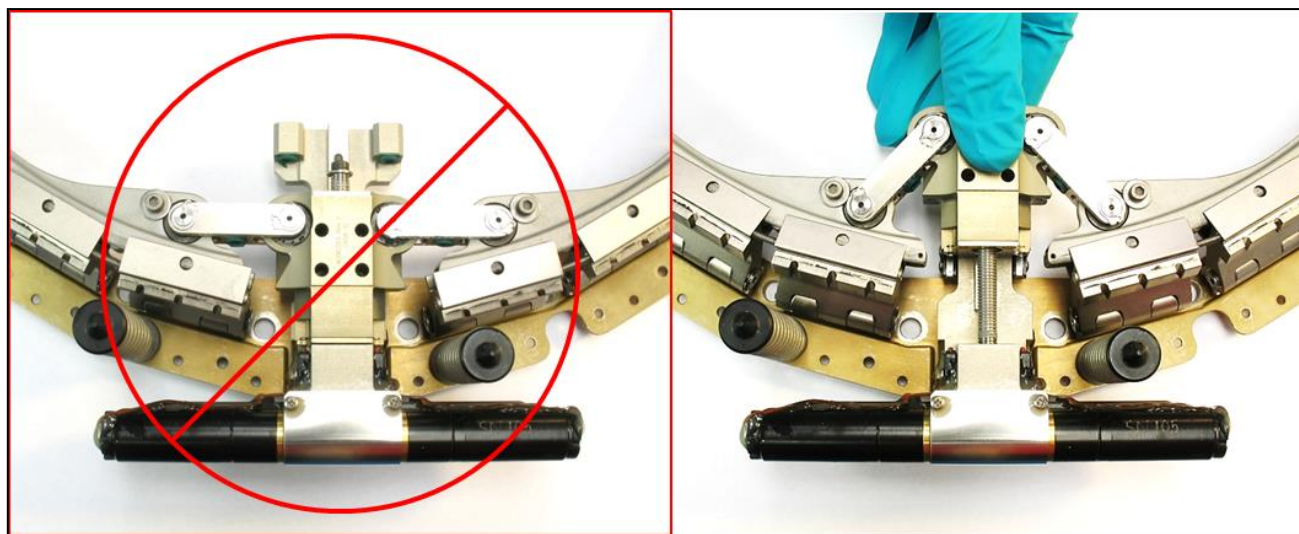
Step	Procedure	Date, Time & Initials	
		Tech.	QA
7.1.1	Verify that the Upper and Lower Rings are attached to adjoining structures IAW Section 6.		
7.1.2	Inspect the Lightband to verify that it is visually free from damage. Check that all Hinged Leaves are properly latched over the Retaining Ring. Check that the Leaf Retaining Cord is seated in the groove of every Hinged Leaf. See Figure 14 for proper orientation.		
7.1.3	Verify the Sliding Tube can move fully radially inward such that it contacts the Motor Bracket deploy hard stops. This is required to allow the Lightband to be compressed. See Figure 15. If it cannot, go to Section 11.		



a) Incorrect Leaf position.

b) Correct Leaf position.

Figure 14: Verifying Leaf positions.



a) Incorrect position (stowed state)

b) Correct position (deployed state)

Figure 15: Verifying pre-stow Sliding Tube position.

Step	Procedure	Date, Time & Initials	
		Tech.	QA
7.1.4	<p>Verify the system being used to compress the Lightband has a total axial (XLB) stiffness less than 2,000 lbf/in (the entire loop from the Upper Ring around to the Lower Ring). This applies to a crane system offloading a SV, a compression clamp fixture, etc. An isolation system (if attached to the Lightband) can be included in this stiffness calculation. See Figure 16.</p> <p>This compliance ensures the Lightband is able to expand or contract slightly when being stowed. If the system is overly stiff the Lightband motors will not be able to impart the necessary power required to stretch/compress the system.</p>		
7.1.5	<p>Verify the lateral (YLB & ZLB) stiffness between the Upper and Lower Rings is less than 50 lbf/in.</p> <p>This compliance ensures the Lightband can self-align while stowing and prevent the motors from stalling.</p>		
7.1.6	<p>If using a payload supported by a crane to compress the Lightband:</p> <ol style="list-style-type: none"> 1. The Lower Ring shall be level within 0.2 deg. 2. Let the payload hang freely such that the Upper Ring is above all parts of the Lower Ring. The Rings shall be concentric within 0.2 in. 3. The Rings shall be parallel within 0.07 in. <p>These requirements ensure the Lightband can self-align while stowing and prevent the motors from stalling.</p>		
7.1.7	<p>Bring the Upper Ring and Lower Rings close together in preparation for alignment checks.</p> <p>Alignment between the Upper and Lower Rings shall be verified prior to or just after the extended Separation Springs have contacted the Upper Ring but before any force is applied to compress the Lightband. Verify the following per Figure 17:</p> <ol style="list-style-type: none"> 1. Cutout in Upper Ring lines up over Motor Bracket on Lower Ring. 2. ALL Separation Connector/Switch cutouts align. 3. ALL Separation Spring tips protrude through appropriate holes in the Upper Ring. <p>For horizontal integration see Section 11.</p>		

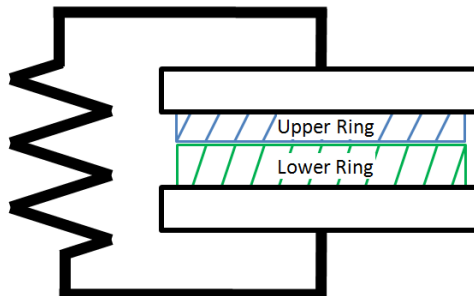


Figure 16: Verifying compliance in Lightband compression system.

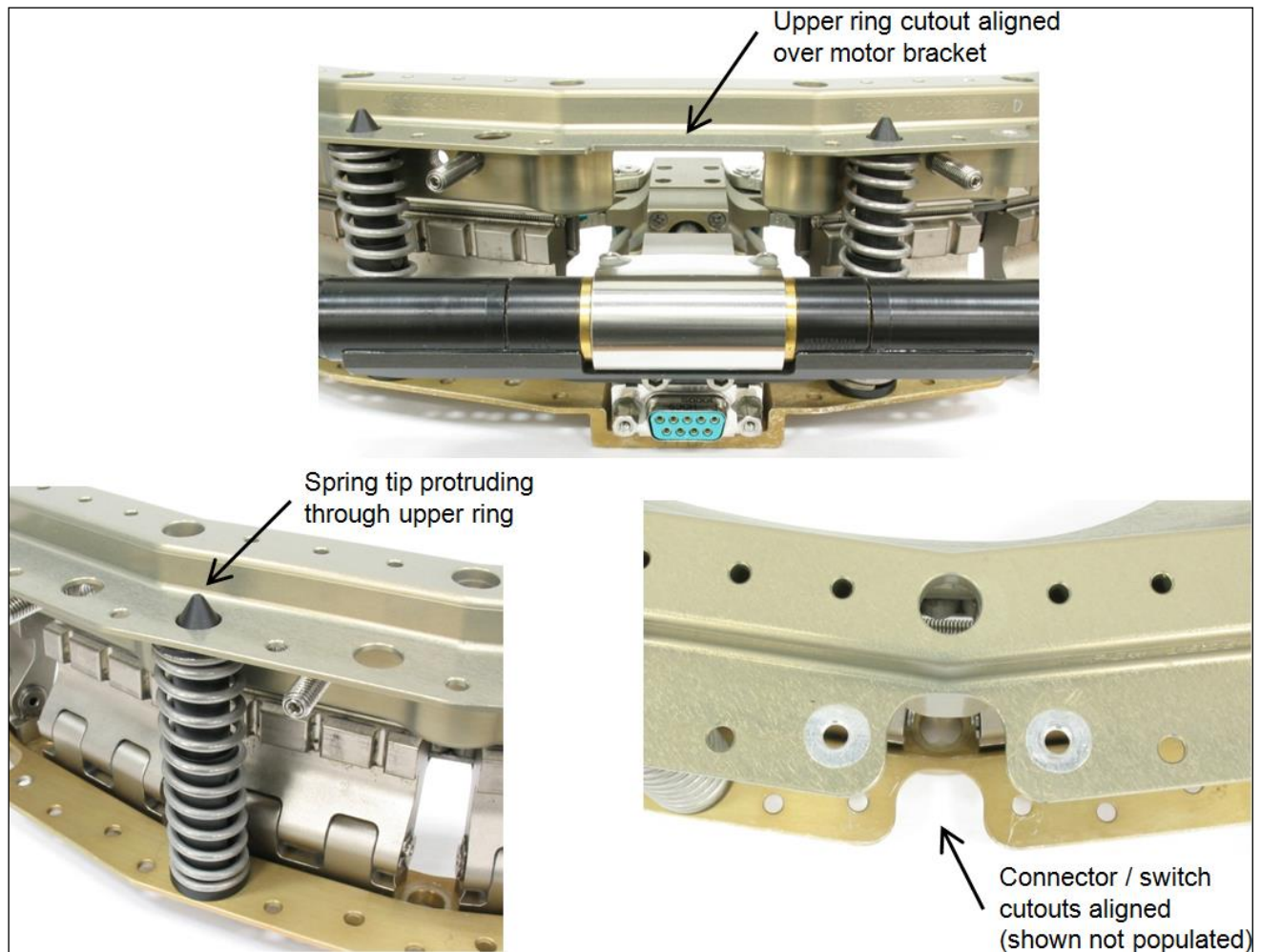


Figure 17: Aligning the Upper and Lower Rings.

Step	Procedure	Date, Time & Initials	
		Tech.	QA
7.1.8	The Separation Springs are often distributed asymmetrically around the Lightband to induce tip-off or compensate for an offset CG. Using a central single compression point may not be adequate.		
7.1.9	<p>Compress the Lightband. This can be achieved by placing weights on the Upper Ring, offloading the payload, compressing in a fixture, etc. The total applied force shall be 20-30 lbf per Separation Spring.</p> <p>Separation Spring quantity = _____</p> <p>Minimum force = _____ springs x 20 lbf = _____ lb</p> <p>Maximum force = _____ springs x 30 lbf = _____ lb</p> <p>If possible apply the force gradually and check that no Hinged Leaves are caught under the Upper Ring as it compresses.</p> <p>Stop once the minimum force is applied.</p> <p>Note: PSC has designed a Lightband Compression Tool for use when applying this force is impractical (horizontal integration, sensitive payload, etc). See Section 14.</p>		
7.1.10	Once the minimum force has been applied to the Lightband it is necessary to verify that the Lightband is properly compressed. Figure 18 shows a cross section of the stowed Lightband. Verify the pre-stow height (distance between flanges) in at least 4 places around the Lightband is 1.333 ± 0.010 in. If any measurement is not within specification verify proper alignment and compressive force. Increase force as necessary from previous step until Lightband is properly compressed. Do not exceed the maximum force calculated in Step 7.1.9.		

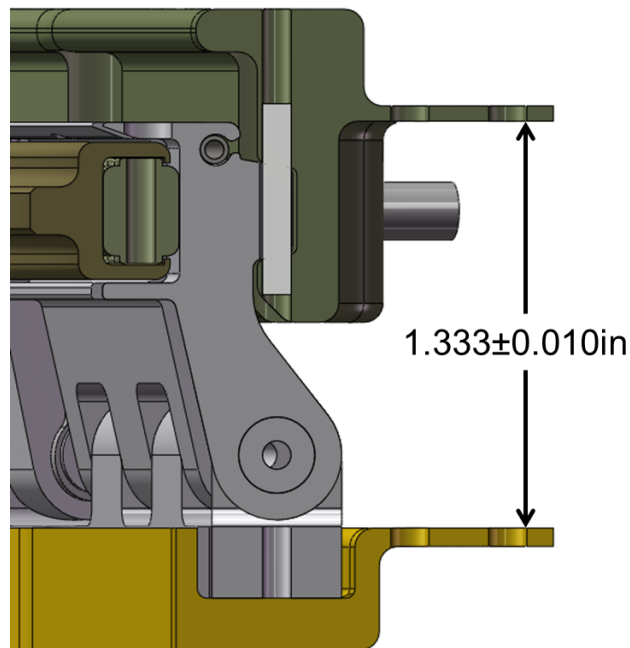


Figure 18: Verifying Lightband pre-stow height.

