Report 11653
9 March 2000

AEROJET

Integrated Advanced Microwave Sounding Unit-A (AMSU-A)

Engineering Test Report

AMSU-A2 S/N 108 Disturbance Torque and Angular Momentum Measurements

Contract No. NAS 5-32314
CDRL 207

Submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Submitted by:

Aerojet
1100 West Hollyvale Street
Azusa, California 91702

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INTEROFFICE MEMO
DATE: 09-March-2000
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TO: J. Linn

FROM: R. Bahng

SUBJECT: AMSU-A2 S/N 108 Disturbance Torque and Angular Momentum Measurements.

COPIES TO: J. Christman, A. Nieto, P. Patel, J. Pieper, R. Platt, D. Tran, Electronic File

REFERENCES:

1. IS-2624483, Unique Interface Specification for the Advanced Microwave Sounding Unit-A2 (AMSU-A2), RCA Corporation Astro-Electronics.
2. S-480-79, Performance Assurance Requirements for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
3. S-480-80, Performance and Operation Specification for the EOS/METSAT Integrated Programs, Goddard Space Flight Center.
4. AE-26151/12, Process Specification: Momentum Compensation and Uncompensation Test Procedure for the AMSU-A System, GenCorp Aerojet Azusa, July 8, 1998.
5. OC-462 Rev. 4, Advanced Microwave Sounding Unit (AMSU-A) Momentum Compensation Test Procedure, GenCorp Aerojet Azusa.
6. Shop Order 798170, P/N 1331200-2-MOM, Momentum Compensation Test Procedure for AMSU-A2 S/N 108, GenCorp Aerojet Azusa.
7. Drawing No. 1333965, AMSU-A2 Thermal Interface Control and Instrument Configuration Drawing, GenCorp Aerojet Azusa.
8. Matra Marconi Space Memorandum MO.NT.MMT.SY.0088, Analysis of Microdynamics Characterisation of AMSU-A1 and AMSU-A2, June 28, 1999.
9. Aerojet Interoffice Memorandum 1999#512, "AMSU-A2 S/N 109 Disturbance Torque and Angular Momentum Measurements," R. Bahng to L. Paliwoda, September 30, 1999.
10. Aerojet Interoffice Memorandum 1999#336, "METSAT AMSU-A2 S/N 107 Disturbance Torque and Momentum Measurements," R. Bahng to L. Paliwoda, June 30, 1999.
11. Aerojet Interoffice Memorandum 1999#182, "METSAT AMSU-A2 S/N 105 Disturbance Torque and Momentum Measurements," R. Bahng to L. Paliwoda, March 30, 1999.

PURPOSE

This memorandum, for the AMSU-A2 (Advanced Microwave Sounding Unit-A2) Project, reports the disturbance torque measurements of the uncompensated and compensated A2 module with assembly serial number 108 (Aerojet part number 1331200-2, Rev. AE). The measurements were performed in order to comply with the Unique Instrument Interface Specification on disturbance torque (RCA IS-2624483, paragraph 3.2.1.4).

SUMMARY

The disturbance torque and momentum of the AMSU-A2 module, with assembly serial number 108, were measured on February 18, 2000 at the GenCorp Aerojet Azusa environmental testing facility. The measurements were taken in accordance with Aerojet Process Specification AE-26151/12 and Facility Test Procedure OC-462, Revision 4.

The measured disturbance torque of the compensated AMSU-A2 S/N 108 unit was compared to the disturbance torque profile, of the compensated AMSU-A2 unit, shown in the Interface Specification (Figure 12C in RCA IS-2624483). The peak disturbance torque of the A2 S/N 108 module was measured to be 22.5 lb-in (pound-inches), while the peak disturbance torque shown in the Interface Specification is approximately 33 lb-in. The disturbance torque profile in the Interface Specification is interpreted to be about the antenna rotation axis, which is also the disturbance torque axis that is compensated. The measured peak disturbance torque of the AMSU-A2 S/N 108 unit is 32% lower than the peak exhibited in the Interface Specification profile. However, measurements of lower disturbance torque values than the specification values are acceptable because they imply less severe torque disturbances to the spacecraft. The differences between the residual torque disturbances may be attributed to a lighter, composite reflector used on the METSAT AMSU-A2 S/N 108 than the heavier, beryllium reflector used in the unit that was tested previously to obtain the specification profile. The compensator shaft was also redesigned to have the equivalent rotational moment of inertia as the composite reflector, and supporting rotational components, in the recent METSAT AMSU-A2 modules (after S/N 105). The aforementioned disturbance torque peak values are about an axis parallel to the rotation axis of the AMSU-A2 primary reflector.

The peak disturbance torque of the uncompensated METSAT AMSU-A2 S/N 108 unit was measured to be 80.8 lb-in; this implies that the compensator reduces the peak disturbance torque by 72%. The RMS (root-mean-square) disturbance torque of the compensated AMSU-A2 S/N 108 unit, over 10 seconds of data acquisition, was calculated to be 2.96 lb-in. The uncompensated RMS disturbance torque was calculated to be 12.4 lb-in. These measurements show a 76% reduction of RMS disturbance torque with the instrument compensated. A RMS disturbance torque was not provided in the Interface Specification for basis of comparison.

The measured disturbance torque profiles were integrated over time to derive angular momentum profiles. The peak angular momentum, of the compensated AMSU-A2 S/N 108 module, was derived to be approximately 0.157 lb-in-sec (pound-inch-seconds). The peak angular momentum of the uncompensated unit was determined to be 1.073 lb-in-sec. The derived peak angular momentum values indicate that the AMSU-A2 S/N 108 module exhibits a 85% reduction in peak angular momentum with compensation.

Spectral analysis of the disturbance torque data was performed. The Fourier Transform of the disturbance torque data, of the compensated A2 S/N 109 unit, exhibits peaks at 5 Hz (Hertz), higher-order harmonics of 5 Hz, and 90 Hz. The peak at 5 Hz, including the higher-order harmonics (10, 15, 20 Hz, ...), appear to be associated with the stepping of the reflector as it sweeps through 5 beam

positions every second. The peak at 90 Hz coincides with the settling frequency associated with the "jitter" of the reflector between each step command. The uncompensated instrument also exhibits peak Fourier components at 5 Hz, higher-order harmonics of 5 Hz, and 90 Hz. Peaks of the Fourier spectrum at 220 Hz were observed in the transverse-axis disturbance torque (compensated) data. These 220 Hz peaks may be associated with resonance of the force plate; the natural frequency of the loaded force plate is reduced from approximately 800 Hz (unloaded) due to the additional mass of an adapter plate and the AMSU-A2 module.

The measured disturbance torque profile of the compensated METSAT AMSU-A2 S/N 108 module complies with the profile shown in the Interface Specification. The disturbance torque measurements show that the compensator motor reduces uncompensated peak and RMS torque disturbances by at least 76%, about the axis of reflector rotation. With compensation, the peak angular momentum is reduced by 85%.

BACKGROUND

The AMSU-A2 antenna sweeps through thirty earth-viewing beam positions, and cold/warm calibration positions for each revolution. Five earth-viewing scenes are scanned in one second; the period of each scene is 0.2 second. The intermittent rotation of the AMSU-A2 antenna, while stepping through earth viewing scenes and sweeping to cold/warm calibration positions, imparts a disturbance torque to the module and the spacecraft that it is installed on. The disturbance torque, about an axis parallel to the antenna rotation axis, is proportional to the rotational moment of inertia and slew rate (angular acceleration) of the antenna. Products of inertia, or dynamic imbalances, of the antenna cause torque disturbances in the axes normal to the rotation axis. A compensator is utilized in the METSAT AMSU-A2 instrument to reduce torque disturbances about the rotational antenna axis. The compensator is a motor which houses a rotating shaft with a rotational moment of inertia equivalent to that of the antenna, and other rotating components. The compensator reduces torque disturbances about the rotation axis by stepping in the opposite direction of the antenna. The disturbance torque test is performed in order to demonstrate that the compensated AMSU-A2 instrument in full-operation imparts torque disturbances within acceptable limits.

Analytical equations will be used to show the functional relationship between the disturbance torque, momentum, moments of inertia, angular velocity, and angular acceleration of the antenna. The torque, or sum of the moments about an origin, can be expressed as a function of the angular momentum by the conservation of angular momentum equation,

$$\vec{T}_o = \sum \vec{M}_o = \frac{d\vec{H}_{oR}}{dt} + \vec{\Omega}_R \times \vec{H}_o$$

The application of torque $\boldsymbol{T}$ to the antenna, by the DC torque motor, changes the angular momentum $\boldsymbol{H}$ of the antenna. The angular momentum $\boldsymbol{H}$ of the antenna, for rotation of the antenna about the fixed Y-axis, is defined by the following,

$$H_X = -I_{XY}\omega$$
$$H_Y = I_{YY}\omega$$
$$H_Z = -I_{ZY}\omega$$

where the angular velocity of the antenna Ω is ωj (**j** is a unit vector in the Y-axis) and I_{YY} is the rotational moment of inertia of the antenna. I_{XY} and I_{ZY} are the antenna's products of inertia terms which arise from asymmetry of the antenna about the XZ-plane. Substitution of the angular momentum, ***H***, in the conservation of angular momentum equation yields expressions for the torque ***T***:

$$T_X = -I_{XY}\alpha - I_{ZY}\omega^2$$
$$T_Y = I_{YY}\alpha$$
$$T_Z = -I_{ZY}\alpha + I_{XY}\omega^2$$

The angular acceleration of the antenna is α. Because angular momentum cannot be directly measured with the test setup, the integration of the torque profile over time is performed to derive the angular momentum about the antenna rotation axis,

$$H_Y(t) = \int_0^t T_Y(\tau)\,d\tau$$

The disturbance torque and angular momentum of the instrument, as measured by the force plate, are opposite (in sign) to the torque and angular momentum of the reflector. The torque of the instrument is a reaction (according to Newton's Third Law) to the torque that is applied to the reflector by the DC motor. The disturbance torque $T_{inst.}$ and angular momentum $H_{inst.}$ of the instrument, as measured by the force plate, are related to the torque $T_{ant.}$ and angular momentum $H_{ant.}$ of the antenna (reflector):

$$T_{X,inst.} = -T_{X,ant.} = I_{XY}\alpha + I_{ZY}\omega^2$$
$$T_{Y,inst.} = -T_{Y,ant..} = -I_{YY}\alpha$$
$$T_{Z,inst.} = -T_{Z,ant.} = I_{ZY}\alpha - I_{XY}\omega^2$$

$$H_{X,inst.} = -H_{X,ant.} = I_{XY}\omega$$
$$H_{Y,inst.} = -H_{Y,ant.} = -I_{YY}\omega$$
$$H_{Z,inst.} = -H_{Z,ant.} = I_{ZY}\omega$$

Predicted disturbance torque and momentum profiles of the antenna and instrument are shown in Figure 3. A "cartoon" response of the reflector motor to step commands is shown in Figure 3. The reflector beam position, as a function of time, is plotted for the reflector response to two consecutive step commands (to earth-viewing scenes). The reflector performs a slew from the previous antenna position to the first scene, then dwells for viewing. This sequence is repeated for the second scene. The angular momentum of the reflector, which is proportional to the time-derivative of the reflector beam position, is plotted in Figure 3. The torque of the reflector, which is proportional to the time-derivative of the angular momentum, is also plotted in Figure 3. The disturbance torque pattern for each reflector slew shows a torque impulse followed by a restoring torque impulse. The disturbance torque and angular momentum of the instrument (profiles on the right side in Figure 3) are opposite (in sign) to the torque and momentum of the antenna (profiles on the left side in Figure 3).

DISCUSSION OF RESULTS

A block diagram of the test equipment setup is shown in Figure 4. The test setup utilizes a Kistler 9253A force plate that measures forces and moments in three orthogonal axes, a 5017A charge amplifier for the conversion of the charges from the force plate to voltages, and a Tekronix TestLab 2520 for data acquisition. The analog force and moment voltage signals are stored on a Metrum RSR 512 tape recorder for data backup. The Kistler 9253A force plate utilizes four piezoelectric force transducers. Each of the four force transducers measures the three components of force. The outputs from the four transducers are combined to give six DOFs (degrees of freedom): forces in all three axes, and moments about all three axes (refer to Figure 5). The force plate cannot resolve whether only an applied torque causes a measured moment, or a combination of torque and offset force causes that moment. It will be assumed in the subsequent analyses that the measured moments are due to only torque disturbances from the reflectors, and all other sources of moments will be neglected. Therefore the terms "torque" and "moment" will be used interchangeably in this report. All measurements were acquired with a sampling frequency of 2000 Hz in order to achieve a 1000 Hz Nyquist frequency, or 1000 Hz frequency bandwidth in the spectral analysis (Fourier Transform plots). An illustration of the AMSU-A2 module mounted on the force plate is shown in Figure 2. The METSAT AMSU-A2 instrument's coordinate axes X_{A2}, Y_{A2}, and Z_{A2} are different from the force plate's coordinate axes X, Y, and Z, respectively.

