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EOS/AMSU-A BLACKBODY SPACECRAFT TEST TARGETS OPERATION AND MAINTENANCE MANUAL

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1. SCOPE

The purpose of this report is to provide a description of the spacecraft test targets and readout console as described in section 5.3.3 of the performance specification S-480-80. The spacecraft targets are to be used to provide a well known radiometric reference for testing the functionality of the AMSU-A instruments at the spacecraft contractor's facility. They are not intended to be used for calibration of the instrument. The hardware and firmware configurations are presented, along with verification results, set-up details, and operation instructions.

2. APPLICABLE DOCUMENTS

2.1 Applicable Documents

The following documents shall apply.

2.1.1 Specifications

NASA (Goddard Space Flight Center (GSFC))

GSFC S-480-79	Performance Assurance Requirements for the EOS/METSAT Integrated Programs AMSU-A Instrument (PAR)
GSFC S-480-80	Performance And Operation Specification for the EOS/METSAT Integrated Programs AMSU-A Instrument (POS)

TRW

D24844	Interface Control Document For The Advanced Microwave Sounding Unit Module A1 (AMSU-A1)
D24845	Interface Control Document For The Advanced Microwave Sounding Unit Module A2 (AMSU-A2)

Military

MIL-F-5509	Fittings, Flared Tube, Fluid Connection
MIL-F-18866	Fittings, Hydraulic Tube, Flared, 37 degree and Flareless, Steel

2.1.2 Other Documents

Azonix System 1000 Manual	General Azonix Operating Instructions
Azonix ACP1 Manual	Configuration Program Instruction Manual For The Azonix 1000 Computational Measurement And Control System
Azonix ACP1 Program	IBM PC Diskettes (Qty 2, 5.25" 360K density)

2.1.3 Drawings

1333150	AMSU-A1 Fixed And Variable Calibration Target Assembly
1333151	Target Assembly, A1
1333160	AMSU-A2 Fixed And Variable Calibration Target Assembly
1333161	Target Assembly, A2
1333202	Standard, Calibration Assembly - A2
1357249	Blackbody Target Monitor Assembly

3. SYSTEM DESCRIPTION

The blackbody spacecraft test target system consists of 3 targets and a dual Azonix System 1000 configuration (readout console). These parts are listed in Table I.

Table I Spacecraft Target Calibration Test Hardware

Item	Quantity	Description	Part #
1	1	AMSU-A2 Calibration Target	1333202-3
2	1	AMSU A1-1 Calibration Target	1333150-6
3	1	AMSU A1-2 Calibration Target	1333150-5
4	1	Blackbody Target Monitor Assembly	1357249-1

The targets are equivalent to the cold "space" calibration blackbody target per paragraph 5.3.3.2 of S-480-80. Each target has embedded PRTs distributed about the base of the load. There are 7 PRTs for the A1-1 and 7 PRTs for the A1-2 targets, while there are 10 PRTs for the larger A2 target. The Azonix controllers and expansion chassis are arranged together in a relay chassis as shown in Figure 1. Each mainframe controller communicates to 2 expansion chassis via a common bus provided via a ribbon cable. The functions associated with the A2 calibration target are all located within the B1 mainframe and expansion boxes 1 and 2 beneath it (see Figure 1). The functions associated with the A1-1 and A1-2 targets are mostly contained within the A1 mainframe and expansion boxes, except for two PRTs which reside in the B1 expansion box 2.

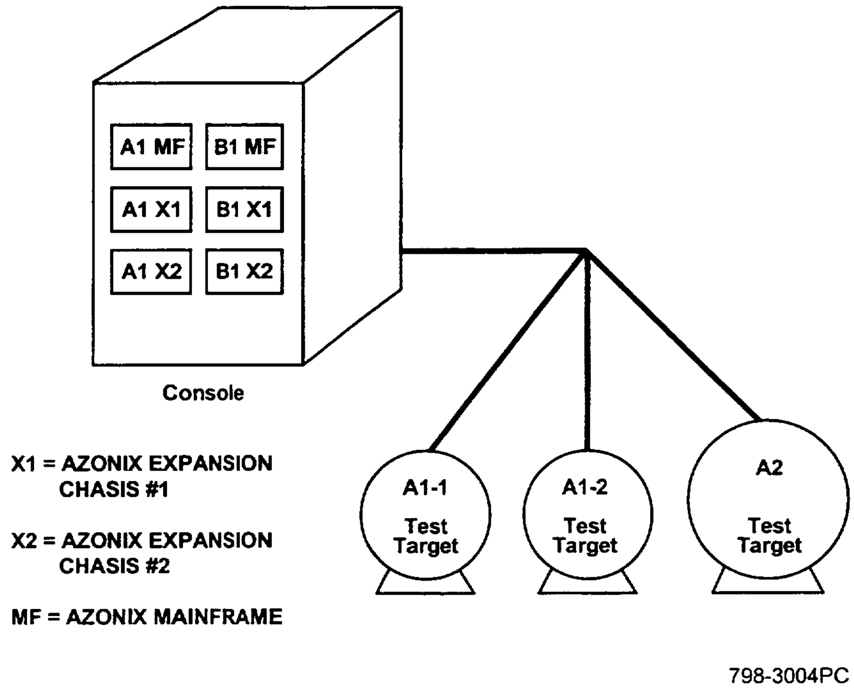

Figure 1 AMSU-A Spacecraft Target Hardware Configuration

3.1 Azonix 1000 System Description

The Azonix System 1000 is a general purpose, computational, measurement, and control system. This model has 64 channels per mainframe, which are configured to perform a variety of functions including 4-wire PRT temperature indication, D/A conversion, and mathematical calculations. The power requirement is 110 ± 22 V at 60 Hz. Each Azonix chassis consumes approximately 9 watts resulting in a total of 54 watts for the whole console. Each chassis is fused for ½ amp. The input power is filtered for EMI/RFI and is further conditioned by a linear power supply. Nevertheless, power line isolation transformers with surge suppression or uninterruptible power supplies are recommended for security as would be suggested for any computer hardware. The mainframe contains two, 8-bit microprocessors as well as CMOS and EPROM memory.

