APOLLO TRAINING

GUIDANCE AND NAVIGATION SUBSYSTEM

COURSE NUMBER A-920

MARCH 25, 1966 FOR TRAINING PURPOSES ONLY
G&C FUNCTIONAL CONTROL LOOPS

GUIDANCE & NAVIGATION SYSTEM

BODY OR NAV AXES ATT ERRORS

SPS THRUST ON-OFF

STABILIZATION AND CONTROL SYSTEM

RCS AUTO ON-OFF

SPS ON-OFF

SPS GIMBAL COMMANDS

PROPULSION RCS & SPS

DISPLAY & SWITCH COMMANDS

TRANSLATION COMMANDS

TOTAL ATTITUDE

DIRECT RCS ROTATION COMMANDS

TRANSLATION CONTROL

MAIN DISPLAY CONSOLE

ROTATION CONTROL
VELOCITY CORRECTION

NAVIGATIONAL FIX

OPTICAL SIGHTINGS

OPTICAL INSTRUMENTS

SPACECRAFT ATTITUDE

ACCELERATION

INERTIAL GUIDANCE

INFORMATION

COMPUTER

DISCRETES ENGINES "ON" & "OFF"

STEERING SIGNALS

SPACECRAFT CONTROL

GN-9008
INTERFACE OF G AND N SUBSYSTEMS

- STATUS OF INERTIAL SUBSYSTEM
- ALIGNMENT AND CONTROL COMMANDS
- CHANGES IN VELOCITY
- ATTITUDE

COMPUTER SUBSYSTEM

THRUSt COMMAND
STATUS OF OPTICS
OPTICAL ANGLES AND MARK COMMANDS

TO STABILIZATION AND CONTROL SYSTEM

ASTRONAUT

INERTIAL SUBSYSTEM

TO STABILIZATION AND CONTROL SYSTEM

OPTICAL SUBSYSTEM

STEERING ERROR

TO STABILIZATION AND CONTROL SYSTEM

GN-9088A
G&N HARDWARE
NAV BASE AND OPTICAL UNIT ASSEMBLY
BLOCK 1 COMPUTER
100 SERIES

COVER PLATE

REMOVABLE CORE ROPE MODULES

POWER CONNECTOR 05A5P5

(LOGIC) - TRAY A

(MEMORY) - TRAY B

COLD PLATE

TEST CONNECTOR 05A5P3

OUTSIDE WORLD CONNECTOR 05A5P4

GN-229A
G&N SYSTEM EQUIPMENT LOCATION

NAVIGATION BASE

LOWER DISPLAY AND CONTROL PANEL

MAIN DISPLAY AND CONTROL PANEL

OPTICAL ASSEMBLY

CDU

PSA

AGC

GN-9163A
LOCATION OF GUIDANCE AND NAVIGATION EQUIPMENT IN SPACECRAFT

OPTICAL ASSEMBLY

COUPLING DISPLAY UNIT CDU

INERTIAL MEASUREMENT UNIT IMU

NAVIGATION BASE NB

POWER SERVO ASSEMBLY PSA

APOLLO GUIDANCE COMPUTER AGC

LOWER DISPLAY AND CONTROL PANEL LOWER D&C

GN-9005
G&N CONTROLS & DISPLAYS
MAIN DISPLAY CONSOLE LOCATOR

FAM-6001
FAM-6002
FAM-6003
FAM-6004
FAM-6005
FAM-6006
FAM-6007
FAM-6008
FAM-6009
FAM-6010
FAM-6011
FAM-6012
FAM-6013
FAM-6014
FAM-6015
FAM-6016
FAM-6017
FAM-6018
FAM-6019
FAM-6020
FAM-6021
FAM-6022
FAM-6023
GN-207A
FLIGHT DIRECTOR ATTITUDE INDICATOR

NOTES:
1. ATTITUDE ERROR = ATTITUDE DESIRED - ACTUAL ATTITUDE.
2. THE BALL IS OF THE INSIDE-OUT CONVENTION.
3. EULER ANGLE CONVENTION IS PITCH, YAW, ROLL.
4. THE BALL ATTITUDE SHOWN IS PITCH 345°, YAW 335°, AND ROLL 300°, WITH RESPECT TO THE NAVIGATION BASE INDEX.
NOTE: The SXT and SCT scopes are stowed behind a compartment door.
PANEL 97 LOWER EQUIPMENT BAY