The usable frequency range of the force plate is limited by drift of the charge amplifiers at DC (direct current), and the natural frequency of the force plate, loaded with the additional mass of the AMSU-A2 module and adapter plate, at the upper frequency limit. The lower frequency limit, or drift of the charge amplifiers, is influenced by temperature changes; temperature changes cause drift of the zero signal levels. The lower limit of frequency range of the system is also determined by the quality of the electrical insulation; the RC time constant for DC measurements is dependent on the open circuit resistance (quality of the insulation between signal line and connecting ground). Amplification of the forces, at the natural frequency of the force plate system, influences the upper frequency limit of the measurements. Loading the force plate with additional mass has the effect of reducing the natural frequency of the force plate. The natural frequency of the force plate without additional mass is approximately 800 Hz in all three axes. The natural frequency of the AMSU-A disturbance torque setup could be determined by performing frequency analysis of data obtained from tapping the force plate with an instrumented impulse hammer (tap test).

The calibration of the test setup was validated for the AMSU-A2 S/N 108 disturbance torque test by measuring known forces and moments applied to the force plate. Static forces and moments were applied to the force plate by placing 4 and 10 pound masses at different locations relative to the origin of the force plate. The results of the calibration verifications are plotted in Figure 6. The measured versus applied moment, about the force plate X and Y-axes, are shown. Error bars of ±10%, in the expected measured moments, are shown in the two plots. The measurements demonstrate that applied moments about the X and Y-axes can be measured within 10% accuracy over a –62 to 62 lb-in range. A torque about the plate Z-axis was applied to the force plate by tightening a screw on top of the force plate to 360 lb-in torque with an instrumented torque wrench. The torque was measured to be 355 lb-in; this is within 10% of the applied value.

Table I presents a summary of RMS measured disturbance torque, over 10 seconds of data acquisition, of the METSAT AMSU-A2 S/N 108 unit. RMS values of the background noise are also shown. The RMS disturbance torque of the compensated A2 module was measured to be 4.66, 2.96, and 3.43 lb-in about the instrument X_{A2}, Y_{A2}, and Z_{A2} axes, respectively. The RMS disturbance torque of the uncompensated module was measured to be 4.89, 12.4, and 2.18 lb-in about the instrument X_{A2}, Y_{A2}, and Z_{A2} axes, respectively. The RMS torque for background noise was measured to be 0.175, 0.718, and 0.443 lb-in about the instrument X_{A2}, Y_{A2}, and Z_{A2} axes, respectively. Signal-to-noise ratios were calculated for each channel, and are also shown in Table I. The signal-to-noise ratios, which varied between 12.3 and 28.5 dB, were adequate for the measurements.

Table II presents a summary of the peak unfiltered, 10 Hz low-pass filtered, and 100 Hz low-pass filtered disturbance torque profiles. An IIR (Infinite Impulse Response) Butterworth filter was utilized to perform the low-pass filtering of the data. The data was filtered with a cutoff frequency of 10 Hz, for AOCS (Attitude Orbital Control System, from DC to 10 Hz) studies, and 100 Hz, for microdynamics (from DC to 100 Hz) studies. The unfiltered torque profiles are not fully useful because they contain frequency components arising from resonance of the force plate system at high frequencies (larger than 100 Hz); the disturbance torque profiles should be independent of the test setup. However, using disturbance torque peak values from the unfiltered data, which contain the higher frequency components, may be conservative because they are generally larger than the peak values from the low-pass filtered data. Plots of the peak unfiltered, 10 Hz low-pass filtered, and 100 Hz low-pass filtered disturbance torque profiles are shown in Figures A1 through A3 for the uncompensated AMSU-A2 S/N 108 module, and Figures B1 through B3 for the compensated module. The results clearly demonstrate that the low frequency (less than 10 Hz) disturbance torque of the *compensated* unit is minimal (less than 3 lb-in).

Profiles of the measured disturbance torque and derived angular momentum, during full operation of the METSAT AMSU-A2 S/N 108, are plotted in Figures 8 and 9 for the uncompensated and compensated module, respectively. Spectral analysis data are shown in Figure 10 for the uncompensated and compensated modules. Figures 11 and 12 are plots of the RSS (root-sum-squares) disturbance torque and angular momentum magnitude for the uncompensated and compensated modules, respectively.

The measured and Interface Specification disturbance torque profiles are shown in Figure 7. A cursory examination of the two plots shows that the measured disturbance torque profile of the compensated METSAT AMSU-A2 S/N 108 module complies with the profile shown in the Interface Specification. The peak disturbance torque of the A2 S/N 108 module was measured to be 22.5 lb-in (pound-inches), while the peak disturbance torque shown in the Interface Specification is approximately 33 lb-in. A cursory inspection of the profiles shows that the RMS values may be equivalent. The disturbance torque profile in the Interface Specification is interpreted to be about the antenna rotation axis (Y_{A2}), which is the axis in which the disturbance torque is compensated.

Profiles of the measured disturbance torque and angular momentum, during full operation of the METSAT AMSU-A2 S/N 108, are plotted in Figures 8 and 9 for the uncompensated and compensated module, respectively. The profiles are about an axis parallel to the reflector rotation axis. Disturbance torque and angular momentum profiles in the transverse axes are included in the appendix.

Spectral analysis (Fourier Transform plots) are shown for the uncompensated and compensated AMSU-A2 S/N 108 module in Figure 10. The FFT (Finite-Fourier-Transform) of the disturbance torque exhibit peaks at 5 Hz (Hertz), higher-order harmonics of 5 Hz, and 90 Hz. The peak at 5 Hz, including the higher-order harmonics (10, 15, 20 Hz, ...), appear to be associated with the stepping of the reflector as it sweeps through 5 beam positions every second. The peak at 90 Hz coincides with the settling frequency associated with the "jitter" of the reflector between each step command. The uncompensated instrument also exhibits peak Fourier components at 5 Hz, higher-order harmonics of 5 Hz, and 90 Hz. Peaks of the Fourier spectrum at 220 Hz were observed in the transverse-axis disturbance torque data. The peak at 220 Hz is suspected to be the natural frequency of the force plate, with the additional weight of the adapter plate, approximately 60 pounds, and AMSU-A2 module, approximately 110 pounds. The natural frequencies of the unloaded force plate (approximately 88 pounds), are 800, 750, 850 Hz in the plate X, Y, and Z axes, respectively.

Figure 11 shows plots of the *uncompensated* disturbance torque and angular momentum magnitudes, which are the square root of the sum of the squares of the orthogonal torque components about the instrument X, Y, and Z-axes. The disturbance torque and angular momentum magnitude profiles of the *compensated* module are shown in Figure 12. The large peaks, in the uncompensated RSS angular momentum profile, correspond to the reflector slew to warm/cold calibration positions. The smaller peaks correspond to the reflector's earth-viewing scans. The peak exhibited disturbance torque magnitudes are approximately 82 and 34 lb-in for the uncompensated and compensated A2 S/N 108 module, respectively. The peak exhibited angular momentum magnitudes are approximately 1.0 and 0.16 lb-in-sec for the uncompensated and compensated A2 S/N 108 module, respectively.

CONCLUSIONS AND RECOMMENDATIONS

The measured disturbance torque profile of the compensated METSAT AMSU-A2 S/N 108 module complies with the profile shown in the Interface Specification. The disturbance torque measurements show that the compensator motor reduces the uncompensated peak and RMS torque disturbances by at least 76%, and reduces the peak angular momentum disturbance by 85%. The disturbance torque profile in the Interface Specification is assumed to be about an axis parallel to rotation axis of the primary reflector, or the instrument Y-axis. The calibration of the test setup was verified and shown to measure static moments within ±10% accuracy. It is recommended to demonstrate the dynamic response and calibration of the test setup in any future tests. Comparisons of the AMSU-A2 S/N 108 data with data from previously tested units show agreement in the measurements. All aspects of the AMSU-A2 S/N 108 momentum compensation test were satisfactory.

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Table I. RMS (Root-Mean-Square) and Peak AMSU-A2 S/N 108 Disturbance Torque/Angular Momentum.

	Nadir Axis (X_{A2})	Velocity Axis (*Y_{A2})	Sun Axis (Z_{A2})
RMS Torque Uncompensated (lb-in)	4.89	12.4	2.18
RMS Torque Compensated (lb-in)	4.66	2.96	3.43
Peak Torque Uncompensated (lb-in)	34.9	80.8	11.6
Peak Torque Compensated (lb-in)	31.7	22.5	15.4
Peak Angular Uncompensated Momentum (lb-in-s)	0.043	1.073	0.042
Peak Angular Compensated Momentum (lb-in-s)	0.083	0.157	0.052
RMS Torque of Noise (lb-in)	0.175	0.718	0.443
Signal to Noise Ratio (Compensated to Noise) (dB)	28.5	12.3	17.8

*Axis Parallel to Antenna/Drive Motor Shaft.

The antenna is compensated in the axis parallel to the rotation axis.

Root-Mean-Square Torque over 10 seconds: $T_{RMS} = \left[\frac{1}{10\sec} \int_0^{10\sec} T^2(t) \cdot dt \right]^{1/2}$

Signal to Noise Ratio (decibels, dB): $S/N = 20 \cdot \log \frac{T_{unit,RMS}}{T_{noise,RMS}}$

Table II. Summary of Unfiltered, 100 Hz Low-Pass Filtered, and 10 Hz Low-Pass Filtered Peak Torques

	Unfiltered	100 Hz Low-Pass Filtered	10 Hz Low-Pass Filtered
Uncompensated AMSU-A2 S/N 108			
T_{XA2} (lb-in)	34.9	3.83	0.486
T_{YA2} (lb-in)	80.6	68.4	24.6
T_{ZA2} (lb-in)	11.6	8.35	0.840
Compensated AMSU-A2 S/N 108			
T_{XA2} (lb-in)	31.7	3.60	0.508
T_{YA2} (lb-in)	22.5	13.5	2.08
T_{ZA2} (lb-in)	15.4	3.60	0.609

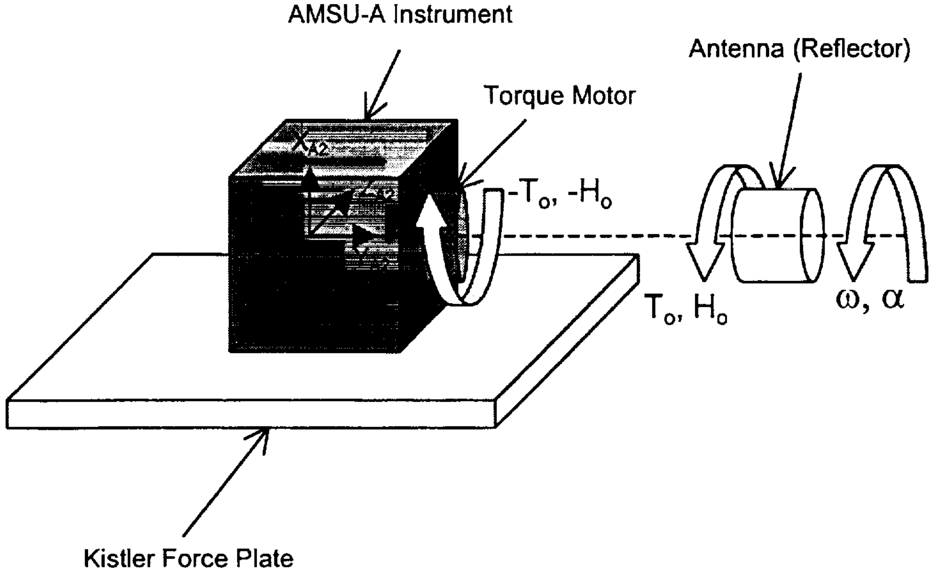


Figure 1. The disturbance torque of the instrument, as measured by the force plate, is the reaction due to the torque applied to the antenna.

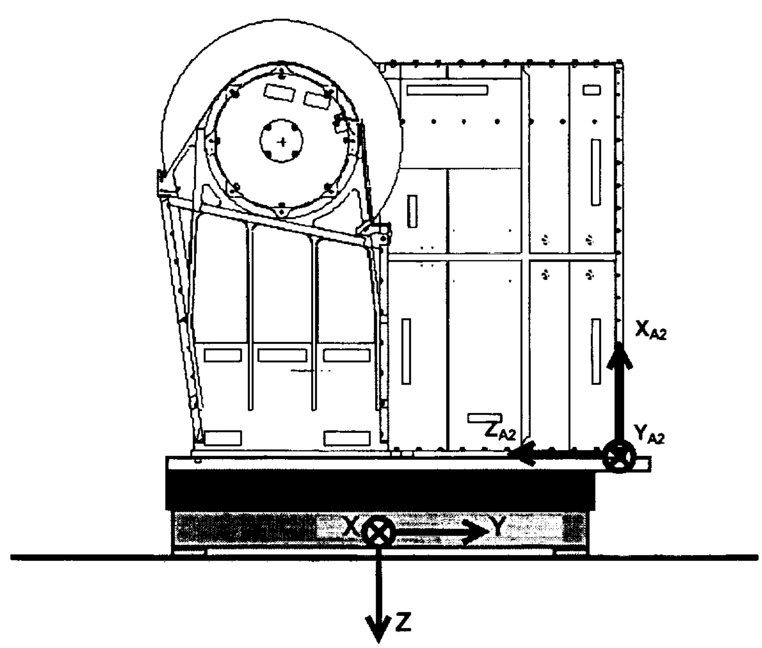


Figure 2. The coordinate axes X_{A2}, Y_{A2}, and Z_{A2} of the AMSU-A2 instrument are different from the Kistler Force Plate coordinate axes, X, Y, and Z, respectively.

