SUBSYSTEM :ELECT POWER DIST & CONT FMEA NO 05-6 -2361 -2 REV:03/02/90
ASSEMBLY :INV. DIST & CONT ASSY 1,2,3 CRIT.FUNC: 1R
P/N RI :MC431-0129-0001/0002 CRIT. HDW: 3
P/N VENDOR: VEHICLE 102 103 104
QUANTITY :3 EFFECTIVITY: X X X
:THREE(ONE PER EACH AC PHASE(S): PL LO OO X DO LS
:BUS ARRAY)

REDUNDANCY SCREEN: A-FAIL B-N/A C-PASS

PREPARED BY:			APPROVED BY:		APPROVED BY (NASA):	
DES	R	PHILLIPS	DES	3/1/90	SSM	3/30/90
REL	T	KIMURA	REL	3-6-90	REL	3/29/90
QE	J	COURSEN	QE		QE	12 MAR 90

ITEM:
SENSOR, VOLTAGE - AC OVER/UNDER VOLTAGE SENSOR, AC BUS SYSTEM

FUNCTION:
MONITORS ALL THREE PHASES OF AN INVERTER ARRAY BUS SET FOR INCORRECT AC VOLTAGES. PROVIDES SIGNAL FOR INDIVIDUAL INVERTER (PHASE) ISOLATION IF OVER VOLTAGE OR OVERLOAD CONDITION IS SENSED. 81V76A35VS1, 82V76A36VS1, 83V76A37VS1

FAILURE MODE:
LOSS OF OUTPUT, FAILS OPEN, SHORTS TO GROUND

CAUSE(S):
PIECE PART FAILURE, CONTAMINATION, VIBRATION, MECHANICAL SHOCK, PROCESSING ANOMALY, THERMAL STRESS

EFFECT(S) ON:
(A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE (E)FUNCTIONAL CRITICALITY EFFECT:

(A) LOSS OF FUNCTION. IN "AUTO" MODE - LOSS OF CAPABILITY TO AUTOMATICALLY DISCONNECT AFFECTED INVERTER FROM ITS AC BUS. IN "MONITOR" MODE - LOSS OF SIGNAL TO CAUTION AND WARNING INDICATING OUT-OF-TOLERANCE INVERTER (ASSUMES PRIOR INVERTER FAILURE).

(B) LOSS OF AUTOMATIC OVERVOLTAGE PROTECTION FOR CONNECTED AC LOADS.

(C,D) FIRST FAILURE - NO EFFECT.

SUBSYSTEM :ELECT POWER DIST & CONT FMEA NO 05-6 -2361 -2 REV:03/02/90

EFFECT(S) ON (CONTINUED):
(A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE (E) FUNCTIONAL CRITICALITY EFFECT:

(E) POSSIBLE LOSS OF CREW/VEHICLE DUE TO DAMAGE TO CRITICAL LOAD EQUIPMENT CAUSED BY LENGTHENED EXPOSURE TO OVERVOLTAGE CONDITION WITH LOSS OF "AUTO" TRIP CAPABILITY. REQUIRES THE FOLLOWING SCENARIO:

(1) LOSS OF AC VOLTAGE SENSOR OUTPUT.
(2) OVERVOLTAGE FAILURE IN ASSOCIATED INVERTER (SINGLE PHASE). IF FAILED INVERTER IS NOT ISOLATED FROM THE BUS OVERVOLTAGE DAMAGE MAY PROPAGATE TO REMAINING PHASES OF CRITICAL LOADS CONNECTED TO THAT BUS.
(3) LOSS OF A SECOND THREE-PHASE AC BUS.

FAILS "A" SCREEN SINCE GROUND TESTING IS CONSIDERED INVASIVE DUE TO THE DIFFICULTY IN SIMULATING AN OVERVOLTAGE.