DC VOLTS

FUNCTION SELECT
CM RCS HTRS

OFF

TEST SELECT

OFF

PANEL 97, AUXILIARY DISPLAY PANEL,
FORWARD RIGHTHEHAND EQUIPMENT BAY
G&N INTERFACE SYSTEMS

COMMUNICATIONS & INSTRUMENTATION SYSTEM

TELEMETRY & MONITORING

OPTICAL LINE-OF-SIGHT

COOLANT FLUID

GUIDANCE & NAVIGATION SYSTEM

STEERING ERROR & THRUST COMMANDS

ENVIROMENTAL CONTROL SYSTEM

PRIMARY POWER

ELECTRICAL POWER SYSTEM

SPACECRAFT CONTROL LOOP

REACTION CONTROL SYSTEM

ATTITUDE CONTROL SIGNAL

THRUST CONTROL SIGNAL

VEHICLE DYNAMICS

REACTION JET

MAIN PROPULSION ENGINE

SERVICE PROPULSION SYSTEM

G&N-500A
OPTICS SUBSYSTEM
OPTICAL SCHEMATIC

SEXTANT

LINE OF SIGHT 1
LINE OF SIGHT 2

TRUNNION DRIVE

FIELD 1.8- EACH
MAGNIFICATION 28X

SCANNING TELESCOPE

LINE OF SIGHT

TRUNNION DRIVE

FIELD
MAGNIFICATION
60 DEG
1X

SHAFT
DRIVE

SHAFT
DRIVE

GN-176 A
OPTICAL SYSTEM AXES

ZERO OPTICS
SHAFT AXES AND TRUNNION AXES COINCIDENT WITH NAV. BASE AXES

SHAFT AXIS ROTATION

TRUNNION AXIS ROTATION

GN-9175A
SEXTANT CUTAWAY

1. OPTICAL BASE
2. COOLANT CONNECTIONS
3. BALL MOUNT
4. STUD HOLES FOR MOUNTING BELLOWS COVER
5. FIXED RIGHT-ANGLE MIRRORS
6. TRUNNION AXIS RESOLVER (64X)
7. COVER-FASTENING ROD
8. INDEXING MIRROR
9. BEAM SPLITTER
10. TRUNNION DRIVE GEAR BOX
11. OBJECTIVE LENS ASSEMBLY
12. INTERMEDIATE LENS ASSEMBLY
13. SHAFT AXIS DRIVE MOTOR
14. RETICLE
15. LIGHT-TRANSMITTING ROD
16. RETICLE LAMP
17. SHAFT-AXIS RESOLVER (16X)
18. SHAFT DRIVE GEAR BOX
19. EYEPiece SOCKET & SEAL
20. EYEPiece OBJECTIVE LENS
21. EYEPiece MIRRORS
22. EYEPiece OCULAR
SEXTANT TRUNNION AXIS ASSEMBLY

- 64X RESOLVER STATOR
- 64X RESOLVER ROTOR
- BEAMSPLITTER
- FIXED TRUNNION MIRRORS (2)
- TRUNNION AXIS BALL BEARING (2)
- TRUNNION DRIVE GEAR
- TRUNNION DRIVE GEARBOX
- MIRROR
- MIRROR MOUNT
- FRAME
- 1X RESOLVER STATOR
- 1X RESOLVER ROTOR
COUPLING DISPLAY UNIT

1/4 SPEED RESOLVER

1 SPEED RESOLVER

MOTOR TACHOMETER

16 SPEED RESOLVER

DIGITAL PICKOFF HEAD

SLEW SWITCH

2 SPEED RESOLVER

DISPLAY DIALS

THUMB WHEEL ADJUSTMENT

DIGITAL PICKOFF GEAR
(64 TEETH)
CDU BLOCK DIAGRAM

MOTOR-GENERATOR

TRUNNION CDU

RESOLVER RECEIVER

64-TOOTH ENCODER

32

16X

0.2% REV

10% REV

360% REV

RESOLVER

COMPUTING RESOLVER

(RESOLVER TRANSMITTER WHEN USED IN SHAFT LOOP)

RESOLVER TRANSMITTER

3.87

DIALS

MANUAL DRIVE

GN-9130
CDU FUNCTIONAL DIAGRAM

NOTE: K5 FOR OUTER GIMBAL MECHANIZATION ONLY
2 DENOTES OPEN LEAD ON DG CIRCUIT WITH
K5 ENERGIZED

ENCODER ELECTRONICS
DIGITAL TO ANALOG CONVERTER
COU FAIL, INDICATOR
DISPLAY DIALS
10°/REV
SELECTOR CIRCUIT

CDU

MOTOR TACH

28 V 800 CPS/C°

DISPLAY DIALS
30°/REV
10°/REV
0.25°/REV
THUMB WHEEL

COARSE ALIGN AMPLIFIER

TO SPACECRAFT STABILIZATION CONTROL SYSTEM

DOABLE DAC

GN-288
TO ZERO OPTICS RELAY
FROM RESOLVER TRANSMITTER $\frac{1}{4}x$

FROM RESOLVER RECEIVED $16x$ (TRUNNION)
TWO SPEED SWITCH
MOTOR DRIVE PREAMP
MOTOR DRIVE AMP
TACHOMETER FEEDBACK
MOTOR GENERATOR
RESOLVER RECEIVER
RESOLVER TRANSMITTER

TRUNNION
FROM RESOLVER TRANSMITTER $\frac{1}{2}x$
TO ZERO OPTICS RELAY

FROM RESOLVER RECEIVED $16x$ (SHAFT)
TWO SPEED SWITCH
MOTOR DRIVE PREAMP
MOTOR DRIVE AMP
TACHOMETER FEEDBACK
MOTOR GENERATOR
RESOLVER TRANSMITTER

SEXTANT SHAFT
SEXTANT POSITION SERVO LOOPS
GN-9132
INTEGRATING SERVO LOOPS
(MANUAL—DIRECT MODE)

GN-9134
INTEGRATING SERVO LOOPS
(MANUAL - RESOLVED MODE)
INTTEGRATING SERVO LOOPS (ZERO OPTICS MODE)
LAND MARKS
IMU ALIGNMENT MEASUREMENT