7.2 Stowing the Lightband

Step	Procedure	Date, Time & Initials	
		Tech.	QA
7.2.1	<p>Voltage and Current for each motor shall be measured and recorded for every operation. This procedure incorporates an oscilloscope to measure and record data. Other methods may be used. Ensure data is measured and recorded at a sample rate of no less than 1,000 samples per second and resolution of no less than 0.02 Amps and 0.1 Volts.</p> <p>Caution: If oscilloscope channels share common ground be cognizant of their effect on the circuit.</p>		
7.2.2	<p>Set up the 'Stow - Power and Measurement Circuit' per Figure 19. Voltage and current for each "motor" (resistor) shall be measured.</p> <p>Do not connect the Lightband.</p>		
7.2.3	Verify the resistance between the power supply and Lightband will be less than 1.0 ohm for each motor. This applies to the complete loop (power and return).		
7.2.4	<p>Set the power supply voltage according to Lightband size.</p> <p>Diameter 31.0 in and greater: 30 to 31 Vdc</p> <p>Diameter less than 31.0 in: 27 to 28 Vdc</p>		
7.2.5	Set the current limit on the power supply to 6.5 ±0.1 A .		
7.2.6	Set the timer relay to apply power for 1.5 ±0.05 sec .		
7.2.7	<p>Set up the 'Stow - Test Circuit' per Figure 19.</p> <p>This circuit uses a 10 ohm resistor (≥100 W) to simulate each Lightband motor.</p>		
7.2.8	<p>Connect the 'Stow - Test Circuit' to the 'Stow - Power and Measurement Circuit' per Figure 19. When ready, apply power to the circuit and verify the following:</p> <ol style="list-style-type: none"> 1) The entire voltage and current profiles for both "motors" are measured. 2) Timer relay applies power for specified time. 3) Current for each "motor" is about 1/10 of applied voltage. ($I=V/R$). 4) Data properly saves (transferable data set; e.g. viewable on computer, picture in focus, etc.). <p>If any parameters are not met, make the required changes and run the test circuit again. The test circuit may be run as many times as necessary to ensure the power and measurement circuit is performing as required. Upon completion of this step the 'Stow - Power and Measurement Circuit' shall not be changed.</p>		
7.2.9	<p>Ensure the Lightband is in the temperature range specified in Section 4.</p> <p>The Lightband may be damaged if stowing outside of this temperature range.</p>		
7.2.10	Remove the 'Stow - Test Circuit' and connect the Lightband to the 'Stow – Power and Measurement Circuit' per Figure 20. Do not apply power to the Lightband.		

7.2.11	<p>Prepare to stow the Lightband. See Figure 21 and Table 1 for the anticipated current draw and power duration.</p> <p>When ready apply power to stow the Lightband.</p> <p>If the current limit is reached or the timer relay runs longer than the specified time manually cut power. Contact PSC immediately. A visual inspection of the Lightband may be performed, but do not change configuration.</p>		
7.2.12	<p>Save the voltage and current profiles for both motors. It is acceptable to take a picture of the oscilloscope screen; however tabulated data and high fidelity graphs are preferred.</p>		
7.2.13	<p>Figure 21 shows typical stow voltage and current profiles. Complete Table 1 to verify all parameters are within tolerance. Single data point exceedances are acceptable. Also, a slow sample rate may alias data. Do not filter data. Contact PSC immediately if a discrepancy is found.</p>		
7.2.14	<p>Figure 22 shows the state of the switches in the Motor Bracket Assembly after the Lightband has been stowed. Measure resistance directly at the Lightband's DB-9 socket connector by completing Table 4. See Figure 44. Contact PSC if a discrepancy is found.</p>		
7.2.15	<p>If weights or a fixture were used to compress the Lightband they may be removed at this time.</p>		

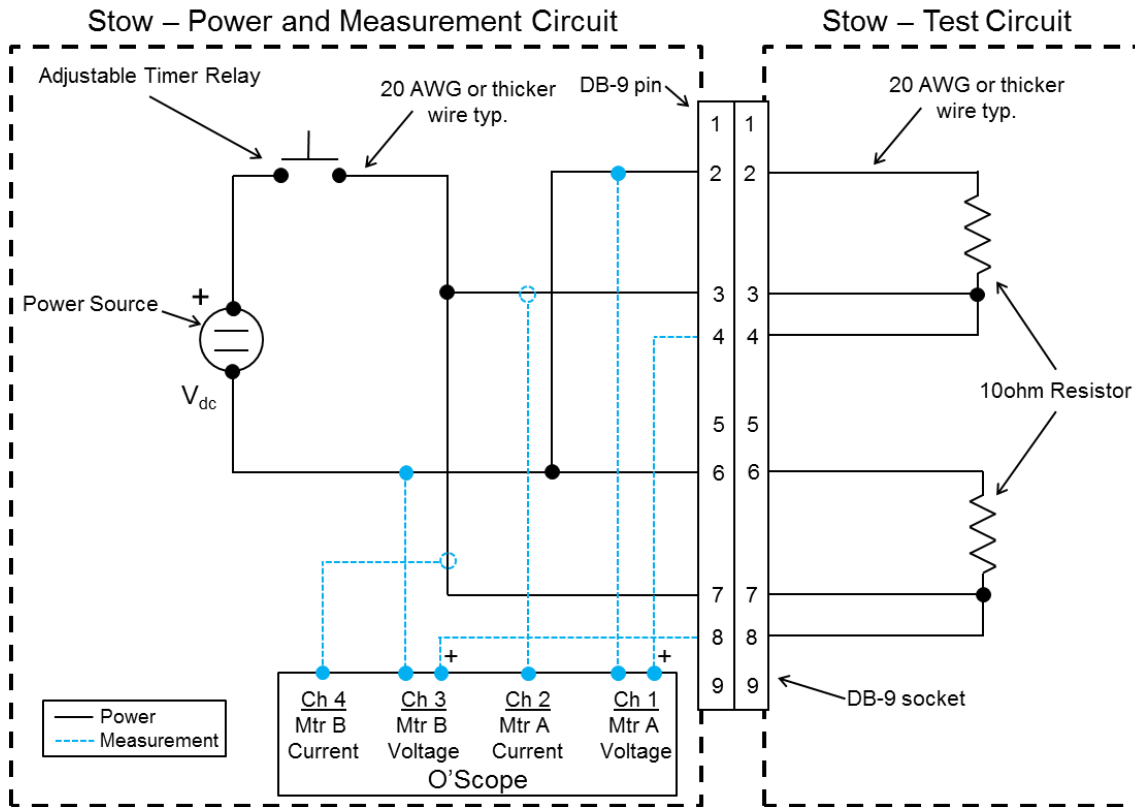


Figure 19: Stow Test Circuit

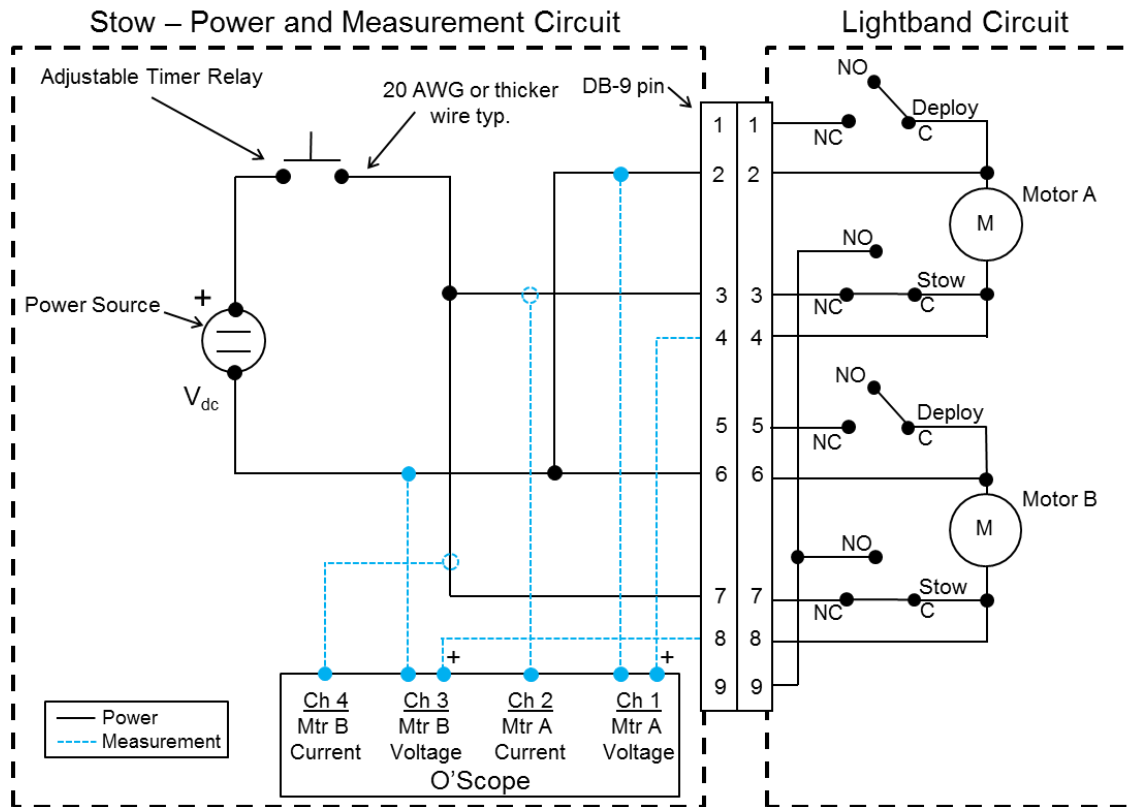


Figure 20: Stow Circuit

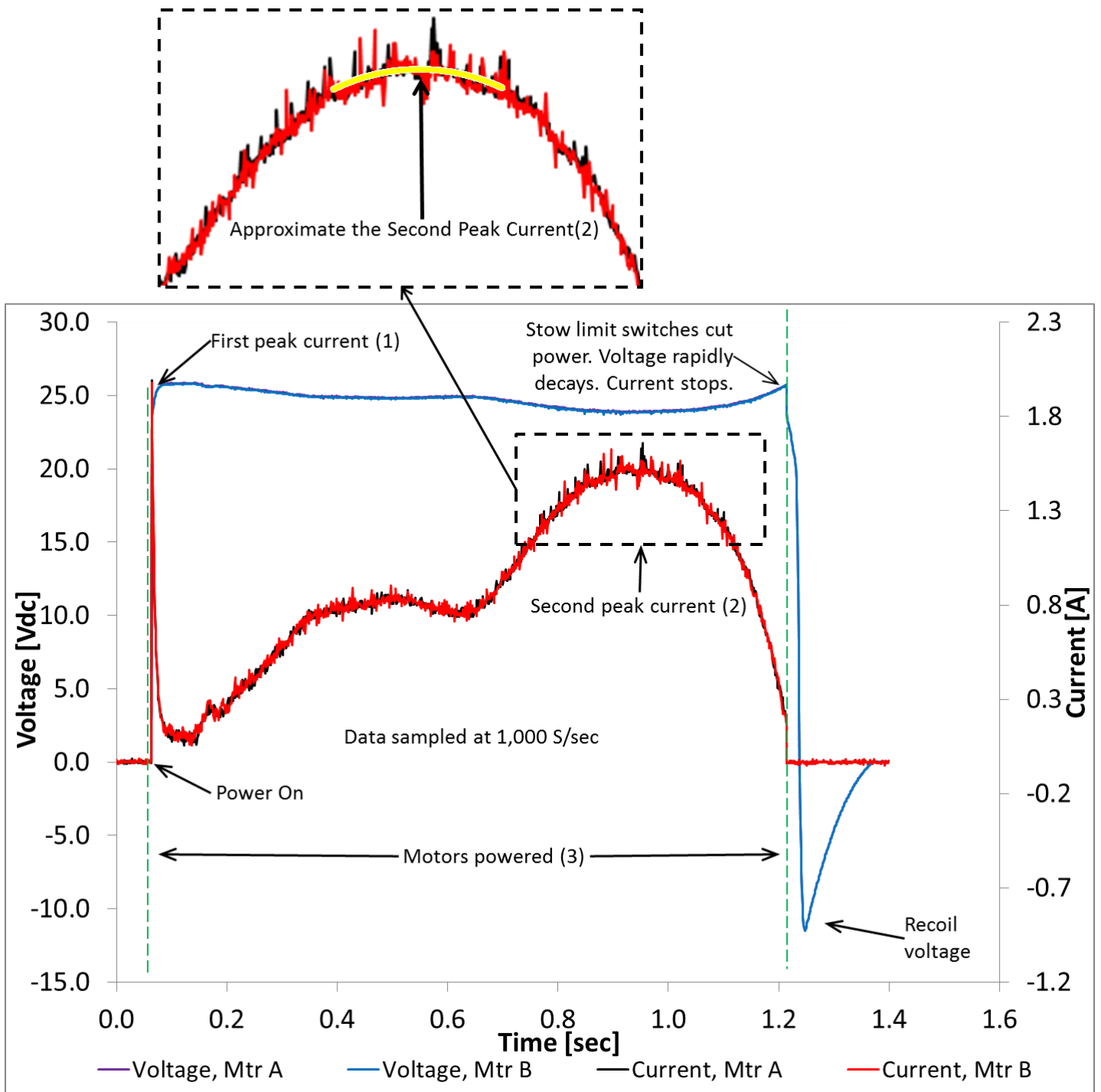


Figure 21: Typical stow voltage and current profiles at P = 1.0 Atm and T = +23 deg C

