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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.

Prepared by

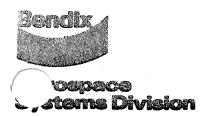
A. W. Romans ALSEP Reliability

Department

Approved by:

ALSEP Reliability

Manager



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### 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 assessment, 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.



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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

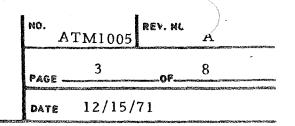
## 4.1.1 Synthesizer

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.





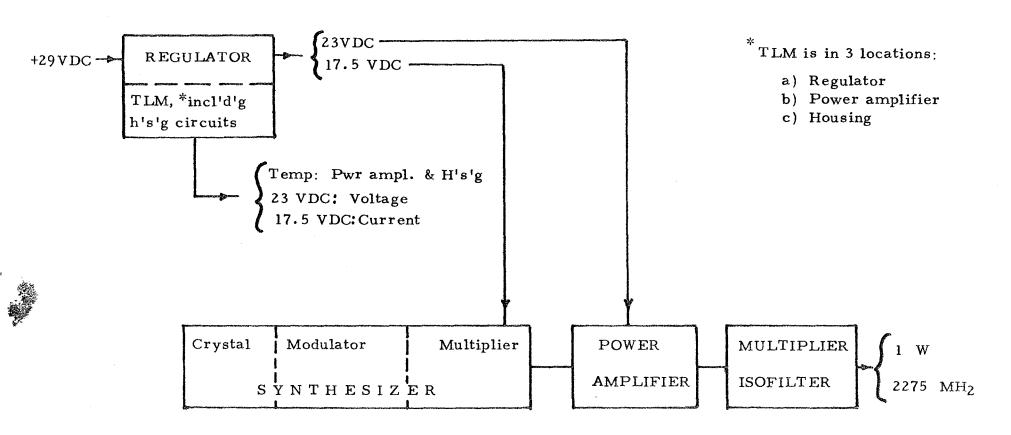


Figure 1



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# 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.



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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 FLALURE 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



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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

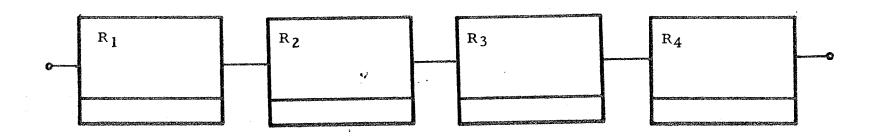
The reliability goal is .9800. The transmitter meets this goal when all of the appropriate failure mode probabilities are considered. The prediction becomes .983143 when the probabilities are accounted for.

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,  $\lambda$  is failure rate, t is mission time, 17520 hours



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# Legend:

R<sub>1</sub> - Synthesizer

R<sub>2</sub> - Power Amplifier

R<sub>3</sub> - Multiplier-Isofilter

 $\mathbf{R_4}$  - Housing and Regulator

Transmitter Reliability Block Diagram



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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        | $Q \times 10^{-5}$ |
|---------------------|----------|--------------------|
| 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.



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APPENDIX A

PSK TRANSMITTER

DETAIL FAILURE MODE,

EFFECTS & CRITICALITY

ANALYSIS

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PSK Transmitter
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Major Sub-Assy's DWG NO. 2005260C DWG NO. 2005178C