STABLE MEMBER COORDINATES

X_{sm} → Z_{sm} → SHAFT AXIS

Y_{sm} → STAR LOS

X_{s} → Z_{s} → STAR COORDINATES

SEXTANT FIELD OF VIEW
ORBITAL NAVIGATION MEASUREMENT

TELESCOPE FIELD OF VIEW

TELESCOPE LOS

LANDMARK

SHAFT AXIS ($A_s = 0$)

$X_{sc}$

$Z_{sc}$

$A_t$
EARTH ORBIT NAVIGATION

EARTH ORBIT GEOMETRY

EARTH ORBIT GEOMETRY FIGURE 1

VIEW ON SURFACE FIGURE 3

DIRECTION OF MOTION

EARTH HORIZON LOS

LANDMARK RECOGNITION LIMIT

COVERAGE ON SURFACE FIGURE 2
MIDCOURSE POSITION DETERMINATION
MIDCOURSE NAVIGATIONAL MEASUREMENT

LANDMARK

LANDMARK LOS

MOON

STAR LOS

STAR

SEXTANT FIELD OF VIEW

MOON

TELESCOPE FIELD OF VIEW

GN-9103A
INERTIAL SUBSYSTEM
INERTIAL SUBSYSTEM INTERFACE
APOLLO STABLE MEMBER CONFIGURATION

6" CUBE BERYLLIUM

1G ADA

IA

IGA

IC

ZG

IA

X C

Y A

ZA

IA

ADA

IRIG

PIP

ADA

IGA

GN- 9007 A
INTERGIMBAL ASSEMBLY

- Slip Ring Assembly
- Bearings
- Gyro Error Resolver
- Coarse Resolver
- Stable Member
- Middle Gimbal
- DC Torque Motor
25 IRIG, SIMPLIFIED CUTAWAY VIEW

- INPUT AXIS
- OUTPUT AXIS
- CASE
- PIVOT
- BEARING
- SIGNAL GENERATOR DUCOSYN
- FLOAT
- SPIN AXIS
- SPIN REFERENCE AXIS
- TORQUE GENERATOR DUCOSYN
- GYRO WHEEL ASSEMBLY

GN-240
DUCOSYN SIGNAL GENERATOR OPERATION

PRIMARY EXCITATION

E OUT

ROTOR AT NULL

COUNTER-CLOCKWISE ROTATION

GN-239
DUCOSYN TORQUE GENERATOR OPERATION

ROTOR AT HULL

POSITIVE TORQUING SIGNALS APPLIED

TG+  TG-
TG (COMM)
MAGNETIC SUSPENSION

CYLINDRICAL ROTOR

STATOR

SUSPENSION CAPACITORS

MAGNETIC SUSPENSION EXCITATION

GN-237
ANGULAR DIFFERENTIATING ACCELEROMETER

CASE

INPUT AXIS

STOP

PERMANENT MAGNET

COIL

TORSION WIRE

FLUID

CASE

BELLOWS

PERMANENT MAGNET

COIL

FLOAT

± 15°
GYRO ERROR RESOLVER

\[ E_{mg} = E(Zg) \cos A_{ig} + E(Xg) \sin A_{ig} \]

\[ E_{oG} = E(Xg) \cos A_{ig} - E(Zg) \sin A_{ig} \]
GIMBAL SERVO AMPLIFIER

FROM ADA PREAMP
FILTER & DC DECOUPLER

FROM IRIG PREAMP
DEMODULATOR AND FILTER
REFERENCE INPUT

TEST INPUT

FEED BACK + GAIN CONTROL

GAIN SETTING
INNER GIMBAL 2.87 AMPS/VOLT
MIDDLE GIMBAL 14 AMPS/VOLT
OUTER GIMBAL 28 AMPS/VOLT
TORQUING LOOP, IRIG

120 MA CONSTANT CURRENT

DC DIFF. AMPLIFIER + PVR MODULE

CURRENT CONTROL AMPLIFIER

DIFFERENTIAL AMPLIFIER

6 VOLT PRECISION VOLTAGE REFERENCE

CURRENT MONITOR RESISTOR

SCALE FACTOR RESISTOR

DUMMY LOAD CURRENT

BALANCING RESISTOR

TERNARY CURR SWITCH

RESET

+TM

–TM
IRIG TORQUING LOOP PULSE RELATIONSHIP

- RESET PULSE 3200 CPS
  - 3 μs
  - 312.5 μs

- SET PULSE 3200 CPS
  - 3 μs
  - 312.5 μs

- + OR - T CURRENT SWITCH
  - 309.5 μs
  - 3 μs
  - 120 MA

- DUMMY CURRENT SWITCH
  - 3 μs
  - 120 MA

- CONST. CURRENT SUPPLY OUTPUT
  - 120 MA

- RESET PULSES FROM COMPUTER TO TERNARY CURRENT SWITCH FLIP-FLOP
- + OR - T PULSES FROM COMPUTER
- OUTPUT OF + T OR - T CURRENT SWITCH TO CALIBRATION MODULE
- CURRENT DRAW THROUGH DUMMY CURRENT SWITCH
- 120 MA
FLOATED PENDULUM UNIT