The Azonix system is configured for hardware via option boards which plug into the mainframe and expansion chassis to provide up to a 12 board capacity per system. The mainframe must then be programmed via RS232 or panel input to communicate with the chosen hardware configuration, perform any necessary calculations, and display/output the desired parameters. Two systems are required to interface with the 3 spacecraft targets. Although the system is referred to as having 64 channels, not all can be addressed depending on the option slot configuration.

For this application, each mainframe and its associated expansion chassis can provide 24 physical channels, or functions. These include 12 channels of PRT interface circuits (RT44 units) and 12 channels of D/A output (GIO5 units) for analog ohms indication. Each channel is associated with a particular circuit card within the mainframe or expansion chassis as listed in Tables II and III. Note also that each channel has calibration coefficients associated with each particular circuit card. These are supplied by the manufacturer and are entered into the non-volatile memory of the Azonix mainframes. They are required to provide the proper scale factors to accommodate gain variation which results from manufacturing tolerances.

Table II AMSU-A1 Spacecraft Target Azonix Configuration And Serial Numbers

Azonix Un	Channel #	Device	S/N	Calib. Coeff.				60 Hz User Ch. Factor
				M		B		
Exp. Box	2	RT44	8.9E+08	1.89200	E-02	3.28522	E-02	1
"	4	RT44	8.9E+08	1.89370	E-02	1.25572	E-01	1
"	6	RT44	8.9E+08	1.89281	E-02	-0.93026	E-01	1
"	8	RT44	8.9E+08	1.88952	E-02	1.92093	E-02	1
"	10	RT44	8.9E+08	1.89063	E-02	5.97882	E-02	1
"	12	RT44	8.9E+08	1.89094	E-02	3.34007	E-02	1
"	14	RT44	8.61E+08	1.88020	E-03	0.00900	E 00	10
"	16	RT44	8.61E+08	1.88024	E-03	0.00700	E 00	10
Exp. Box	18	RT44	8.61E+08	1.88218	E-03	-0.00200	E 00	10
"	20	RT44	8.61E+08	1.88253	E-03	0.00200	E 00	10
"	22	RT44	8.61E+08	1.88342	E-03	0.01200	E 00	10
"	24	RT44	8.61E+08	1.87829	E-03	0.00200	E 00	10
A1 Mnfrm	29	GIO5	8.9E+08	3.99608	E+02	2.02837	E+03	0.03, -5.4
"	30	GIO5	"	3.99345	E+02	2.02610	E+03	0.03, -5.4
"	31	GIO5	"	3.99138	E+02	2.02923	E+03	0.03, -5.4
"	32	GIO5	"	3.99616	E+02	2.02943	E+03	0.03, -5.4
"	41	GIO5	8.9E+08	3.99880	E+02	2.02949	E+03	0.03, -5.4
"	42	GIO5	"	3.99952	E+02	2.03016	E+03	0.03, -5.4
"	43	GIO5	"	3.99728	E+02	2.03058	E+03	0.3, -5.4
"	44	GIO5	"	3.99952	E+02	2.03088	E+03	0.3, -5.4
"	53	GIO5	8.9E+08	3.99345	E+02	2.03079	E+03	0.3, -5.4
"	54	GIO5	"	3.99218	E+02	2.02978	E+03	0.3, -5.4
"	55	GIO5	"	3.99672	E+02	2.03167	E+03	0.3, -5.4
"	56	GIO5	"	3.99162	E+02	2.02936	E+03	0.3, -5.4

Table III AMSU-A2 Spacecraft Target Azonix Configuration And Serial Numbers

Azonix Un	Channel #	Device	S/N	Calib. Coeff.				60 Hz User Ch. Factor
				M		B		
Exp. Box	2	RT44	8.61E+08	1.88661	E-03	0.00300	E 00	10
"	4	RT44	8.61E+08	1.88351	E-03	0.00200	E 00	10
"	6	RT44	8.61E+08	1.88947	E-03	-0.00100	E 00	10
"	8	RT44	8.61E+08	1.87705	E-03	0.00100	E 00	10
"	10	RT44	8.61E+08	1.88608	E-03	-0.00600	E 00	10
"	12	RT44	8.61E+08	1.87970	E-03	-0.00600	E 00	10
"	14	RT44	8.61E+08	1.88448	E-03	0.00300	E 00	10
"	16	RT44	8.61E+08	1.88182	E-03	0.00200	E 00	10
Exp. Box	18	RT44	8.61E+08	1.88697	E-03	-0.00300	E 00	10
"	20	RT44	9.1E+08	1.88821	E-03	0.00800	E 00	10
"	22	RT44	8.61E+08	1.88111	E-03	0.00700	E 00	10
"	24	RT44	8.61E+08	1.88590	E-03	0.00100	E 00	10
A2 Mnfrm	29	GIO5	8.9E+08	4.00336	E+02	2.02949	E+03	0.3, -5.4
"	30	GIO5	"	4.00008	E+02	2.02962	E+03	0.3, -5.4
"	31	GIO5	"	3.99992	E+02	2.02962	E+03	0.3, -5.4
"	32	GIO5	"	4.00080	E+02	2.03903	E+03	0.3, -5.4
"	41	GIO5	8.9E+08	3.99553	E+02	2.03112	E+03	0.3, -5.4
"	42	GIO5	"	3.99337	E+02	2.03040	E+03	0.3, -5.4
"	43	GIO5	"	3.99672	E+02	2.03069	E+03	0.3, -5.4
"	44	GIO5	"	3.99736	E+02	2.03005	E+03	0.3, -5.4
"	53	GIO5	8.9E+08	4.00136	E+02	2.03207	E+03	0.3, -5.4
"	54	GIO5	"	4.00072	E+02	2.03195	E+03	0.3, -5.4
"	55	GIO5	"	4.00312	E+02	2.03032	E+03	0.3, -5.4
"	56	GIO5	"	4.00112	E+02	2.03077	E+03	0.3, -5.4

The first 12 channels (number 2 through 24) are PRT interface circuits. Each circuit card drives a quantity of two, 4-wire PRTs. These cards have an address associated with the configuration of jumper wires located on the card. This address determines the channel numbers of the two PRT circuits on that card. Note that the channel number must always be even. The output of the card is an ohms indication of the associated PRT. The ohms may be converted to temperature via equation (1) and the coefficients in Table XI.