Table 1: Stow Electrical Verification

Stow Electrical Parameters							
MLB Size	Item	Description	Units	Allowable		Actual	
				Min	Max	Motor A	Motor B
8.000-12	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	0.5	1.4		
	3	Motors powered duration	sec	0.55	1.10		
11.732-18	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	0.8	1.5		
	3	Motors powered duration	sec	0.6	1.1		
13.000-20	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	0.9	1.7		
	3	Motors powered duration	sec	0.65	1.1		
15.000-24	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	1.0	1.8		
	3	Motors powered duration	sec	0.65	1.1		
18.250-28	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	1.1	1.8		
	3	Motors powered duration	sec	0.65	1.2		
19.848-28	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	1.2	1.8		
	3	Motors powered duration	sec	0.8	1.2		
23.250-32	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	1.2	2.1		
	3	Motors powered duration	sec	0.8	1.3		
24.000-36	1	First peak current	A/mtr	1.9	3.0		
	2	Second peak current	A/mtr	1.2	2.1		
	3	Motors powered duration	sec	0.8	1.3		
31.600-48	1	First peak current	A/mtr	2.15	3.2		
	2	Second peak current	A/mtr	1.6	2.3		
	3	Motors powered duration	sec	0.7	1.3		
38.810-60	1	First peak current	A/mtr	2.15	3.2		
	2	Second peak current	A/mtr	1.6	2.3		
	3	Motors powered duration	sec	0.7	1.3		

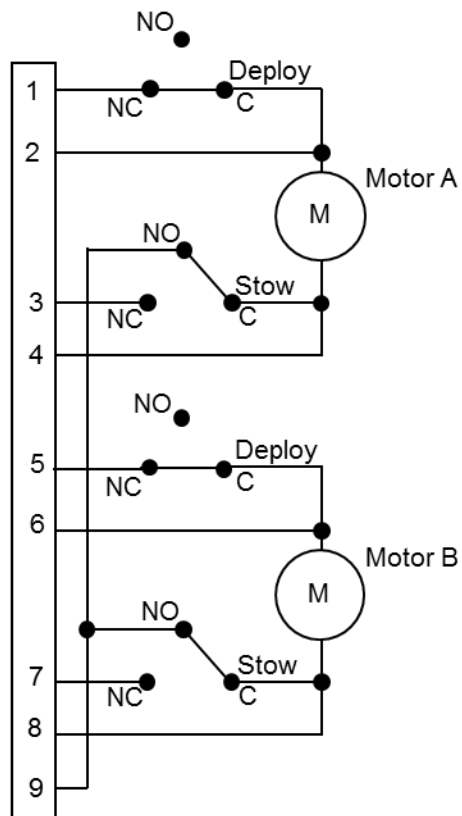


Figure 22: Switch state after Lightband has been stowed

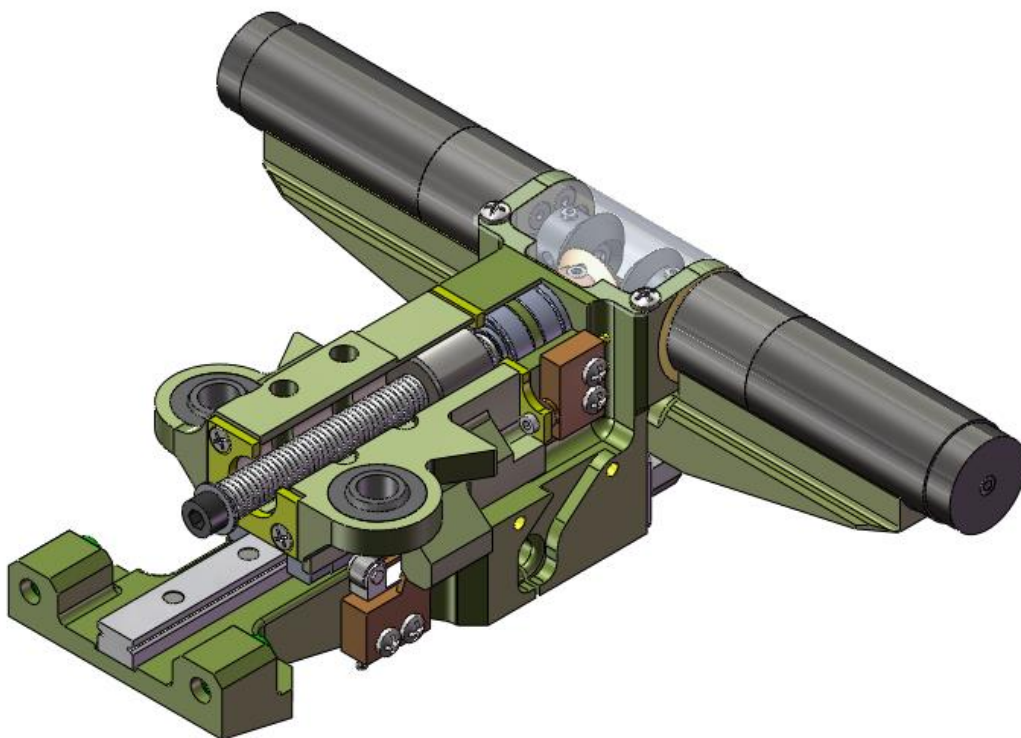


Figure 23: Motor Bracket Assembly shown stowed

8. Setting-for-Flight the Lightband

8.1 Setting the Lightband for Flight

Step	Procedure	Date, Time & Initials	
		Tech.	QA
8.1.1	Voltage and Current for each motor shall be measured and recorded for every operation. This procedure incorporates an oscilloscope to measure and record data. Other methods may be used. Ensure data is measured and recorded at a sample rate of no less than 1,000 samples per second and resolution of no less than 0.02 Amps and 0.1 Volts. Caution: If oscilloscope channels share common ground be cognizant of their effect on the circuit.		
8.1.2	Set up the 'Set-for-Flight – Power and Measurement Circuit' per Figure 24. Do not connect the Lightband.		
8.1.3	May skip this step if no components/wiring were added since stowing. Verify the resistance between the power supply and Lightband connector is less than 1.0 ohm for each motor. This applies to the complete loop (power and return).		
8.1.4	Set the voltage at 15 to 16 Vdc.		
8.1.5	Set the current limit on the power supply to 3.5 ±0.1 A.		
8.1.6	Set the timer relay to apply power for 1.4 ±0.05 sec.		
8.1.7	Set up the 'Set-for-Flight – Test Circuit' per Figure 24. This uses a 10 ohm resistor (≥30 W) to simulate each Lightband Motor.		
8.1.8	Connect the 'Set-for-Flight – Test Circuit' to the 'Set-for-Flight – Power and Measurement Circuit' per Figure 24. When ready, apply power and verify the following: 1) The entire voltage and current profiles for both "motors" are measured. 2) Timer relay applies power for specified time. 3) Current for each "motor" is about 1/10 of applied voltage. ($I=V/R$). 4) Data properly saves (transferable data set; e.g. viewable on computer, picture in focus, etc.). If any parameters are not met, make the required changes and run the test circuit again. The test circuit may be run as many times as necessary to ensure the power and measurement circuit is performing as required. Upon completion of this step the 'Set-for-Flight – Power and Measurement Circuit' shall not be changed.		
8.1.9	Remove the 'Set-for-Flight – Test Circuit' and connect the Lightband to the 'Set-for-Flight – Power and Measurement Circuit' per Figure 25. Do not apply power to the Lightband.		

Step	Procedure	Date, Time & Initials	
		Tech.	QA
8.1.10	<p>When ready apply power to set-for-flight the Lightband. The motors will free run for ~1.1 seconds and then the Sliding Tube will move off the stow limit switches. This will be apparent when the current spikes, begins to cycle on and off rapidly and/or chatter is heard coming from the Motor Bracket Assembly, stimulating an electro-mechanical natural frequency.</p> <p>If the current limit is reached or the timer relay runs longer than the specified time manually cut power. Contact PSC immediately. A visual inspection of the Lightband may be performed, but do not change configuration.</p>		
8.1.11	Save the voltage and current profiles for both motors. It is acceptable to take a picture of the oscilloscope screen; however raw data and high fidelity graphs are preferred.		
8.1.12	Figure 26 shows typical set-for-flight voltage and current profiles. Complete Table 2 to verify all parameters are within tolerance. Single data point exceedances are acceptable. Also, a slow sample rate may alias data. Do not filter data. Contact PSC if a discrepancy is found.		
8.1.13	Figure 27 shows the state of the switches in the Motor Bracket Assembly after the Lightband has been set-for-flight. Measure resistance directly at the Lightband's DB-9 socket connector by completing Table 4. See Figure 44. Contact PSC if a discrepancy is found.		