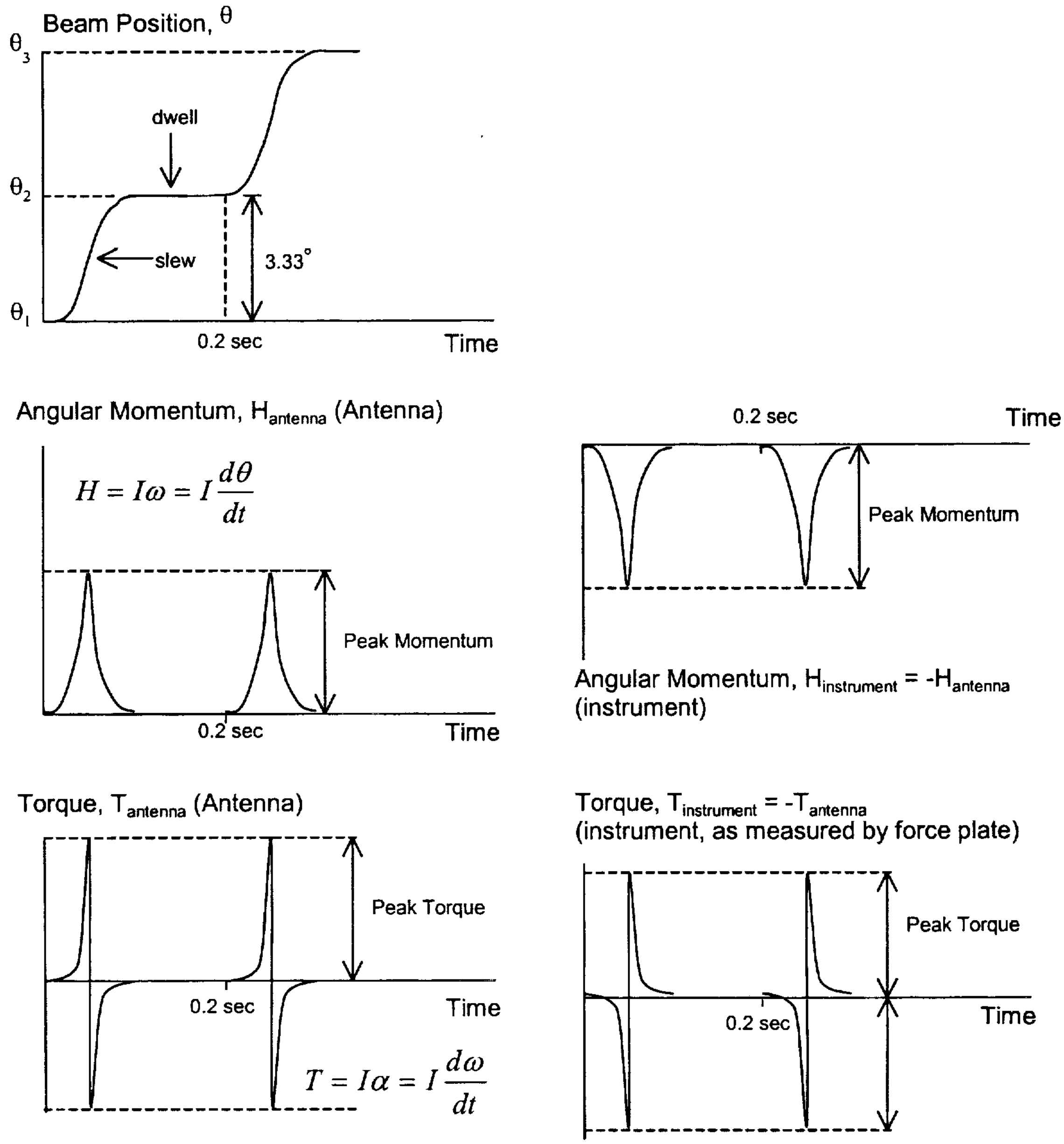


Figure 3. Antenna Beam Position, Angular Momentum, and Disturbance Torque for a Sweep Through Two Scenes.

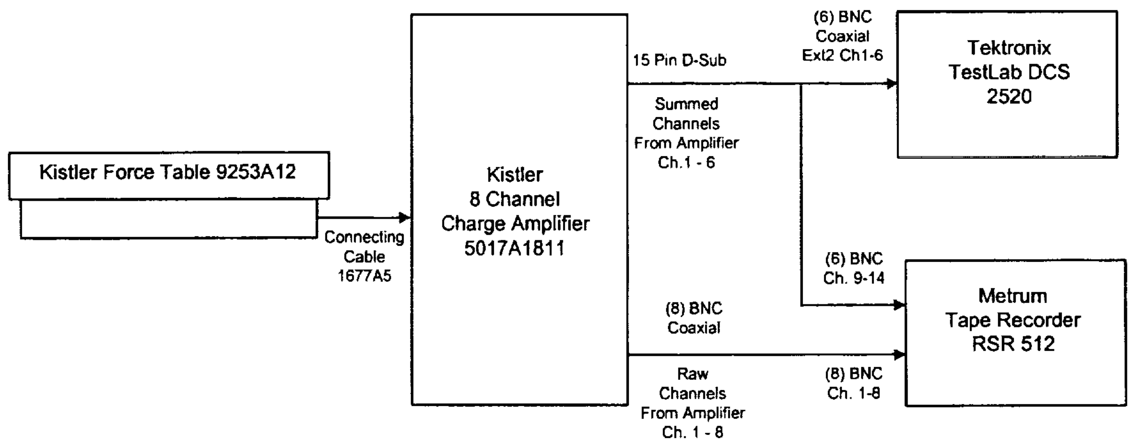


Figure 4. Block Diagram of Disturbance Torque Test Setup

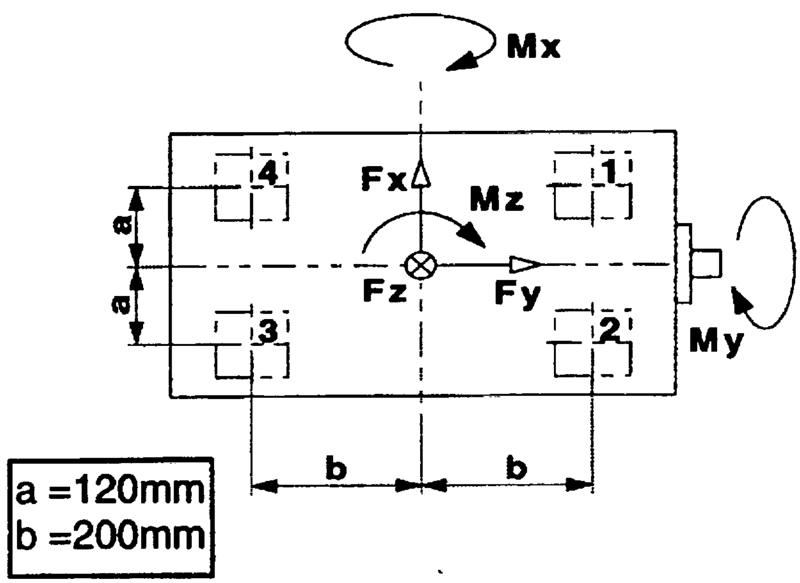
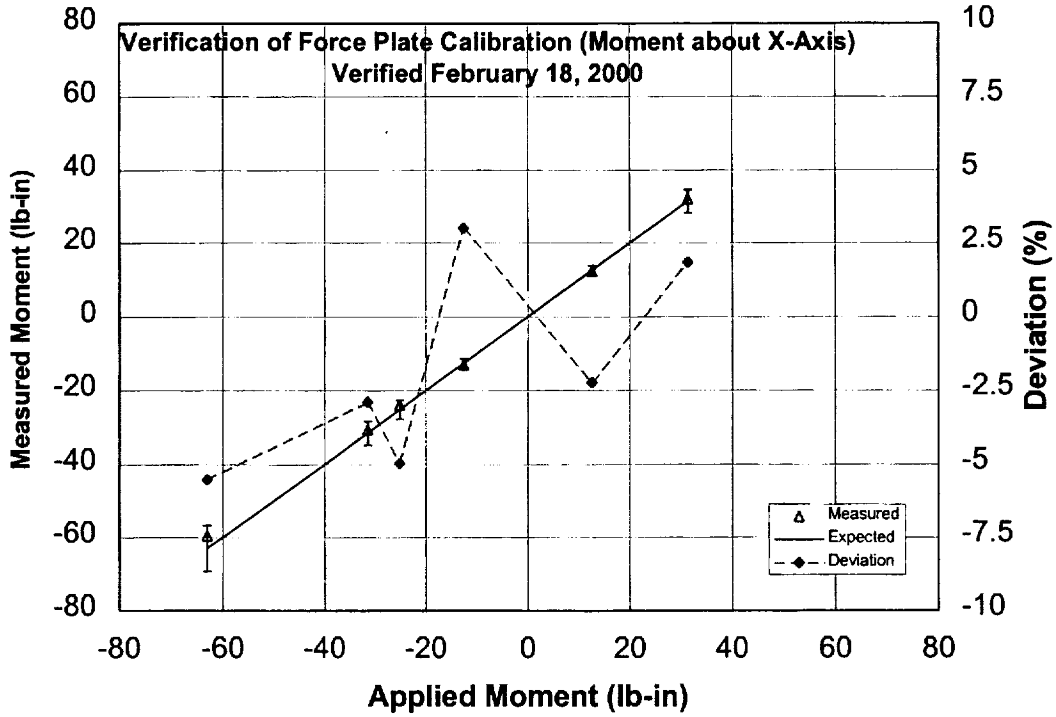


Figure 5. The Kistler Force Plate assembles the forces measured at the four transducers (at 1, 2, 3, and 4) and outputs the net applied force and moment.



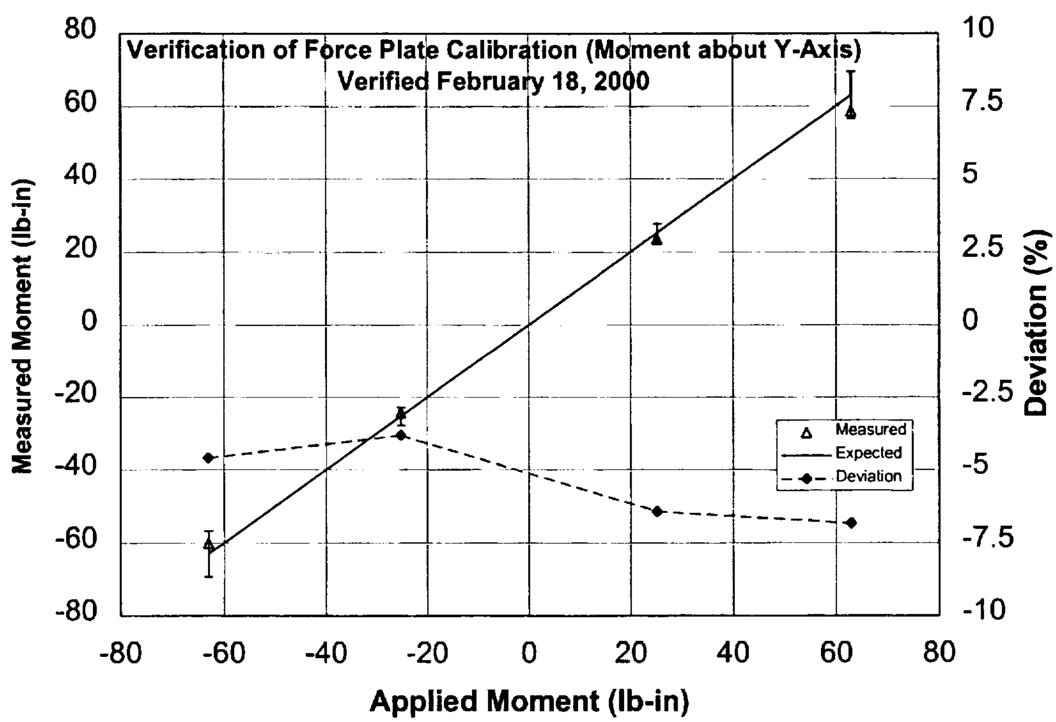


Figure 6. Verification of Kistler Force Plate/Charge Amplifiers Calibration.