DISPOSITION & RATIONALE:
(A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY (E)OPERATIONAL USE:
(A,B,C,D) DISPOSITION AND RATIONALE

(A) DESIGN

PHYSICAL DESCRIPTION

THE AC SENSOR IS A SOLID-STATE DEVICE CONSISTING OF THREE PRINTED CIRCUIT BOARDS CONTAINING SOLID-STATE COMPONENTS. THE ELECTRICAL, ELECTRONIC AND ELECTRICAL MECHANICAL COMPONENTS ARE SELECTED FROM OR IN ACCORDANCE WITH THE ORBITER PREFERRED PARTS LIST (OPPL) REQUIREMENTS. COMPONENT APPLICATIONS ARE EVALUATED TO ASSURE COMPLIANCE WITH DERATING REQUIREMENTS. THE PRINTED CIRCUIT BOARDS ARE MOUNTED ON HEAT SINKS TO PROVIDE A THERMAL PATH THROUGH THE CASE TO THE NEXT ASSEMBLY. THE LEADS ARE BROUGHT OUT THROUGH A 37 PIN CONNECTOR. THE UNIT IS CONSIDERED ENVIRONMENTALLY SEALED, WITH A COVER/GASKET TYPE SEAL.

FUNCTIONAL DESCRIPTION

ONE SENSOR IS INSTALLED WITHIN EACH INVERTER DISTRIBUTION AND CONTROL ASSEMBLY (IDCA). THERE ARE THREE IDCA'S, ONE IN EACH FORWARD FUSELAGE AVIONICS BAY. EACH ASSEMBLY, ONE FOR EACH OF THE THREE AC BUS SETS, PROVIDES AC CIRCUIT PROTECTION.

THE AC OVER/UNDER VOLTAGE SENSING UNIT IS USED FOR SENSING A THREE-PHASE, 400 HZ AC BUS FOR OVERVOLTAGE OR UNDERVOLTAGE. EACH PHASE IS SENSED INDIVIDUALLY. IT ALSO MONITORS OVERLOAD SIGNALS FORM THE THREE INVERTERS SUPPLYING POWER TO THIS BUS. WHEN AN OVERVOLTAGE OR UNDERVOLTAGE OCCURS ON THE BUS, OR AN OVERLOAD ON THE INVERTERS OF SUFFICIENT DURATION, THE AC SENSOR WILL SEND A LATCHED SIGNAL TO THE CAUTION AND WARNING AND THE MULTIPLEXER/DEMULTIPLEXER. IF THE AC SENSOR IS IN THE AUTOMATIC MODE AN

(A) DESIGN (CONTINUED)

AN OVERVOLTAGE OR OVERLOAD CONDITION EXISTS, IT WILL OPEN A RELAY BETWEEN THE INVERTER AND THE PHASE OF THE BUS THAT HAD THE ANOMALY. IF THE SENSOR IS IN THE MONITOR MODE, NO SIGNAL WILL BE SENT TO OPEN THE RELAY. THESE OUTPUT SIGNALS MAY BE REMOVED BY RESETTING THE SENSOR AFTER THE FAULT IS CLEARED.

DESIGN EVOLUTION
DURING THE SUPPLIER TESTS VARIOUS FAILURES ON THE AC SENSOR OCCURRED AND MARGINAL TOLERANCES WERE EXPERIENCED IN OUTPUT PERFORMANCE FOR OVER/UNDER VOLTAGE SENSITIVITY, TRANSIENTS DURING TURN-ON, BORDERLINE OVERLOAD CHARACTERISTICS MORE THAN NORMAL AND LOW INSULATION RESISTANCE MEASUREMENTS. SUPPLIER'S CORRECTIVE ACTION SATISFACTORILY REMOVED THE INITIAL PROBLEMS BY IMPROVING WORKMANSHIP, MANUFACTURING PROCESSES AND INSPECTION PROCEDURES, BETTER SELECTION OF APPLICABLE COMPONENTS, AND IMPROVED COMPONENT MOUNTING, BONDING AND WIRE ROUTING. THE DESIGN CHANGES RESULTED IN THE FLIGHT CONFIGURATION AC OVER/UNDER VOLTAGE SENSOR P/N MC431-0129-0001, LATER UPGRADED TO THE -0002. THE -0002 SENSOR DIFFERS FROM THE -0001 BY ADDITIONAL CAPACITORS INCORPORATED TO COMPENSATE PARAMETER DRIFTS. THE -0001 IS EFFECTIVE FOR OV-102. THE -0002 IS EFFECTIVE FOR OV-103 AND SUBS.