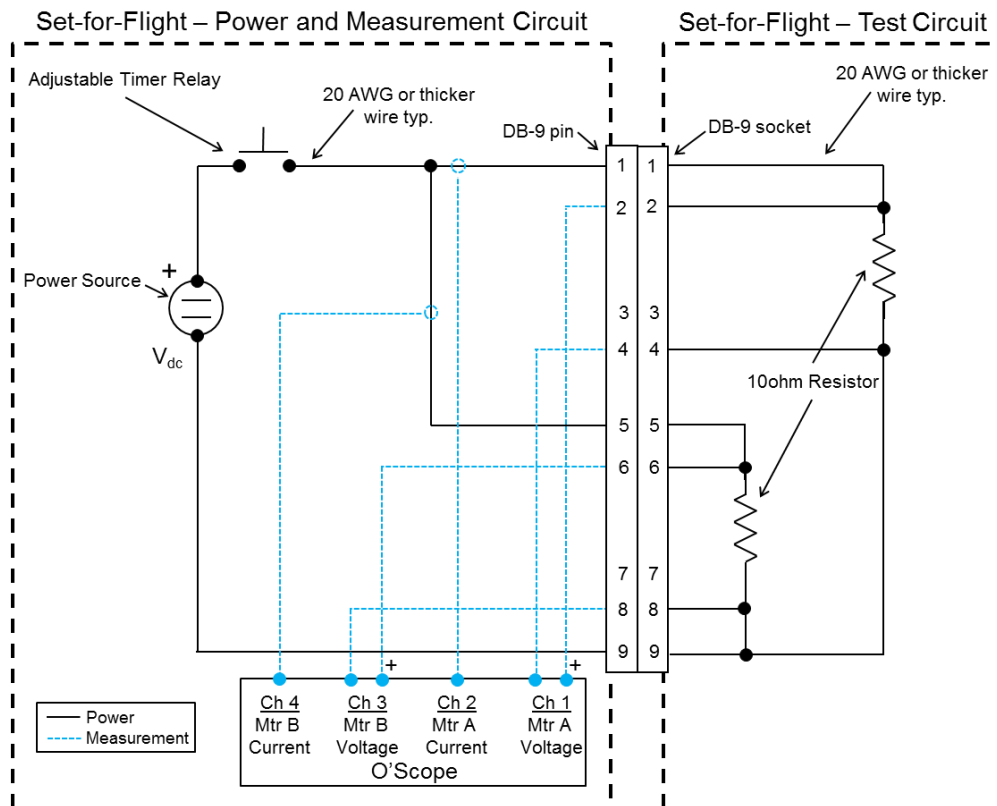


Figure 24: Set-for-Flight Test Circuit

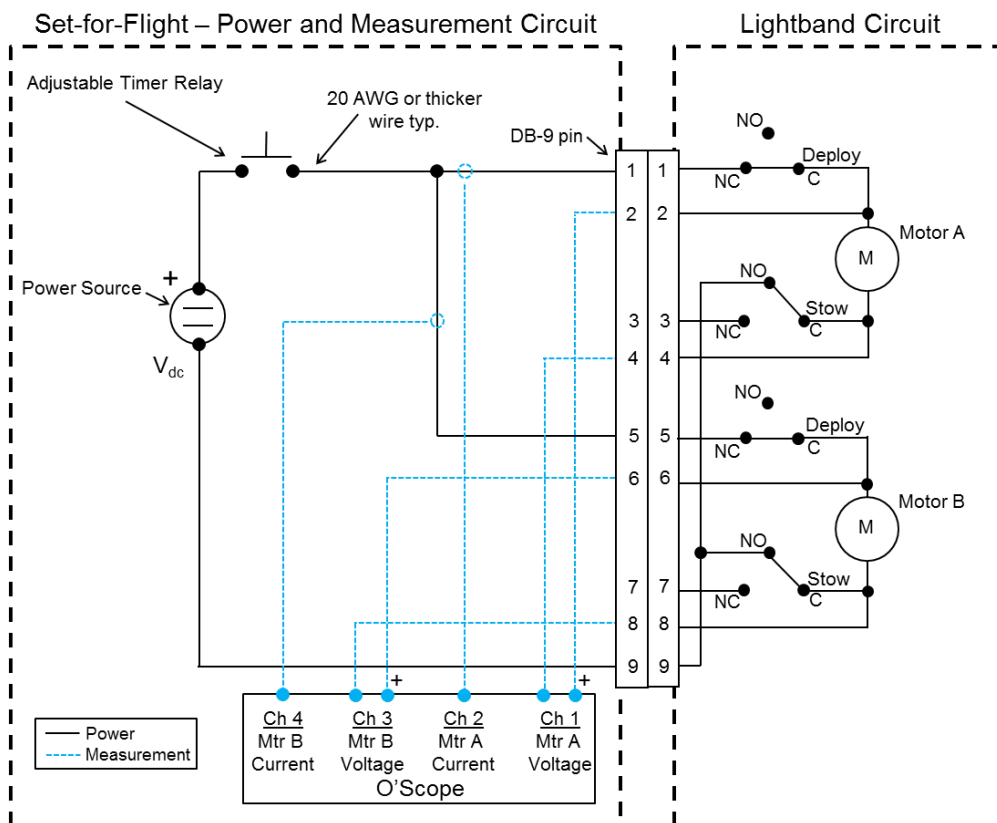


Figure 25: Set-for-Flight Circuit

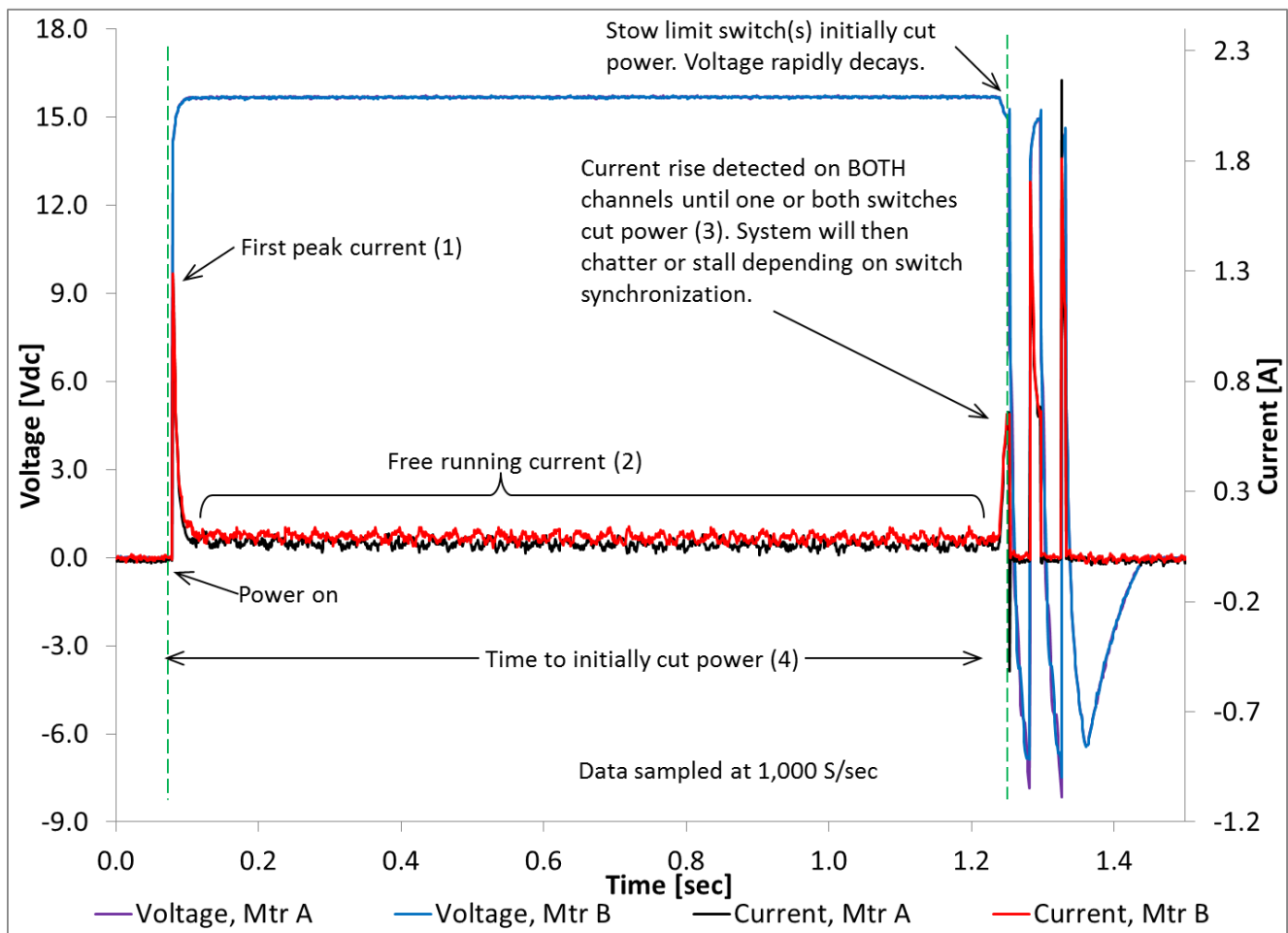


Figure 26: Typical set-for-flight voltage and current profiles at P = 1.0 Atm and T = +23 deg C

Table 2: Set-For-Flight Electrical Verification

Set-For-Flight Electrical Parameters						
Item	Description	Units	Allowable		Actual	
			Min	Max	Motor A	Motor B
1	First peak current	A/mtr	1.05	1.7		
2	Free-running current (average)	A/mtr	0.02	0.18		
3	Post free-run current rise	A/mtr	0.2	1.7		
4	Time to initially cut power*	sec	1.0	1.3		

*It is acceptable for 1 motor to exceed the maximum allowed time to initially cut power.

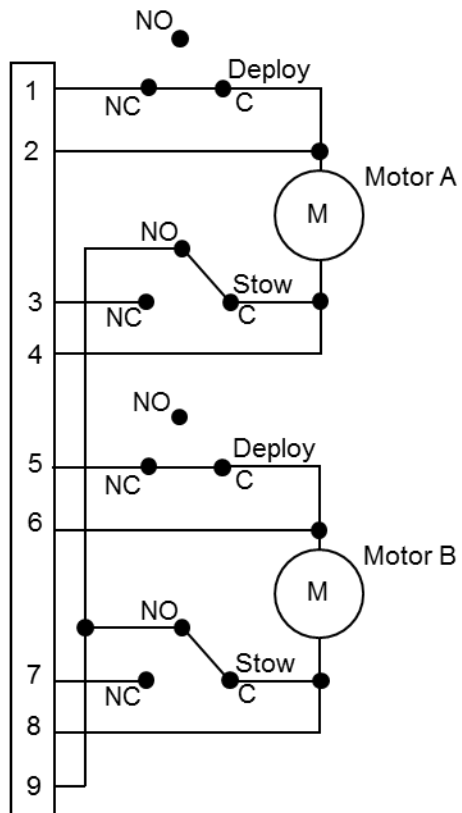


Figure 27: Switch state after Lightband has been set-for-flight.

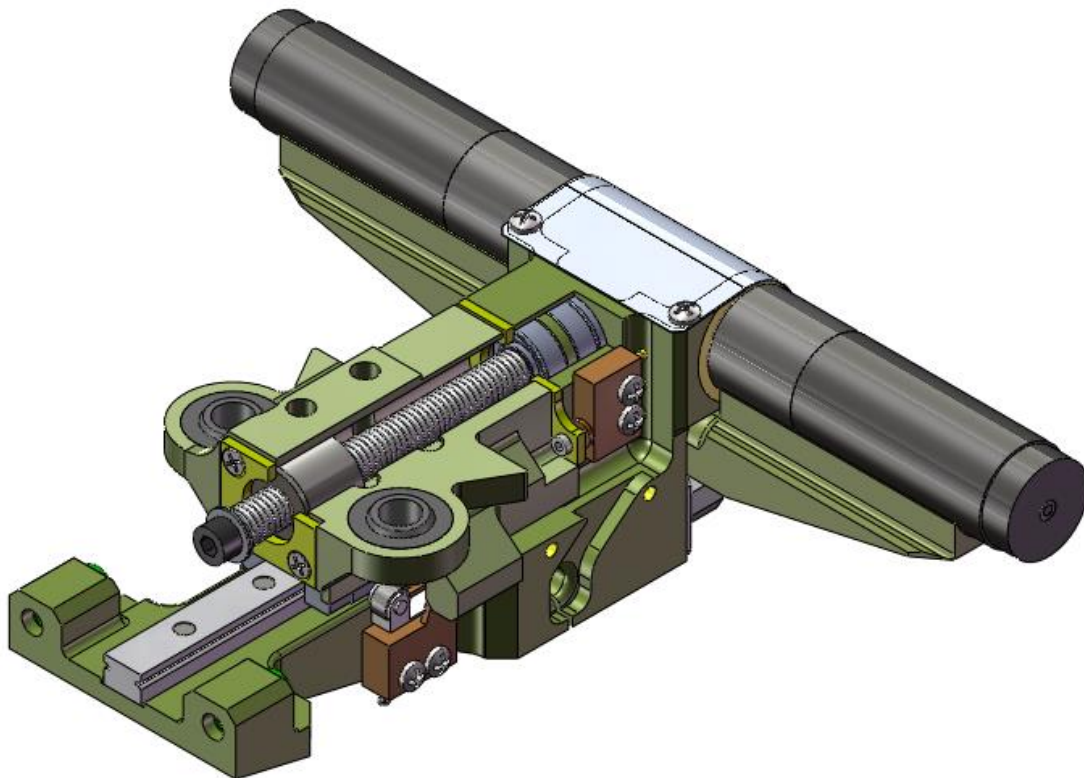


Figure 28: Motor Bracket Assembly shown set-for-flight

9. Deploying the Lightband

9.1 Deploying the Lightband

Step	Procedure	Date, Time & Initials	
		Tech.	QA
9.1.1	<p>Voltage and Current for each motor shall be measured and recorded for every operation. This procedure incorporates an oscilloscope to measure and record data. Other methods may be used. Ensure data is measured and recorded at a sample rate of no less than 1,000 samples per second and resolution of no less than 0.02 Amps and 0.1 Volts.</p> <p>Caution: If oscilloscope channels share common ground be cognizant of their effect on the circuit.</p>		
9.1.2	<p>Set up the 'Deploy – Power and Measurement Circuit' per Figure 29.</p> <p>Incorporate an adjustable timer relay to precisely control the time power is applied. See Figure 43. Do not connect the Lightband.</p>		
9.1.3	<p>May skip this step if no components/wiring were added since set-for-flight.</p> <p>Verify the resistance between the power supply and Lightband connector is less than 1.0 ohm for each motor. This applies to the complete loop (power and return).</p>		
9.1.4	Set the voltage at 24 to 32 Vdc . When possible use the minimum voltage as this maximizes the Lightband's operating life.		
9.1.5	Set the current limit on the power supply to 6.5 ±0.1 A .		
9.1.6	Set the timer relay to apply power for 0.5 ±0.05 sec .		
9.1.7	<p>Set up the 'Deploy – Test Circuit' per Figure 29.</p> <p>This uses a 10 ohm resistor (≥100 W) to simulate each Lightband motor.</p>		
9.1.8	<p>Connect the 'Deploy – Test Circuit' to the power supply. When ready, apply power and verify the following:</p> <ol style="list-style-type: none"> 1) The entire voltage and current profiles for both "motors" are measured. 2) Timer relay applies power for specified time. 3) Current for each "motor" is about 1/10 of applied voltage. ($I=V/R$). 4) Data properly saves (transferable data set; e.g. viewable on computer, picture in focus, etc.). <p>If any parameters are not met, make the required changes and run the test circuit again. The test circuit may be run as many times as necessary to ensure the power and measurement circuit is performing as required. Upon completion of this step the 'Deploy – Power and Measurement Circuit' shall not be changed.</p>		

