



**Aerospace
Systems Division**

ATM 1058

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DATE 9/17/71

LSG Flight Sensor Closed Loop
Performance Computer Analysis

Prepared by: *M. Dela Cruz*
M. Dela Cruz

Approved by: *K. Hsi*
K. Hsi



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A computer analysis of the closed loop performance of the flight sensor was performed on 15 September. This analysis was necessary; since the curves generated for Figure 4 of TP 2365522, the acceptance test at LaCoste and Romberg, were based upon nominal sensor parameters and the allowable tolerances on the parameters were not included. Therefore, the test results showed the flight sensor to be out-of-tolerance with respect to Figure 4. Using the computer analysis with the measured sensor parameters, Figure 4 was revised accordingly and the flight sensor was found to be within tolerance.

The nominal plate spacing used in the curve was 508 microns. The actual sensor was 520 microns (Specification is 530 microns maximum). Attached are the results, attachments 4 and 5, and program, attachments 1, 2, 3 and 6, for the computer run that includes the actual sensor parameters of i) plate spacing and ii) stop to stop beam deflection. The two curves, attachments 4 and 5, show the upper limit and lower limit for the acceptance curve of Figure 4 based on these parameters.

PROBLEM INPUT STATEMENTS

INIT

```

PARAM UINIT=0.,DELG=1.E-6
PARAM KAMP=1785
PARAM VSAT=14.
PARAM ERRX=0.
PARAM S1=(1.40,1.86,2.34)
PARAM MASS=.0225
PARAM MRATIO =1.
PARAM DR=1.37
PARAM KINT=.02
PARAM PRD=10.
PARAM FREQ=3300
PARAM EPS=8.85E-12
PARAM AREA=2.E-4
PARAM CSTRAY=30.E-12
PARAM VOSC=.5
PARAM DNOT=.520E-3
PARAM VNOT=6.4
PARAM RLOAD=5.E6
PARAM ETA=1.45
      CNOT=EPS*AREA/DNOT
      OMEGA=2*3.14159*FREQ
      KS1=2*OMEGA*RLOAD*CNOT
      KS2=CMEGA*RLOAD*(2.*CNOT+CSTRAY)
      KS3=SQRT(1.+KS2**2)
      KS=KS1*ETA/KS3
      KDEMOD=2./3.14159
      PHI=ATAN(1./KS2)
      A=(2.*CNOT*ETA**2)/DNOT**2
      KN1=(1.-KS*COS(PHI))*VOSC**2
      KN=.5*A*(KN1+2.*VNOT**2)
      KA=2.*CNOT*VNOT*ETA/DNOT
S2=2*3.14159/(PRD*SQRT(MRATIO))
      KEX=1./S2**2
      KXS=KS*VOSC/DNOT
      KXP=KXS*KAMP
      KXD=KXP*KDEMOD
      KXINT=KXD*KINT
      KED=KEX*KXD
      KEINT=KEX*KXINT
KINTFD=KA/MASS/DR
      KLOOP=KEINT*KINTFD
      IKLOOP=1./KLOOP
      IKEINT=1./KINTFD
      IKXINT=IKEINT/KEX
      IKSINT=IKXINT/KXS
      IKPINT=IKSINT/KAMP
      IKDINT=IKPINT/KDEMOD
PARAM FRMOMG =5.22E-3,TIDOMG =2.44E-6
      SXD=1.E-7*KXD
      SND=1.E-10*KXD
      SXP=1.E-7*KXP
      SNP=1.E-10*KXP
      SXS=1.E-7*KXS
      SNS=1.E-10*KXS
      FRMXI=8.E-8*IKEINT
      FRMNI=8.E-11*IKEINT
      FRMXD=FRMXI*FRMOMG /KINT
    
```

```

FRMND=FRMNI*FRMQMG /KINT
FRMXP=FRMXD/KDEMOD
FRMNP=FRMND/KDEMOD
FRMXS=FRMXP/KAMP
FRMNS=FRMNP/KAMP
FRMXX=FRMXS/KXS
FRMNX=FRMNS/KXS
TIDXI=2.5E-6*IKEINT
TIDNI=2.E-8*IKEINT
TIDXD=TIDXI*SQRT(TIDCMG **2+.0004**2)/KINT
TIDND=TIDNI*SQRT(TIDCMG **2+.0004**2)/KINT
TIDXP=TIDXD/KDEMOD
TIDNP=TIDND/KDEMOD
TIDXS=TIDXP/KAMP
TIDNS=TIDNP/KAMP
TIDXX=TIDXS/KXS
TIDNX=TIDNS/KXS
ATIDXD=ATIDXI*SQRT(TIDCMG **2+.0004**2)/KINT
ATIDND=ATIDNI*SQRT(TIDCMG **2+.0004**2)/KINT
ATIDXP=ATIDXD/KDEMOD
ATIDNP=ATIDND/KDEMOD
ATIDXS=ATIDXP/KAMP
ATIDNS=ATIDNP/KAMP
ATIDXX=ATIDXS/KXS
ATIDNX=ATIDNS/KXS
XINIT=DELG*(1.+ERRX)/DR/S2**2

