Bendix
Aerospace Systems Division

ALSEP Array E
PSK Transmitter
Failure Mode, Effects and Criticality Analysis

ATM 1005 | A

DATE 12-15-71

This ATM document is the Reliability FMECA (Failure Mode, Effects and Criticality Analysis) of the Teledyne Telemetry Company's PSK Transmitter; Revision A reflects the failure modes and failure probabilities of the design presented at TTC's final design review (FDR).

The ALSEP Array E, PSK Transmitter Parts Application Analysis, ATM 1006, Table 1 presents parts changes and additions in tabular form. This FMECA has incorporated these changes and changed the prediction in accordance with the update.

This analysis concludes that the numerical reliability prediction meets the reliability goal established in the CEI specification. The SPFS (Single Point Failure Summary) provides rationale for non-redundant circuitry within a single transmitter. The ALSEP System provides two S-band transmitters for one function. Thus, eliminating SPF's in the ALSEP transmitter subsystem. The detailed FMECA (Appendix A) gives the failure mode, failure effect on assembly and end item, quantitative failure probability and criticality on all the EEE transmitter parts. It is from this detailed analysis that a majority of the narrative analysis is derived.

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TABLE OF CONTENTS

1.0 INTRODUCTION

The PSK (phase shift keying) transmitter subcontract (SC-935) was let to Teledyne Telemetry Company (TTC) to fulfill the requirements in the NASA Contract NAS 9-5829. An ALSEP Reliability Program Plan (BSR 3024) was written in accordance with NAS 9-5829 to provide for a subcontract reliability program plan. TTC has a BxA approved Reliability Program Plan, #2005177B, providing for a FMECA and the requirements therein.

This FMECA report is based on the PSK transmitter design presented at the subcontractor's FDR. Changes were made since the detailed FMECA was written. These changes are given in Parts Application Analysis, details of ATM 1006, Rev. A.

2.0 REQUIREMENTS

The FMECA requirements include, but are not limited to, a) failure mode and effect identification, b) failure classification, i.e., critical, major or minor, c) failure probability of components, d) reliability prediction, 3) single point failure analysis and assesment, f) circuit description, g) functional and reliability block diagrams. The FMECA is required for PDR and updated for designs presented at CDR and FDR.

The telemetry circuits were adequately reviewed at PDR and CDR with respect to meeting the requirements of Exhibit B, ARD 503B, 3.1.1.16, wherein it is stated that the telemetry". . . shall not cause degradation in the transmitter operation . . ." The telemetry parts analysis is presented in the detailed portion of the PAA, ATM 1006 and Appendix A.

3.0 SUMMARY OF ANALYSIS RESULTS

The reliability goal (Exhibit B, ARD-503B, 3.1.2.1) of .9800 is met considering the appropriate failure mode probabilities. The value is .982150 for probability of success with no failures based on appropriate failure modes.

SPFs (single point failures) cannot be practically eliminated in the design of a single transmitter. Detail analysis of this subject is treated in Section 4.0 herein. Although redundant circuitry is not provided in the transmitter, The ALSEP transmitter subsystem has two transmitters, one designated as the "operating" unit and one as the stand-by unit. Command switching is available, providing positive selection control. Thus, the SPF conditions, when applied to the ALSEP transmitter subsystem, are eliminated.

The failure mode probability in any particular instance is very low due to hi-rel part selection or where non-standard parts are used, appropriate screening and testing is required for conformance sufficiently adequate to assure low failure rates.

4.0 DETAIL ANALYSIS

Figure 1 is a functional block diagram of the transmitter. The referenced block diagram indicates a series relationship except for the MEMA regulator. In a reliability block diagram the regulator would be the second block in a series of blocks as follows: a) housing, b) regulator, c) synthesizer, d) power amplifier, e) isofilter.

4.1 CIRCUIT DESCRIPTION

4.1.1 Synthesizer

The synthesizer is shown in Figure 1, the transmitter block diagram. A crystal oscillator is employed, oscillating at 94.4 MHz. The oscillator output is applied to the PSK Modulator at zero dbm.

The 94.4 MHz is split into two channels. Each channel is phase shifted and resistively attenuated. The phase shift networks use identical components to ensure their tracking each other through temperature and aging, thus maintaining a constant differential phase shift. The resistive attenuators are adjusted such that amplitude balance is maintained between channels.

At this point diode switches select either of the two channels; their outputs are then combined in a resistive adder. A multiple nand gate, connected as an R-S flip-flop, drives the diode switches. This ensures accurate complimentary switching and a zero reference phase state under zero modulation conditions. The PSK modulated signal at 94.4 MHz is multiplied 8 times and filtered.