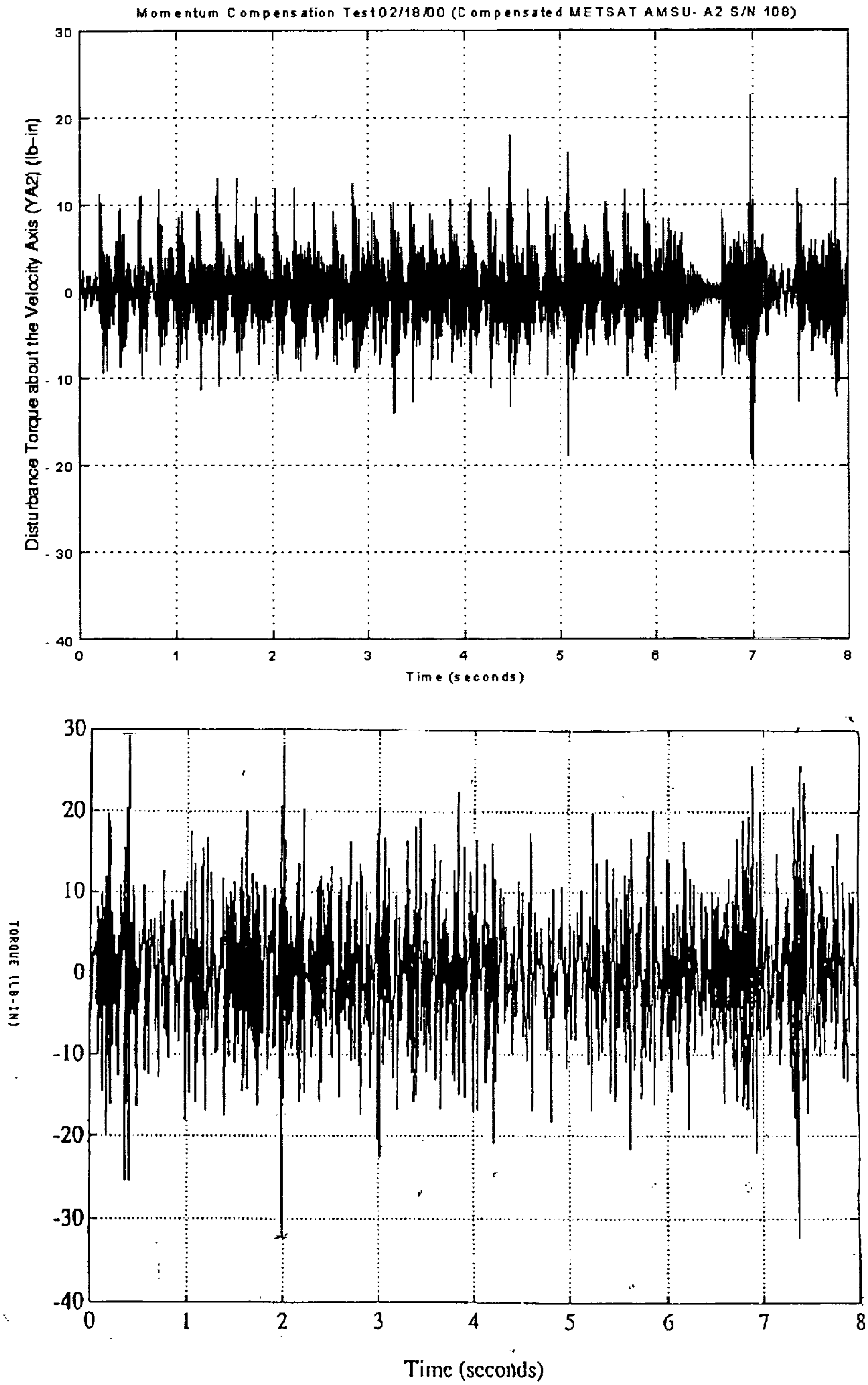


Figure 7. Compensated AMSU-A2 Disturbance Torque Profiles: S/N 108 measured (above), and Interface Specification (below).

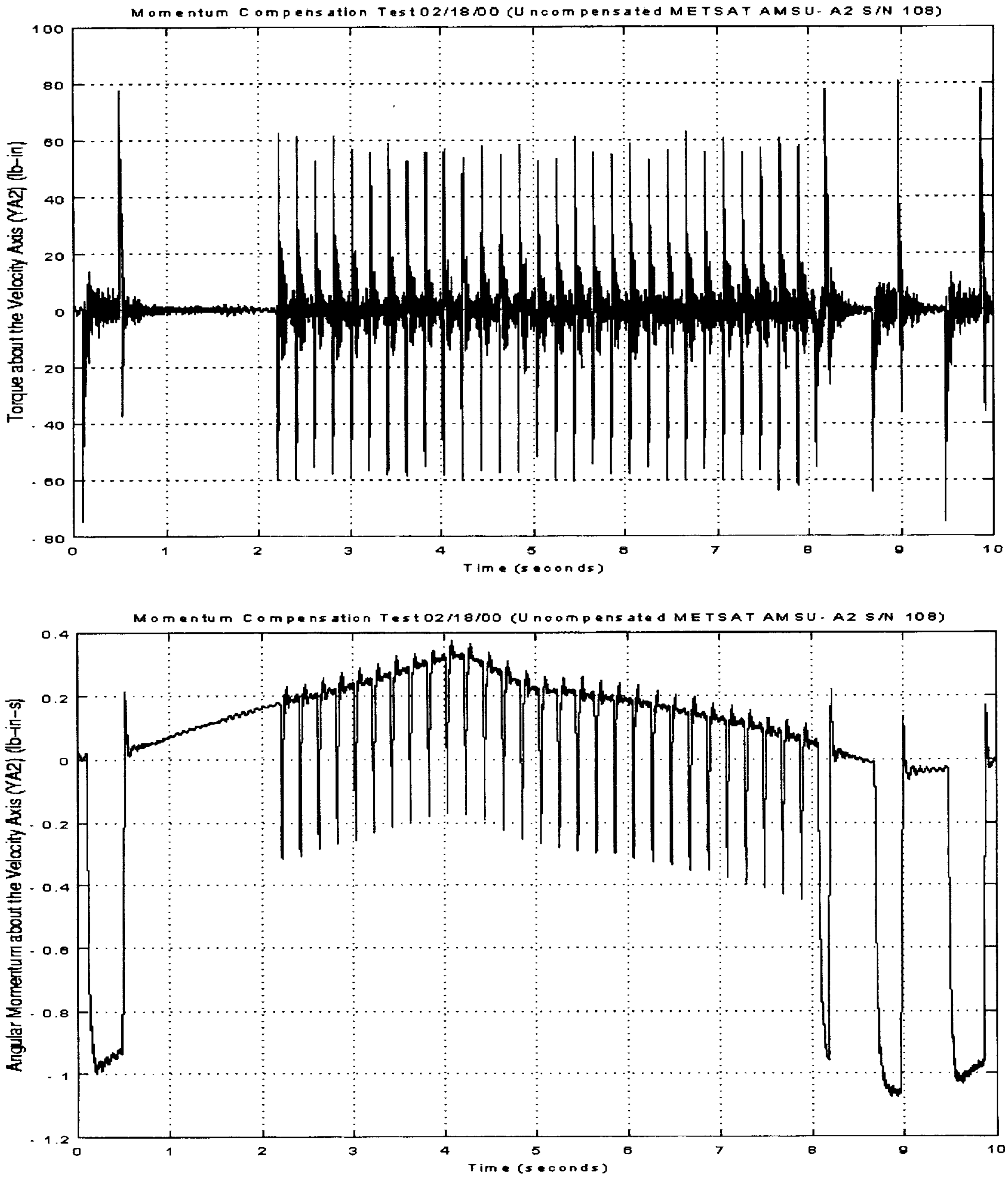


Figure 8. AMSU-A2 S/N 108 Uncompensated Disturbance Torque (above) and Angular Momentum (below).

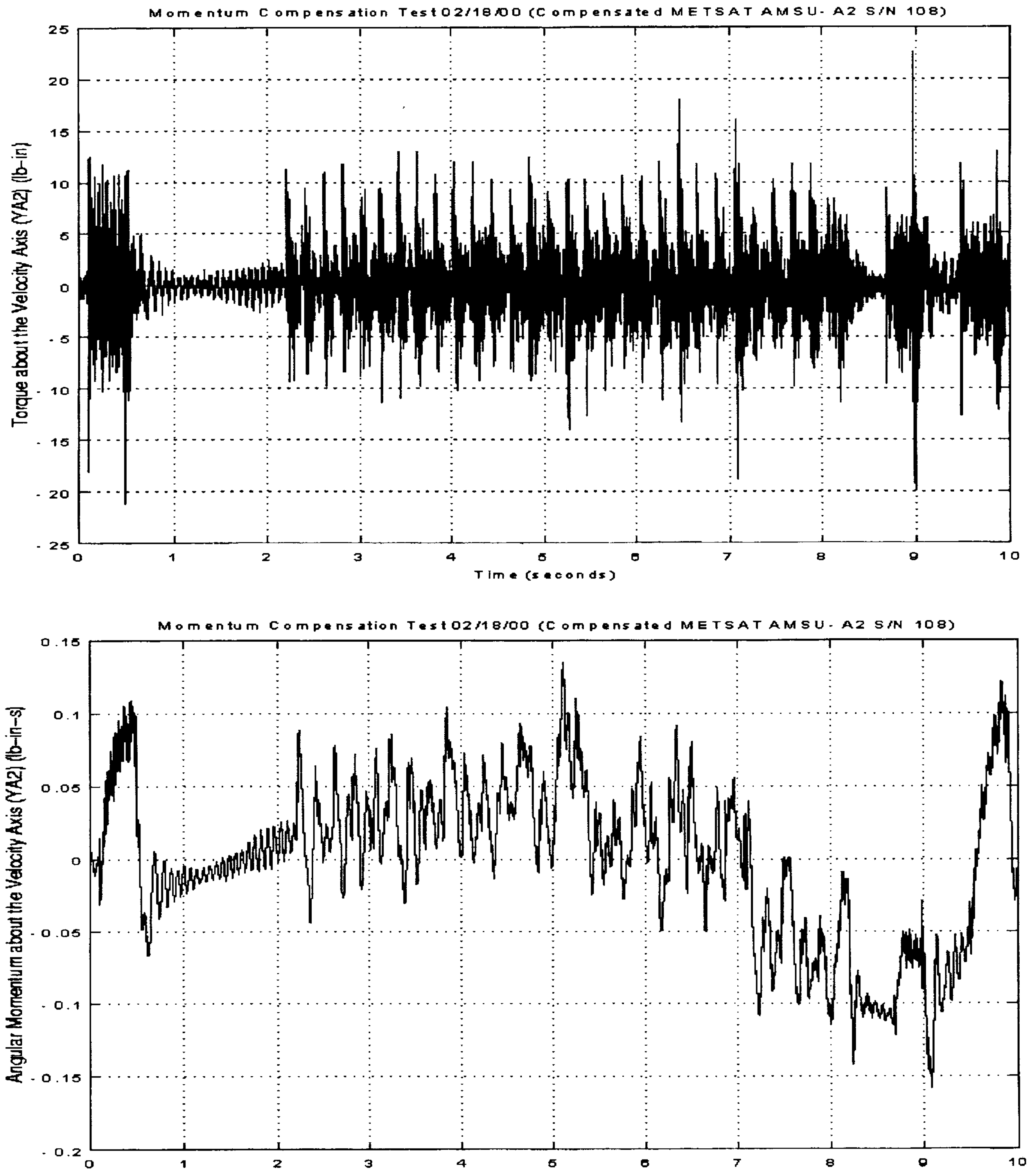


Figure 9. AMSU-A2 S/N 108 Compensated Disturbance Torque (above) and Momentum (below).