Step	Procedure	Date, Time & Initials	
		Tech.	QA
9.1.9	<p>The Upper Ring shall be constrained during deployment. If separating (allowing the Separation Springs to fully extend) skip to step 9.1.10. If separating is not required, then a force shall be applied to prevent movement of the Upper Ring. Apply a compressive force on the Upper Ring per the calculations below.</p> <p>Separation Spring quantity = _____</p> <p>Minimum Compressive Force = ____ springs x 20 lb = ____ lb</p> <p>Maximum Compressive Force = ____ springs x 30 lb = ____ lb</p> <p>Offload any object heavier than the maximum compression force.</p> <p>Skip to step 9.1.11.</p>		
9.1.10	<p>If separating (allowing the Separation Springs to fully extend) it is required to constrain the Upper Ring after the Separation Springs reach end of stroke. Deploy Upper Ring Stops or similar shall be used. See Section 14. If separating with a mass attached to the Upper Ring you must offload the weight of the mass to achieve separation (elongation of Separation Springs).</p> <p>Separation Spring quantity = _____</p> <p>Maximum Tensile Force = ____ springs x 5 lb = ____ lb</p> <p>Maximum Compressive Force = ____ springs x 5 lb = ____ lb</p> <p>If Separation Springs are placed asymmetrically the Upper Ring may not remain parallel to the Lower Ring as the Lightband Separates. If separating a Lightband with Roll Brackets consult PSC on how to constrain the Upper Ring.</p>		
9.1.11	Remove the 'Deploy – Test Circuit' and connect the Lightband to the 'Deploy – Power and Measurement Circuit' per Figure 30. Do not apply power to the Lightband.		
9.1.12	<p>When ready apply power to deploy the Lightband. The Lightband should separate in less than 0.1 seconds. The deploy limit switches on the Motor Bracket Assembly will automatically cut power to the motors.</p> <p>If a force was applied per step 9.1.9 the Upper Ring will not move. This force will be removed at a later step, allowing the Separation Springs to extend.</p> <p>If the current limit is reached or the timer relay runs longer than the specified time manually cut power. Contact PSC immediately. A visual inspection of the Lightband may be performed, but do not change configuration.</p>		
9.1.13	Save the voltage and current profiles for both motors. It is acceptable to take a picture of the oscilloscope screen; however raw data and high fidelity graphs are preferred.		
9.1.14	Figure 31 shows typical deploy voltage and current profiles. Complete Table 3 to verify all parameters are within tolerance. Single data point exceedances are acceptable. Also, a slow sample rate may alias data. Do not filter data. Contact PSC immediately if a discrepancy is found.		
9.1.15	Slowly remove the weight/force on the Upper Ring, allowing the Separation Springs to elongate.		

Step	Procedure	Date, Time & Initials	
		Tech.	QA
9.1.16	Figure 32 shows the state of the switches in the Motor Bracket Assembly after the Lightband has been properly deployed. Measure resistance directly at the Lightband's DB-9 connector by completing Table 4. See Figure 44. Contact PSC if a discrepancy is found.		

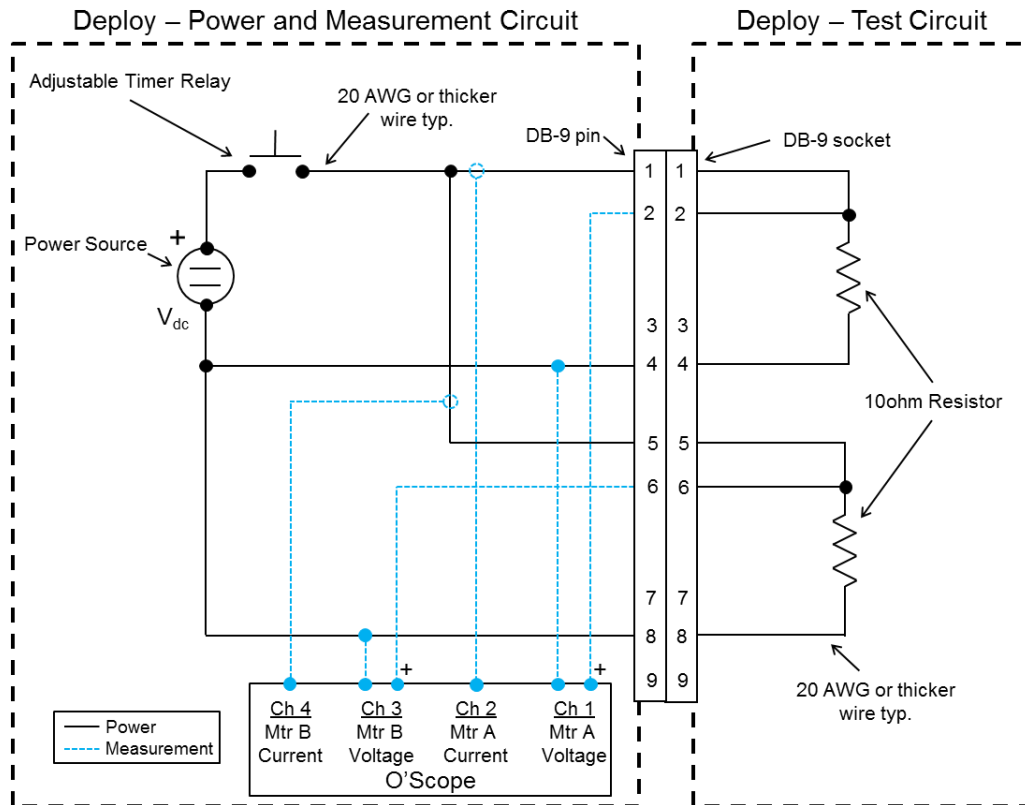


Figure 29: Deploy Test Circuit

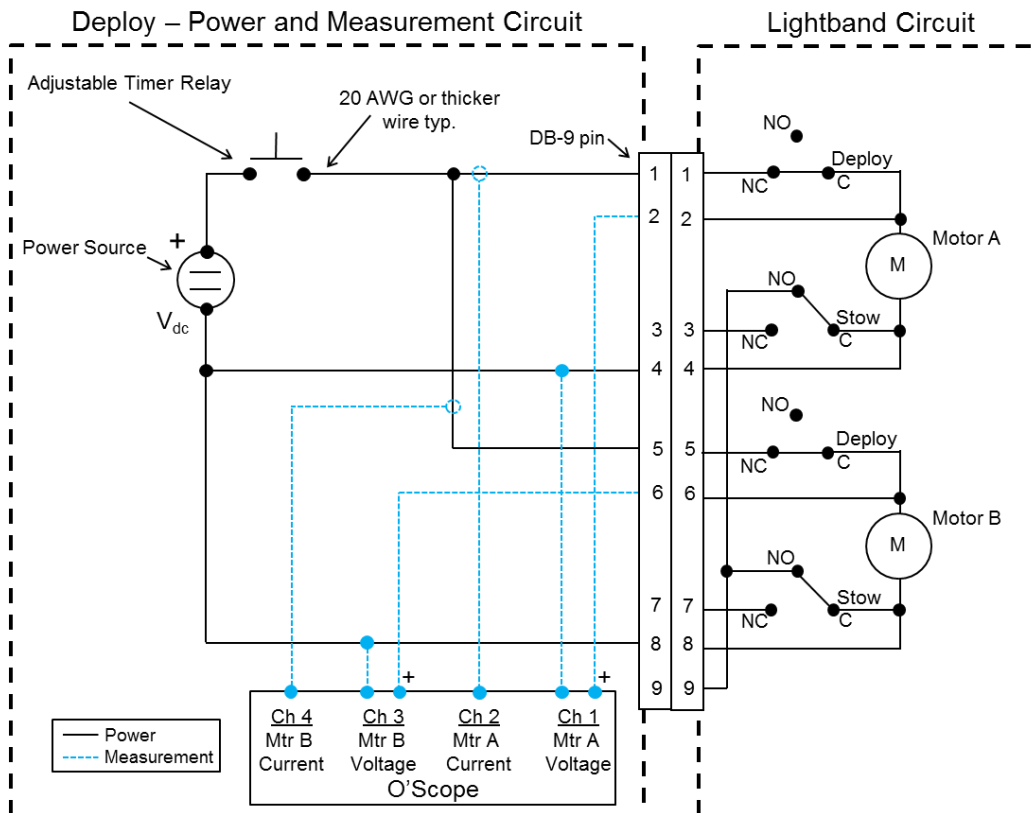


Figure 30: Deploy Circuit

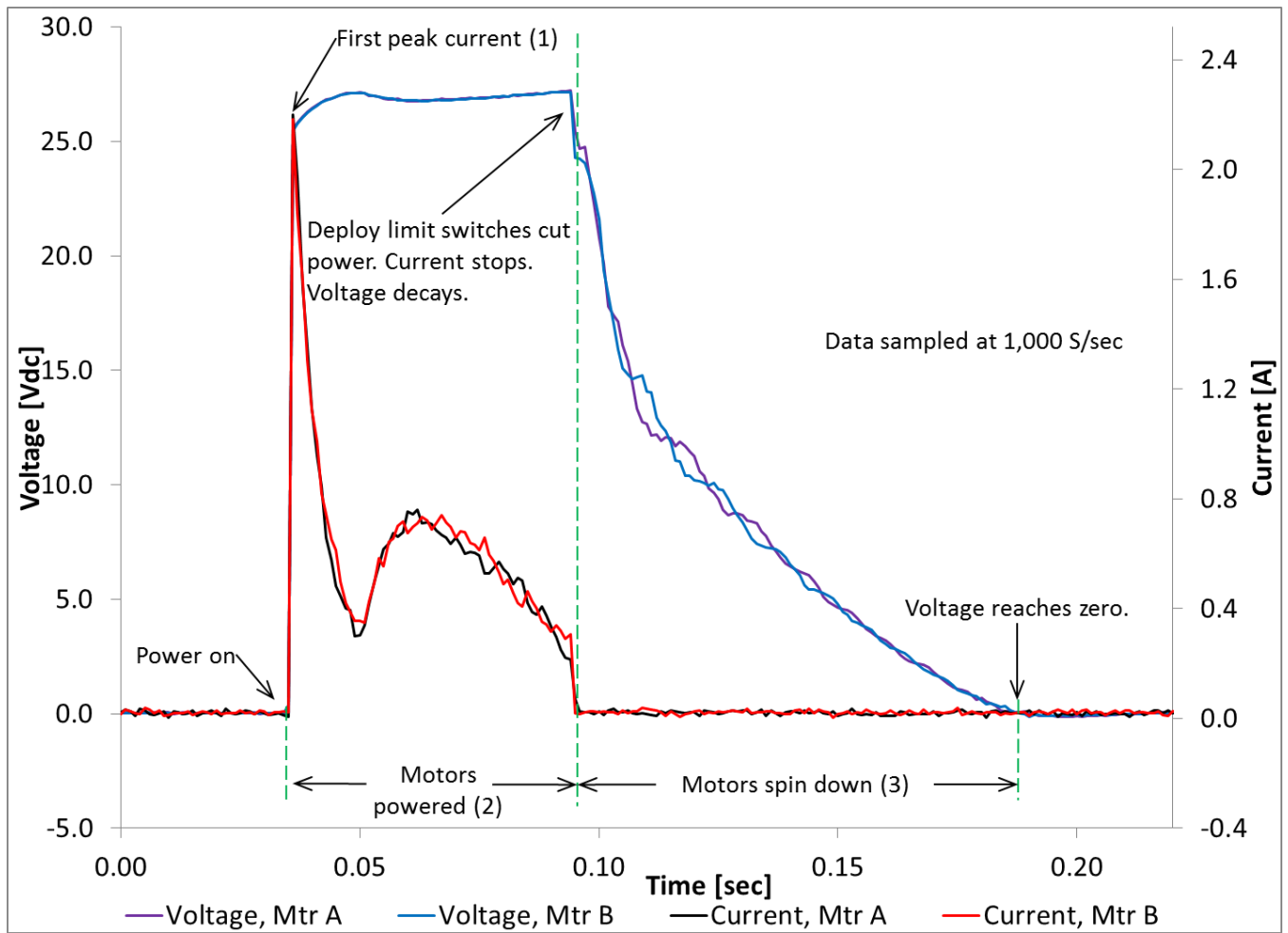


Figure 31: Typical deploy voltage and current profiles at P = 1.0 Atm and T = +23 deg C