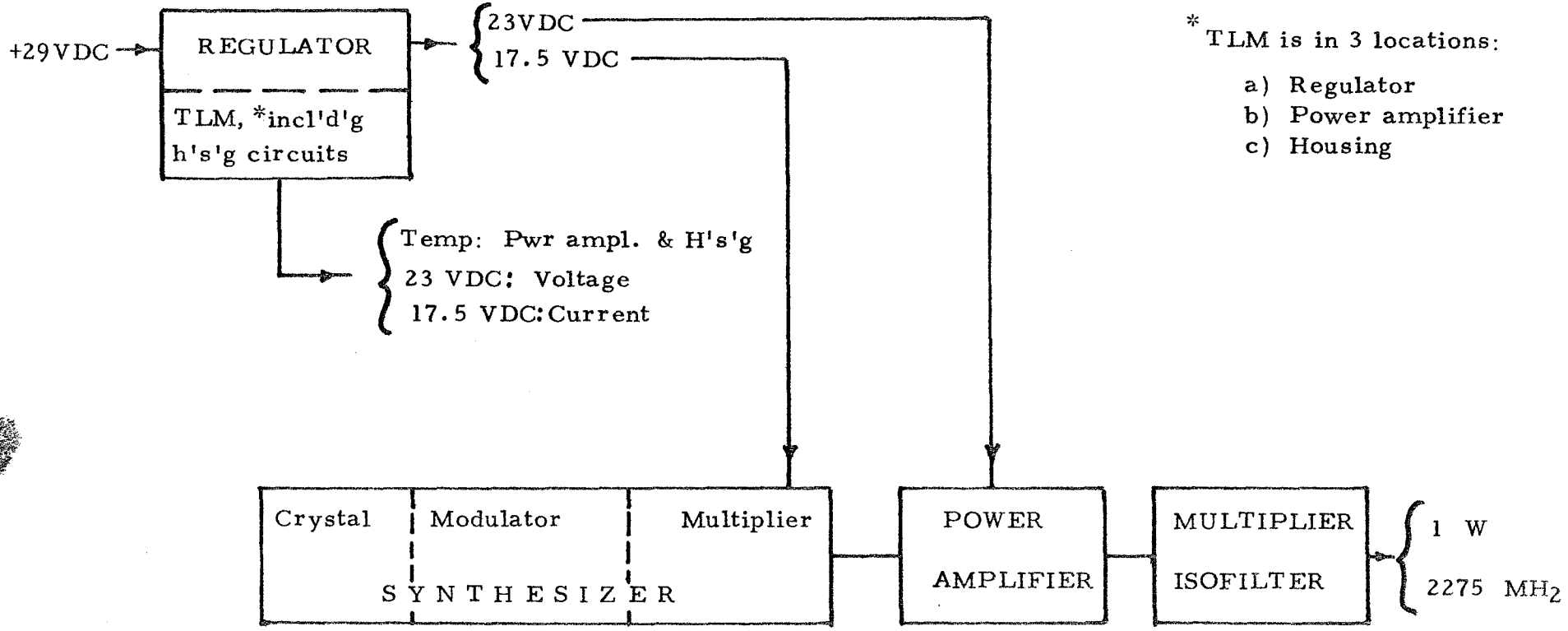


Figure 1

PSK Transmitter Functional Block Diagram

4.1.2 Power Amplifier

The resultant 760 MHz, at a +13 dbm level, is applied to a high efficiency two stage power amplifier. The performance (22dB of gain in two stages) and collector efficiency (greater than 50%) are achieved by the use of TRW 2GHz devices and low loss passive circuit elements. Four filter networks consisting of 4 capacitors each are designed to filter high and low frequencies. Two basic capacitance values would suffice, but multiple capacitors of a value common throughout the transmitter were selected to minimize the value and types of capacitors used.

4.1.3 Multiplier-Iso-filter

The 3.2 watts of PSK modulated 760 MHz is then multiplied three times with an HPA 0300 series varactor diode. The diode output is matched into a three-port circulator with its third port terminated. This circuit configuration provides a resistive termination for the higher order harmonics generated by the varactor and reflected by the two-pole output filter. The result is an easily tuned, thermally stable, efficient multiplier.

4.1.4 Regulator

The primary power source will be conditioned with a MEMA Regulator. The MEMA regulator provides 17.5 VDC at 30 ma to the oscillator and multiplier stages and 23.0 VDC to the first and second power amplifiers.

4.2 Single Point Failure Summary

The FMECA critical and major failures have been reviewed for possible elimination by the parallel redundant and dual series approach in order to eliminate Single Point Failures.

In a transmitter of the type used in the ALSEP program, power must be generated at a relatively low level and frequency, to insure meeting the frequency accuracy requirements of the specification. After this power is generated it must be amplified in level and multiplied in frequency to meet the output requirements of the specification. As present technology limits available stage gains, and multiplication integers; signal processing must occur in several successive stages. This type of design leads to single point failures which are not compensated except by redundancy at the transmitter assembly level.

Analysis of the PSK transmitter at the unit level shows that it is better to rely on the inherent reliability of the components to minimize failures; rather than to provide multiple component paths for the signal. Circuits operating at the frequencies utilized in this transmitter are extremely complex because lead length inductance and parasitic (stray) capacitance are not negligible as they are at lower frequencies. When a bypass capacitor is chosen, its value is selected so that the L-C combination of lead inductance and capacitance provides a minimum impedance at the frequency of interest. When two bypass capacitors are used in parallel their values are dependent upon each other because of the way that they are coupled together by the mutual inductance of the circuit wiring. If either capacitor opened a circuit failure could result because the other capacitor may no longer present a low enough impedance to prevent degeneration or circuit instability. Also if either capacitor shorted a circuit malfunction would result. Therefore two bypass capacitors in parallel could offer poorer reliability than a single bypass capacitor. The same type of case can be made for all coupling and tuning components. If two DC bias resistors were used instead of one, a bias shift of two to one would result if one failed. Such drastic bias changes are sure to either saturate or cut-off stage much the same as if a single resistor failure was encountered. Multiple transistors offer the same type of problem. It is extremely difficult to get them to share the power load without resorting to hybrid type power splitters and combiners. Also, if one fails it may cause the other one to fail too. Clearly, reliability through piece part redundancy is impractical at these frequencies. It is better to provide transmitter redundancy as they could be hybrid coupled and therefore completely isolated from each other.

Two transmitters are provided in the ALSEP central station downlink. They are independently, command controlled, with one in the back-up or stand-by mode. Thus, from a system standpoint SPF's are eliminated

4.3 WORST CASE OR MOST CRITICAL FIALURE MODES

4.3.1 Main Housing

An open in the power supply solid tantalum capacitor (C1, 2005178 schematic) would result in no RF output from the transmitter. This is extremely remote and is zero in the ATM 605A, Failure Rate Data for ALSEP, failure mode apportionment tables.

4.3.2 Regulator

A short in voltage set resistor R516 or power supply filter capacitor C503 (schematic 2005178) would result in no output from the

transmitter. This is extremely remote with respect to the resistor since ATM-605A indicates this failure mode is zero for this type resistor. The capacitor selected has a proven space applications history plus additional screening, burn-in and lot conformance testing.

4.3.3 Multiplier-Isofilter

A short in tuning capacitor C603 would result in no output from the transmitter. The capacitor selected has proven space applications history plus additional screening, burn-in and lot conformance testing.

4.3.4 Power Amplifier

Opens in several capacitors would result in no output from the transmitter. The coupling and tuning capacitors are C401, C425 and C414, schematic 2005178. Failure in the open mode is extremely unlikely. ATM 605A indicates this type capacitor will not fail in the open mode.

4.3.5 Synthesizer

Opens in coupling capacitors C356 and C357 would result in no output from the transmitter. This is not likely since ATM 605A indicates this failure mode is zero for this type capacitor.