(B) TEST

QUALIFICATION/CERTIFICATION

CERTIFICATION TESTING AND ANALYSIS ARE COMPLETED AND APPROVED. QUALIFICATION TESTS INCLUDE THE FOLLOWING:

CAUSES
a Piece part failure
b Contamination
c Vibration
d Mechanical shock
e Processing anomaly
f Thermal stress

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
ACCEPTANCE	X	X	X		X	X
QUAL/ACCEPTANCE (QAVT AT 0.067 g^2/HZ)	X		X		X	
RANDOM VIBRATION (0.09 g^2/HZ, 48 MIN)	X		X		X	
VISUAL EXAMINATION	X	X			X	
PERFORMANCE	X	X	X		X	X
INSULATION RESISTANCE		X			X	
DIELECTRIC WITHSTANDING VOLTAGE		X			X	
OPERATIONAL (OVERLOAD, UNDERVOLTAGE, OVERVOLTAGE, OVERLOAD SIGNAL VOLTAGE)		X			X	
FINAL EXAMINATION	X	X			X	

(B) TEST (CONTINUED)

QUALIFICATION/CERTIFICATION TEST PERFORMED AT THE NEXT ASSEMBLY LEVEL (IDCA) INCLUDE:

CAUSES
a Piece part failure
b Contamination
c Vibration
d Mechanical shock
e Processing anomaly
f Thermal stress

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
QUAL/ACCEPTANCE (QAVT AT 0.067 g^2/HZ)	X		X		X	
EMI (SL-E-0002)		X			X	
THERMAL CYCLING (20 TO 140 ^{o}F, 7½ CYC)						X
BENCH HANDLING SHOCK (4 DROPS per MIL-STD-810, METHOD 516.1, PR. V)				X		

ACCEPTANCE AND SCREENING

ALL PRODUCTION UNITS ARE SUBJECTED TO 100% ACCEPTANCE TESTING WHICH INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
VISUAL EXAMINATION	X	X			X	
INSULATION RESISTANCE		X			X	
DIELECTRIC WITHSTANDING VOLTAGE		X			X	
FUNCTIONAL	X				X	
THERMAL (ATT)						X
VIBRATION (AVT)	X		X		X	
PERFORMANCE	X				X	

ACCEPTANCE TEST AT THE NEXT ASSEMBLY (IDCA):

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
VISUAL EXAMINATION					X	
INSULATION RESISTANCE					X	
VIBRATION (0.04 g^2/HZ)			X			
FUNCTIONAL	X				X	
CONTINUITY		X			X	

(B) TEST (CONTINUED)

GROUND TURNAROUND TEST

VERIFY PROPER AC BUS SENSOR OPERATION IN "AUTO", "MONITOR" AND "OFF" MODES AND WITH AC SENSOR CONTROL CIRCUIT BREAKER OPENED AND CLOSED. THIS TEST VERIFIES SENSOR OUTPUT, OVERLOAD SENSING AND UNDERVOLTAGE SENSING; HOWEVER, DOES NOT VERIFY OVERVOLTAGE SENSING. TEST IS PERFORMED EVERY FIFTH FLIGHT.

(C) INSPECTION

RECEIVING INSPECTION (FAILURE CAUSE e)

RECEIVING INSPECTION VERIFIES ALL INCOMING PARTS AND MATERIALS, INCLUDING PERFORMANCE OF VISUAL AND DIMENSIONAL EXAMINATIONS, IN ACCORDANCE WITH REQUIREMENTS. CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL (FAILURE CAUSE b)

QUALITY CONTROL (QC) VERIFIES PROPER MAINTENANCE OF CLEANLINESS CONTROL.

ASSEMBLY/INSTALLATION (FAILURE CAUSE a,b,e)

INSPECTION POINTS ARE DETERMINED BY QUALITY ENGINEERING IN ACCORDANCE WITH APPLICABLE REQUIREMENTS AND ARE DOCUMENTED ON INSPECTION PLANNING. WORK STATION DISCIPLINES ADHERED TO AND OBSERVED MORE THAN FIVE TIMES PER WEEK BY QC.