| PART/COMPONENT |  | FAILURE MODE   | EFFECT OF FAILURE  |  | FAILURE  | CRITIC-  |
|----------------|--|--|--|--|--|--|
| Sagnificance.  | SYMBOL.  | TAILUIL PIOUL.   | ASSEMBLY   | END ITEM   | FAILURE<br>PROBABILITY<br>Q × 10 <sup>-5</sup>   | ALITY  |
| 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/<br>Multiplier   | Inoperative  | Loss of Output   | No RF Output   | 4.3973   | Critical   |
| 4              | Regulator;<br>Housing  | Inoperative  | Loss of Output   | No RF Output   | 375.0302<br>3.3274   | Critical   |
| 5              | Telemetry<br>Monitors  | Inoperative  | Loss of Output   | Loss of Failed Telemetry<br>Function Only  |  | Minor  |
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| PART/COMPONENT   | FAILURE MODE   | Constitution of the Consti | A STATE OF THE PROPERTY OF THE | OF FAILURE   | FAILURE  | CRITIC-  |
| SYMBOL   | PAILURE PIUVE  | (OL)   | ASSEMBLY   | NO ITEM  | PROBABILITY<br>Q × 10 <sup>5</sup>   | ALITY  |
| 1 C  | 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 <sub>1</sub> , FL <sub>2</sub>  | SHORT  | .90  | Noise on DC Lines  | Degraded Performance   | .7867  | Minor  |
| 5  | OPEN   |  | No B+  | No RF Output   |  | Critical   |
| 6  | DRIFT  | . 10   | None   | None   | .0864  | A STATE OF THE STA |
| 7 R <sub>1</sub> , R <sub>3</sub> , R <sub>4</sub> ,   | <b>S</b> HORT  |  | Improper Temperature Indication  | None   |  | Minor  |
| cr <sub>i</sub> , rt <sub>i</sub>  | Market Control of the |  |  |  |  |  |
| 8  | OPEN   |  | Improper Temperature   | None   |  | Minor  |
| 9  | DRIFT  |  | Improper Temperature Indication  | None   |  | Minor  |
| 10 Modul. Input, C   | 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 <sub>3</sub>  | 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   | The state of the s | Minor  |
| 16 EMI Filter, FL <sub>4</sub>   | SHORT  | .90  | Lose Housing Temp. TLA.  | None   | ewicona, and a second  | Minor  |
| 17   | OPEN   |  | Lose Housing Temp. TLM   | None   | - The state of the | Minor  |
| 18   | DRIFT  | .10  | No Effect  | None   | and state of the s | Minor  |
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PSK Transmitter Z005150A PAGE A4 of 32

ASS'Y
Main Housing Z005178C ATM 1005 ATM

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET PART/COMPONENT EFFECT OF FAILURE FAILURE PROBABILITY Q × 10<sup>5</sup> CRITIC-FAILURE MODE SYMBOL ALITY (OL) ASSEMBLY END ITEM 19 EMI Filter, FL SHORT .90 Lose PA Temp. TLM None Minor OPEN Lose PA Temp. TLM None Minor 21 DRIFT .10 No Effect No Effect Minor 22 PA Temp. Sense SHORT .90 Lose PA Temp. TLM None MinorC429 OPEN No Effect No Effect Minor 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 DRIFT .10 No Effect No Effect Minor

ALSEP ARRAY E TTC ATM 1005 ATM

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

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| PA   | URT/COMPONENT<br>SYMBOL  | FAILURE MODE   |  | ,我们就是一个时间,我们就是一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个 | FAILURE  | FAILURE<br>PROBABILITY<br>Q x 10 <sup>-5</sup>   | CRITIC-  |
| <b>}</b>   | A T I I BOOT   | BOMER CONTROL MERCH DAMAR CONTROL COMPANY COMPANY OF THE CONTROL CONTR | (oc)   | ASSEMBLY   | END ITEM   | Q x 10 <sup>-5</sup>   | 1 ~~   |
| 1  | Crystal Oscillator<br>Y301, C301   | SHORT  | .50  | No Output  | No Output  | .6124  | Critical   |
| 2  | A CONTRACTOR OF THE CONTRACTOR | OPEN   | .05  | No Output  | No Output  | .0596  | Critical   |
| 3  | Company and a second   | DRIFT  | .45  | Wrong Output Frequency                               | Wrong Output Frequency   | .5513  | Minor  |
| 4  | Q301   | C-B, B-E<br>SHORT  | .25  | No Output  | No Output  | <b>2</b> 4.5243  | Critical   |
| 5  |  | OPEN<br>C, E, B,   | .75  | No Output  | No Output  | 73.5558  | Critical   |
| 6  |  | DRIFT  |  | Q Point Shift  | None   |  | Minor  |
| 7  | C302, C305,<br>C307  | SHORT  | .90  | Detuning   | No Output  | 2.3633   | Critical   |
| 8  |  | OPEN   |  | Signal Blocking                                      | No Output  | <b>-</b> ••  | Critical   |
| 9  |  | DRIFT  | .10  | Detuning   | Wrong Output Frequency   | 0.2623   | Minor  |
| 10   | C306, C308,<br>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  |
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Synthesizer 2005178C PATE