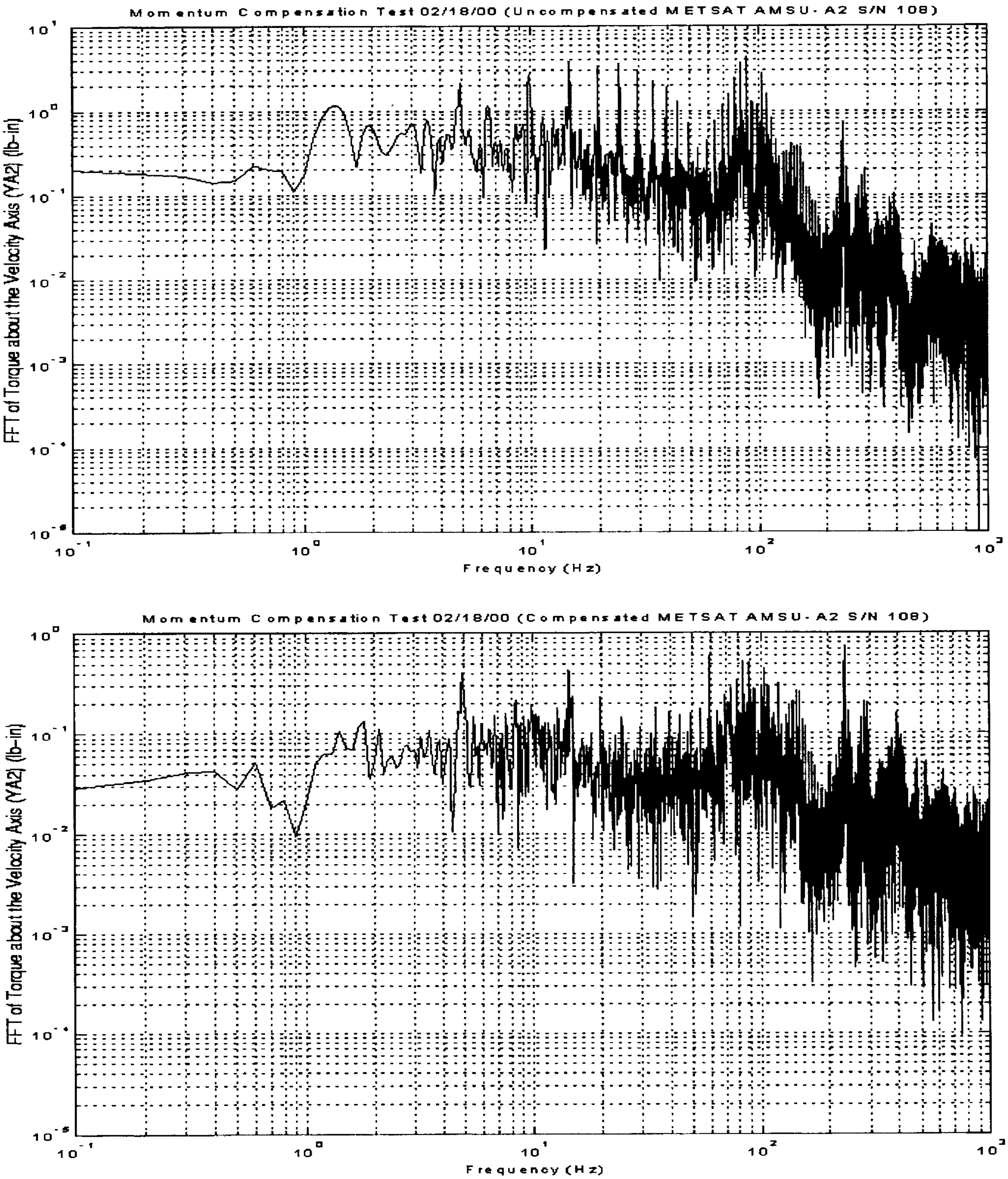


Figure 10. Fourier Transforms of Uncompensated Torque (above), and Compensated Torque (below).

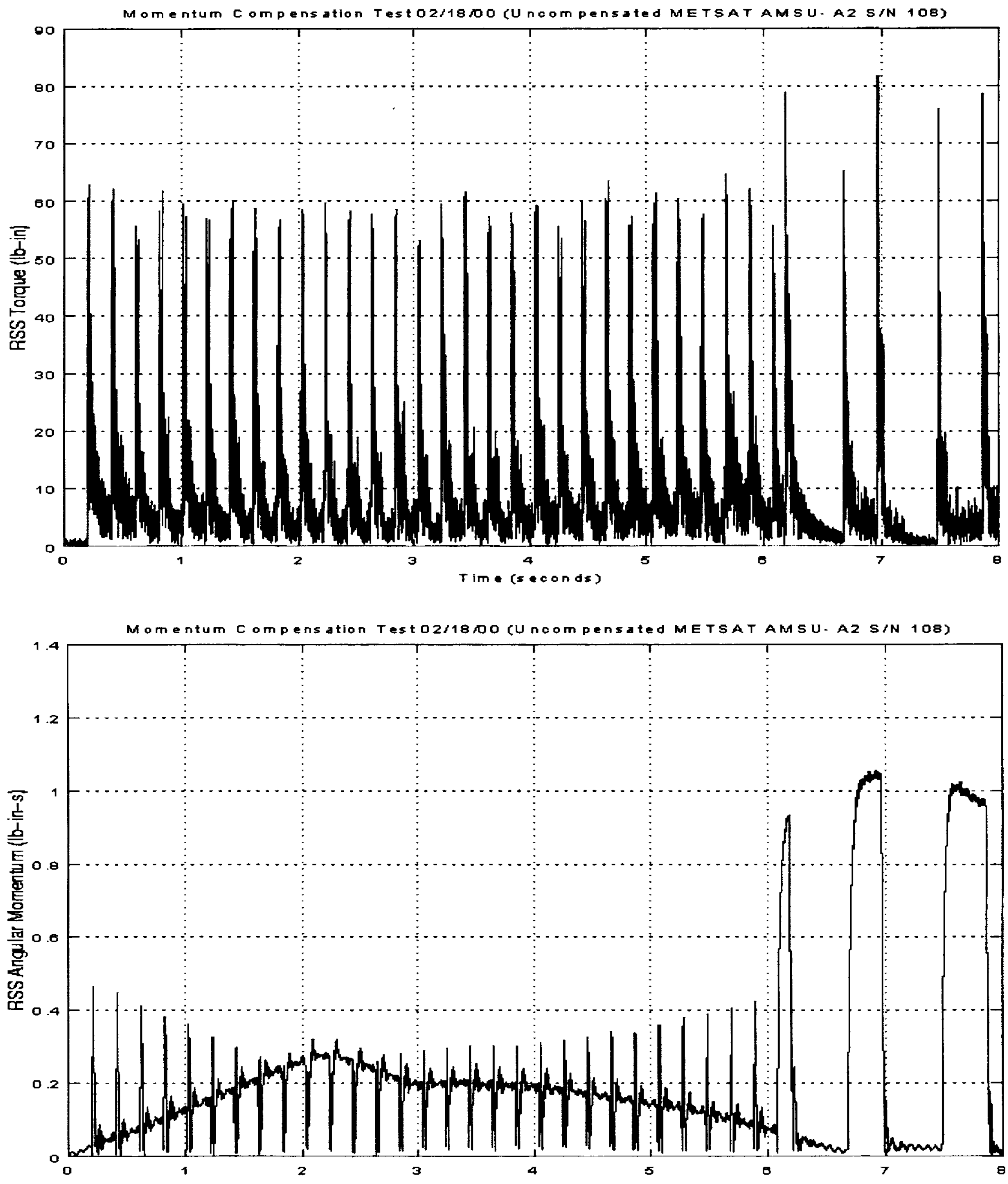


Figure 11. Uncompensated Disturbance Torque (Above) and Angular Momentum (Below) Magnitudes.

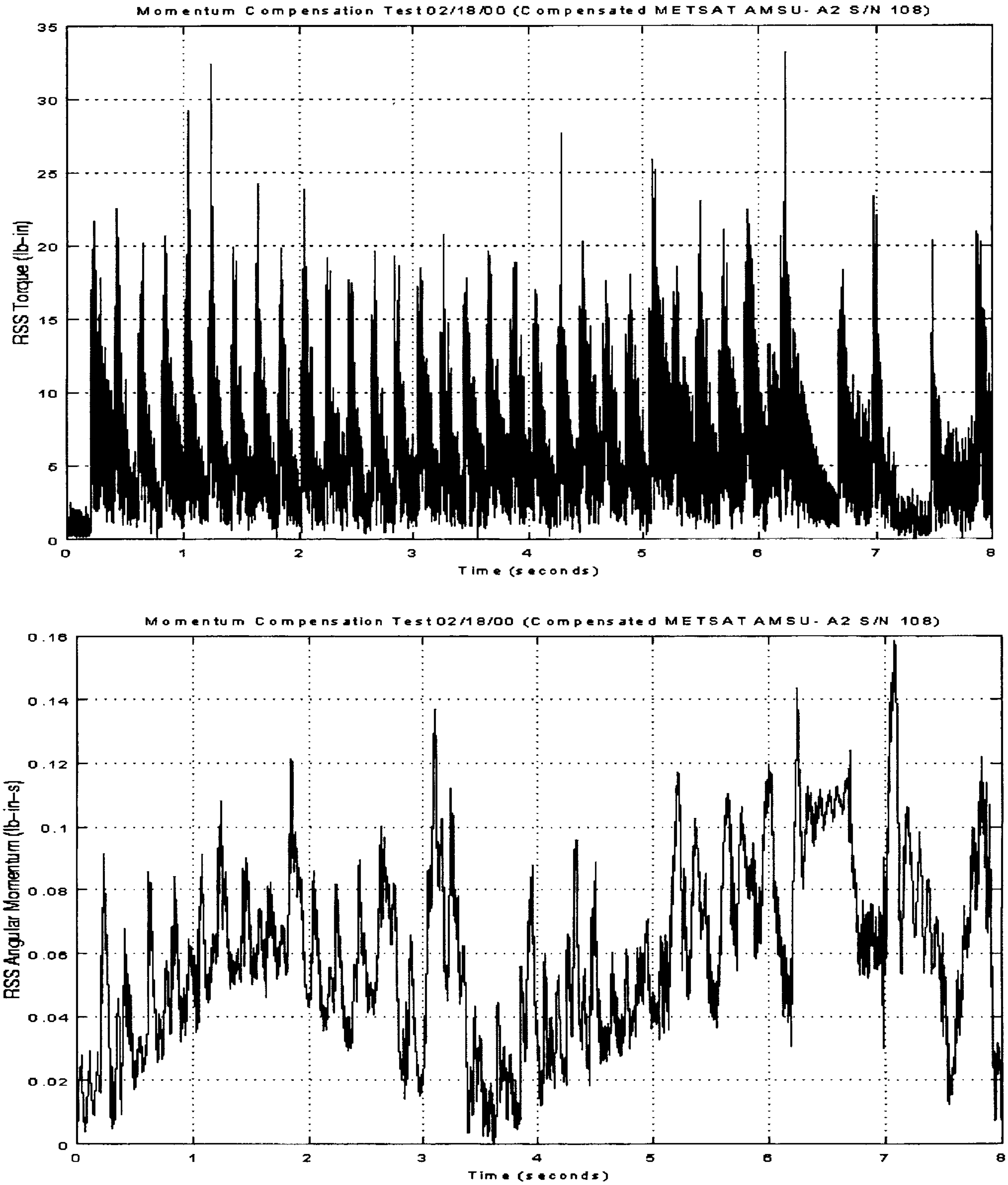
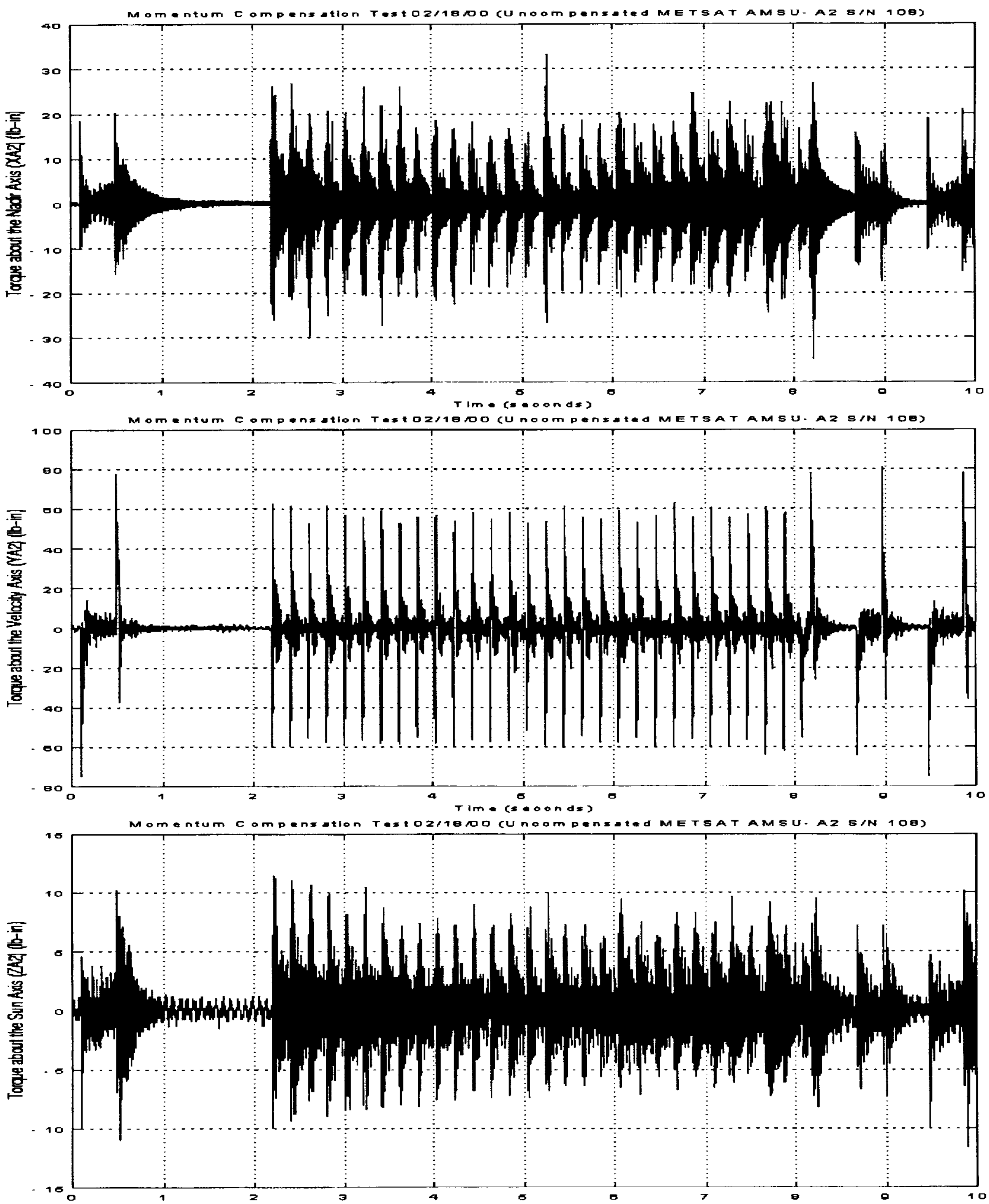


Figure 12. Compensated Disturbance Torque (Above) and Angular Momentum (Below) Magnitudes.