The second twelve channels (number 29 through 56) are identified as GIO5 circuit cards. These are described as general purpose input/output boards. They are used as D/A converters in this application to provide a 0 to 5 V output corresponding to the temperature. The GIO5 circuit cards have an address associated with the configuration of jumper wires located on the card. This address determines the channel number of the current and voltage input/outputs on the card. The starting channel number must always be odd and must also be 1, 5, 9, 13.....1 + 4N, up to 53 (N=13). Each card contains ten channels: four current, four voltage, and two relay channels. Only the four voltage channels are used. Consequently, each four voltage out channels consume 12 channels of space. This progression of channel usage can be seen in Tables II and III.

The structure of the Azonix system is such that there are 64 channels. There are three main types of channels that may be programmed. These are the physical channel, the user channel, and the math expression channel; all are interrelated. The physical channel refers to the option board hardware and is configured to interface the boards to the system. The user channel is responsible for the digital display of the corresponding channel hardware function and may provide linear scaling of the data. The math channel provides advanced processing of the data before it is displayed and can provide nonlinear functions and calculus operations. Table IV illustrates this relationship for the spacecraft configuration. Physical channel 2 contains the output of PRT number 636, S/N 522. User channel 2 displays the output of this physical channel, in ohms. Math channel (expression) 3 takes the output of channel 2 in ohms, uses it as input to a third order polynomial for PRT number 522, and displays the actual temperature in degrees Kelvin in user channel 3. Physical channel 33 then takes the output of user channel 2 (ohms), linearly scales this number, sends it to physical channel 29, converts from digital to analog, and provides a 0 to 5 V output which is proportional to the PRT ohms. This progression is repeated for all 12 PRTs, in both mainframes.

Besides the physical, user, and math channel configurations the Azonix system has several additional input requirements to complete the programming. These are the display scan table, the channel scan table, the RS232 configuration, and the clock. The display and channel table must be configured to reflect the channels as used to provide proper operation of the unit. The RS232 table must be configured to be compatible with the computer which will interface with the Azonix mainframe. Programming of the Azonix System may be done through the front panel but is much more efficiently accomplished via the RS232 interface and an IBM PC-compatible computer running under DOS. Azonix provides a configuration program called "ACP1" which provides a menu-assisted programming environment. This is how the supplied system was configured. The detailed programming sequence is described in the Azonix publications ACP1 Manual & Azonix 1000 Instruction Manual.

Tables II and III contain a column entitled "user channel factor". This is a scale factor present in the display user channel which allows one to modify the data by a linear equation of the form $y = mx + b$. For the RT44 units, this factor is either $m = 1$ or 10 depending on the data sheets from the manufacturer. For the GIO5 cards, the coefficients are $m = 0.03$, $b = -5.4$ ($m = 0.3$ for channels where RT44 $m = 10$). These coefficients were determined to provide a 38 degree K dynamic range for the analog output of the GIO5 circuits. Thus, for a 0 to 5 V output, the corresponding ohms will be roughly 180 to 346, respectively. This also corresponds to approximately 76 to 114 K. This should provide a good working range near liquid nitrogen temperatures. A larger dynamic range was not considered practical as the accuracy of the D/A converter would have yielded larger errors. Currently, the D/A conversion adds a ± 0.04 K error as configured. Temperature readout via the RS232 bus or the front panel is more accurate and gives the full dynamic range of 76 to 330 K.

Tables IV and V list the channels that provide ohms, degrees Kelvin, and volts corresponding to the target PRTs as listed. These values may be accessed from the front panel, the RS232 interface, or in the case of the volts out, the back panels of the Azonix boxes. The configuration of the back panels are described in Tables VI and VII. Here, terminal strips are located for connection of wires to the PRT sensors and the analog out signals. Note the expansion boxes have ST01 terminal strips with 14 connections available. These are for the PRT wires as indicated by the individual markings. The two mainframes are configured with ST03 terminal strips and have 23 connections available. These are for the analog out signals. Screws are numbered in ascending order, from left to right, as viewed from the back. Tables VI and VII are intended to map spatially, one for one, with the back panel connections for ease.

3.2 Blackbody Target Description

The three supplied calibration targets provide a known radiometric temperature to the AMSU-A1 and AMSU-A2 instruments. The targets are illustrated in Drawings 1333150 for A1 and 1333202 for A2. An emissivity approaching unity is accomplished through the use of microwave absorbing material which coats pyramidal shaped copper cones. These cones may be seen by viewing inside the open end of the target. The pyramid ends are quite sharp and brittle and should not come in contact with any objects. Below the pyramidal cones is a massive copper base. This thermal mass is required for the temperature stability and uniformity necessary for quality measurements. The A2 target weighs 115.86 lbs while the A1-1 and A1-2 targets weigh 36.22 lbs each. In the base are located 4-wire PRT sensors for physical temperature indication. The base is also in intimate contact with a coiled liquid nitrogen tube that provides the heat exchange for cooling. Multi-layer insulation (MLI) is wrapped around the whole body of the target to provide thermal insulation. It is recommended that the target only be handled via the fiberglass base, the handles (A1), or the lifting fixture loop (A2).

The target PRT wires are white in color and are labeled per Tables VI and VII. Any additional wires at the back of the target or under the MLI blanket are not used and do not require connection.

Each target has two fittings on the back for connection of nitrogen lines. These are illustrated on Drawings 1333151 for A1 and 1333161 for A2. The nitrogen "inlet" is the connector near the center of the target and the "outlet" is located near the edge of the target as shown on the drawing. The connections themselves are flared stainless steel tubing ends with a corresponding nut in accordance with MS51531. The A2 unit uses the MS51531B8S nut which is defined as 3/4 - 16 UNF-2B on ½" tube O.D. The A1 unit uses the MS51531B6S nut which is defined as 9/16-18 UNF-2B on 3/8" tube O.D.