FAILURE PROBABILITY ALITY

END ITEM Q x 105

| PART/COMPONENT                              | FAILURE MODE   |  | EFFECT OF FAILURE         |  |  | CRITIC  |
|---|--|--|---------------------------|--|--|---|
| SYMBOL  *********************************** | то при   | $(\alpha)$   | ASSEMBLY                  | END ITEM   | FAILURE<br>PROBABILITY<br>Q × 10 <sup>5</sup>  | ALITY   |
| 13 C309                                     | SHORT  | .90  | Severe Drain on Regulator | No Output  | 0.7867   | Critica   |
| 14  | OPEN   |  | Circuit Instability       | Low Output   |  | Major   |
| 15  | DRIFT  | . 10   | Non e                     | None   |  |   |
| 16 L301                                     | SHORT  | .50  | No Output                 | No Output  | 0.1743   | Critic  |
| 17  | OPEN   | .30  | Severe Detuning           | No Output  | 0.1043   | Critic  |
| 18  | DRIFT  | .20  | No Detuning               | Wrong Output Frequency   | .0685  | Minor   |
| 19 R301, R303                               | SHORT  |  | No Output                 | No Output  |  | Critic  |
| 20  | OPEN   | .05  | No Output                 | No Output  | .0342  | Critic  |
| 21  | DRIFT  | .95  | Q Point Shift             | None   |  | Mono  |
| 22 R304                                     | SHORT  |  | Destruction of Q301       | No Output  |  | Critic  |
| 23  | OPEN   | .05  | No Output                 | No Output  | .0164  | Critic  |
| 24  | DRIFT  | . 95   | Q Point Shift             | None   |  | Mino:   |
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PSK Transmitter DWG\_2005170E PAGE A7 of 32

ASSYnthesizer DWG\_2005178C DATE 12-15-71

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

| PART/COMPONENT                  | FAILURE MODE   |  | EFFECT O             | F FAILURE 20051      | FAILURF  | -15-71<br>CRITIC- |
|---------------------------------|--|--|----------------------|----------------------|--|-------------------|
| SYMBOL.                         | Control of the Contro | (oc)   | ASSEMBLY             | END ITEM             | PROBABILITY Q × 105  | ALITY             |
| 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,<br>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          | 1.3307   | Minor             |
| 34 R310, R313,<br>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                              | PRIFT  | .10  | None                 | None                 |  | Minor             |
| 40 CR302, CR303,<br>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             |
|                                 |  |  |                      |                      | will realize a work of the control o |                   |
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SISTEM ALSEP ARRAY E SID ITEM PSK Transmitter ASSIY ATM1005 FEV. A DWG NO. 2005170 E DWG NO. PAGE A8 of 32

| and and a state of the state of | FAILURE MODE, EFFEC | T & CRIT | ICALITY ANALYSIS WORKSH | EET PSK Transmitter 2005 17 ASSY DW6 NO. Synthesizer 2005 17   | DATE   | 8 <b>of</b> 32<br>15-71 |
|--|---------------------|----------|-------------------------|--|--|-------------------------|
| PART/COMPONENT<br>SYMBOL   | FAILURE MODE        | (œ)      | EFFECT<br>ASSEMBLY      | OF FAILURE  END ITEM   | FAILURE<br>PROBABILITY<br>Q × 10 <sup>-5</sup> | CRITIC<br>ALITY         |
| 43 R343  | SHORT               |          | No Output               | No Output  | in a   | Critical                |
| 44   | OPEN                | .05      | Detuning                | Low Output   | .0164  | Major                   |
| <b>4</b> 5   | 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,<br>R344, C358,<br>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,<br>C314, C319,<br>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 *                 |
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PREPARED BY NSIEM ALSEP ARRAY E ATMIOOS END NEM PSK Transmitter DWG NO. 2005170E PAGE A8 of 32 FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET DMS NO. 2005178C PART/COMPONENT EFFECT OF FAILURE FAILURE PROBABILITY Q × 10<sup>5</sup> CRITIC-FAILURE MODE SYMBOL. ALITY ASSEMBLY END ITEM (OL) 43 R343 SHORT No Output No Output Critical 44 OPEN .05 Detuning Low Output .0.164 Major 45 DRIFT .95 None None Minor R339 SHORT Detuning Low Output Major 47 OPEN .05 Signal Blocking No Output. .0164 Critical 48 DRIFT .95 None None Minor C310, C313, SHORT .72 No Output One Phase Degraded Performance 2.7745 Major R344, C358, C359 50 OPEN Phase Error & AM .01 Degraded Performance .0372 Major 51 DRIFT .27 Phase Error & AM Degraded Performance 1.0401 Minor C311, C312, SHORT .69 Phase Error & AM Degraded Performance 2.8997 Major C314, C319, L303, L304 53 OPEN .08 Phase Error & AM Degraded Performance 0.3352 Major DRIFT 54 .23 Phase Error & AM Degraded Performance 0.9655 Minor #