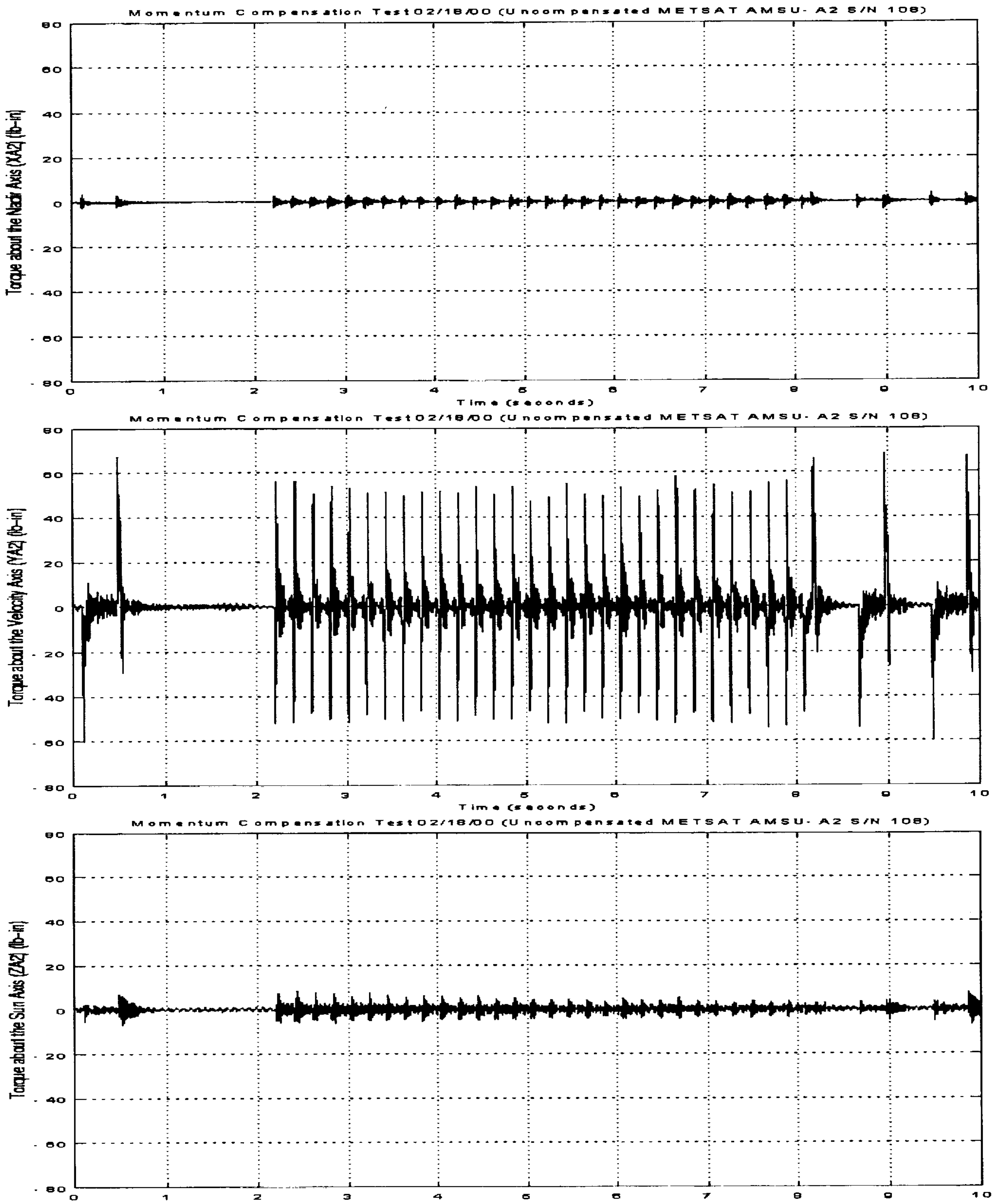
APPENDIX: DISTURBANCE TORQUE (UNFILTERED, 100 HZ LOW-PASS FILTERED, AND 10 HZ LOW-PASS FILTERED), ANGULAR MOMENTUM (TORQUE-TIME INTEGRAL), AND FFT PLOTS

A. UNCOMPENSATED AMSU-A2 S/N 108

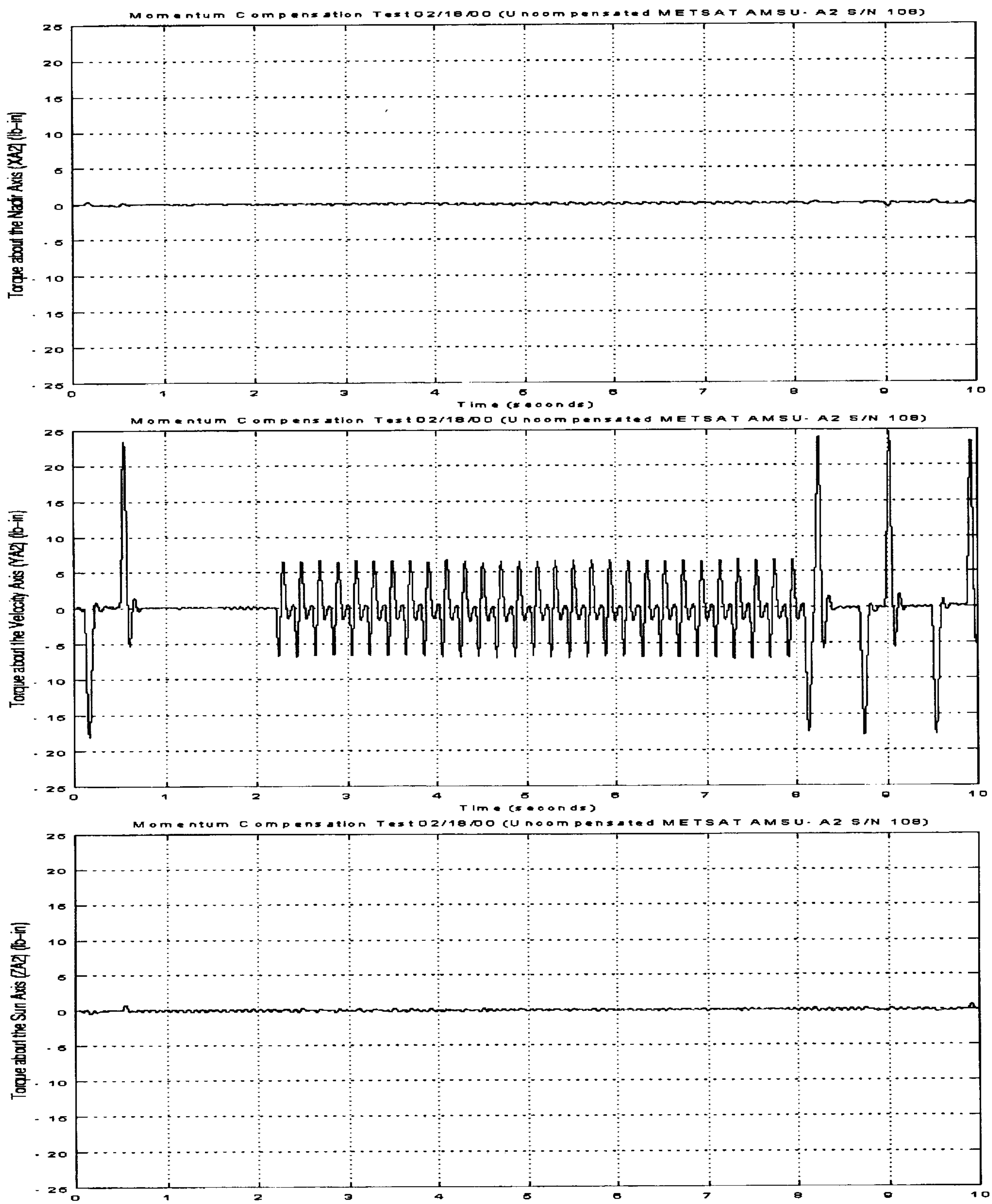
B. COMPENSATED AMSU-A2 S/N 108



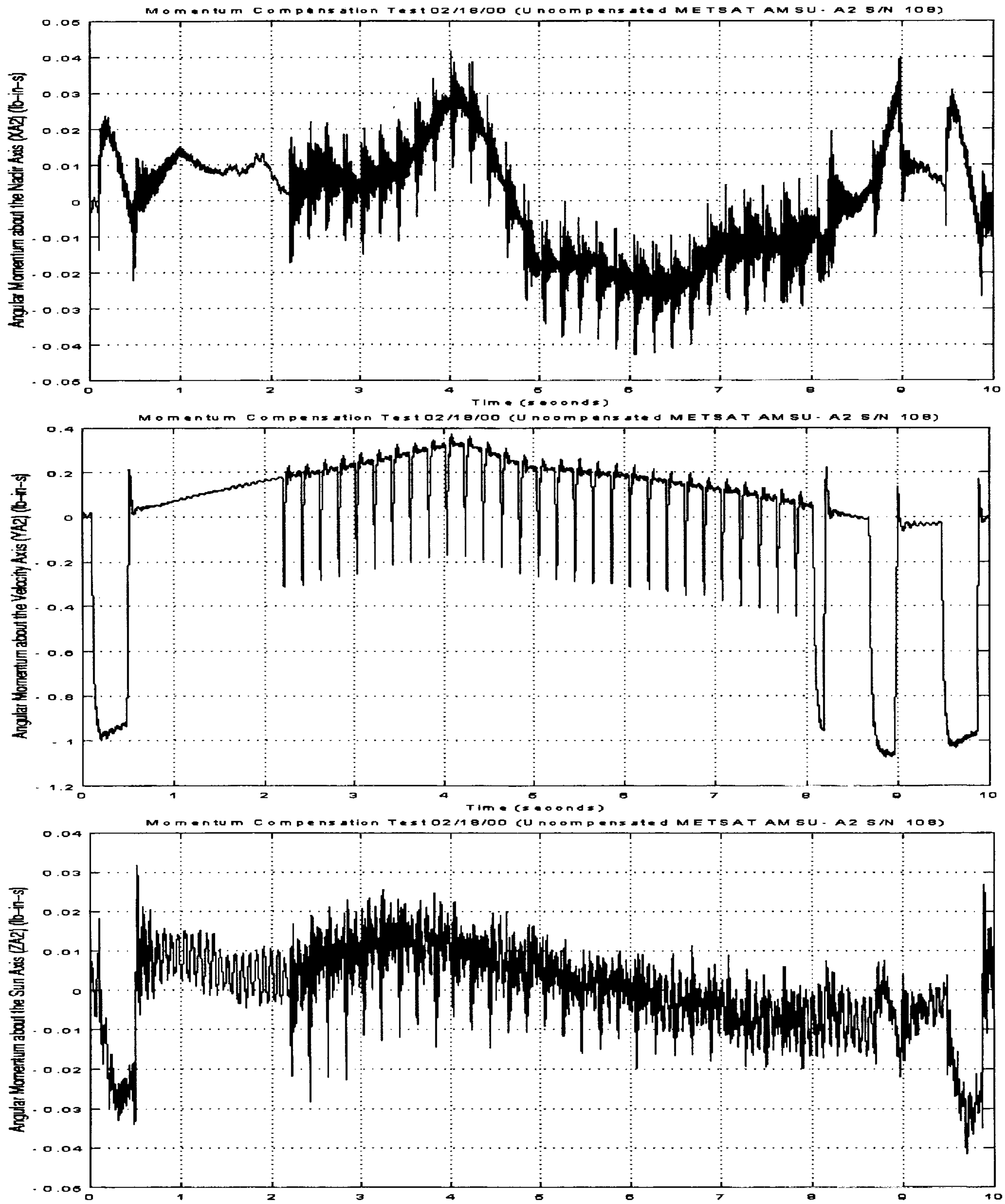
A1. Uncompensated disturbance torque (unfiltered) of the AMSU-A2 S/N 108 unit.