Table IV Spacecraft Target A1 Channel Designations

	TARGET
USER CHANNEL.......02: A1 PRT #636 SN 522 (OHMS)	A1-1
USER CHANNEL.......03: A1 PRT #636 (DEGK)	
USER CHANNEL.......04: A1 PRT #637 SN 541 (OHMS)	
USER CHANNEL.......05: A1 PRT #637 (DEGK)	
USER CHANNEL.......06: A1 PRT #638 SN 507 (OHMS)	
USER CHANNEL.......07: A1 PRT #638 (DEGK)	
USER CHANNEL.......08: A1 PRT #639 SN 548 (OHMS)	
USER CHANNEL.......09: A1 PRT #639 (DEGK)	
USER CHANNEL.......10: A1 PRT #640 SN 504 (OHMS)	
USER CHANNEL.......11: A1 PRT #640 (DEGK)	
USER CHANNEL.......12: A1 PRT #641 SN 526 (OHMS)	
USER CHANNEL.......13: A1 PRT #641 (DEGK)	
USER CHANNEL.......14: A1 PRT #642 SN 557 (OHMS)	
USER CHANNEL.......15: A1 PRT #642 (DEGK)	
USER CHANNEL.......16: A1 PRT #629 SN 629 (OHMS)	A1-2
USER CHANNEL.......17: A1 PRT #629 (DEGK)	
USER CHANNEL.......18: A1 PRT #630 SN 630 (OHMS)	
USER CHANNEL.......19: A1 PRT #630 (DEGK)	
USER CHANNEL.......20: A1 PRT #631 SN 590 (OHMS)	
USER CHANNEL.......21: A1 PRT #631 (DEGK)	
USER CHANNEL.......22: A1 PRT #632 SN 544 (OHMS)	
USER CHANNEL.......23: A1 PRT #632 (DEGK)	
USER CHANNEL.......24: A1 PRT #633 SN 623 (OHMS)	
USER CHANNEL.......25: A1 PRT #633 (DEGK)	
USER CHANNEL.......33: PRT #636 ANALOG OUT (VOLTS)	A1-1
USER CHANNEL.......34: PRT #637 ANALOG OUT (VOLTS)	
USER CHANNEL.......35: PRT #638 ANALOG OUT (VOLTS)	
USER CHANNEL.......36: PRT #639 ANALOG OUT (VOLTS)	
USER CHANNEL.......45: PRT #640 ANALOG OUT (VOLTS)	
USER CHANNEL.......46: PRT #641 ANALOG OUT (VOLTS)	
USER CHANNEL.......47: PRT #642 ANALOG OUT (VOLTS)	
USER CHANNEL.......48: PRT #629 ANALOG OUT (VOLTS)	A1-2
USER CHANNEL.......57: PRT #630 ANALOG OUT (VOLTS)	
USER CHANNEL.......58: PRT #631 ANALOG OUT (VOLTS)	
USER CHANNEL.......59: PRT #632 ANALOG OUT (VOLTS)	
USER CHANNEL.......60: PRT #633 ANALOG OUT (VOLTS)	
PHYSICAL CHANNEL...02: A1 PRT #636 SN 522	
PHYSICAL CHANNEL...04: A1 PRT #637 SN 541	
PHYSICAL CHANNEL...06: A1 PRT #638 SN 507	
PHYSICAL CHANNEL...08: A1 PRT #639 SN 548	
PHYSICAL CHANNEL...10: A1 PRT #640 SN 504	
PHYSICAL CHANNEL...12: A1 PRT #641 SN 526	
PHYSICAL CHANNEL...14: A1 PRT #642 SN 557	
PHYSICAL CHANNEL...16: A1 PRT #629 SN 629	
PHYSICAL CHANNEL...18: A1 PRT #630 SN 630	
PHYSICAL CHANNEL...20: A1 PRT #631 SN 590	
PHYSICAL CHANNEL...22: A1 PRT #632 SN 544	
PHYSICAL CHANNEL...24: A1 PRT #633 SN 623	
PHYSICAL CHANNEL...29: VOLTAGE OUT - PRT #636	
PHYSICAL CHANNEL...30: VOLTAGE OUT - PRT #637	
PHYSICAL CHANNEL...31: VOLTAGE OUT - PRT #638	
PHYSICAL CHANNEL...32: VOLTAGE OUT - PRT #639	
PHYSICAL CHANNEL...41: VOLTAGE OUT - PRT #640	

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Table IV Spacecraft Target A1 Channel Designations (Continued)

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PHYSICAL CHANNEL...42: VOLTAGE OUT - PRT #641
PHYSICAL CHANNEL...43: VOLTAGE OUT - PRT #642
PHYSICAL CHANNEL...44: VOLTAGE OUT - PRT #629
PHYSICAL CHANNEL...53: VOLTAGE OUT - PRT #630
PHYSICAL CHANNEL...54: VOLTAGE OUT - PRT #631
PHYSICAL CHANNEL...55: VOLTAGE OUT - PRT #632
PHYSICAL CHANNEL...56: VOLTAGE OUT - PRT #633
MATH EXPRESSION....03: CH2 TEMP CALC.
MATH EXPRESSION....05: CH4 TEMP CALC.
MATH EXPRESSION....07: CH6 TEMP CALC.
MATH EXPRESSION....09: CH8 TEMP CALC.
MATH EXPRESSION....11: CH10 TEMP CALC.
MATH EXPRESSION....13: CH12 TEMP CALC.
MATH EXPRESSION....15: CH14 TEMP CALC.
MATH EXPRESSION....17: CH16 TEMP CALC.
MATH EXPRESSION....19: CH18 TEMP CALC.
MATH EXPRESSION....21: CH20 TEMP CALC.
MATH EXPRESSION....23: CH22 TEMP CALC.
MATH EXPRESSION....25: CH24 TEMP CALC.
RS232 PARAMETERS...  :
REAL-TIME CLOCK....  :
DISPLAY SCAN 1.....  : TRW A1 MAINFRAME
DISPLAY SCAN 2.....  : NOT USED
CHANNEL SCAN 1.....  : TRW A1 MAINFRAME
CHANNEL SCAN 2.....  : NOT USED
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Table V Spacecraft Target A2 Channel Designations