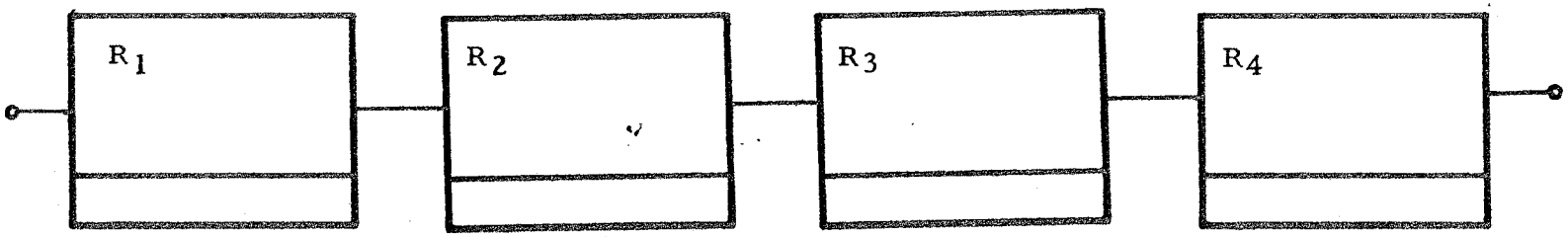
4.4 PREDICTION

The reliability goal is .9800. The transmitter meets this goal when all of the appropriate failure mode probabilities are considered. The prediction becomes .983143 when the probabilities are accounted for.

a. From PAA failure rate data only (not differentiating for applicability of failure modes), Figure 2 summarizes transmitter reliability. Basic relationships are as follows:

$e^{-\lambda t} = R$ where, λ is failure rate,
t is mission time, 17520 hours

$Q = 1 - R$



Legend:

R_1 - Synthesizer

R_2 - Power Amplifier

R_3 - Multiplier-Isofilter

R_4 - Housing and Regulator

Transmitter Reliability Block Diagram

Figure 2

b. The alpha (α) values shown in the detailed FMECA, Appendix A were obtained from ATM 605A and used to apportion the failure rates for the components as given in the PAA, ATM 1006, Revision A. Taking the α percentage of the applicable failure rate times the mission period of 17520 hours and applying the relations given in subparagraph "a" above, the following probabilities result:

Assembly	R	$Qx10^{-5}$
2005150 Housing	.999967	3.3274
2005170 Synthesizer	.987877	1212.280
2005180 Pwr Ampl.	.999031	96.8741
2005160 Regulator	.996225	375.0302
2005190 Isofilter	.999956	4.3973
2362877 Transmitter	.983143	1685.707

5.0 CONCLUSIONS

The PSK S-band transmitter must rely on hi-rel and space proven parts appropriately screened and tested for its performance without redundancy of any circuitry. Because of this single thread design, parts were carefully chosen and source control specifications written to provide long life and low failure rates.

To overcome the SPF's of the single thread design, the ALSEP transmitter subsystem has two transmitters, independently controlled, with either one capable of meeting 2 year reliability requirement and the other in standby (power off) mode.

APPENDIX A

PSK TRANSMITTER

DETAIL FAILURE MODE,

EFFECTS & CRITICALITY

ANALYSIS

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM 1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005260C	PAGE: A2 of 32	
ASSY: Major Sub-Assy's	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE (∝)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
1 Synthesizer	Inoperative	Loss of Output	No RF Output	1212.280	Critical
2 Power Amplifier	Inoperative	Loss of Output	No RF Output	96.8741	Critical
3 Isofilter/ Multiplier	Inoperative	Loss of Output	No RF Output	4.3973	Critical
4 Regulator; Housing	Inoperative	Loss of Output	No RF Output	375.0302 3.3274	Critical
5 Telemetry Monitors	Inoperative	Loss of Output	Loss of Failed Telemetry Function Only	—	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM 1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005150A	PAGE: A3 of 32	
ASSY: Main Housing	DWG NO.: 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
1	C_1	SHORT	.90	Detuning	Low RF Output	.7867	Major
2		OPEN	--	Signal Blocking	No RF Output	--	Critical
3		DRIFT	.10	Detuning	Low RF Output	.0864	Major
4	FL_1, FL_2	SHORT	.90	Noise on DC Lines	Degraded Performance	.7867	Minor
5		OPEN	--	No B+	No RF Output	--	Critical
6		DRIFT	.10	None	None	.0864	
7	R_1, R_3, R_4, CR_1, RT_1	SHORT	--	Improper Temperature Indication	None	--	Minor
8		OPEN	--	Improper Temperature	None	--	Minor
9		DRIFT	--	Improper Temperature Indication	None	--	Minor
10	Modul. Input, C_2	SHORT	.90	Lose Modulation	Lose Output Signal	.7867	Critical
11		OPEN	--	No Effect	No Effect	--	Minor
12		DRIFT	.10	No Effect	No Effect	--	Minor
13	Reg. Filter, FL_3	SHORT	.90	Noise on 17.5 VDC Lines	Degraded Performance	.7867	Major
14		OPEN	--	No 17.5 VDC B+	Unstable Output	--	Major
15		DRIFT	.10	None	None	--	Minor
16	EMI Filter, FL_4	SHORT	.90	Lose Housing Temp. TLM.	None	--	Minor
17		OPEN	--	Lose Housing Temp. TLM	None	--	Minor
18		DRIFT	.10	No Effect	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM 1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005150A	PAGE: A4 of 32	
ASSY: Main Housing	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
19 EMI Filter, FL_5	SHORT	.90	Lose PA Temp. TLM	None	--	Minor
20	OPEN	--	Lose PA Temp. TLM	None	--	Minor
21	DRIFT	.10	No Effect	No Effect	--	Minor
22 PA Temp. Sense C429	SHORT	.90	Lose PA Temp. TLM	None	--	Minor
23	OPEN	--	No Effect	No Effect	--	Minor
24	DRIFT	.10	No Effect	No Effect	--	Minor
25 C430	SHORT	.90	Lose PA Temp. TLM	None	--	Minor
26	OPEN	--	No Effect	No Effect	--	Minor
27	DRIFT	.10	No Effect	No Effect	--	Minor
28 C431	SHORT	.90	Lose PA Temp. TLM	None	--	Minor
29	OPEN	--	No Effect	No Effect	--	Minor
30	DRIFT	.10	No Effect	No Effect	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: ITC	NO.: ATM 1005	REV: A
END ITEM: PSK Transmitter	DWG NO.: 2005170E		PAGE A5 of 32
ASSY: Synthesizer	DWG NO.: 2005178C		DATE: 12-15-71