Table 3: Deploy Electrical Verification

Deploy Electrical Parameters						
Item	Description	Units	Allowable		Actual	
			Min	Max	Motor A	Motor B
1	First peak current	A/mtr	1.7	3.5		
2	Motor powered duration	sec	0.045	0.10		
3	Motor spin down duration	sec	0.03	0.40		

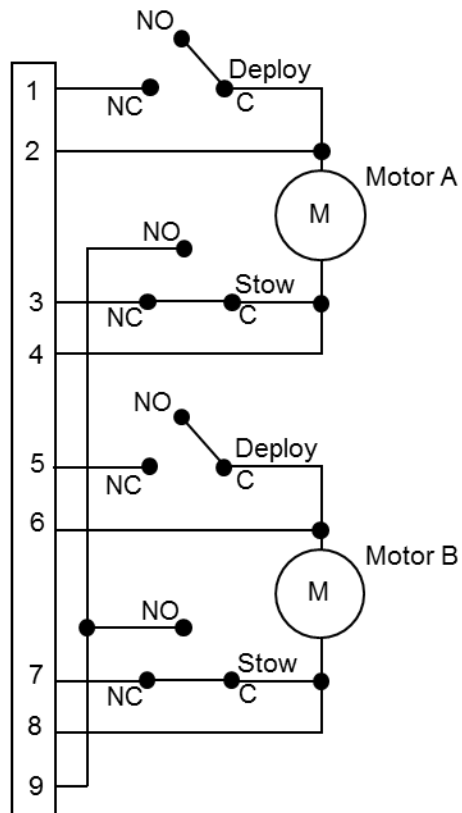


Figure 32: Switch state after Lightband has been deployed.

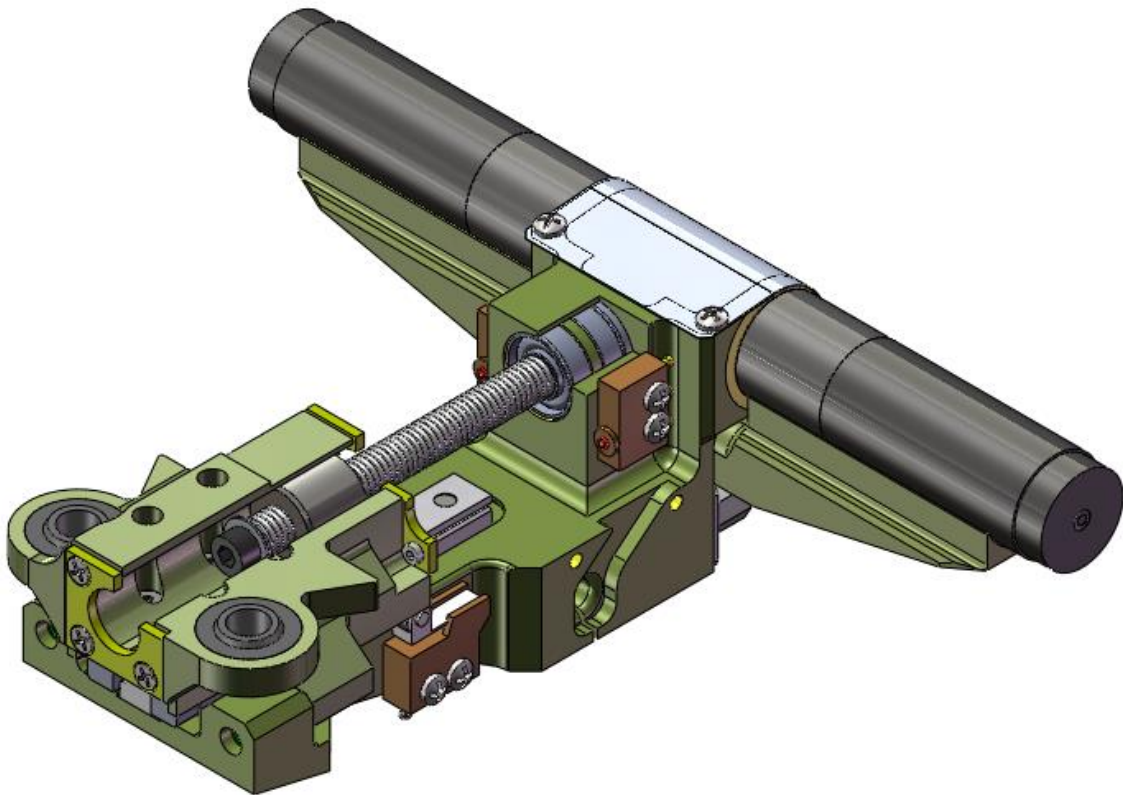


Figure 33: Motor Bracket Assembly shown deployed

10. Removing the Lightband from Adjoining Structures

10.1 Unbolting the Upper and Lower Rings

Step	Procedure	Date, Time & Initials	
		Tech.	QA
10.1.1	<p>Removing the Lower Ring on a MLB 15.000-24 only: All other sizes shall omit step.</p> <p>Remove the Lower Ring by reversing step 6.1.6. If adjoining structure holes were threaded, back out the fasteners slowly to prevent jamming the heads against the Leaf Pins. Once all fasteners are loose, hold the washer against the Lower Ring and pull the screw out separately. Push the Leaf Pins to either side if they rub the screw head. See Figure 34 & Figure 35. Skip to step 10.1.3.</p>		
10.1.2	<p>Removing the Lower Ring on all Lightbands other than a MLB 15.000-24.</p> <p>Remove the Lower Ring by reversing step 6.1.7.</p> <p>It is often helpful to hold the washer against the Lower Ring while pulling the screw out separately. See Figure 34 & Figure 35.</p>		
10.1.3	Remove the Upper Ring from the adjoining structure by reversing step 6.1.9.		



Figure 34: Removing a SHC screw from the Lower Ring, outer view



Figure 35: Removing a SHC screw from the Lower Ring, inner view

11. Preparing the MLB to be compressed

The position of the Sliding Tube determines whether the MLB can be compressed. Hence, before the MLB is compressed it is imperative that the Sliding Tube is able to move fully radially inward such that it can contact the Motor Bracket deploy hard stops per step 7.1.3. See Figure 15.

Step	Procedure	Date, Time & Initials	
		Tech.	QA
11.1.1	There are a number of possible reasons for executing this section. The most common occurs when unpacking the MLB as it is shipped with the Sliding Tube pre-loaded against the Motor Bracket stow hard stop to inhibit motion during shipping.		
11.1.2	Set up the 'Sliding Tube – Power Circuit' per Figure 38. Do not connect the Lightband.		
11.1.3	Verify the resistance between the power supply and Lightband connector is less than 1.0 ohm for each motor. This applies to the complete loop (power and return).		
11.1.4	Set the voltage at 8 ±0.5 Vdc.		
11.1.5	Set the current limit on the power supply to 1.8 ±0.1 A.		
11.1.6	Set the timer relay to apply power for 5.0 ±0.5 sec.		
11.1.7	Set up the 'Sliding Tube – Test Circuit' per Figure 38. This uses a 10 ohm resistor (≥30 W) to simulate each Lightband motor.		
11.1.8	Connect the 'Sliding Tube – Test Circuit' to the power supply. When ready, apply power and verify the following: <ul style="list-style-type: none"> Current for each "motor" is about 1/10 of applied voltage. ($I=V/R$). (This can be verified by reading the voltage and current on the power supply.) <p>If any parameters are not met, make the required changes and run the test circuit again. The test circuit may be run as many times as necessary to ensure the power circuit is performing as required. Upon completion of this step the 'Sliding Tube – Power Circuit' shall not be changed.</p>		
11.1.9	Remove the 'Sliding Tube – Test Circuit' and connect the Lightband to the 'Sliding Tube – Power Circuit' per Figure 39. Do not apply power to the Lightband.		
11.1.10	Manually push the Sliding Tube radially outwards (towards the motors) with one finger when the power is applied to the Lightband. See Figure 36. Ensure nothing is touching the Ball Screw and that your finger is not on the surfaces shown in Figure 37.		
11.1.11	When ready apply power to move the Sliding Tube. The Sliding Tube will move radially inward until the deploy limit switches on the Motor Bracket Assembly automatically cut power to the motors. If the current limit is reached or the timer relay runs longer than the specified time manually cut power. Contact PSC immediately.		
11.1.12	Ensure that the Sliding Tube is able to move fully radially inward such that it contacts the Motor Bracket deploy hard stops. See Figure 15. If applicable, continue to step 7.1.3.		