	TARGET
USER CHANNEL.......02: A2 PRT #633 SN 519 (OHMS)	A2
USER CHANNEL.......03: A2 PRT #633 (DEG K)	
USER CHANNEL.......04: A2 PRT #634 SN 524 (OHMS)	
USER CHANNEL.......05: A2 PRT #634 (DEG K)	
USER CHANNEL.......06: A2 PRT #635 SN 527 (OHMS)	
USER CHANNEL.......07: A2 PRT #635 (DEG K)	
USER CHANNEL.......08: A2 PRT #636 SN 531 (OHMS)	
USER CHANNEL.......09: A2 PRT #636 (DEG K)	
USER CHANNEL.......10: A2 PRT #637 SN 536 (OHMS)	
USER CHANNEL.......11: A2 PRT #637 (DEG K)	
USER CHANNEL.......12: A2 PRT #638 SN 539 (OHMS)	
USER CHANNEL.......13: A2 PRT #638 (DEG K)	
USER CHANNEL.......14: A2 PRT #639 SN 540 (OHMS)	
USER CHANNEL.......15: A2 PRT #639 (DEG K)	
USER CHANNEL.......16: A2 PRT #640 SN 542 (OHMS)	
USER CHANNEL.......17: A2 PRT #640 (DEG K)	
USER CHANNEL.......18: A2 PRT #641 SN 549 (OHMS)	
USER CHANNEL.......19: A2 PRT #641 (DEG K)	
USER CHANNEL.......20: A2 PRT #642 SN 550 (OHMS)	
USER CHANNEL.......21: A2 PRT #642 (DEG K)	
USER CHANNEL.......22: A1 PRT #634 SN 515 (OHMS)	A1-2
USER CHANNEL.......23: A1 PRT #634 (DEG K)	
USER CHANNEL.......24: A1 PRT #635 SN 621 (OHMS)	
USER CHANNEL.......25: A1 PRT #635 (DEG K)	
USER CHANNEL.......29: A2 PRT #633 ANALOG OUT (VOLTS)	A2
USER CHANNEL.......30: A2 PRT #634 ANALOG OUT (VOLTS)	
USER CHANNEL.......31: A2 PRT #635 ANALOG OUT (VOLTS)	
USER CHANNEL.......32: A2 PRT #636 ANALOG OUT (VOLTS)	
USER CHANNEL.......41: A2 PRT #637 ANALOG OUT (VOLTS)	
USER CHANNEL.......42: A2 PRT #638 ANALOG OUT (VOLTS)	
USER CHANNEL.......43: A2 PRT #639 ANALOG OUT (VOLTS)	
USER CHANNEL.......44: A2 PRT #640 ANALOG OUT (VOLTS)	
USER CHANNEL.......53: A2 PRT #641 ANALOG OUT (VOLTS)	
USER CHANNEL.......54: A2 PRT #642 ANALOG OUT (VOLTS)	
USER CHANNEL.......55: A1 PRT #634 ANALOG OUT (VOLTS)	A1-2
USER CHANNEL.......56: A1 PRT #635 ANALOG OUT (VOLTS)	

PHYSICAL CHANNEL...02: A2 PRT #633 SN 519
PHYSICAL CHANNEL...04: A2 PRT #634 SN 524
PHYSICAL CHANNEL...06: A2 PRT #635 SN 527
PHYSICAL CHANNEL...08: A2 PRT #636 SN 531
PHYSICAL CHANNEL...10: A2 PRT #637 SN 536
PHYSICAL CHANNEL...12: A2 PRT #638 SN 539
PHYSICAL CHANNEL...14: A2 PRT #639 SN 540
PHYSICAL CHANNEL...16: A2 PRT #640 SN 542
PHYSICAL CHANNEL...18: A2 PRT #641 SN 549
PHYSICAL CHANNEL...20: A2 PRT #642 SN 550
PHYSICAL CHANNEL...22: A1 PRT #634 SN TBD
PHYSICAL CHANNEL...24: A1 PRT #635 SN TBD
PHYSICAL CHANNEL...29: VOLTAGE OUT - PRT #633
PHYSICAL CHANNEL...30: VOLTAGE OUT - PRT #634
PHYSICAL CHANNEL...31: VOLTAGE OUT - PRT #635
PHYSICAL CHANNEL...32: VOLTAGE OUT - PRT #636
PHYSICAL CHANNEL...41: VOLTAGE OUT - PRT #637

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Table V Spacecraft Target A2 Channel Designations (Continued)