SIGNAL GENERATOR

PENDULOUS MASS ARM

PM PENDULOUS MASS

MAGNETIC SUSPENSION

MAGNETIC SUSPENSION

TORQUE GENERATOR

CENTER OF MASS OF FLOAT LOCATED AT POINT OF EQUIVALENT PENDULOUS MASS

PAA PENDULOUS ARM AXIS

PRA PENDULOSITY REFERENCE AXIS

OA OUTPUT AXIS

IA INPUT AXIS

GN-179
INTERROGATOR

SWITCH PULSE (SP)

0 PHASE SIGNAL

INTERROGATOR PULSE (IP)

DIFFERENTIAL CIRCUIT

SCHMITT TRIGGER + T

FLIP FLOP

SET

RESET

DATA

T-SET

T+SET
BINARY CURRENT SWITCH

DATA PULSE

T+SET

T-SET

+ SET

- SET

FLIP FLOP

+ T CURRENT SWITCH

+ TORQUE CURRENT

NEGATIVE VELOCITY PULSE

POSITIVE VELOCITY PULSE

- T CURRENT SWITCH

- TORQUE CURRENT
FORWARD - BACKWARD COUNTER

Positive velocity pulse: 

Negative velocity pulse: 

COMPLEMENTING FLIP-FLOP

COMPLEMENTING FLIP-FLOP
ZERO ENCODER MODE

IMU

AGC

CDU AND ELECTRONICS

LOWER DISPLAY AND CONTROL PANEL

STAB LOOP

STABILIZATION LOOP ELECTRONICS

28V 800 CPS

GN-265
COARSE ALIGN

CDU AND ELECTRONICS

COARSE ALIGN LOOP

COARSE ALIGN AMPLIFIER

STABILIZATION LOOP ELECTRONICS

IMU

STAB LOOP

AGC

LOWER DISPLAY AND CONTROL PANEL

imu-cdu difference meter

GN-9099A
COARSE ALIGN MECHANIZATION
(INNER GIMBAL)

- TM
- GSA
- DEMODULATOR
- PREAMP
- FILTER
- ENCODER ELECTRONICS
- ENCODER
- INCREASE
- DECREASE
- 800 CPS
- 28V DC
- CDU COMMANDS
- DIGITAL TO ANALOG CONVERTER
- +CDU ANGLE
- -CDU ANGLE
- AC
- 800 CPS DEMOD
- DC

28V 800 CPS
FINE ALIGN

FINE ALIGNMENT TORQUING ELECTRONICS

AGC

CDU AND ELECTRONICS

LOWER DISPLAY AND CONTROL PANEL

STAB LOOP ELECTRONICS

STABILIZATION LOOP

GN-9104
FINE ALIGN LOOP
(INNER GIMBAL)

Diagram of the fine align loop with various components and connections, including:
- TM
- Y IRIG
- Y ADA
- IX
- SINE AIG
- COSINE AIG
- SINE 16 AIG
- COSINE 16 AIG
- Encoder
- Encoder Electronics
- IMU-CDU Difference Meter
- Error Meter Demodulator
- Constant Current Source
- Calibration Module
- Ternary Current Switch
- AGC
- DEMOD
- FILTER
- PRE-AMP
- GSA
- Motor Drive AMP
- 28 VDC

Specifications:
- 28V 800 CPS SINE AIG
- 28V 800 CPS COSINE AIG
- -90°
- 360° REV

GN-346
RELATIONSHIP OF BALL INDICATOR AND IMU

BALL ATTITUDE INDICATOR

SPACECRAFT ROLL AXIS

G & N INERTIAL MEASUREMENT UNIT

INNER AXIS AlIGNED NORMAL TO ORBIT PLANE DURING ORBITAL OPERATIONS

33°

GN-184
FDAI/IMU GIMBAL RELATIONSHIP

- GIMBAL ANGLE RESOLVER
- EULER ERROR
- TOTAL ATTITUDE
- BEARING
- MGA RESOLVER & MOTOR
- OGA RESOLVER & MOTOR
- GUIDANCE AND NAVIGATION GIMBALED PLATFORM
- DISPLAYED ATTITUDE
  - $\phi_e = 0^\circ$
  - $\psi_e = 0^\circ$
  - $\theta_e = 0^\circ$
COMPUTER SUBSYSTEM, GENERAL INTERFACE

- **Display Data to Telemetry**
- **Block Uplink**
- **Alarms**
- **Engine Control**
- **Radar Timing, Control, and Status Signals (Not Used)**
- **Downlink Word**
- **Timing Signals**
- **Downlink Sync Signals**
- **Uplink Word**

**Display and Keyboards (DSKY's)**

- **Mode Switching**
- **Manual Inputs**
- **Alarms**
- **CDU Drive Signals**
- **Timing Signals**
- **Gyro Torquing Commands**
- **Alarms**
- **Mode Indications**
- **Velocity Increments**
- **CDU Position**

**Apollo Guidance Computer**

**Optical Subsystem**

- **Mode Indications**
- **Scanning Telescope and Sextant Drive Signals**
- **Scanning Telescope and Sextant Shaft Angles**