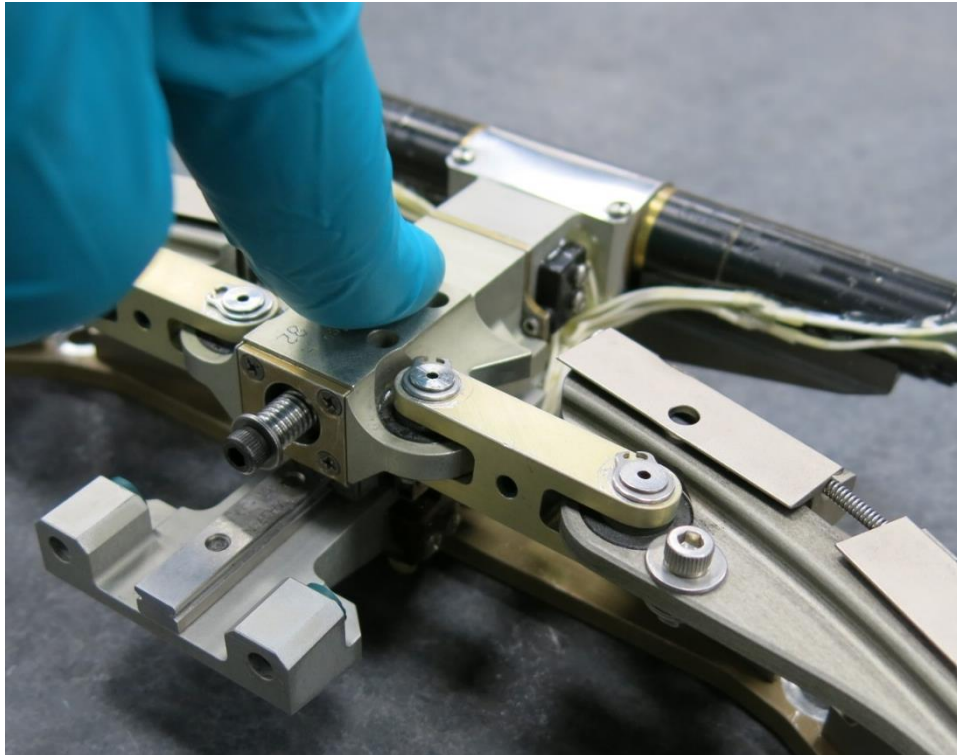


Figure 36: Properly pushing Sliding Tube radially outward

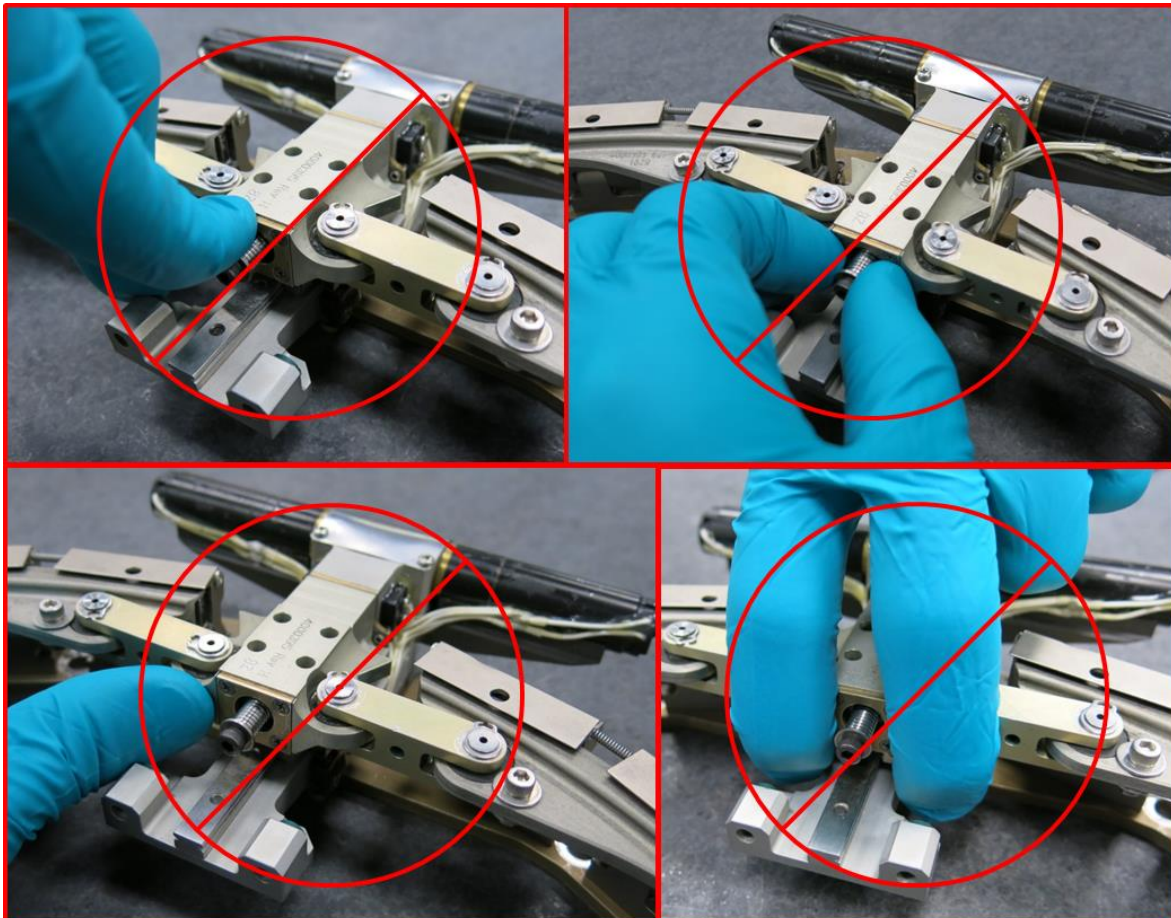


Figure 37: Improperly pushing Sliding Tube radially outward

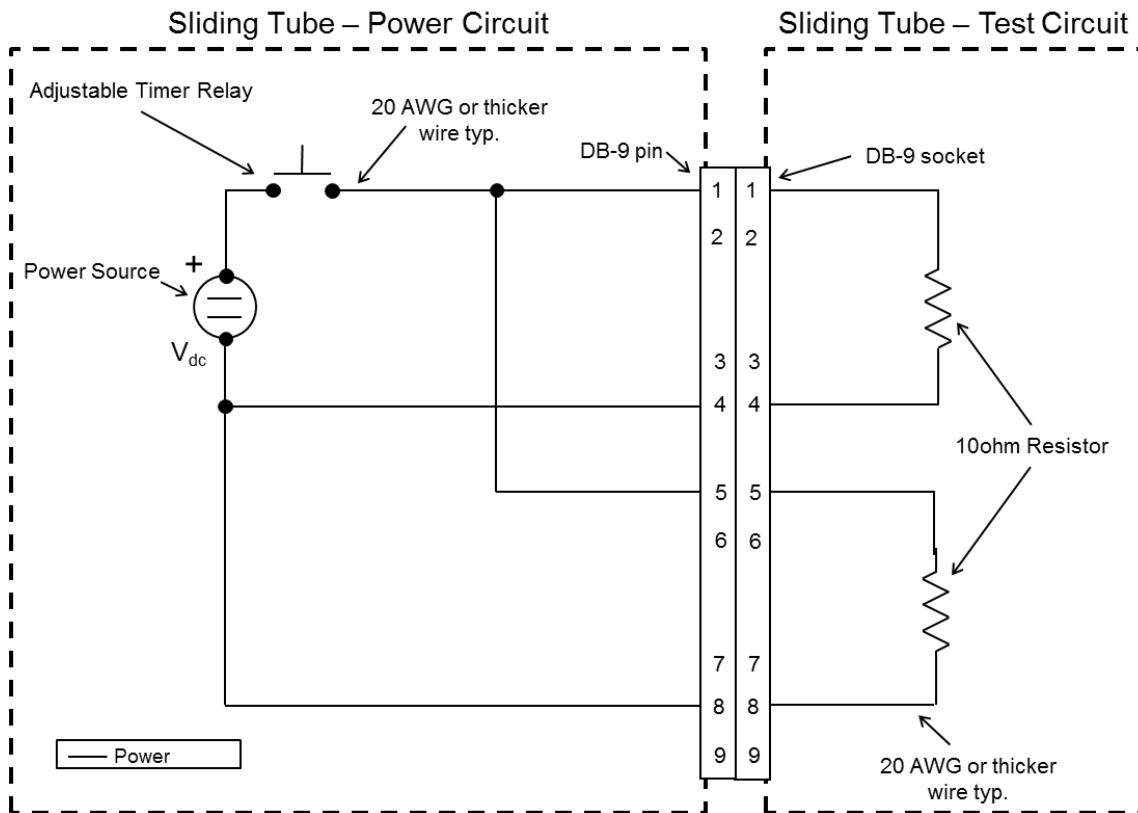


Figure 38: Sliding Tube Test Circuit

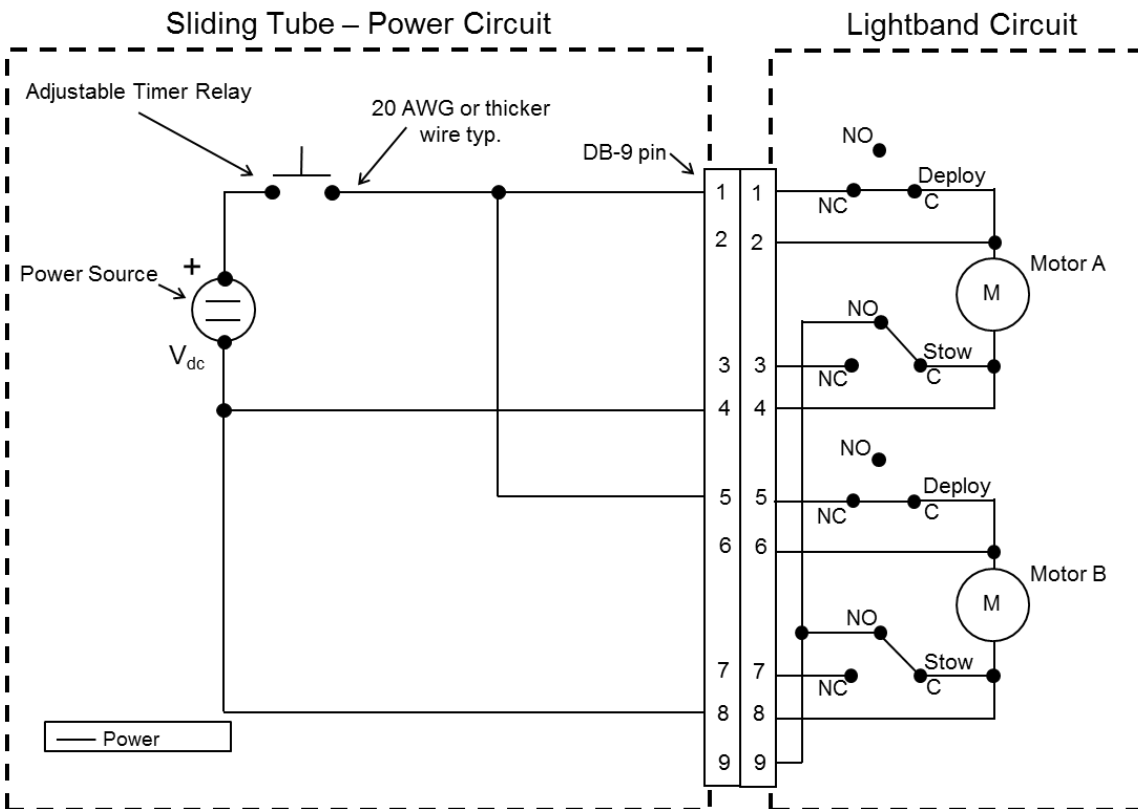


Figure 39: Sliding Tube Circuit

12. Horizontal Integration (Optional)

Horizontal integration may be necessary due to space vehicle (SV) and/or launch vehicle (LV) limitations. This section describes the steps and precautions necessary to ensure proper stowing of the Lightband.

12.1 Compressing the Lightband

Step	Procedure	Date, Time & Initials	
		Tech.	QA
12.1.1	Is an isolation system attached to the Lower Ring? If so, it may be easier to stow the Lightband with transition rings, remove the transition rings, and then bolt the already mated Lightband to the LV and SV. Contact PSC for details.		
12.1.2	The Lower Ring, mounted to the LV, shall be perpendicular to level within $\pm 0.2^\circ$. See Figure 40.		
12.1.3	Micro-adjustment of the SV height, pitch and roll is essential. This can be accomplished with a hydro-set, vernier screws, turnbuckles, etc.		
12.1.4	The structure supporting the SV (crane, tilt-cart, etc.) shall have sufficient compliance to allow for SV movement when stowing. The vertical stiffness shall be less than 2,000 lb/in. Consider and verify compliance in ALL 6 degrees of freedom (DOF). For instance, will the crane stretch, the tilt cart compress or even be lifted up? Can the SV pitch, roll or yaw as necessary?		
12.1.5	A load cell shall be installed in-line with the SV support structure.		
12.1.6	Move the SV close to the LV until the tips of the Separation Springs are close to the bottom edge of the Upper Ring (<0.5 in) but not yet overlapping. Align the Upper Ring to the Lower Ring in translation and rotation. See step 7.1.7 for alignment features. Ensure the springs will not be inhibited from engaging their corresponding holes in the Upper Ring flange. It is essential to align all 6 SV DOF prior to actually compressing the Lightband. See Figure 41.		
12.1.7	Verify no part of the Lower Ring is contacting the Upper Ring and then record the SV load cell reading: _____		
12.1.8	Move the SV closer to the LV until the conical tips of the Separation Springs are <0.10 in from the Upper Ring flange. ALL spring tips shall be centered in their corresponding Upper Ring flange holes. The lower and Upper Rings shall be parallel within 0.02 in. Adjust the SV alignment as necessary. The load cell shall remain within 10 lb of the step 12.1.7 reading.		
12.1.9	Move the SV closer to the LV until the conical tips of ALL Separation Springs are engaged and centered in the Upper Ring flange holes. The lower and Upper Rings shall be parallel within 0.01 in. Adjust the SV alignment as necessary. The load cell shall remain within 10 lb of the step 12.1.7 reading.		
12.1.10	Slowly compress the Lightband. See Section 14 if using the Lightband Compression Tool (LCT). Continually monitor the load cell. It shall remain within 10 lb of the step 12.1.7 reading. When fully compressed the distance between Lightband flanges shall conform to Step 7.1.10. Also verify that the flange distance at the top, bottom, left and right of the Lightband are within 0.005 in of one another. See Figure 42. An improperly aligned SV may move up or down, left or right, pitch, roll and yaw during the stow process, requiring additional power that the Lightband motors cannot generate. Proper alignment is essential.		
12.1.11	Record final load cell reading: _____		
12.1.12	Return to Section 7.2 to stow the Lightband.		