```

DYNAM

XX=X*KS*VOSC*KAMP/DNOT

PROCED

UPD=BLK(XX,XXABS, LEG,SHI,KDEMOD)

XXABS=ABS(XX)

IF(XXABS-5.) 1,1,2

1

UPD=XX*KDEMOD

GO TO 3

2

LEG=SQRT(XX**2-5. **2)

SHI=ATAN(5./LEG)

UPD=XX*KDEMOD*(1.-COS(SHI))+5. *(1.-(2./3.14159)*SHI)

3

CONTINUE

ENDPRO

UPDN=LIMIT(-VSAT,VSAT,UPD)

UU=KINT*UPDN

UUU=INTGRL(UINIT,UU)

U=LIMIT(-VSAT,VSAT,UUU)

UNORM=U*KA/(MASS*DELG)

FEED=(KA*U-X*KN-A*X*U**2)/(MASS*DR)

ERROR=DELG/DR-FEED

DX=ERROR-2.*S1*S2*D-S2*S2*X

DXX=INTGRL(C.,DX)

PROCED

D=CLK(X,DXX)

IF(ABS(X)-.50E-4) 6,7,7

6

D=DXX

GO TO 15

7

IF(X-.50E-4) 11,8,8

8

IF(DXX) 9,9,10

9

D=DXX

GO TO 15

10

D=0

GO TO 15

11

IF(DXX) 10,12,12

12

D=DXX

15

CONTINUE

ENDPRO

XXX=INTGRL(XINIT,D)

```

X=LIMIT(-.50E-4,.50E-4,XXX)
Y=DEBUG(1,0.)
TIMER DELT=95,FINTIM=100,PRDEL=2.,OUTDEL=2.
ABSERR UUU=1.E-4,DXX=1.E-10,XXX=1.E-9
RELERR UUU=1.E-3,DXX=1.E-3,XXX=1.E-3
PRTPLT UNORM
LABEL GRAV XSTEP RESP EARTH OPER DELG=100 UGALS,T=10,
METHOD RKS
END
RESET PRTPLT
RESET RANGE
RESET LABEL
PARAM PRD=9,S1=(1.26,1.68,2.1)
LABEL GRAV XSTEP RESP EARTH OPER DELG=100UGALS,T=9
PRTPLT UNORM
END
RESET PRTPLT
RESET RANGE
RESET LABEL
PARAM PRD=8,S1=(1.1,1.49,1.87)
PRTPLT UNORM
LABEL GRAV XSTEP RESP EARTH OPER DELG=100 UGALS,T =8.
END
RESET PRTPLT
RESET RANGE
RESET LABEL
PARAM PRD=8.5,S1=(1.54,1.19,1.97)
PRTPLT UNORM
LABEL GRAV XSTEP RESP EARTH OPER DELG=100 UGALS,T=8.5
END
RESET PRTPLT
RESET RANGE
RESET LABEL
PARAM PRD=9.5,S1=(1.33,1.77,2.22)
LABEL GRAV XSTEP RESP EARTH OPER DELG=100 UGALS,T=9.5
PRTPLT UNORM
END
STOP

```

OUTPUT VARIABLE SEQUENCE

OUTPUT	VARIABLE	SEQUENCE								
CNOT	OMEGA	KS2	PHI	KS3	KS1	KS	KN1	A	KN	
KDEMCD	KXS	KXP	KXD	S2	KEX	KED	KA	KINTFD	KXINT	
KEINT	KLOOP	IKLOOP	IKEINT	IKXINT	IKSINT	IKPINT	IKDINT	SXD	SND	
SXP	SNP	SXS	SNS	FRMXI	FRMXD	FRMXP	FRMXS	FRMXX	FRMNI	
FRMND	FRMNP	FRMNS	FRMNX	TIDXI	TIDXD	TIDXP	TIDXS	TIDXX	TIDNI	
TIDND	TIDNP	TIDNS	TIDNX	ATIDXD	ATIDXP	ATIDXS	ATIDXX	ATIDND	ATIDNP	
ATIDNS	ATIDNX	XINIT	X	XX	UPD	UPDN	UU	UUU	D	
J	FEED	ERROR	DX	DXX	XXX	UNORM	Y			