**Space-Craft**

**Inertial Subsystem**
AGC CHARACTERISTICS

GENERAL PURPOSE & CONTROL COMPUTER
PARALLEL DIGITAL MACHINE
WORD LENGTH - 16 BITS
NUMBER SYSTEM - ONE'S COMPLIMENT
ODD PARITY
"NOR" MICRO LOGIC ELEMENTS
FIXED MEMORY REGISTERS - 24, 576
ERASABLE MEMORY REGISTERS - 1024
CLOCK RATE - 1.024 MC
MEMORY CYCLE TIME - 11.7 µ SEC
REGULAR INSTRUCTIONS - 11
INTERPRETIVE INSTRUCTIONS - 72
INTERRUPT OPTIONS - 6
NUMBER OF COUNTERS - 20
ADD TIME - 23 µ SEC
DOUBLE PRECISION ADD - 234 µ SEC
MULTIPLY TIME - 93 µ SEC
# Word Formats

## A. Data Words (Central Processor)

<table>
<thead>
<tr>
<th>Bit Positions</th>
<th>16</th>
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- **MAGNITUDE**

## B. Data Words (Memory)

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- **MAGNITUDE**

## C. Basic Instruction Words (Memory)

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- **RELEVANT ADDRESS**

## D. Basic Instruction Words (Central Processor)

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- **RELEVANT ADDRESS**
AGC BLOCK DIAGRAM

ADDRESS CODE

12 TIMING PULSES

SEQUENCE GENERATOR

ORDER CODE

FIXED MEMORY

ERASABLE MEMORY

FORCED ADDRESS

PARITY BIT

REAL TIME FROM TIMER

INPUT INTERFACE

OUTPUT INTERFACE

TELEMETRY DOWNLINK OUTPUT

REAL TIME

CONTROL PULSES

COUNTER INCREMENT PRIORITY CONTROL

PROGRAM INTERRUPT PRIORITY CONTROL

IN0 IN1 IN2 IN3 OUT0 OUT1 OUT2 OUT4

X Y U

A Q Z LP B P

GN-90268
SYMBOLS

SYMBOL

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AND CIRCUIT

SYMBOL

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NOR EQUIVALENT CIRCUIT

(d) FLIP FLOP

SYMBOL

<table>
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<tr>
<th>SET</th>
<th>RESET</th>
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<tr>
<td>1</td>
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BASIC STORAGE ELEMENT

WRITE PULSE

CLEAR PULSE

READ PULSE

WRITE

$\frac{3}{4} \mu\text{sec}$

CLEAR

$\frac{1}{4} \mu\text{sec}$

READ

$\frac{3}{4} \mu\text{sec}$

LOGIC LEVEL

WRITE

1

0

CLEAR

1

0

READ

1

0

GN-309
ERASABLE MEMORY CORE THREADING

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>X</th>
<th>Y</th>
<th>INHIBIT</th>
<th>SENSE</th>
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<tr>
<td>WRITE ONE</td>
<td>$-\frac{1}{2}x$</td>
<td>$-\frac{1}{2}y$</td>
<td>0</td>
<td>$-\frac{1}{2}s$</td>
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<tr>
<td>WRITE ZERO</td>
<td>$-\frac{1}{2}x$</td>
<td>$-\frac{1}{2}y$</td>
<td>$+\frac{1}{2}i$</td>
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<tr>
<td>READ (CLEAR)</td>
<td>$+\frac{1}{2}x$</td>
<td>$+\frac{1}{2}y$</td>
<td>0</td>
<td>$+\frac{3}{2}g00$</td>
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FIXED MEMORY ORGANIZATION

WORD SELECTION

1. SELECT 1 OF 3 ROPES (8,192 WDS OF 24,576 WDS)
2. SELECT 2 OF 8 BANKS (2,048 WDS OF 8,192 WDS)
3. SELECT 2 OF 256 CORES (16 WDS OF 2,048 WDS)
4. SELECT 1 OF 16 STRANDS (1 WD OF 16 WDS)
ROPE CORE

SENSE LINES

INHIBIT LINES | SENSE LINES
--- | ---
A B B 4 3 2 1

CORE 0
CORE 1
CORE 2
CORE 3

WORD 0
WORD 1
WORD 2
WORD 3

X INDICATES LINE INHIBITS CORE FROM SWITCHING
FIXED MEMORY ORGANIZATION AND SELECTION

BANK REG.

S. REGISTER

BITS II & II = 0,0 ERASABLE MEMORY

ROPE SELECTION

RESET

SET

INHIBIT WIRES

STRAND SELECTION

ROPE

ROPE

RETURN CIRCUITRY

RETURN CIRCUITRY

RETURN CIRCUITRY

ROPE SELECTION SIGNALS

GN-325
ADDRESS OF NEXT INSTRUCTION

STORAGE

NEXT INSTRUCTION

PREPARE FOR NEXT INSTRUCTION.

