FM-1.

JEM-X Detector Assembly
for
INTEGRAL Satellite

Determination of Moment of Inertia.

(IN-13-JEM-0111)

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1. INTRODUCTION

Flight Model 1 of Jem-X Detector Assembly is one of the two detectors to be flown on the Integral satellite. After the Detector Assembly, consisting of the Detector part and the electronic box, (the so-called DFEE box), were fully assembled, the Moments of Inertia were determined. This document explains the measurement method and shows the measurement results.

2. METHOD OF DETERMINATION

The Moments of Inertia (MoI) are determined with the help of the dedicated stand for MoI determination based on the method of Torsional Pendulum. The Jem-X Detector Assembly is mounted on the special fixture that is in advanced tested separately. The MoI determination stand is shown in fig.1.

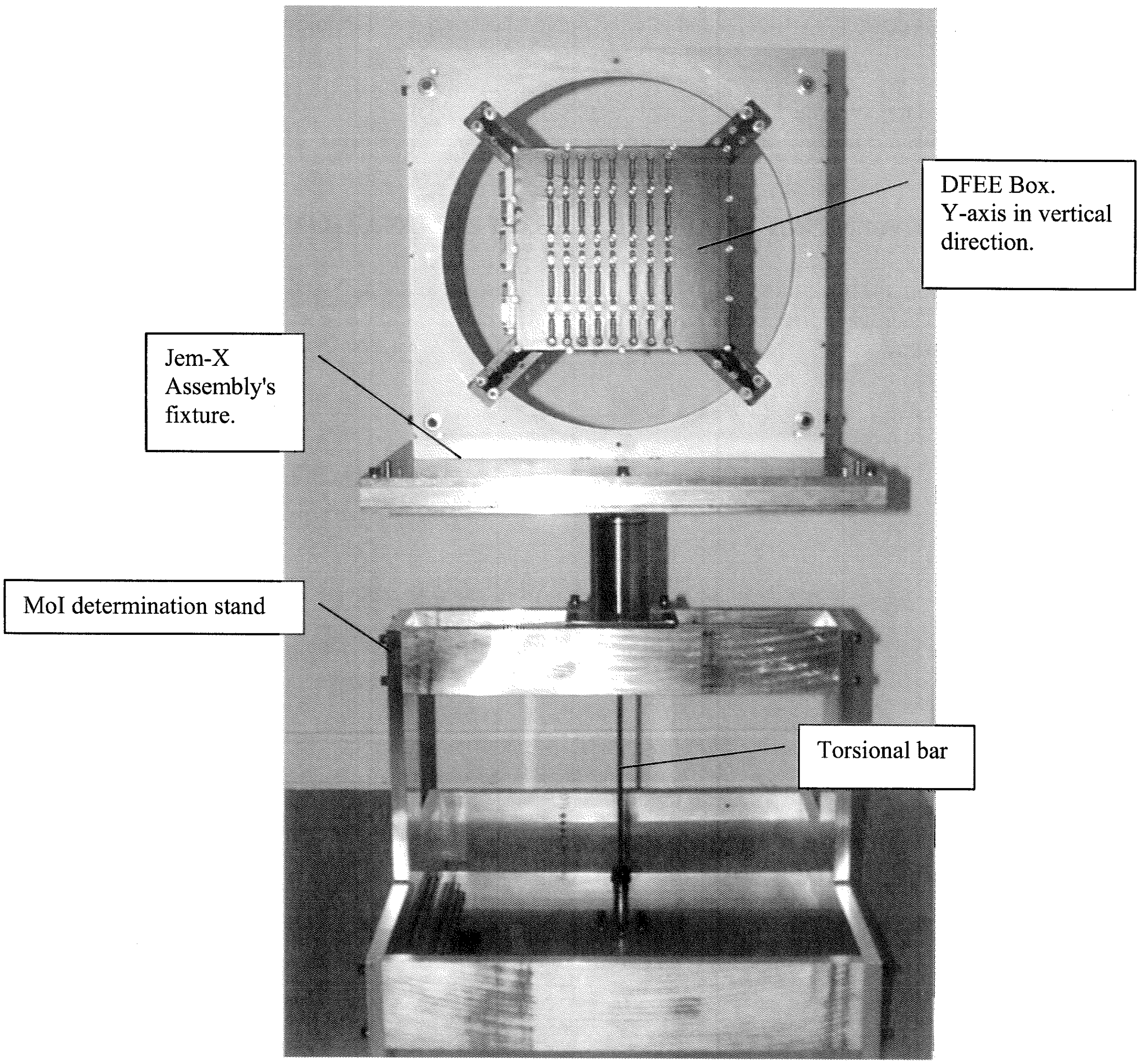

Fig. 1. Moment of Inertia Stand with fixture and DFEE box mounted for test along Y-axis.