CRITICAL PROCESSES (FAILURE CAUSE b,e)

ALL CRITICAL PROCESSES AND CERTIFICATIONS ARE MONITORED AND VERIFIED BY QC AS PROCESS CONTROL SURVEILLANCE ACTIVITY (OPERATIONS AUDIT). THE CRITICAL PROCESSES ARE SOLDERING, BONDING OF COMPONENTS FOR MECHANICAL STABILITY/THERMAL CONDUCTIVITY, COMPONENT PLACEMENT, WIRE ROUTING, AND CRIMPING. FORMAL CERTIFICATION FOR SOLDERING AND QUALIFICATION FOR CRIMPING ARE MAINTAINED.

TESTING

ACCEPTANCE TESTS, INCLUDING VIBRATION, THERMAL, INSULATION RESISTANCE, DIELECTRIC STRENGTH AND PERFORMANCE ARE OBSERVED AND VERIFIED BY QC.

HANDLING/PACKAGING (FAILURE CAUSE c,d)

HANDLING OF CMOS DEVICES TO PRECLUDE ELECTROSTATIC DISCHARGE (ESD) VERIFIED BY QC. PARTS PACKAGED AND PROTECTED ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS.

(D) FAILURE HISTORY

CAR A3535
AFTER ACCEPTANCE VIBRATION, THE VISUAL EXAMINATION DETECTED A BOWED PRINTED CIRCUIT BOARD IN THE AC SENSOR. THE BOARD WAS LOOSE AND DISCLOSED A DAMAGED HEAT RAIL. FAILURE ANALYSIS REVEALED INSUFFICIENT BONDING AND AN EXCESSIVE GAP BETWEEN THE HEAT RAILS ON TOP AND BOTTOM OF PRINTED CIRCUIT BOARD. THE GAP WAS THE RESULT OF EXCESSIVE TORQUE APPLIED TO A HOLDING SCREW, PULLING THE HEAT RAIL LOOSE FROM THE BONDING MATERIAL AND BOWING THE BOARD. THE CORRECTIVE/REMEDIAL ACTION CONSISTED OF IMPROVING REBONDING TECHNIQUES AND THE ADDITION OF SHIMS BETWEEN HEAT RAILS. THIS WAS MADE EFFECTIVE FOR ALL FLIGHT UNITS.

CAR'S AB9425 AND AB9426
DURING ACCEPTANCE THERMAL TEST, WHILE AT HIGH TEMPERATURE, THE AC SENSOR OUTPUT SIGNAL VOLTAGE WAS ZERO WHEN IT SHOULD BE 28 VOLTS DURING OVERVOLTAGE TESTING. FAILURE ANALYSIS DISCLOSED A REGULATOR TRANSISTOR ALLOWED A TRANSIENT GLITCH TO PASS THROUGH DURING THE TURN-ON PHASE. THE TRANSIENT LEVEL CAUSED THE LOGIC CIRCUIT TO LOCKUP PREVENTING THE AC SENSOR SIGNAL VOLTAGE FROM FUNCTIONING. THE CORRECTIVE ACTION AUTHORIZED A DESIGN CHANGE TO ELIMINATE THE TURN-ON TRANSIENT GLITCH (IDTA-M33073). THE MODIFICATION ADDED A CAPACITOR TO THE BOARD ASSEMBLY BETWEEN THE TRANSISTOR Q12 COLLECTOR AND SIGNAL GROUND. THE AC SENSOR WITH THIS MODIFICATION BECAME P/N MC431-0129-0002, EFFECTIVE FOR OV-103 AND SUBSEQUENT. THE -0 CONFIGURATION IS CONSIDERED SATISFACTORY FOR ITS INTENDED USAGE AS IT PASSED THE ACCEPTANCE TESTS WHICH SERVE AS AN EFFECTIVE SCREEN FOR DETECTION OF ANY DEVICES WITH OUT-OF-TOLERANCE THRESHOLDS.

(E) OPERATIONAL USE

NONE