TIME: 1 MCT

(Subinst: STD 2)
COUNTER INPUT INTERFACE FLOW DIAGRAM

NOTE:
(+ ) INPUT
EXECUTE
PINC C(CTR) +1

(-) INPUT
EXECUTE
MINC C(CTR) -1

"x" PIPA INPUT

(+) EXECUTE
PINC C(CTR) +1

(-) EXECUTE
MINC C(CTR) -1

SEQUENCE GENERATOR

6 BIT COUNTER ADDRESS (FOR PIPAX=0044)
CENTRAL PROCESSING BLOCK DIAGRAM
## INPUT-OUTPUT BIT ASSIGNMENTS

### BLOCK-100

<table>
<thead>
<tr>
<th>BIT REGISTER</th>
<th>16</th>
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<tr>
<td>INO</td>
<td>MARK</td>
<td>S.R</td>
<td>G/N ENTRY MODE</td>
<td>G/N</td>
<td>G/N ATT. MODE</td>
<td>SR</td>
<td>SR</td>
<td>SP</td>
<td>SP</td>
<td>SP</td>
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<td>INI</td>
<td>2</td>
<td>4</td>
<td>H</td>
<td>O</td>
<td>U</td>
<td>R</td>
<td>C</td>
<td>O</td>
<td>U</td>
<td>N</td>
<td>T</td>
<td>E</td>
<td>R</td>
<td></td>
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<tr>
<td>IN2</td>
<td>PARITY FAIL</td>
<td>G/N MON. MODE</td>
<td>SCS</td>
<td>ΔV MODE</td>
<td>IMU FAIL</td>
<td>PIPA</td>
<td>CDU FAIL</td>
<td>SM/CM SEP</td>
<td>SIVB SEP</td>
<td>SATN ULL.</td>
<td>GUID REL</td>
<td>LIFT OFF</td>
<td>F</td>
<td>T</td>
<td>200PPS</td>
<td>1</td>
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<tr>
<td>IN3</td>
<td>OR OF C1-C35</td>
<td>COMP. CONTR. OPT.</td>
<td>SP</td>
<td>NC</td>
<td>ZERO OPT</td>
<td>STAR PRES</td>
<td>TRKR ON</td>
<td>SP</td>
<td>NC</td>
<td>SP</td>
<td>NC</td>
<td>K3 ENTRY</td>
<td>TRN SW</td>
<td>K2 ATT. CONTR</td>
<td>N3 MANUAL CDU</td>
<td>K2 COARSE ALIGN</td>
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<tr>
<td>OUT 0</td>
<td>RELAY WORD 4</td>
<td>RELAY WORD 3</td>
<td>RELAY WORD 2</td>
<td>RELAY WORD 1</td>
<td>RELAY BIT 10</td>
<td>RELAY BIT 9</td>
<td>RELAY BIT 8</td>
<td>RELAY BIT 7</td>
<td>RELAY BIT 6</td>
<td>RELAY BIT 5</td>
<td>RELAY BIT 4</td>
<td>RELAY BIT 3</td>
<td>RELAY BIT 2</td>
<td>RELAY BIT 1</td>
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<td>OUT 1</td>
<td>SP</td>
<td>SP</td>
<td>ENG ON</td>
<td>SP</td>
<td>SP</td>
<td>SP</td>
<td>BLOCK END PULSE</td>
<td>ID WORD</td>
<td>SP</td>
<td>NC</td>
<td>SP</td>
<td>NC</td>
<td>RUP2 &amp; TRAP RESET</td>
<td>SP</td>
<td>NC</td>
<td>CHECK FAIL</td>
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<tr>
<td>OUT 2</td>
<td>-</td>
<td>+</td>
<td>CDU</td>
<td>GYRO</td>
<td>X</td>
<td>Y</td>
<td>Z</td>
<td>-</td>
<td>+</td>
<td>OPT X</td>
<td>OPT Y</td>
<td>THRUST</td>
<td>RADAR A</td>
<td>RADAR B</td>
<td>RADAR C</td>
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<tr>
<td>OUT 3</td>
<td>S</td>
<td>P</td>
<td>A</td>
<td>R</td>
<td>E</td>
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<tr>
<td>OUT 4</td>
<td>D</td>
<td>O</td>
<td>W</td>
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<td>I</td>
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</tbody>
</table>

NC = NOT CONNECTED

---

NC = NOT CONNECTED
DEVELOPMENT AND CONTROL OF PROGRAM CONTROLLED DRIVE

SET TO PROPER CONFIGURATION TO DRIVE THE DESIRED HARDWARE IN THE DESIRED DIRECTION.

SET TO OVERFLOW MINUS REQUIRED NUMBER OF PULSES THROUGH PROG. CONTROL.

OUT COUNTER

INCREMENT OUT COUNTER

COUNTER INTERRUPT PRIORITY CONTROL

3200 PPS 3µ SEC PULSE WIDTH

3200 PPS 3µ SEC PULSE WIDTH

TO TRINARY CURRENT SWITCHES

TO CDU DAC'S

3200 PPS 3µ SEC PULSE WIDTH

OR

GN-332
### UPLINK WORD FORMAT

<table>
<thead>
<tr>
<th>BIT CONTENTS</th>
<th>KEYCODE</th>
<th>KEYCODE</th>
<th>KEYCODE</th>
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<tbody>
<tr>
<td>16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1</td>
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</tbody>
</table>

GN-334
UPLINK INTERFACE FLOW DIAGRAM

- **Serial Uplink Word Input**
- **Counter Priority**
  - **Sequence Generator**
  - **Write Amps**
  - **E. Memory**
  - **Adder**

**Notes:**
1. "1" Bit Input
   - Execute Shink
   - \( C(CTR) + C(CTR) + 1 = \text{NEW } C(CTR) \)

2. "0" Bit Input
   - Execute Shinc
   - \( C(CTR) + C(CTR) = \text{NEW } C(CTR) \)
DOWNLINK