SYSTEM
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ALSEP ARRAY E

NO. ATM1005

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|--|--|--------------|----------------------------------|------------------------|--|--|----------|
| PART/COMPONENT   | FAILURE MODE   |              | EFFECT (                         | OF FAILURE             | FAILURE                                |  | CRITIC-  |
| SYMBOL   | enterpolity (FFE)  | ( <b>%</b> ) | ASSEMBLY                         | END ITEM               | Ellipsonosta estatuigia angola portuga | FAILURE<br>PROBABILITY<br>Q × 10 <sup>-5</sup> | ALITY    |
| 55 Modulator<br>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<br>SHORT  | .25          | Phase Error & AM                 | Degraded Performance   |  | 58.6733  | Major    |
| 59   | OPEN<br>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    |
|  |  |              |                                  |                        |  | -  |          |
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PSK Transmitter ASSY Synthesizer FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET ATE 12-15-71 PART/COMPONENT FAILURE PROBABILITY Q × 10<sup>-5</sup> EFFECT OF FAILURE CRITIC-FAILURE MODE SYMBOL ALITY (OL) ASSEMBLY END ITEM 64 R305, R316 SHORT None None Minor R317, R318 65 OPEN One Phase Missing . 05 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 Minor C315, C321, SHORT .90 Severe Drain on Regulator No Output 1.7017 Critical C355 71 OPEN Possible Instability Low Output Major 72 DRIFT . 10 None None Minor Post Modulation C-B, B-E .25 No Output No Output 17.5178 Critical Amplifier Q304 SHORT 74 OPEN .75 No Output No Output 52.5455 Critical C, E, B **7**5 DRIFT Q Point Shift None Minor

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| -   | FAILURE MODE, EFFEC  | T & CRIT          | ICALITY ANALYSIS WORKSH   | EET ASSY DW6 NO. Synthesizer 200517  | OC DAIL A  | 11 of 32<br>5-71   |
|---|--|-------------------|---------------------------|--|--|--|
| PART/COMPONENT                              | 1  |                   |                           | OF FAILURE   | FAILURE  | CRITIC-  |
| SYMBOL                                      | FAILURE MODE   | (o <sub>L</sub> ) | ASSEMBLY                  | END ITEM   | PROBABILITY<br>Q × 105   | ALITY  |
|   |  |                   |                           | All of the state o | The second secon | THE STREET PROPERTY OF THE STREET, STR |
| 76 C323, C328,<br>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                                     | <b>S</b> HORT  | .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,<br>C330, L307,<br>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  |
|   |  |                   |                           |  |  |  |
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ASSY DWG NO 12-15-71