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
1	Crystal Oscillator Y301, C301	SHORT	.50	No Output	No Output	.6124	Critical
2		OPEN	.05	No Output	No Output	.0596	Critical
3		DRIFT	.45	Wrong Output Frequency	Wrong Output Frequency	.5513	Minor
4	Q301	C-B, B-E SHORT	.25	No Output	No Output	24.5243	Critical
5		OPEN C, E, B,	.75	No Output	No Output	73.5558	Critical
6		DRIFT	--	Q Point Shift	None	--	Minor
7	C302, C305, C307	SHORT	.90	Detuning	No Output	2.3633	Critical
8		OPEN	--	Signal Blocking	No Output	--	Critical
9		DRIFT	.10	Detuning	Wrong Output Frequency	0.2623	Minor
10	C306, C308, C316	SHORT	.85	No Output	No Output	2.9772	Critical
11		OPEN	--	Detuning	Low Output	--	Major
12		DRIFT	.15	Detuning	Wrong Output Frequency	0.5245	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV. A
END ITEM: PSK Transmitter	DWG NO.: 2005170E	PAGE A6 of 32	
ASS'Y: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
13 C309	SHORT	.90	Severe Drain on Regulator	No Output	0.7867	Critical
14	OPEN	--	Circuit Instability	Low Output	--	Major
15	DRIFT	.10	Non e	None	--	
16 L301	SHORT	.50	No Output	No Output	0.1743	Critical
17	OPEN	.30	Severe Detuning	No Output	0.1043	Critical
18	DRIFT	.20	No Detuning	Wrong Output Frequency	.0685	Minor
19 R301, R303	SHORT	--	No Output	No Output	--	Critical
20	OPEN	.05	No Output	No Output	.0342	Critical
21	DRIFT	.95	Q Point Shift	None	--	Monor
22 R304	SHORT	--	Destruction of Q301	No Output	--	Critical
23	OPEN	.05	No Output	No Output	.0164	Critical
24	DRIFT	.95	Q Point Shift	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM ALSEP ARRAY E	PREPARED BY TTC	NO. ATM 1005	REV. A
END ITEM PSK Transmitter	DWG. NO. 2005170E	PAGE A7 of 32	
ASSY Synthesizer	DWG. NO. 2005178C	DATE 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
25 L302	SHORT	.50	Possible Instability	Degraded Performance	0.1743	Major
26	OPEN	.30	No Output	No Output	0.1043	Critical
27	DRIFT	.20	None	None	--	Minor
28 R336	SHORT	--	Slight Detuning	None	--	Minor
29	OPEN	.05	Signal Blocking	No Output	.0164	Critical
30	DRIFT	.95	None	None	--	Minor
31 R309, R312, R313, R314	SHORT	--	No Output One Phase	Degraded Performance	--	Major
32	OPEN	.05	Spurious AM	Spurious AM	.0685	Minor
33	DRIFT	.95	Spurious AM	Spurious AM	I.3307	Minor
34 R310, R313, R337, R338	SHORT	--	Spurious AM	Spurious AM	--	Minor
35	OPEN	.05	No Output One Phase	Degraded Performance	.0685	Major
36	DRIFT	.95	Spurious AM	Spurious AM	1.3307	Minor
37 Phase Shifters and Modulator	SHORT	.90	None	None	0.6303	Minor
38 C356, C357	OPEN	--	Signal Blocking	No Output	--	Critical
39	DRIFT	.10	None	None	--	Minor
40 CR302, CR303, R341, R342	SHORT	.20	Phase Error & AM	Degraded Performance	64.6592	Major
41	OPEN	.10	No Output One Phase	Degraded Performance	32.3012	Major
42	DRIFT	.70	Phase Error & AM	Spurious AM	225.8927	Major

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170E	PAGE: A8 of 32	
ASS'Y: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
43	R343	SHORT	--	No Output	No Output	--	Critical
44		OPEN	.05	Detuning	Low Output	.0164	Major
45		DRIFT	.95	None	None	--	Minor
46	R339	SHORT	--	Detuning	Low Output	--	Major
47		OPEN	.05	Signal Blocking	No Output	.0164	Critical
48		DRIFT	.95	None	None	--	Minor
49	C310, C313, R344, C358, C359	SHORT	.72	No Output One Phase	Degraded Performance	2.7745	Major
50		OPEN	.01	Phase Error & AM	Degraded Performance	.0372	Major
51		DRIFT	.27	Phase Error & AM	Degraded Performance	1.0401	Minor
52	C311, C312, C314, C319, L303, L304	SHORT	.69	Phase Error & AM	Degraded Performance	2.8997	Major
53		OPEN	.08	Phase Error & AM	Degraded Performance	0.3352	Major
54		DRIFT	.23	Phase Error & AM	Degraded Performance	0.9655	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170E	PAGE: A8 of 32	
ASSY: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
43	R343	SHORT	--	No Output	No Output	--	Critical
44		OPEN	.05	Detuning	Low Output	.0164	Major
45		DRIFT	.95	None	None	--	Minor
46	R339	SHORT	--	Detuning	Low Output	--	Major
47		OPEN	.05	Signal Blocking	No Output	.0164	Critical
48		DRIFT	.95	None	None	--	Minor
49	C310, C313, R344, C358, C359	SHORT	.72	No Output One Phase	Degraded Performance	2.7745	Major
50		OPEN	.01	Phase Error & AM	Degraded Performance	.0372	Major
51		DRIFT	.27	Phase Error & AM	Degraded Performance	1.0401	Minor
52	C311, C312, C314, C319, L303, L304	SHORT	.69	Phase Error & AM	Degraded Performance	2.8997	Major
53		OPEN	.08	Phase Error & AM	Degraded Performance	0.3352	Major
54		DRIFT	.23	Phase Error & AM	Degraded Performance	0.9655	Minor