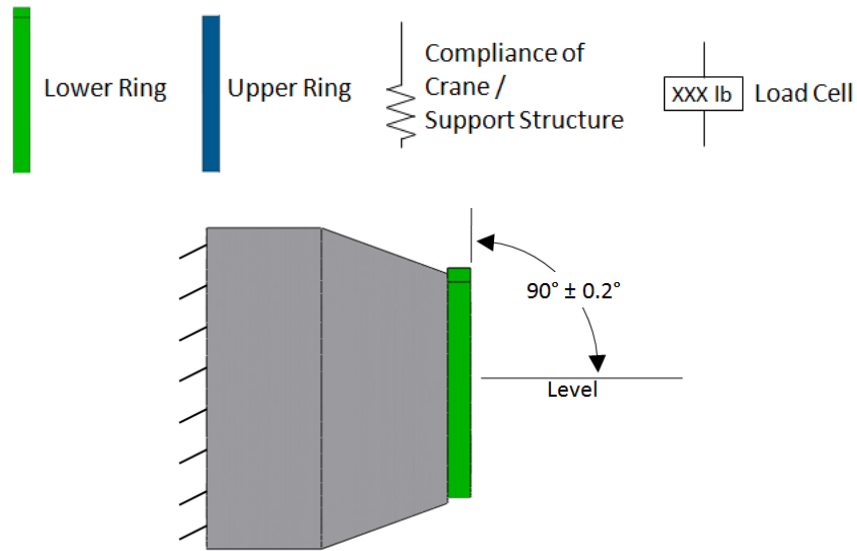


Figure 40: Verify Lower Ring is leveled prior to mating SV.

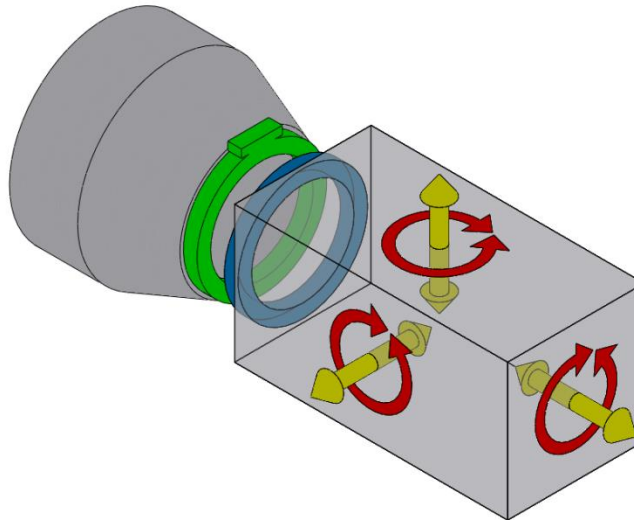


Figure 41: Be cognizant of translational AND rotational alignment AND compliance.

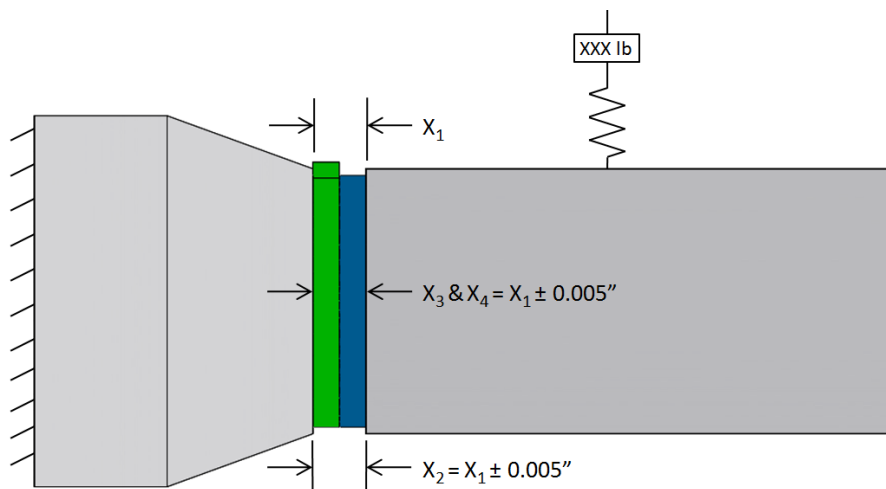


Figure 42: Verify parallelism of compressed Lightband.

13. Lightband Electrical Verification

Measuring the electrical resistance of components in the Motor Bracket Assembly is essential for verifying proper functionality and diagnosing potential problems. Take the measurements directly at the Lightband electrical interface (DB-9 socket connector). See Figure 44. Motor resistance may vary slightly depending on commutator position. Contact PSC and do not operate the Lightband if any value is out of spec.

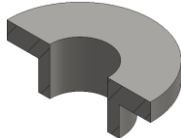




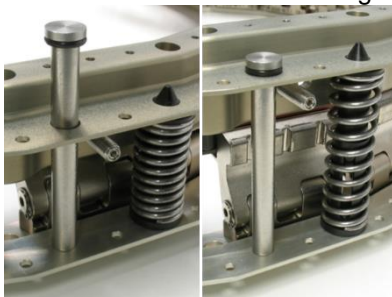
PSC recommends using a DMM. It will not cause damage to or operate the Lightband. If using a milliohm meter, four wire Kelvin probe system, ensure the test current is <0.01 A to prevent rotating the motors.

Table 4: Motor Bracket Assembly Resistance Measurement

Motor Bracket Resistances				
Lightband State	Object Being Measured	Pin Connections	Resistance [ohm]	
			Allowable	Measured
Post Stow	Motor A	2 , 4	8.0 - 11.0	
	Motor B	6 , 8	8.0 - 11.0	
	Deploy Limit Switch A	1 , 2	< 0.3	
	Deploy Limit Switch B	5 , 6	< 0.3	
	Stow Limit Switch A	3 , 4	> 1E6	
	Stow Limit Switch B	7 , 8	> 1E6	
	Stow Limit Switch A	4 , 9	< 0.3	
	Stow Limit Switch B	8 , 9	< 0.3	
Post Set-For-Flight	Motor A	2 , 4	8.0 - 11.0	
	Motor B	6 , 8	8.0 - 11.0	
	Deploy Limit Switch A	1 , 2	< 0.3	
	Deploy Limit Switch B	5 , 6	< 0.3	
	Stow Limit Switch A	3 , 4	> 1E6	
	Stow Limit Switch B	7 , 8	> 1E6	
	Stow Limit Switch A	4 , 9	< 0.3	
	Stow Limit Switch B	8 , 9	< 0.3	
	Motor A Deploy Circuit	1 , 4	8.0 - 11.0	
	Motor B Deploy Circuit	5 , 8	8.0 - 11.0	
Post Deploy	Motor A	2 , 4	8.0 - 11.0	
	Motor B	6 , 8	8.0 - 11.0	
	Deploy Limit Switch A	1 , 2	> 1E6	
	Deploy Limit Switch B	5 , 6	> 1E6	
	Stow Limit Switch A	3 , 4	< 0.3	
	Stow Limit Switch B	7 , 8	< 0.3	

14. Best Practices and Lessons Learned

The following is a table of best practices and lessons learned over years of Lightband operation and training. These are not required for proper Lightband operation. Unless noted, PSC will not directly supply any of the items listed below, however the drawings/schematics are available upon request.

Tip #	Step(s)	Best Practice / Lesson Learned	References
1	6.1.3	If using #10 fasteners (0.19 in dia) to attach Lightband, PSC requires using shoulder washers to center the fastener. You shall receive permission directly from PSC for use of #10 fasteners on a flight unit.	PSC Doc 4000669 
2	6.1.6	On the MLB 15.000-24 PSC has used ¼-28 SHC fasteners with the head diameter reduced to 0.340 in. This eliminates the interference fit described in step 6.1.6.	PSC Doc 4000845 
3	7.1.1	PSC uses custom aluminum transition rings as adjoining structures for all Lightband operations and testing. They provide the necessary stiffness to operate the Lightband and ease attachment to other structures.	PSC Doc 2000741 
4	7.1.10	Use of a go/no-go gage is easier than calipers to verify the Lightband's pre-stow height.	PSC Doc 2002486 
5	7.1.9 12.1.10	PSC has designed a Lightband Compression Tool (LCT) when the necessary force to compress the Lightband cannot be applied (sensitive payload, horizontal integration, etc.). It uses tie-wraps looped around a needle bearing on each Lightband flange. This item CAN be purchased from PSC. Use of this item may affect Separation Spring location and quantity.	PSC Doc 2002159 
6	9.1.9	PSC occasionally uses custom guide rods (Deploy Upper Ring Stops) to restrain the Lightband during separation. They stop the Upper Ring at full Separation Spring extension. This is helpful if the Lightband cannot be restrained via weights or humans (TVAC testing, etc.).	PSC Doc 2000843 with O-rings 

15. Setup Pictures

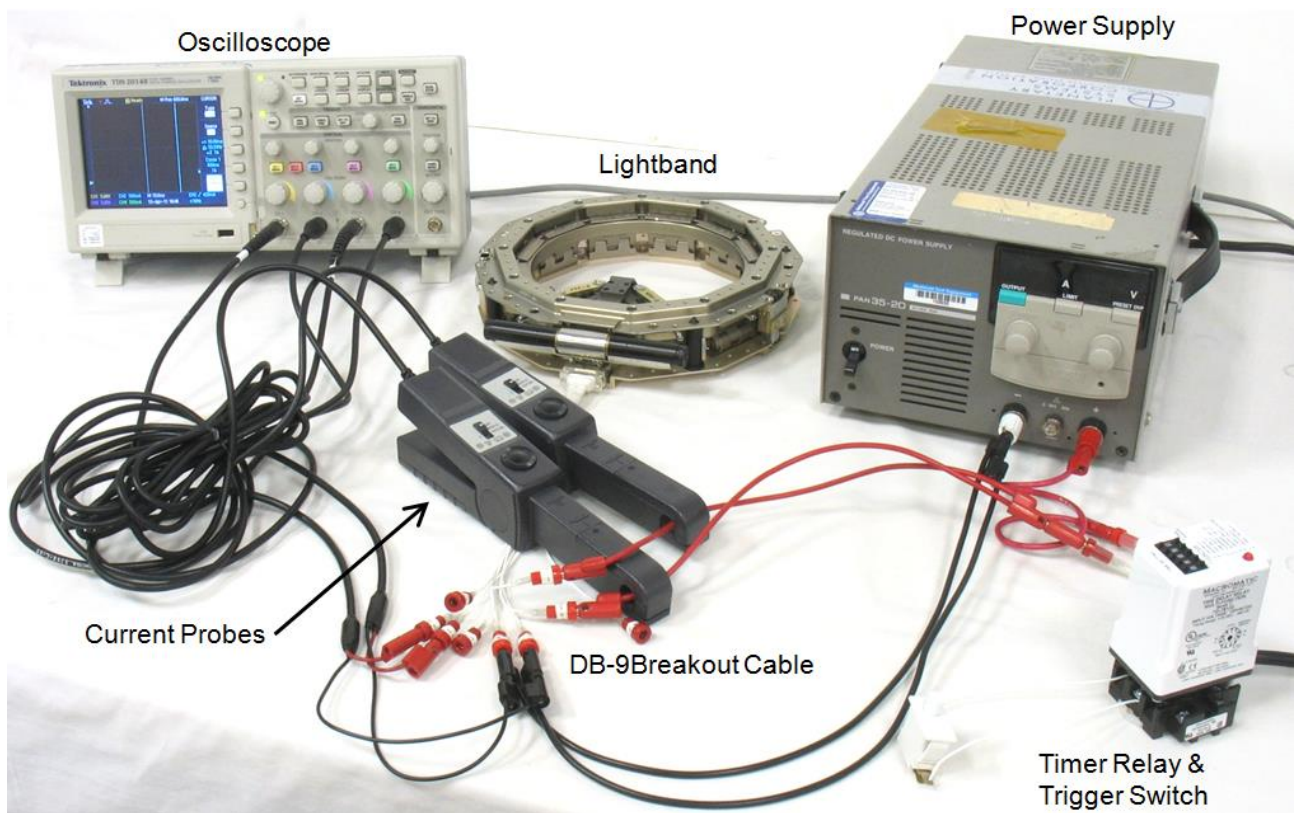


Figure 43: Example of equipment used to operate Lightband and record voltage and current.



Figure 44: DMM and DB-9 breakout cable used to measure Motor Bracket Assembly resistance.