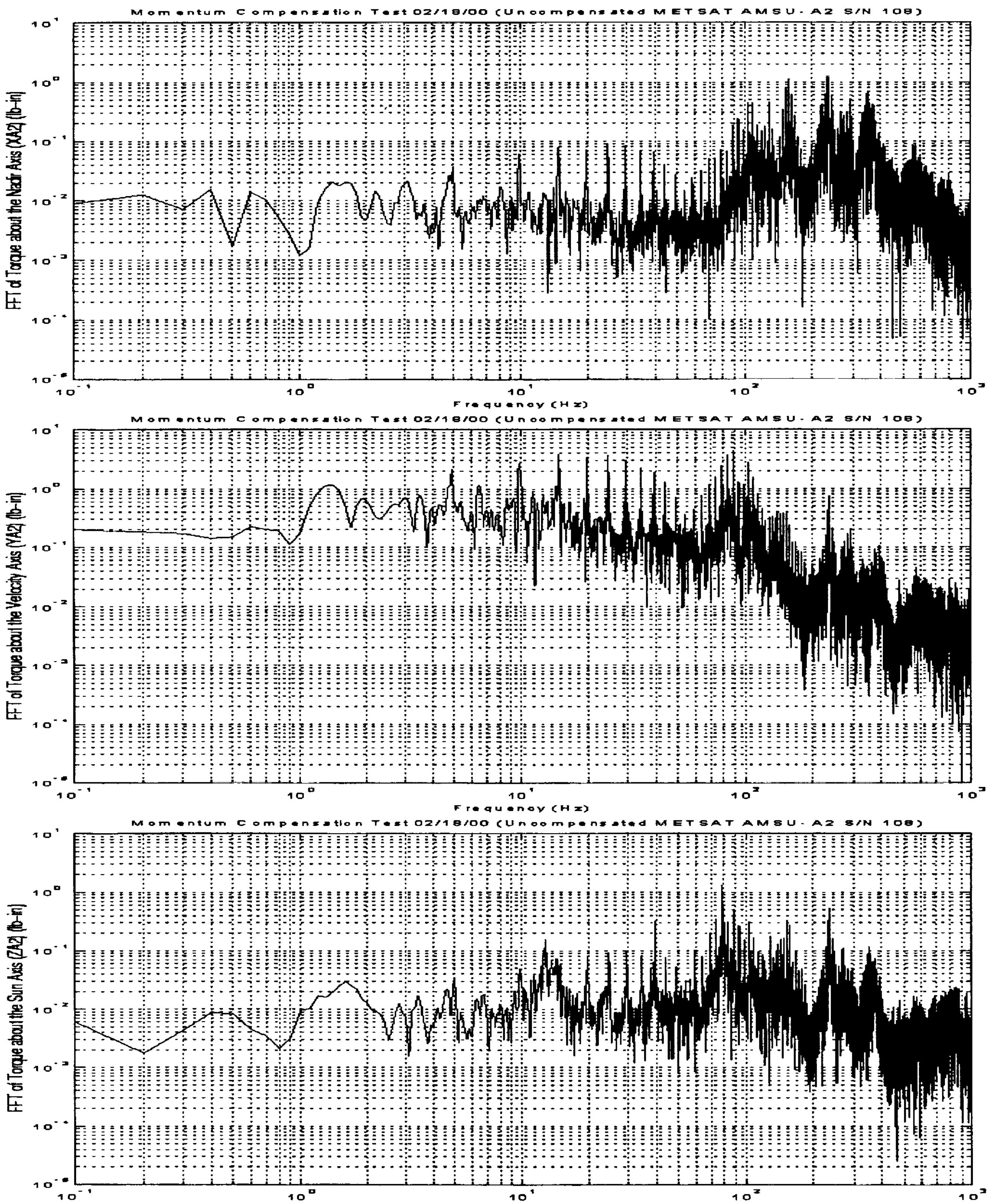
A2. Uncompensated disturbance torque (100 Hz low-pass filtered) of the AMSU-A2 S/N 108 unit.



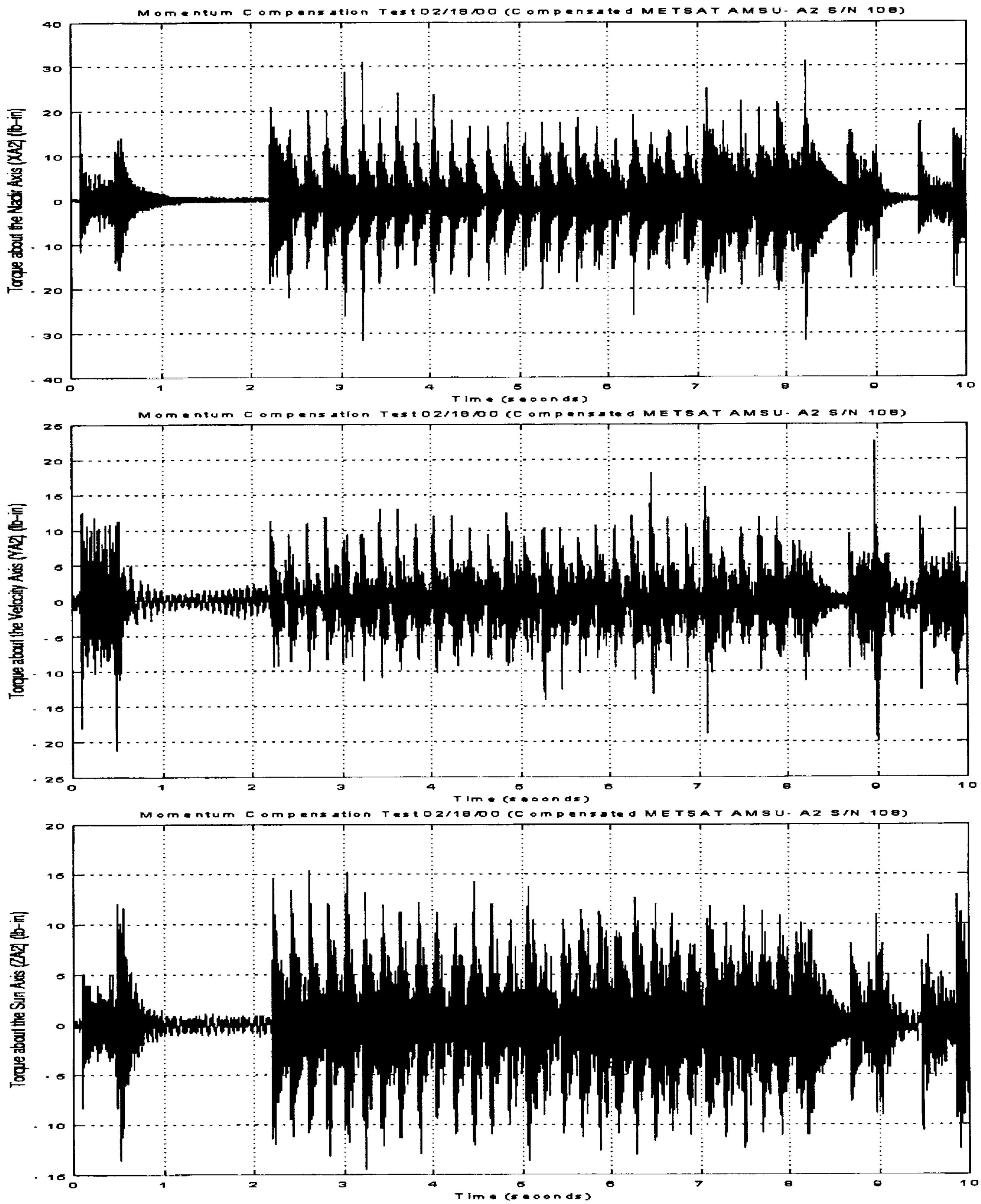
A3. Uncompensated disturbance torque (10 Hz low-pass filtered) of the AMSU-A2 S/N 108 unit.



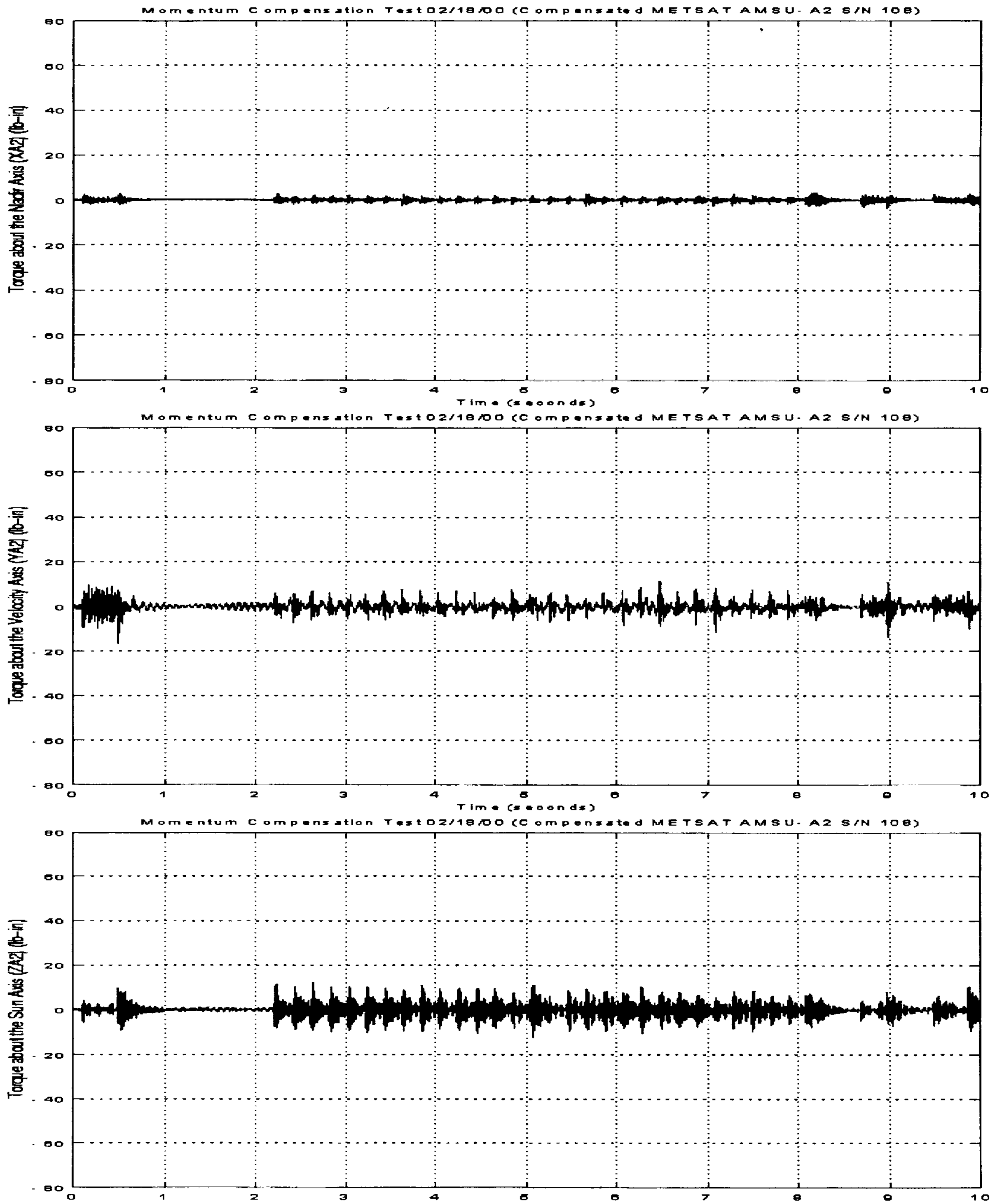
A4. Uncompensated angular momentum (time-integral of disturbance torque) of the AMSU-A2 S/N 108 unit.