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PHYSICAL CHANNEL...42: VOLTAGE OUT - PRT #638
PHYSICAL CHANNEL...43: VOLTAGE OUT - PRT #639
PHYSICAL CHANNEL...44: VOLTAGE OUT - PRT #640
PHYSICAL CHANNEL...53: VOLTAGE OUT - PRT #641
PHYSICAL CHANNEL...54: VOLTAGE OUT - PRT #642
PHYSICAL CHANNEL...55: VOLTAGE OUT - PRT #634
PHYSICAL CHANNEL...56: VOLTAGE OUT - PRT #635
MATH EXPRESSION....03: CH 2 TEMP. CALC.
MATH EXPRESSION....05: CH 4 TEMP. CALC.
MATH EXPRESSION....07: CH 6 TEMP. CALC.
MATH EXPRESSION....09: CH 8 TEMP. CALC.
MATH EXPRESSION....11: CH 10 TEMP. CALC.
MATH EXPRESSION....13: CH 12 TEMP. CALC.
MATH EXPRESSION....15: CH 14 TEMP. CALC.
MATH EXPRESSION....17: CH 16 TEMP. CALC.
MATH EXPRESSION....19: CH 18 TEMP. CALC.
MATH EXPRESSION....21: CH 20 TEMP. CALC.
MATH EXPRESSION....23: CH 22 TEMP. CALC
MATH EXPRESSION....25: CH 24 TEMP. CALC
RS232 PARAMETERS...  :
REAL-TIME CLOCK....  :
DISPLAY SCAN 1.....  : TRWA2 BENCH TEST SYS.
DISPLAY SCAN 2.....  : NOT USED
CHANNEL SCAN 1.....  : TRWA2 BENCH TEST SYS.
CHANNEL SCAN 2.....  : NOT USED
```

Table VI AMSU-A1 Spacecraft Target - Azonix Back Panel

Board Position	Channel #'s	PRT #	PRT Input Terminal Location													
Exp. Box 1			1 shield	2 sense +	3 excite +	4 ground	5 shield	6 sense -	7 excite -	8 shield	9 sense +	10 excite +	11 ground	12 shield	13 sense -	14 excite-
A	2, 4	636, 637		TB4A 3	TB4A 1			TB4A 4	TB4A 2		TB4A 7	TB4A 5			TB4A 8	TB4A 6
B	6, 8	638, 639		TB4A 11	TB4A 9			TB4A 12	TB4A 10		TB4A 15	TB4A 13			TB4B 1	TB4A 14
C	10, 12	640, 641		TB4B 4	TB4B 2			TB4B 5	TB4B 3		TB4B 8	TB4B 6			TB4B 9	TB4B 7
D	14, 16	642, 629		TB4B 12	TB4B 10			TB4B 13	TB4B 11		TB3A 3	TB3A 1			TB3A 4	TB3A 2
Exp Box 2																
A	18, 20	630, 631		TB3A 7	TB3A 5			TB3A 8	TB3A 6		TB3A 11	TB3A 9			TB3A 12	TB3A 10
B	22, 24	632, 633		TB3A 15	TB3A 13			TB3B 1	TB3A 14		TB3B 4	TB3B 2			TB3B 5	TB3B 3
C		empty														
D		empty														

		Function	PRT Output Terminal Location													
A1 Mnfrm.			1	2	3	4	5	6	7	8	9	10			22	23
A	29...32	D/A out	639 +		638 +		637 +		636 +		return -					case gnd
B	41...44	D/A out	629 +		642 +		641 +		640 +		return -					case gnd
C	53...56	D/A out	633 +		632 +		631 +		630 +		return -					case gnd
D		empty														

NOTE:
1) Blank entry = no connection required.
2) Terminal numbers increase left to right when viewed from rear of Azonix.
3) D/A output terminal 9 is externally wired to terminal 23 for ground per mfg req.
4) Connections for A1-2 target PRT # 634 & 635 are made on A2 Azonix expansion box No. 2.
Please reference table: AMSU GE A2 - AZONIX BACK PANEL.

Table VII AMSU-A2 Spacecraft Target - Azonix Back Panel

Board Position	Channel #'s	PRT #	PRT Input Terminal Location													
Exp. Box 1			1 shield	2 sense +	3 excite +	4 ground	5 shield	6 sense -	7 excite -	8 shield	9 sense +	10 excite +	11 ground	12 shield	13 sense -	14 excite-
A	2, 4	633, 634		633 S+	633 E+			633 S-	633 E-		634 S+	634 E+			634 S-	634 E-
B	6, 8	635, 636		635 S+	635 E+			635 S-	635 E-		636 S+	636E+			636S-	636 E-
C	10, 12	637, 638		637 S+	637 E+			637 S-	637 E-		638 S+	638 E+			638 S-	638 E-
D	14, 16	639, 640		639 S+	639 E+			639 S-	639 E-		640 S+	640 E+			640 S-	640 E-
Exp Box 2																
A	18, 20	641, 642		641 S+	641 E+			641 S-	641 E-		642 S+	642 E+			642 S-	642 E-
B	22, 24	634, 635		TB3B 8*	TB3B 6*			TB3B 9*	TB3B 7*		TB3B 12	TB3B 10*			TB3B 13	TB3B 11*
C		empty														
D		empty														

		Function	PRT Output Terminal Location													
A2 Mnfrm.			1	2	3	4	5	6	7	8	9	10			22	23
A	29...32	D/A out	636 +		635 +		634 +		633 +		return -					case gnd
B	41...44	D/A out	638 +		637 +		636 +		635 +		return -					case gnd
C	53...56	D/A out	635 +		634 +		642+		641 +		return -					case gnd
D		empty														

NOTE:
1) Blank entry = no connection required.
2) Terminal numbers increase left to right when viewed from rear of Azonix.
3) PRT 634 & 635 are from A1-2 target.
4) The * designates terminals originating from the A1-2 target wire harness.
5) D/A output terminal 9 is externally wired to terminal 23 for ground per mfg req.

3.3 Azonix - Target Verification Test

The spacecraft targets were connected to the Azonix System 1000 to test for proper operation. Each PRT has four wires that must be connected to the Azonix. These are referred to as: sense +, excite +, sense -, excite -. The wires are labeled as indicated in Tables VI and VII. The labeled wires were connected to the corresponding Azonix terminals as shown for the test. The targets were in a temperature controlled lab with a light, insulating wrap around them to avoid drafts. The Azonix System was energized and ohms/temperature readings were recorded for every PRT of A1-1, A1-2, and A2. Each target was measured in a short time period (roughly 10 minutes) to avoid any temperature drift. The results are shown in Table VIII, IX, and X. The ohms readings were taken directly from the display on the even channels, 2 through 24. The temperature readings were taken directly from the display on the odd channels, 3 through 25. These temperatures are derived from the ohms reading using a least-squares, third-order-polynomial fit to the ohms/temperature data supplied for each PRT by the manufacturer. Inspection of Tables VIII, IX, and X reveals good agreement between the PRT indicated temperatures. The standard deviation for the three targets is between 0.07 and 0.8 K. This is typical of a target in thermal equilibrium and verifies proper performance. The analog outputs of the GIO5 cards were also tested. Here, a precision decade box was attached to the Azonix terminal strip to simulate a PRT near liquid nitrogen temperatures. Each channel was tested at 200 and 300 ohms to verify the voltage out changed per the equation Vout = .03 x (ohms) – 5.4 volts. The display was compared to the corresponding terminal out via a digital voltmeter display. The agreement was exact.