SYSTEM	PREPARED BY	NO.	REV.
ALSEP ARRAY E	TTC	ATM1005	A
END ITEM: PSK Transmitter	DWG NO.: 2005170 E	PAGE A9 of 32	
ASS'Y: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
55 Modulator Driver Z302	High Output	.50	No effect or destruction of Z302	No effect or no output	17.5178	Critical
56	Low Output	.50	No Output	No Output	17.5178	Critical
57	DRIFT	--	None	None	--	Minor
58 Q302, Q303	C-B, B-E SHORT	.25	Phase Error & AM	Degraded Performance	58.6733	Major
59	OPEN C, E, B	.75	One Phase Missing	Degraded Performance	175.9201	Major
60	DRIFT	--	None	None	--	Minor
61 CR301	SHORT	.30	No Output	No Output	17.6057	Critical
62	OPEN	.10	Destruction of Z302	No Output	5.8680	Critical
63	DRIFT	.60	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170 E	PAGE: A10 of 32	
ASS'Y: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
64	R305, R316 R317, R318	SHORT	--	None	None	--	Minor
65		OPEN	.05	One Phase Missing	Degraded Performance	.0685	Major
66		DRIFT	.95	None	None	--	Minor
67	R319	SHORT	--	Destruction of Z302 & CR301	No Output	--	Critical
68		OPEN	.05	No Output	No Output	.0164	Critical
69		DRIFT	.95	None	None	--	Minor
70	C315, C321, C355	SHORT	.90	Severe Drain on Regulator	No Output	1.7017	Critical
71		OPEN	--	Possible Instability	Low Output	--	Major
72		DRIFT	.10	None	None	--	Minor
73	Post Modulation Amplifier Q304	C-B, B-E SHORT	.25	No Output	No Output	17.5178	Critical
74		OPEN C, E, B	.75	No Output	No Output	52.5455	Critical
75		DRIFT	--	Q Point Shift	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170E	PAGE: A11 of 32	
ASS'Y: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
76	C323, C328, C329	SHORT	.90	No Output	No Output	2.3633	Critical
77		OPEN	--	Signal Blocking	No Output	--	Critical
78		DRIFT	.10	Detuning	Low Output	.2622	Major
79	C324	SHORT	.90	Destruction of Q304	No Output	.7867	Critical
80		OPEN	--	Signal Degeneration	No Ootput	--	Critical
81		DRIFT	.10	None	None	--	Minor
82	C325	SHORT	.90	Severe Drain on Regulator	No Output	.7867	Critical
83		OPEN	--	Possible Instability	Low Output	--	Major
84		DRIFT	.10	None	None	--	Minor
85	C326, C327, C330, L307, C360, C322	SHORT	.73	No Output	No Output	4.7311	Critical
86		OPEN	.04	Detuning	No Output	0.2577	Critical
87		DRIFT	.23	Detuning	Low Output	1.4901	Major

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM ALSEP ARRAY E	PREPARED BY TTC	NO. ATM1005	REV. A
END ITEM PSK Transmitter	DWG NO. 2005170 E	PAGE A12 of 32	
ASS'Y Synthesizer	DWG NO. 2005178C	DATE 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
88	L305, L306	SHORT	.25	Detuning	No Output	.1743	Critical
89		OPEN	.25	No Output	No Output	.1743	Critical
90		DRIFT	.50	Detuning	Low Output	.3486	Major
91	R320, R321	SHORT	--	No Output	No Output	--	Critical
92		OPEN	.05	No Output	No Output	.0342	Critical
93		DRIFT	.95	Q Point Shift	None	--	Minor
94	R322	SHORT	--	Destruction of Q305	No Output	--	Critical
95		OPEN	.05	No Output	No Output	.0164	Critical
96		DRIFT	.95	Q Point Shift	None	.3322	Minor
97	L308	SHORT	.25	Possible Instability	Degraded Performance	.0864	Major
98		OPEN	.25	No Output	No Output	.0864	Critical
99		DRIFT	.50	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170 E	PAGE: A13 of 32	
ASSY: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL		FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^5$	CRITICALITY
100	Frequency Quadrupler Q305	C-B, B-E SHORT	.25	No Output	No Output	17.5178	Critical
101		OPEN C, E, B	.75	No Output	No Output	52.5452	Critical
102		DRIFT	--	Q Point Shift	None	--	Minor
103	C331	SHORT	.90	Severe Drain on Regulator	No Output	0.3144	Critical
104		OPEN	--	Possible Instability	Degraded Performance	--	Major
105		DRIFT	.10	None	None	--	Minor
106	C332	SHORT	.90	Destruction of Q304	No Output	0.3144	Critical
107		OPEN	--	Signal Degeneration	No Output	--	Critical
108		DRIFT	.10	None	None	--	Minor
109	C333, C335, C337, L309 C361	SHORT	.82	No Output	No Output	4.5955	Critical
110		OPEN	--	Detuning	No Output	--	Critical
111		DRIFT	.18	Detuning	Low Output	1.0088	Major

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAYE	PREPARED BY: TTC	NO. ATM1005	REV. A
END ITEM: PSK Transmitter	DWG NO. 2005170E	PAGE A14 of 32	
ASS'Y: Synthesizer	DWG NO. 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
112	L317	SHORT	.25	Detuning	No Output	.0864	Critical
113		OPEN	.25	No Output	No Output	.0864	Critical
114		DRIFT	.50	Detuning	Low Output	0.1743	Major
115	R323, R324	SHORT	--	No Output	No Output	--	Critical
116		OPEN	.05	No Output	No Output	.0342	Critical
117		DRIFT	.95	Q Point Shift	None	--	Minor
118	R326	SHORT	--	Destruction of Q305	No Output	--	Critical
119		OPEN	.05	No Output	No Output	.0164	Critical
120		DRIFT	.95	Q Point Shift	None	--	Minor
121	C334, C336	SHORT	.90	No Ouptut	No Output	1.5765	Critical
122		OPEN	--	Signal Blocking	No Output	--	Critical
123		DRIFT	.10	Detuning	Low Output	0.1743	Major

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170E	PAGE A15 of 32	
ASSY: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL		FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
124	L310	SHORT	.25	Possible Instability	Degraded Performance	.0864	Major
125		OPEN	.25	No Output	No Output	.0864	Critical
126		DRIFT	.50	None	None	--	Minor
127	Amplifier Q306	SHORT	.25	No Output	No Output	17.5178	Critical
128		OPEN	.75	No Output	No Output	52.5452	Critical
129		DRIFT	--	Q Point Shift	None	--	Minor
130	C338	SHORT	.90	Destruction of Q306	No Output	0.3144	Critical
131		OPEN	--	Signal Degeneration	No Output	--	Critical
132		DRIFT	.10	None	None	--	Minor
133	C339, C340, C344, L312	SHORT	.64	No Output	No Output	3.0264	Critical
134		OPEN	.06	Detuning	No Output	0.2831	Critical
135		DRIFT	.30	Detuning	Low Output	1.4185	Major