ID WORD
WORD ORDER BITS=0
BITS 15-11 =00000
BITS 10-1 =DATA INDEX

DATA WORD
WORD ORDER BITS=1
BITS 15-1 =DATA

RELAY WORD
WORD ORDER BITS=0
BITS 15-12 =RELAY WD ADDRESS
BITS 11-1 =RELAY SETTINGS

INPUT CHARACTER WORD
WORD ORDER BITS=0
BITS 15-12 =0000
BIT 11 =1
BITS 10-8 =UNUSED
BIT 7 =MARK
BIT 6 =0 FOR KYBD
1 FOR UPLK
BITS 5-1 =KYBD OR UPLK DATA

TRANSMISSION RATES-51.2Kc & 1.6Kc
TLM SYSTEM RATES-50pps & 10pps
1 FRAME=128-8 BIT TLM WORDS
5 AGC WORDS IN EACH FRAME

GN-246
TELEMETRY TIMING

BIT RATE
51.2 KC OR 1.6 KC

TL START
50 PPS OR 10 PPS

TL END
50 PPS OR 10 PPS

TELEMETRY SERIAL PULSE TRAIN

ONE FRAME
20 MS PER FRAME @ 51.2 KC BIT RATE

COMPUTER WORDS

20 MS PER FRAME @ 51.2 KC BIT RATE
AGC DISPLAY & KEYBOARD
# Navigation & Main Panel DSKY R Relay Usage Block 1-100

<table>
<thead>
<tr>
<th>BIT CODE</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
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<tr>
<td>1011 DSPORTAB</td>
<td>R121</td>
<td>R120</td>
<td>R119</td>
<td>R118</td>
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<td>R116</td>
<td>R115</td>
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<td>R107</td>
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<td>R105</td>
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<td>R64</td>
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<td>R59</td>
<td>R58</td>
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<td>0101 DSPORTAB 4</td>
<td>R55</td>
<td>R54</td>
<td>R53</td>
<td>R52</td>
<td>R51</td>
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<td>R49</td>
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<td>0100 DSPORTAB 3</td>
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<td>R32</td>
<td>R31</td>
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<td>R25</td>
<td>R24</td>
<td>R23</td>
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<td>R14</td>
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<td>R5</td>
<td>R4</td>
<td>R3</td>
<td>R2</td>
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DSKY DISPLAY AND COMMAND RELAY CIRCUITRY

14 BANKS OF 11 BISTABLE RELAYS

C33 C32 C31 C30 C29 C28 C27 C26 C25 C24 C23
C22 C21 C20 C19 C18 C17 C16 C15 C14 C13 C12
C11 C10 C9 C8 C7 C6 C5 C4 C3 C2 C1
R121 R120 R119 R118 R117 R116 R115 R114 R113 R112 R111
R110 R109 R108 R107 R106 R105 R104 R103 R102 R101 R100
R99 R98 R97 R96 R95 R94 R93 R92 R91 R90 R89
R88 R87 R86 R85 R84 R83 R82 R81 R80 R79 R78
R77 R76 R75 R74 R73 R72 R71 R70 R69 R68 R67
R66 R65 R64 R63 R62 R61 R60 R59 R58 R57 R56
R55 R54 R53 R52 R51 R50 R49 R48 R47 R46 R45
R44 R43 R42 R41 R40 R39 R38 R37 R36 R35 R34
R33 R32 R31 R30 R29 R28 R27 R26 R25 R24 R23
R22 R21 R20 R19 R18 R17 R16 R15 R14 R13 R12
R11 R10 R9 R8 R7 R6 R5 R4 R3 R2 R1

DIODE DECODER & DRIVER CIRCUITS

RELAY DRIVERS

15 15 14 14 13 13 12 12

BIT 15 BIT 14 BIT 13 BIT 12

4 BIT RELAY WORD CODE FROM THE AGC OUT OF REGISTER

BIT 11 BIT 10 BIT 9 BIT 8 BIT 7 BIT 6 BIT 5 BIT 4 BIT 3 BIT 2 BIT 1

II RELAY BITS FROM THE AGC'S OUT O REGISTER
### NAV DSKY C RELAY USAGE BLOCK 1-100

<table>
<thead>
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<td>DSPTAB 13</td>
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<td>C19</td>
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<td>C10</td>
<td>C9</td>
<td>C8</td>
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<td>C4</td>
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<td>C1</td>
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<td>DSPTAB 11</td>
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</tbody>
</table>

- **C33**: TELECOM SWITCH
- **C32**: FQA1 ALIGN
- **C31**: GIMBAL MOTOR ON/OFF
- **C30**: AUTO 0.05 g
- **C29**: G & N FAIL
- **C28**: TRANSLATION ON/OFF
- **C27**: +X SEPARATE COMMAND
- **C26**: CM/SIM
- **C25**: G & N ENTRY MODE SEL.
- **C24**: G & NVV MODE SEL.
- **C23**: G & N ATT. CONTR. MODE SEL.