4. OPERATION

4.1 Electrical Connection

The targets should be connected to the Azonix system via the supplied wires on the targets and, if necessary, by the spacecraft contractor supplied extension cables (see 5.3.4.4 of S-480-80). Wires are marked as indicated in Tables VI and VII. Ignore extra wires not identified with the number shown. Total lead resistance between the Azonix system and target should be under 100 ohms. The excitation current is 0.1 mA resulting in a 0.02 to 0.1 V signal to represent the PRT ohms. The cables and wires should be appropriately shielded if the environment could interfere with these signal levels. It is recommended that "twisted shielded pairs" be used for any extension of the PRT wires. The terminal/wire correspondence is shown in Tables VI and VII. The analog out terminals may be found on the mainframes (lowest chassis) and are to be wired per Tables VI and VII by the spacecraft contractor. The unit may be operated without connection to the analog outputs or all/some of the PRTs.

4.2 Mechanical Orientation

The corresponding spacecraft targets are placed within 1/4 inch of the A1 and A2 instruments using the spacecraft contractor's fixtures per S-480-80, paragraph 5.3.3.2.

4.3 Nitrogen Connections/Nitrogen Supply

The recommended nitrogen plumbing for the three spacecraft targets is shown in Figure 2. Stainless steel tubing is used to supply the nitrogen to the targets. The tubing should be insulated outside the thermal vacuum chamber. The pressure for the LN2 supply should be approximately 4 psi for the supply (inlet side). The pressure on the exhaust side should be as low as possible, preferably below 1.0 psi. Connections to the target nitrogen lines themselves

Table VIII A1-1 Spacecraft Target Azonix Bench Test

TARGET 1333150-6 (A1-1)

PRT / SN	DISPLAY READ OUT OHMS	DISPLAY READ OUT TEMPERATURE (K)
636 / 522	1100.38	294.0
637 / 541	1102.33	294.0
638 / 507	1102.48	294.0
639 / 548	1110.71	294.0
640 / 504	1110.46	294.0
641 / 526	1111.25	294.0
642 / 557	1103.91	294.0

Table IX A1-2 Spacecraft Target Azonix Bench Test

TARGET 1333150-5 (A1-2)

PRT / SN	DISPLAY READ OUT	
	OHMS	TEMPERATURE (K)
629 / 629	1109.08	294.0
630 / 630	1112.51	294.0
631 / 590	1101.31	294.0
632 / 544	1109.54	294.0
633 / 623	1102.63	294.0
634 / 515	1110.07	294.0
635 / 621	1073.29	294.0

Table X A2 Spacecraft Target Azonix Bench Test

TARGET 70143 - 1333202-1 (A2)

PRT / SN	DISPLAY READ OUT	
	OHMS	TEMPERATURE (K)
633 / 519	1102.45	294.0
634 / 524	1108.25	294.0
635 / 527	1109.23	294.0
636 / 531	1101.27	294.0
637 / 536	1098.61	294.0
638 / 539	1110.31	294.0
639 / 540	1109.55	294.0
640 / 542	1103.53	294.0
641 / 549	1099.35	294.0
642 / 550	1112.08	294.0

are made via the use of a flared tube union and a compression sleeve. The A2 unit uses a union, AN815-8, with a compression sleeve, MS51533B8. The A1 units use a union, AN815-6, with a compression sleeve, MS51533B6. The supply "inlet" is in the center of the target and the "outlet" is near the periphery per Drawings 1333150 and 1333160.

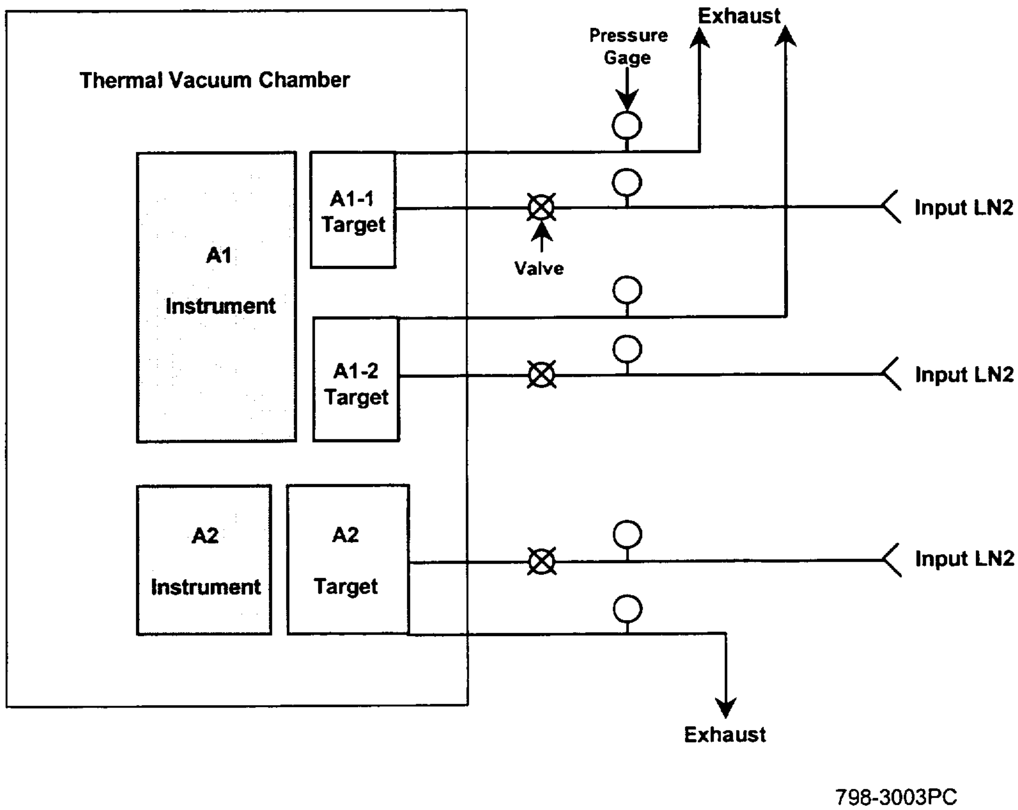

Figure 2 Recommended Nitrogen Plumbing For Spacecraft Targets

The following recommendations for the nitrogen quality and plumbing are provided to assure target temperatures below 85 K.

1) The input nitrogen should be at a low pressure without the presence of gaseous bubbles (no biphase state). Maintenance of the input pressure near 4 psi will help attain this goal. Keep in mind that the temperature will rise approximately 0.5 °C per pound of pressure. Thus, LN2 at 4 psi will be near 79 K.

2) The output lines should be short and as large as possible to minimize back pressure (i.e., larger than 1 inch diameter and less than 40 feet long). Lines should run constantly "downhill".

3) All the input and output lines outside the thermal vacuum chamber should be insulated to prevent icing.

4) Pressure gauges and valves on the input and output lines should be installed to aid in the control of the nitrogen.

4.4 Azonix Operation/Data Acquisition And Processing