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM 1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005178 E	PAGE: A16 of 32	
ASS'Y: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
136 C341, C343	SHORT	.90	No Output	No Output	1.5765	Critical
137	OPEN	--	Signal Blocking	No Output	--	Critical
138	DRIFT	.10	Detuning	Low Output	0.1743	Major
139 C342	SHORT	.90	Severe Drain on Regulator	No Output	0.7867	Critical
140	OPEN	--	Possible Instability	Degraded Performance	--	Major
141	DRIFT	.10	None	None	--	Major
142 L311	SHORT	.25	Detuning	No Output	.0864	Critical
143	OPEN	.25	No Output	No Output	.0864	Critical
144	DRIFT	.50	Detuning	Low Output	0.1743	Major
145 L313	SHORT	.25	Possible Instability	Degraded Performance	.0864	Major
146	OPEN	.25	No Output	No Output	.0864	Critical
147	DRIFT	.50	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO. ATM1005	REV. A
END ITEM: PSK Transmitter	DWG NO. 2005170E	PAGE A17 of 32	
ASSY: Synthesizer	DWG NO. 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
148	R327, R328	SHORT	--	No Output	No Output	--	Critical
149		OPEN	.05	No Output	No Output	.0342	Critical
150		DRIFT	.95	Q Point Shift	None	--	Minor
151	R329	SHORT	--	Destruction of Q306	No Output	--	Critical
152		OPEN	.05	No Output	No Output	.0164	Critical
153		DRIFT	.95	Q Point Shift	None	--	Minor
154	Frequency Doubler Q307	C-B, C-E SHORT	.25	No Output	No Output	24.5243	Critical
155		OPEN C, E, B	.75	No Output	No Output	73.5558	Critical
156		DRIFT	--	Q Point Shift	None	--	Minor
157	C348	SHORT	.90	Destruction of Q307	No Output	0.3144	Critical
158		OPEN	--	Signal Degeneration	No Output	--	Critical
159		DRIFT	.10	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP ARRAY E	TTC	ATM1001	A
END ITEM	DWG NO.	PAGE	
PSK Transmitter	2005170E	A18 of 32	
ASSY	DWG NO.	DATE	
Synthesizer	2005178C	12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
160 C346	SHORT	.70	No Output	No Output	1.2249	Critical
161	OPEN	--	Detuning	No Output	--	Critical
162	DRIFT	.30	Detuning	Low Output	0.5245	Major
163 C345	SHORT	.90	Severe Drain on Regulator	No Output	0.7867	Critical
164	OPEN	--	Possible Instability	Degraded Performance	--	Major
165	DRIFT	.10	None	None	--	Minor
166 C347	SHORT	.90	No Output	No Output	0.7867	Critical
167	OPEN	--	Signal Blocking	No Output	--	Critical
168	DRIFT	.10	Detuning	Low Output	.0864	Major
169 L314	SHORT	.25	Detuning	No Output	.0864	Critical
170	OPEN	.25	No Output	No Output	.0864	Critical
171	DRIFT	.50	Detuning	Low Output	0.1743	Major
172 L315	SHORT	.25	Possible Instability	Degraded Performance	.0864	Major
173	OPEN	.25	No Output	No Output	.0864	Critical
174	DRIFT	.50	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP ARRAY E	TTC	ATM1005	A
END ITEM	DWG NO.	PAGE	
PSK Transmitter	2005170E	A19 of 32	
ASSY	DWG NO.	DATE	
Synthesizer	2005178C	12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^5	CRITICALITY
175	C349, C350	SHORT	.90	Severe Drain on Regulator	No Output	0.6303	Critical
176		OPEN	--	Possible Instability	Degraded Performance	--	Major
177		DRIFT	.10	None	None	--	Minor
178	C352	SHORT	.90	Destruction of Q308	No Output	0.3144	Critical
179		OPEN	--	Signal Degeneration	No Output	--	Critical
180		DRIFT	.10	None	None	--	Minor
181	C351, C353	SHORT	.70	No Output	No Output	2.4512	Critical
182		OPEN	--	Detuning	No Output	--	Critical
183		DRIFT	.30	Detuning	Low Output	1.0505	Major
184	C354	SHORT	.90	Detuning	No Output	0.7867	Critical
185		OPEN	--	Signal Blocking	No Output	.0864	Critical
186		DRIFT	.10	Detuning	Low Output	.0864	Major