The eigen-frequency of the fixture+Detector Assembly is determined by measurement of the oscillation period. This is done electronically with the help of the optical diode and the timer/counter/analyzer. At least ten oscillations are used for determination of the oscillation period. The measurements are repeated at least two times to confirm that the found values are stable.
The necessary data are input in to dedicated Excel Spreadsheet that calculates the MoI with respect to X, Y and Z axes parallel with the User Coordinate System but with origo in the Center of Gravity positioned as determined in advanced.
The whole procedure was commissioned before its application for the FM1 Detector Assembly by measuring the MoI of the simple object with the MoI determined by simple geometrical calculations.

3. MOMENT of INERTIA DETERMINATION SEQUENCE

The Detector Assembly was bolted to the fixture arranged so the MoI could be determined in the X direction. The fixture and the Detector Assembly were brought in to oscillation movement in torsional direction. The eigenfrequency "fo" was determined several times.
The numbers determined are loaded into the Spreadsheet prepared for quick calculations of the MoI.

The procedure is repeated for the Y and Z-axes.
The Spreadsheet is enclosed in enclosure 1.

4. RESULTS of MOMENT of INERTIA DETERMINATION

As seen from the enclosure 1 the MoI of FM1 with respect to the X, Y and Z axis parallel to the Unite Coordinate System and with origo in CoG are:
Ix = 0.50 kgm
Iy = 0.56 kgm
Iz = 0.56 kgm

Experiment to Find Moments of Inertia of an object.

The natural frequency can be written:

f0=1/(2*PI())*SQRT(G*PI()*r^4/(2*L*J))

Where G is modulus of elasticity for lateral stress, r is the radius of the torsion-bar, L is the length of the torsion-bar, and J is the moment of inertia.

Formula can be rewritten to find moment of inertia:

J=G*r^4/(8*PI()*f0^2*L)

G=	7.10E+10	N/m^2	
L=	0.215	m	
dia=2*r=	6.86	mm	Fill in calibrated dia.
r=	0.00343	m	

fill in coordinates for center og gravity according to origo.

X cog=	50.7	mm
Y cog=	158.3	mm
Z cog=	175.2	mm

Fill in mass of item

m=	27.8	kg

Then fill in the coordinates to the equipment shaft center line.

Experiment with item X-axis parallel to equipment shaft axis

Y shaft=	158.5	mm
Z shaft=	173.4	mm

Square distance from shaft center line to center of gravity.

distYZ^2=	3.28E-06	m^2

Experiment with item Y-axis parallel to equipment shaft axis

X shaft=	37	mm
Z shaft=	173.4	mm

Square distance from shaft center line to center of gravity.

distXZ^2=	0.00019093	m^2

Experiment with item Z-axis parallel to equipment shaft axis

X shaft=	37	mm
Y shaft=	158.5	mm

Square distance from shaft center line to center of gravity.

distXY^2=	0.00018773	m^2

Experiment with item X-axis parallel to equipment shaft axis								
First the moment of inertia for base plate with stand (without item) must be found.								
f0=	1.18133333	Hz						
Jattach=	1.30320156	kgm^2						
Then find the natural frequency with the item mounted.								
f0=	1.00225167	Hz						
Jtot=	1.81051837	kgm^2						
Moment of inertia of item alone=(Jtot-Jattach)-distYZ^2*m								
JitemX=	**0.50722562**	**kgm^2**						
This is the moment of inertia around a line through center of gravity parallel to the X-axis.								

Experiment with item Y-axis parallel to equipment shaft axis								
First the moment of inertia for base plate with stand (without item) must be found.								
f0=	1.31433333	Hz						
Jattach=	1.052799	kgm^2						
Then find the natural frequency with the item mounted.								
f0=	1.06	Hz						
Jtot=	1.61861954	kgm^2						
Moment of inertia of item alone=(Jtot-Jattach)-distXZ^2*m								
JitemY=	**0.56051268**	**kgm^2**						
This is the moment of inertia around a line through center of gravity parallel to the Y-axis.								

Experiment with item Z-axis parallel to equipment shaft axis								
First the moment of inertia for base plate with stand (without item) must be found.								
f0=	1.31433333	Hz						
Jattach=	1.052799	kgm^2						
Then find the natural frequency with the item mounted.								
f0=	1.05973333	Hz						
Jtot=	1.61943425	kgm^2						
Moment of inertia of item alone=(Jtot-Jattach)-distXY^2*m								
JitemZ=	**0.56141635**	**kgm^2**						
This is the moment of inertia around a line through center of gravity parallel to the Z-axis.								