The Azonix system is turned on via a switch in the upper rear of the relay rack. This will energize all of the six Azonix units. The mainframe will display "TEST" and will go through a diagnostic procedure. After approximately 10 seconds, the systems will be up and running. The default state will be the "display scroll mode". Here, the unit will step through all of the channels set in the "display scan table". Each channel will be displayed for a second before progressing to the next channel. This process repeats until a specific channel is requested. This is the preferred operating mode. To request a particular user channel, press "shift", "enter", "NN" (where NN = channel number), and press "enter" again. The NN channel number will now be displayed continuously. To look at another channel at this point, press "NN" and "enter". Additional instructions may be found in the Azonix System 1000 Manual.

Tables IV and V list the 36 user channels that contain the three different representations of the temperature data. Channels 2 through 24 (even) contain the PRT ohms, channels 3 through 25 (odd) contain the PRT temperature in degrees K as derived from the ohms value, and channels 33 through 60 contain the volts out present at the rear terminal strips. PRT ohms are converted to a temperature in degrees Kelvin via a third-order polynomial with coefficients determined from a least-squares fit to the manufacturer's tabular data. This formula is given by:

$$Temperature\ (K) = AR^3 + BR^2 + CR + D \qquad (1)$$

Where R = resistance in ohms of PRT

The coefficients A, B, C, and D are given in Table XI for all 24 PRTs.

Temperature of the PRTs may also be acquired from the Azonix via the RS232 interface. The system is currently configured for 9600 baud, character size 7, stop bits 1, even parity. These may easily be changed, if necessary, via the front panel of "ACP1" per the supplied Azonix instruction manual. Commands to, and data from, the Azonix system are accomplished by ASCII codes via the RS232 interface. These codes are listed in sections 5, 6, and 7 of the supplied documentation Azonix 1000 Communications Instruction Manual. These codes can easily be sent or received via any computer with an open RS232 interface. A high level language such as FORTRAN or BASIC makes automatic data acquisition easy.

A third source of temperature data is via the analog outputs of the GIO5 circuits. The voltage present between the terminals 1, 3, 5, 7, and the ground, 9, represent the PRT ohms as indicated in Tables VI and VII. Note that the output is buffered per S-480-80, but it is only accurate up to a 2 mA load. The quoted D/A accuracy is ± 0.1% minimum, ± 0.05% typical. The voltage out will be between 0 and 5 volts, and will reflect the PRT resistance in ohms (R) by the equation:

$$R = \frac{V_{out} + 5.4}{.03} \qquad (2)$$

The ohms must then be converted to temperature for each individual PRT through the use of Equation 1 and the Table XI coefficients.

Table XI Spacecraft Target PRT Polynomial Coefficients

UNIT	PRT S/N	A	B	C	D
A2	519	-4.33170E-09	2.14680E-05	0.21831	35.0858
	524	-4.23530E-09	2.11850E-05	0.21743	35.0996
	527	-2.42410E-09	1.55380E-05	0.22302	34.1336
	531	-5.06220E-09	2.37750E-05	0.21672	35.3904
	536	-4.47150E-09	2.19260E-05	0.22056	35.0694
	539	-4.23770E-09	2.11640E-05	0.21861	35.0180
	540	-4.37710E-09	2.16050E-05	0.21754	35.0931
	542	-4.40410E-09	2.16860E-05	0.21777	35.1213
	549	-4.41060E-09	2.17810E-05	0.22064	35.0264
	550	-4.44030E-09	2.17850E-05	0.21595	35.1823
A1-1	522	-4.35450E-09	2.15320E-05	0.21591	35.1490
	541	-4.18980E-09	2.09320E-05	0.21593	35.0374
	507	-4.30600E-09	2.13560E-05	0.21599	35.0904
	548	-4.31800E-09	2.13940E-05	0.21610	35.1015
	504	-4.34450E-09	2.14890E-05	0.21610	35.1417
	526	-4.34080E-09	2.14680E-05	0.21579	35.1476
	557	-4.49440E-09	2.19880E-05	0.21924	35.1319
A1-2	629	-4.50290E-09	2.20360E-05	0.22052	35.0777
	630	-5.76180E-09	2.59370E-05	0.21764	35.6040
	590	-4.50490E-09	2.20240E-05	0.22080	35.0682
	544	-4.55270E-09	2.21850E-05	0.21932	35.1627
	623	-4.30710E-09	2.13730E-05	0.21568	35.1290
	515	-4.48990E-09	2.19250E-05	0.21832	35.1173
	621	-4.43870E-09	2.18130E-05	0.21879	35.1270

5. MAINTENANCE

The Azonix system does not require any periodic maintenance. Calibration checks may be accomplished to verify the health of the system via the use of a calibrated resistor decade box. Here, the known resistance is placed across the sense+/excite+ to sense-/excite- terminals for each PRT channel. The sense and excite terminals of the same polarity are shorted together at the decade box. The resistance is displayed directly on the mainframe panel. All of the channels may then be compared to each other directly. Typical resistance variations for a set of channels (one target, 1100 ohms) are:

max - min	= 0.3 ohms
standard deviation	= 0.1 ohms

If the standard deviation exceeds 0.2 ohms or the (max - min) exceeds 0.6 ohms it is recommended that the anomolous channel or channels be repaired.

If the Azonix system is found to fail, then the motherboard or the option boards may need to be replaced. This is easily accomplished without removal of the chassis. The motherboard and option cards simply slide out of the chassis per the Azonix System 1000 Manual. New option boards that are installed must be configured for proper address, physically located in place, and the coefficients entered into the firmware. If a new motherboard is installed, the firmware must be loaded into the EPROM before use.