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO. ATM1005	REV. A
END ITEM: PSK Transmitter	DWG NO. 2005170E	PAGE A20 of 32	
ASS'Y: Major Sub-Assy's	DWG NO. 2005178C	DATE 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
187 L316	SHORT	.25	Detuning	No Output	.0864	Critical
188	OPEN	.25	No Output	No Output	.0864	Critical
189	DRIFT	.50	Detuning	Low Output	.1743	Major
190 R333, R334	SHORT	--	No Output	No Output	--	Critical
191	OPEN	.05	No Output	No Output	.0342	Critical
192	DRIFT	.95	Q Point Shift	None	--	Minor
193 R335	SHORT	--	Destruction of Q308	No Output	--	Critical
194	OPEN	.05	No Output	No Output	.0164	Critical
195	DRIFT	.95	Q Point Shift	None	--	Minor
196 Isolution-Osc/ Modul., R345	SHORT	--	Loss of 95 MHz Signal	Lose Output Signal	--	Critical
197	OPEN	.05	Degraded 95 MHz Signal	Degraded Output Signal	.0164	Major
198	DRIFT	.95	No Effect	No Effect	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM 1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005170E	PAGE: A21 of 32	
ASSY: Synthesizer	DWG NO.: 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
199 R346	SHORT	--	Loss of 95 MHz Signal	Lose Output Signal	--	Critical
200	OPEN	.05	Degraded 95 MHz Signal	Degraded Output Signal	.0164	Major
201	DRIFT	.95	No Effect	No Effect	--	Minor
202 R347	SHORT	--	Excessive Current Drain;Destruction of Q309	No Output Signal	--	Critical
203	OPEN	.05	Q309 will not Operate	No Output Signal	.0164	Critical
204	DRIFT	.95	No Effect	No Effect	--	Minor
205 R348	SHORT	--	No Effect	No Effect	--	Minor
206	OPEN	.05	Lose 95 MHz Signal	No Output Signal	.0164	Critical
207	DRIFT	.95	No Effect	No Effect	--	Minor
208 Q309	SHORT	.25	Lose 95 MHz Signal	Lose Output Signal	24.5243	Critical
209	OPEN	.75	Lose 95 MHz Signal	Lose Output Signal	73.5558	Critical
210	DRIFT	--	No Effect	No Effect	--	Minor
211 C361	SHORT	.90	Destruction of Q309	Lose Output Signal	0.7867	Critical
212	OPEN	--	Lose 75 MHz Signal	Lose Output Signal	--	Critical
213	DRIFT	.10	No Effect	No Effect	--	Minor
214 Modul. Driver C317	SHORT	.90	Degraded Flip-Flop Wave Form	Degraded Output Signal	0.7867	Major
215	OPEN	--	No Effect	No Effect	--	Minor
216	DRIFT	.10	No Effect	No Effect	--	Minor
217 C318	SHORT	.90	Degraded Flip-Flop Wave Form	Degraded Output Signal	0.7867	Major
218	OPEN	--	No Effect	No Effect	--	Minor
219	DRIFT	.10	No Effect	No Effect	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM ALSEP ARRAY E	PREPARED BY TTC	NO. ATM 1005	REV. A
END ITEM PSK Transmitter	DWG NO. 2005180C	PAGE A22 of 32	
ASSY Power Ampl. Assy	DWG NO. 2005178C	DATE 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-3}	CRITICALITY
1	Driver Amplifier Q401	C-B, B-E SHORT	.10	No Output	No Output	8.9339	Critical
2		OPEN C, E, B,	.20	No Output	No Output	17.8679	Critical
3		DRIFT	.70	Q Point Shift	None	--	Minor
4	C401, L404	SHORT	.55	Detuning	Low Output	0.6735	Major
5		OPEN	.15	Signal Blocking	No Output	0.1833	Critical
6		DRIFT	.30	Detuning	Low Output	0.3666	Minor
7	C402, C403, C412, C413, C425	SHORT	.78	Detuning	No Output	5.4657	Critical
8		OPEN	--	Detuning	No Output	--	Critical
9		DRIFT	.22	Detuning	Low Output	1.5408	Major
10	C404, C405, C406, C407	SHORT	.90	Q Point Shift	Low Output	3.1531	Major
11		OPEN	--	Instability	Degraded Performance	--	Major
12		DRIFT	.10	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO. ATM 1005	REV. A
END ITEM: PSK Transmitter	DWG NO. 2005180C	PAGE A23 of 32	
ASSY: Power Amplifier	DWG NO. 2005178C	DATE: 12-15-71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
13	C408, C420, C426, C427	SHORT	.90	Severe Regulator Drain	No Output	2.6315	Critical
14		OPEN	--	Signal Blocking	No Output	--	Critical
15		DRIFT	.10	Detuning	Low Output	0.2921	Major
16	C410, C411, C423	SHORT	.90	Severe Regulator Drain	No Output	1.8432	Critical
17		OPEN	--	Instability	Degraded Performance	--	Major
18		DRIFT	.10	None	None	--	Minor
19	R401	SHORT	.10	No Output	No Output	--	Critical
20		OPEN	.20	No Output	No Output	1.1906	Critical
21		DRIFT	.70	None	None	--	Minor
22	R402	SHORT	--	Destruction of Q401	No Output	--	Critical
23		OPEN	.05	No Output	No Output	0.7867	Critical
24		DRIFT	.95	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP ARRAY E	TTC	ATM 1005	A
END ITEM	DWG NO.	PAGE	
PSK Transmitter	2005180C	A24 of 32	
ASS'Y	DWG NO.	DATE	
Power Amplifier	2005178C	12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
25 R403	SHORT	--	Q Point Shift	Low Output	--	Major
26	OPEN	.05	No Output	No Output	0.7867	Critical
27	DRIFT	.95	None	None	--	Minor
28 L403	SHORT	.25	Detuning	No Output	.0864	Critical
29	OPEN	.25	No Output	No Output	.0864	Critical
30	DRIFT	.50	None	None	--	Minor
31 Power Amplifier Q402	C-B, B-E SHORT	.10	No Output	No Output	10.1603	Critical
32	OPEN C, E, B	.20	No Output	No Output	20.3192	Critical
33	DRIFT	.70	Q Point Shift	None	--	Minor
34 C414, L407, C428	SHORT	.62	Detuning	No Output	1.8463	Critical
35	OPEN	.08	Signal Blocking	No Output	0.2369	Critical
36	DRIFT	.30	Detuning	Low Output	0.8925	Major

SYSTEM	PREPARED BY	NO.	REV.
ALSEP ARRAY E	TTC	ATM 1005	A
END ITEM	DWG NO.	PAGE	
PSK Transmitter	2005180C	A25 of 32	
ASSY	DWG NO.	DATE	
Power Amplifier	2005178C	12-15-71	

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
37	C415, C416, C417, C424	SHORT	.90	Severe Drain on Regulator	No Output	2.6315	Critical
38		OPEN	--	Instability	Degraded Performance	--	Major
39		DRIFT	.10	None	None	0.2921	Minor
40	C418, C419	SHORT	.80	No Output	No Output	2.1011	Critical
41		OPEN	--	Detuning	No Output	--	Critical
42		DRIFT	.20	Detuning	Low Output	0.5245	Major
43	L406	SHORT	.25	Detuning	No Output	.0864	Critical
44		OPEN	.25	No Output	No Output	.0864	Critical
45		DRIFT	.50	None	None	--	Minor
46	C422	SHORT	.90	Severe Drain on Regulator	No Output	0.7867	Critical
47		OPEN	--	Possible Instability	Degraded Performance	--	Major
48		DRIFT	.10	None	None	--	Minor

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO.: ATM 1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005180 C	PAGE: A26 of 32	
ASSY: Power Amplifier	DWG NO.: 2005178C	DATE: 12-15-7.	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
49 R404	SHORT	.10	No Output	No Output	1.1206	Critical
50	OPEN	.20	No Output	No Output	2.2411	Critical
51	DRIFT	.70	None	None	7.8477	Minor
52 R405, R406, R408 RT401, CR401,	SHORT	--	Improper Temperature Indication	None	--	Minor
53	OPEN	--	Improper Temperature Indication	None	--	Minor
54	DRIFT	--	Improper Temperature Indication	None	--	Minor
55 L 402, 405	--		Not an actual part. These are transistor base leads.	--	--	--