PARAMETERS NOT INPUT OR OUTPUTS NOT AVAILABLE TO SORT SECTION***SET TO ZERO***

ATIDXI ATIDNI XXABS LEG SHI

OUTPUTS	INPUTS	PARAMS	INTEGS + MEM BLKS	FORTRAN	DATA CDS
82(500)	192(1400)	34(400)	3+ 0= 3(300)	97(600)	55

ENDJOB

```

PARAM UINIT=0.,DELG=1.E-6
PARAM KAMP=1785
PARAM VSAT=14.

```


MINIMUM
0.0

UNORM VERSUS TIME
S1 = 1.1000E 00

MAXIMUM
9.9663E-01

TIME	UNORM	I
0	0.0	+
.0000E 00	7.3743E-C2	---+
.0000E 00	1.4900E-01	-----+
.0000E 00	2.2210E-C1	-----+
.0000E 00	2.9091E-01	-----+
.0000E 01	3.5461E-01	-----+
.2000E 01	4.1308E-01	-----+
.4000E 01	4.6648E-01	-----+
.6000E 01	5.1515E-C1	-----+
.8000E 01	5.5944E-01	-----+
.0000E 01	5.9971E-01	-----+
.2000E 01	6.3632E-01	-----+
.4000E 01	6.6958E-01	-----+
.6000E 01	6.9981E-01	-----+
.8000E 01	7.2727E-01	-----+
.0000E 01	7.5222E-01	-----+
.2000E 01	7.7489E-01	-----+
.4000E 01	7.9549E-01	-----+
.6000E 01	8.1420E-01	-----+
.8000E 01	8.3120E-01	-----+
.0000E 01	8.4664E-01	-----+
.2000E 01	8.6068E-01	-----+
.4000E 01	8.7342E-01	-----+
.6000E 01	8.8500E-01	-----+
.8000E 01	8.9553E-01	-----+
.0000E 01	9.0508E-01	-----+
.2000E 01	9.1377E-01	-----+
.4000E 01	9.2166E-01	-----+
.6000E 01	9.2883E-01	-----+
.8000E 01	9.3534E-01	-----+
.0000E 01	9.4125E-01	-----+
.2000E 01	9.4663E-01	-----+
.4000E 01	9.5151E-01	-----+
.6000E 01	9.5595E-01	-----+
.8000E 01	9.5998E-01	-----+
.0000E 01	9.6364E-01	-----+
.2000E 01	9.6697E-01	-----+
.4000E 01	9.6999E-01	-----+
.6000E 01	9.7274E-01	-----+
.8000E 01	9.7523E-01	-----+
.0000E 01	9.7750E-01	-----+
.2000E 01	9.7955E-01	-----+
.4000E 01	9.8143E-01	-----+
.6000E 01	9.8312E-01	-----+
.8000E 01	9.8467E-01	-----+
.0000E 01	9.8607E-01	-----+
.2000E 01	9.8735E-01	-----+
.4000E 01	9.8850E-01	-----+
.6000E 01	9.8955E-01	-----+
.8000E 01	9.9051E-01	-----+
.0000E 02	9.9138E-01	-----+