**Description**

- **1100**: DSPTAB 11
- **1101**: STAR TRACKER ON
- **1100**: ATTITUDE CONTROL
- **1110**: ON/OFF
- **1100**: ATTITUDE ALIGN
- **1100**: ENCODER ALIGN
- **1100**: ZERO Encoder

---

**Notes**

- **DSPTAB I3**:
  - C33: TELECOM SWITCH
  - C32: FQA1 ALIGN
  - C31: GIMBAL MOTOR ON/OFF
  - C30: AUTO 0.05 g
  - C29: G & N FAIL
  - C28: TRANSLATION ON/OFF
  - C27: +X SEPARATE COMMAND
  - C26: CM/SIM
  - C25: G & N ENTRY MODE SEL.
  - C24: G & NVV MODE SEL.
  - C23: G & N ATT. CONTR. MODE SEL.

- **DSPTAB I2**:
  - C22: STAR TRACKER ON
  - C21: ATTITUDE CONTROL
  - C20: AUTO 0.05 g
  - C19: GIMBAL MOTOR ON/OFF
  - C18: TELECOM SWITCH
  - C17: FQA1 ALIGN
  - C16: G & N FAIL
  - C15: TRANSLATION ON/OFF
  - C14: CM/SIM
  - C13: G & N ENTRY MODE SEL.
  - C12: G & NVV MODE SEL.

- **DSPTAB I1**:
  - C11: STAR TRACKER ON
  - C10: ATTITUDE ALIGN
  - C9: AUTO 0.05 g
  - C8: GIMBAL MOTOR ON/OFF
  - C7: TELECOM SWITCH
  - C6: FQA1 ALIGN
  - C5: G & N FAIL
  - C4: TRANSLATION ON/OFF
  - C3: CM/SIM
  - C2: G & N ENTRY MODE SEL.
  - C1: G & NVV MODE SEL.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACSP</td>
<td>A.C. Spark Plug</td>
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<tr>
<td>ADA</td>
<td>Angular Differentiating Accelerometer</td>
</tr>
<tr>
<td>AGC</td>
<td>Apollo Guidance Computer</td>
</tr>
<tr>
<td>AGE</td>
<td>Apollo Guidance Equipment</td>
</tr>
<tr>
<td>AMR</td>
<td>Atlantic Missile Range</td>
</tr>
<tr>
<td>CDU</td>
<td>Coupling Display Unit</td>
</tr>
<tr>
<td>C.G.</td>
<td>Center of Gravity</td>
</tr>
<tr>
<td>CSS</td>
<td>Computer Sub System</td>
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<td>DNLK</td>
<td>Downlink</td>
</tr>
<tr>
<td>DSPY</td>
<td>Display</td>
</tr>
<tr>
<td>DSKY</td>
<td>Display &amp; Keyboard</td>
</tr>
<tr>
<td>ECS</td>
<td>Environment Control System</td>
</tr>
<tr>
<td>E/M</td>
<td>Erasable Memory</td>
</tr>
<tr>
<td>EO1</td>
<td>Earth Orbit Injection</td>
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<tr>
<td>EPS</td>
<td>Electrical Power System</td>
</tr>
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<td>FDAI</td>
<td>Flight Director Attitude Indicator</td>
</tr>
<tr>
<td>F/M</td>
<td>Fixed Memory</td>
</tr>
<tr>
<td>G.C.</td>
<td>Gimbal Case</td>
</tr>
<tr>
<td>IA</td>
<td>Input Axis</td>
</tr>
<tr>
<td>IRIG</td>
<td>Inertial Reference Integrating Gyro</td>
</tr>
<tr>
<td>IGA</td>
<td>Inner Gimbal Axis</td>
</tr>
<tr>
<td>IMU</td>
<td>Inertial Measurement Unit</td>
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<td>ISS</td>
<td>Inertial Sub System</td>
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<tr>
<td>IU</td>
<td>Instrument Unit</td>
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<tr>
<td>G&amp;N</td>
<td>Guidance &amp; Navigation</td>
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<tr>
<td>KYBD</td>
<td>Keyboard</td>
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<tr>
<td>LNDMK</td>
<td>Landmark</td>
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<tr>
<td>LOI</td>
<td>Lunar Orbit Injection</td>
</tr>
<tr>
<td>LOS</td>
<td>Line Of Sight</td>
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<tr>
<td>LLOS</td>
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<tr>
<td>LSB</td>
<td>Least Significant Bit</td>
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<tr>
<td>MGA</td>
<td>Middle Gimbal Axis</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>Mag Amp</td>
<td>Magnetic Amplifier</td>
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<tr>
<td>MSB</td>
<td>Most Significant Bit</td>
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<tr>
<td>M&amp;DV</td>
<td>Map &amp; Data Viewer</td>
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<tr>
<td>NVB or NB</td>
<td>Navigation Base</td>
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<tr>
<td>OGA</td>
<td>Outer Gimbal Axis</td>
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<td>OA</td>
<td>Output Axis</td>
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<tr>
<td>OSS</td>
<td>Optical Sub System</td>
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<tr>
<td>PIP or</td>
<td>Pulsed Integrating Pendulous</td>
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<td>Accelerometer</td>
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<td>PSA</td>
<td>Power Servo Assembly</td>
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<td>Pendulosity Reference Axis</td>
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<td>Reaction Control System</td>
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<td>Resolver</td>
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<td>SA</td>
<td>Spin Axis</td>
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<tr>
<td>S/C</td>
<td>Spacecraft</td>
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<td>Star Line Of Sight</td>
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<td>SDOF</td>
<td>Single Degree of Freedom</td>
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GN 244
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<th>Abbreviation</th>
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<td>Change in Velocity</td>
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