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP ARRAY E	PREPARED BY: TTC	NO. ATM 1005	REV. A
END ITEM: PSK Transmitter	DWG NO. 2005180C	PAGE A27 of 32	
ASSY: Power Ampl. Assy	DWG NO. 2005178C	DATE: 12-15-71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
56 C429	SHORT	.90	Improper Temp. Indication	None		Minor
57	OPEN	--	" " "	"		"
58	DRIFT	.10	" " "	"		"
59 C430	SHORT	.90	" " "	"		"
60	OPEN	--	" " "	"		"
61	DRIFT	.10	" " "	" These are TLM components that do not affect required operation.		"
62 C431	SHORT	.90	" " "	"		"
63	OPEN	--	" " "	"		"
64	DRIFT	.10	" " "	"		"
65 C422	SHORT	.90	" " "	"		"
66	OPEN	--	" " "	"		"
67	DRIFT	.10	" " "	"		"

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP Array E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSK Transmitter	DWG NO.: 2005160A	PAGE: A28 of 32	
ASSY: Regulator Assy.	DWG NO.: 2005178C	DATE: 12/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
1 CR 507	Short	.40	No reverse voltage protection	None	--	Minor
2	Open	.20	No +29VDC to regulator	No output	24.5243	Critical
3	Drift	.40	None	None	--	Minor
4 R 516	Short	--	No output from regulator	No output	--	Critical
5	Open	.05	Low regulator output	Low output	.0179	Major
6	Drift	.95	None	None	--	Minor
7 C 503	Short	.90	No +29V to regulator	No output	0.7867	Critical
8	Open	--	Possible instability	Degraded performance	--	Major
9	Drift	.10	None	None	--	Minor
10 MEMA*	Short	.50	No B+	No output	175.0454	Critical
11	Open	.30	No B+	No output	105.0636	Critical
12	Drift	.20	Unstable B+	Degraded performance	70.0548	Major

*Microelectric Modular Assembly

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP Array E	TTC	ATM1005	A
END ITEM	DWG NO.	PAGE A29 of 32	
PSK Transmitter	2005160A		
ASSY	DWG NO.	DATE	
Regulator Assy.	2005798C	12/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE (α)	EFFECT OF FAILURE		FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
		ASSEMBLY	END ITEM		
13 R 517	Short	Incorrect voltage or current idication	None		Minor
14	Open	" " " " "	"		"
15	Drift	" " " " "	"		"
16 R 518	Short	" " " " "	"		"
17	Open	" " " " "	"		"
18	Drift	" " " " "	"		"
19 R 519	Short	" " " " "	"		"
20	Open	" " " " "	"		"
21	Drift	" " " " "	"		"
22 R 520	Short	" " " " "	"		"
23	Open	" " " " "	"		"
24	Drift	" " " " "	"		"

These are TLM Components that do not affect required operation.

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP Array E	PREPARED BY: TTC	NO.: ATM1005	REV.: A
END ITEM: PSR Transmitter	DWG NO.: 2005160A		PAGE: A30 of 32
ASSY: Regulator Assy.	DWG NO.: 2005178C		DATE: 12/15/71

PART/COMPONENT SYMBOL	FAILURE MODE (α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
25 R 521	Short	Incorrect voltage or current idication	None		Minor
26	Open	" " " " "	"		"
27	Drift	" " " " "	"		"
28 R 522	Short	" " " " "	"		"
29	Open	" " " " "	"		"
30	Drift	" " " " "	"		"
31 CR 501	Short	" " " " "	"		"
32	Open	" " " " "	"		"
33	Drift	" " " " "	"		"
34 CR 502	Short	" " " " "	"		"
35	Open	" " " " "	"		"
36	Drift	" " " " "	"		"

These are TLM Components that do not affect required operations

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM: ALSEP Array E	PREPARED BY: TTC	NO. ATM1005	REV. A
END ITEM: PSK Transmitter	DWG NO. 2005160A	PAGE A31 of 32	
ASSY: Regulator Assy.	DWG NO. 2005178C	DATE: 12/15/71	

PART/COMPONENT SYMBOL	FAILURE MODE (α)	EFFECT OF FAILURE		FAILURE PROBABILITY $Q \times 10^{-5}$	CRITICALITY
		ASSEMBLY	END ITEM		
37 C 501	Short	Incorrect voltage or current indication	None		Minor
38	Open	" " " " "	"		"
39	Drift	" " " " "	"		"
40 C 502	Short	" " " " "	"		"
41	Open	" " " " "	"		"
42	Drift	" " " " "	"		"
43 C 504	Short	" " " " "	"		"
44	Open	" " " " "	"		"
45	Drift	" " " " "	"		"

These are TLM Components that do not affect required operation.

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

SYSTEM	PREPARED BY	NO.	REV.
ALSEP ARRAY E	TTC	ATM 1005	A
END ITEM	DWG NO.	PAGE	
PSK Transmitter	2005190B	A32 of 32	
ASSY	DWG NO.	DATE	
Multiplier-Isofilter	2005178C	12/15/71	

	PART/COMPONENT SYMBOL	FAILURE MODE	(α)	EFFECT OF FAILURE: ASSEMBLY	EFFECT OF FAILURE: END ITEM	FAILURE PROBABILITY Q x 10^{-5}	CRITICALITY
1	C601, C602, C605, C604	SHORT	.90	Detuning	No Output	0.6303	Critical
2		OPEN	--	Detuning	No Output	--	Critical
3		DRIFT	.10	Detuning	Low Output	.06855	Major
4	C603, L601, L602	SHORT	.47	No Output	No Output	0.4113	Critical
5		OPEN	.16	Signal Blocking	No Output	0.1386	Critical
6		DRIFT	.37	Detuning	Low Output	0.3234	Major
7	CR601	SHORT	.05	No Output	No Output	1.4007	Critical
8		OPEN	.05	No Output	No Output	1.4007	Critical
9		DRIFT	.90	None	None	--	Minor
10	R601	SHORT	--	No Output	No Output	--	Critical
11		OPEN	.05	No Output	No Output	.0164	Critical
12		DRIFT	.95	None	None	--	Minor