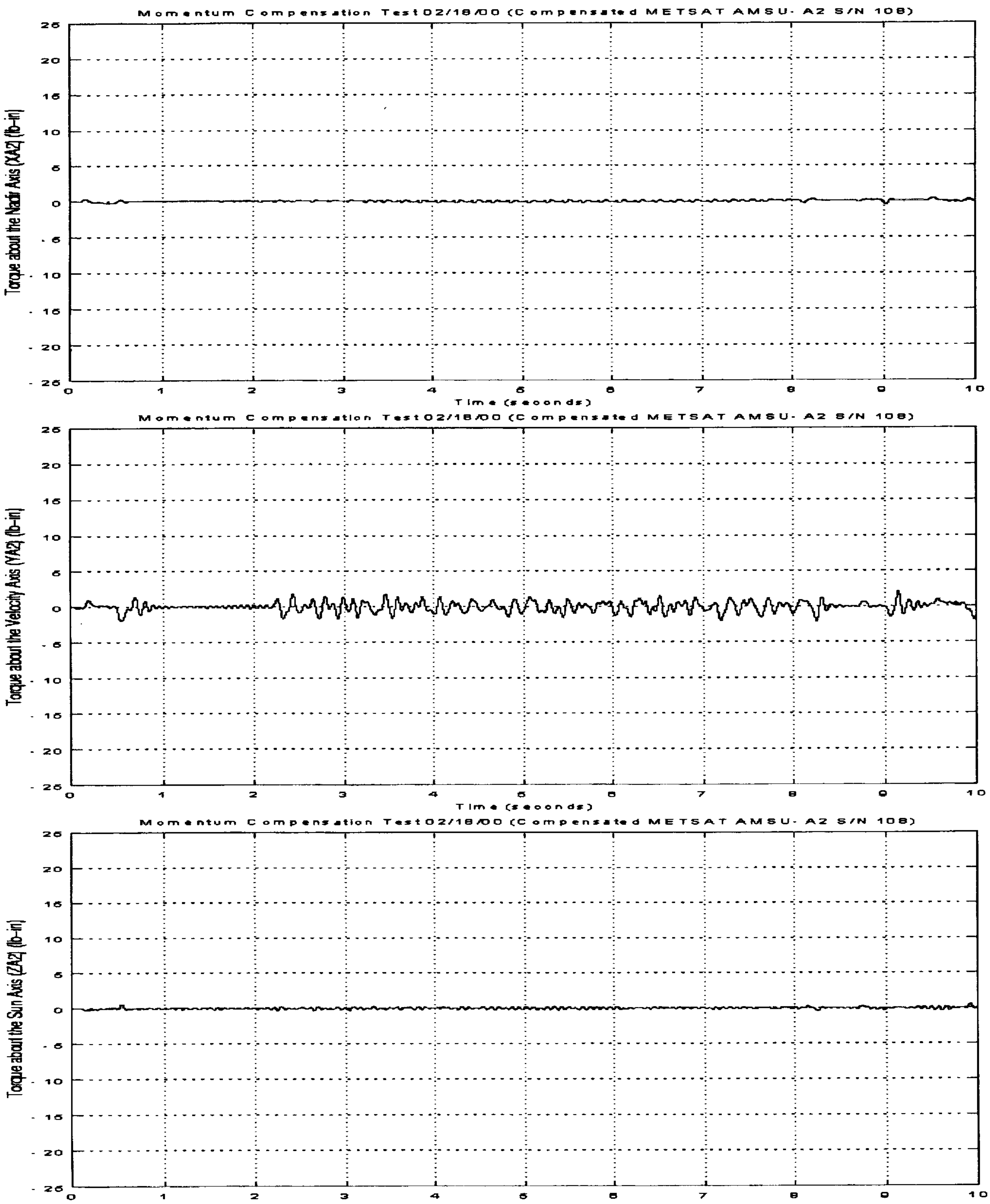
A5. Fourier transform of the disturbance torque of the uncompensated AMSU-A2 S/N 108 unit.



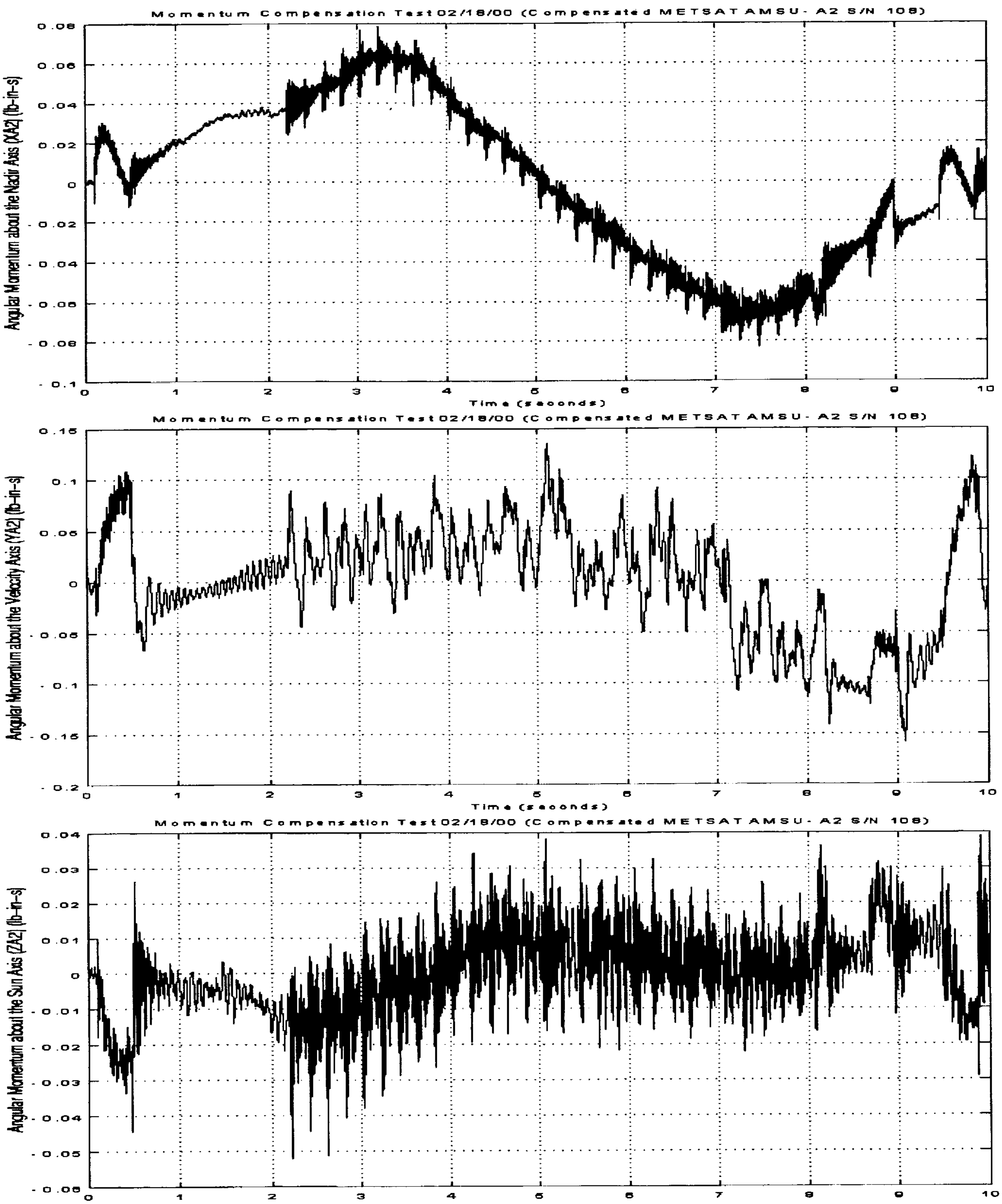
B1. Compensated disturbance torque (unfiltered) of the AMSU-A2 S/N 108 unit.



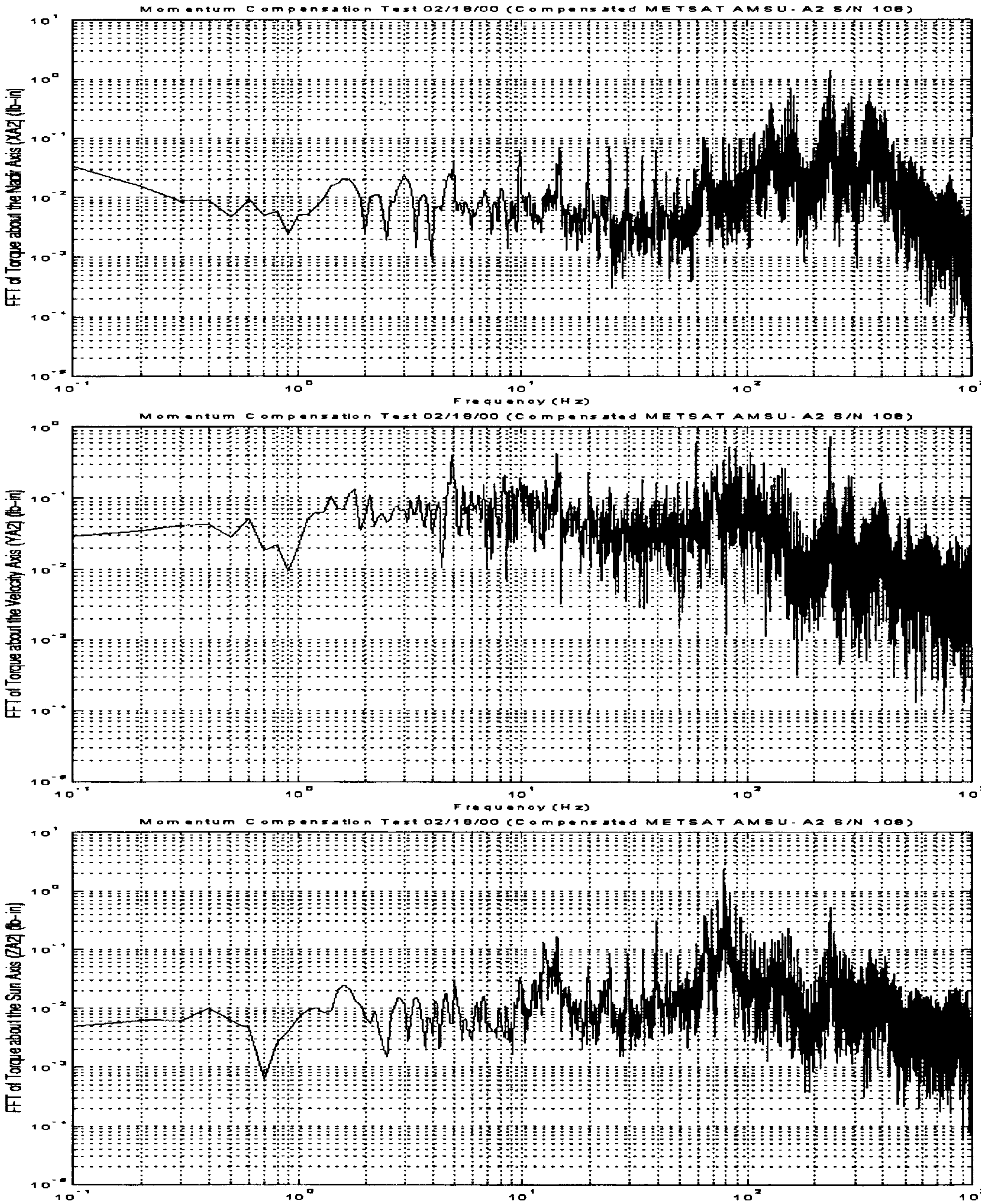
B2. Compensated disturbance torque (100 Hz low-pass filtered) of the AMSU-A2 S/N 108 unit.



B3. Compensated disturbance torque (10 Hz low-pass filtered) of the AMSU-A2 S/N 108 unit.



B4. Compensated angular momentum (time-integral of disturbance torque) of the AMSU-A2 S/N 108 unit.



B5. Fourier transform of the disturbance torque of the compensated AMSU-A2 S/N 108 unit.

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Report Documentation Page

1. Report No. ---	2. Government Accession No. ---	3. Recipient's Catalog No. ---
4. Title and Subtitle: Integrated Advanced Microwave Sounding Unit-A (AMSU-A), Engineering Test Report		5. Report Date: 9 March 2000
		6. Performing Organization Code: ---
7. Author(s): R. Bahng		8. Performing Organization Report No.: 11653
		10. Work Unit No.: ---
9. Performing Organization Name and Address: Aerojet, 1100 W. Hollyvale, Azusa, CA 91702		11. Contract or Grant No.: NAS 5-32314
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		14. Sponsoring Agency Code: ---

15. Supplementary Notes

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16. ABSTRACT (*Maximum 200 words*)

This is the Engineering Test Report, AMSU-A2 S/N 108 Disturbance Torque and Angular Momentum Measurements, for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).

17. Key Words (Suggested by Author(s)): EOS, Microwave System	18. Distribution Statement: Unclassified --- Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
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4. TITLE AND SUBTITLE Integrated Advanced Microwave Sounding Unit-A (AMSU-A), Engineering Test Report		5. FUNDING NUMBERS NAS 5-32314	
6. AUTHOR(S) R. Bahng			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Aerojet 1100 W. Hollyvale Azusa, CA 91702		8. PERFORMING ORGANIZATION REPORT NUMBER 11653 9 March 2000	
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13. ABSTRACT (*Maximum 200 words*) This is the Engineering Test Report, AMSU-A2 S/N 108 Disturbance Torque and Angular Momentum Measurements, for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A).			
14. SUBJECT TERMS EOS Microwave System			15. NUMBER OF PAGES
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17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT SAR

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