MINIMUM
0.0

UNORM VERSUS TIME
S1 = 1.4900E 00

MAXIMUM
9.9663E-01

TIME	UNORM	I
------	-------	---

(6)

```

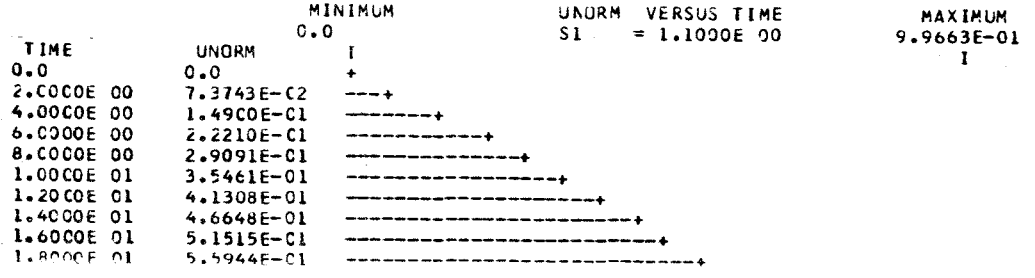
UPDN = 3.3542E-01      U = 0.0      UNORM = 0.0      FEED = -8.3422E-08
ERRCR = 8.1335E-07    X = 1.1833E-06  Y = 0.0
DEBUG OUTPUT KEEP= 1
TIME = 0.0
DELX = 2.0000E 00    DELMIN= 1.0000E-05  FINTIM= 1.0000E 02  PRDEL = 2.0000E 00
OUTDEL= 2.0000E 00    UUU = 0.0      DXX = 0.0      XXX = 1.1833E-06
UU = 6.7085E-03      DX = 8.3423E-08  D = 0.0      UINIT = 0.0
ZZCCC3= 0.0          XINIT = 1.1833E-06  DELG = 1.0000E-06  KAMP = 1.7850E 03
VSAT = 1.4000E 01    ERRX = 0.0      S1 = 1.8700E 00  MASS = 2.2500E-02
MRATIO= 1.0000E 00  DR = 1.3700E 00  KINT = 2.0000E-02  PRD = 8.0000E 00
FREQ = 3.3000E 03    EPS = 8.8501E-12  AREA = 2.0000E-04  CSTRAY= 3.0000E-11
VOSC = 5.0000E-01    DNCT = 5.2000E-04  VNCT = 6.4000E 00  RLDAD = 5.0000E 06
ETA = 1.4500E 00    FRMCMG= 5.2200E-03  TIDMG= 2.4400E-06  ATIDXI= 0.0
ATIDNI= 0.0          XXABS = 5.2688E-01  LEG = 0.0      SHI = 0.0
CNOT = 3.4039E-12    OMEGA = 2.0734E 04  KS1 = 7.0577E-01  KS2 = 3.8160E 00
KS3 = 3.5448E 00    KS = 2.5942E-01  KDEMOD= 6.3662E-01  PHI = 2.5629E-01
A = 5.2934E-05      KN1 = 1.8726E-01  KN = 2.1731E-03  KA = 1.2149E-07
S2 = 7.8540E-01     KEX = 1.6211E 00  KXS = 2.4944E 02  KXP = 4.4526E 05
KXD = 2.8346E 05    KXINT = 5.6692E 03  KED = 4.5953E 05  KEINT = 9.1906E 03
KINTFD= 3.9414E-06  KLCOP = 3.6223E-02  IKLOOP= 2.7607E 01  IKEINT= 2.5372E 05
IKXINT= 1.5651E 05  IKSINT= 6.2742E 02  IKPINT= 3.5150E-01  IKDINT= 5.5213E-01
SXD = 2.8346E-02    SND = 2.8346E-05  SXP = 4.4526E-02  SNP = 4.4526E-05
SXS = 2.4944E-05    SNS = 2.4944E-08  FRMXI = 2.0298E-02  FRMNI = 2.0298E-05
FRMXD = 5.2977E-03  FRMND = 5.2977E-06  FRMXP = 8.3216E-03  FRMNP = 8.3216E-06
FRMXS = 4.6619E-06  FRMNS = 4.6619E-09  FRMXX = 1.8689E-08  FRMNX = 1.8689E-11
TIDXI = 6.3430E-01  TIDNI = 5.0744E-03  TIDXD = 1.2686E-02  TIDND = 1.0149E-04
TIDXP = 1.9927E-02  TIDNP = 1.5942E-04  TIDXS = 1.1164E-05  TIDNS = 8.9311E-08
TIDXX = 4.4755E-C8  TIDNX = 3.5804E-10  ATIDXD= 0.0      ATIDND= 0.0
ATIDXP= 0.0          ATIDNP= 0.0      ATIDXS= 0.0      ATIDNS= 0.0
ATIDXX= 0.0          ATIDNX= 0.0      XX = 5.2688E-01  UPD = 3.3542E-01
UPDN = 3.3542E-01    U = 0.0          UNORM = 0.0      FEED = -8.3422E-08
ERRCR = 8.1335E-C7  X = 1.1833E-06  Y = 0.0

```

VARIABLE	MINIMUM	TIME	MAXIMUM	TIME
UNORM	0.0	0.0	9.9663E-01	1.0000E 02

GRAV XSTEP RESP EARTH OPER DELG=100 UGALS,T =8.

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