| •                        | FAILURE MODE, EFFI | ECT & CRIT | ICALITY ANALYSIS WOR | KSHEET PSK Transmitter 2005  Synthesizer 2005 | 170 E PAGE A1                       | 12 of 32<br>15-71 |
|--------------------------|--------------------|------------|----------------------|---|-------------------------------------|-------------------|
| PART/COMPONENT<br>SYMBOL | FAILURE MODE       |            | EFF                  | ECT OF FAILURE                                | FAILURE                             | CRITIC-           |
| OTP-BOL                  | <del></del>        | (ox)       | ASSEMBLY             | END ITEM                                      | PROBABILITY<br>Q x 10 <sup>-5</sup> | 7-11              |
| 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<br>97 L308            | DRIFT              | . 95       | Q Point Shift        | None  | .3322                               | Minor             |
| 97 L308<br>98            | SHORT              | .25        | Possible Instability | Degraded Performance                          | .0864                               | Major             |
| 99                       | DRIFT              | .25        | No Output            | No Output                                     | .0864                               | Critical          |
| 77                       | DAIR I             | .50        | None                 | None  |                                     | Minor             |
|                          |                    |            |                      |   |                                     |                   |
| i                        |                    |            |                      |   | ŀ                                   | •                 |
|                          |                    |            |                      | · ·   |                                     | No.               |
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SYSTEM
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| FAILURE MODE      |   | EFFECT OF FAILURE   |  |  | CRITIC-      |
|-------------------|---|---|--|--|--------------|
|                   | (nL)  | ASSEMBLY  | END ITEM   | PROBABILITY<br>Q × 10 <sup>-5</sup>  | ALITY        |
| C-B, B-E<br>SHORT | .25   | No Output   | No Output  | 17.5178  | Critical     |
| OPEN<br>C, E, B   | .75   | No Output   | No Output  | 52.5452  | Critical     |
| DRIFT             |   | Q Point Shift   | None   |  | Minor        |
| SHORT             | .90   | Severe Drain on Regulator   | No Output  | 0.3144   | Critical     |
| OPEN              |   | Possible Instability  | Degraded Performance   |  | Major        |
| DRIFT             | .10   | None  | None   |  | Minor        |
| SHORT             | .90   | Destruction of Q304   | No Output  | 0.3144   | Critical     |
| OPEN              |   | Signal Degeneration   | No Output  |  | Critical     |
| DRIFT             | . 10  | None  | None   |  | Miner        |
| SHORT             | .82   | No Output   | No Output  | 4.5955   | Gritical     |
| OPEN              |   | Detuning  | No Output  |  | Critical     |
| DRIFT             | .18   | Detuning  | Low Output   | 1.0088   | Major        |
|                   |   |   |  |  |              |
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|                   | OPEN C, E, B DRIFT SHORT OPEN DRIFT SHORT OPEN DRIFT SHORT OPEN DRIFT SHORT | (&)  C-B, B-E SHORT  OPEN C, E, B  DRIFT SHORT  OPEN DRIFT SHORT OPEN DRIFT SHORT OPEN SHORT OPEN SHORT SHORT DRIFT SHORT | C-B, B-E SHORT  OPEN .75 No Output  C, E, B  DRIFT Q Point Shift  SHORT .90 Severe Drain on Regulator  OPEN Possible Instability  DRIFT .10 None  SHORT .90 Destruction of Q304  OPEN Signal Degeneration  DRIFT .10 None  SHORT .82 No Output | C-B, B-E SHORT  OPEN .75 No Output No Output  DRIFT Q Point Shift None  SHORT .90 Severe Drain on Regulator No Output  OPEN Possible Instability Degraded Performance  DRIFT .10 None None  SHORT .90 Destruction of Q304 No Output  OPEN Signal Degeneration No Output  DRIFT .10 None None  SHORT .90 Destruction of Q304 No Output  OPEN Signal Degeneration No Output  DRIFT .10 None None  SHORT .82 No Output No Output  OPEN Detuning No Output   | FAILURE MODE |

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FOR NO.
PSK Transmitter

2005170 E

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ASSIV

Synthesizer

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| PART/COMPONENT   | FAILURE MODE | EFFECT OF FAILURE   |            | FAILURE  | CRITIC-  |  |
|--|--------------|---------------------|------------|--|----------|--|
| SYMBOL   | (α)          | ASSEMBLY            | END ITEM   | PROBABILITY<br>Q x 10 <sup>5</sup>   | ALITY    |  |
| 112  |              |                     |            |  |          |  |
| 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    |  |
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ALSEP ARRAY E NO. ATM1005 OWG NO. 2005170E NO TEM PSK Transmitter PAGE A15 of 32 FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET ASS'Y Synthesizer DWG NO. 2005178C DATE 12-15-71 PART/COMPONENT EFFECT OF FAILURE PROBABILITY Q × 10<sup>-5</sup> FAILURE CRITIC-FAILURE MODE SYMBOL ALITY (OL) ASSEMBLY END ITEM L310 SHORT . 25 Possible Instability Degraded Performance .0864 Major 125 OPEN . 25 No Output No Output .0864 Critical 126 DRIFT None .50 None Minor Amplifier Q306 SHORT No Output . 25 No Output 17.5178 Critical 128 OPEN No Output .75 No Output 52.5452 Critical 129 DRIFT Q Point Shift None Minor C338 SHORT Destruction of Q306 .90 No Output 0.3144 Critical 131 OPEN Signal Degeneration No Output Critical 132 DRIFT . 10 None None Minor 133 C339, C340, SHORT No Output . 64 No Output 3.0264 Critical C344, L312 134 OPEN Detuning .06 No Output Critical 0.2831 135 DRIFT Detuning .30 Low Output 1.4185 Major

ALSEP ARRAY E TTC ATM 1005 A

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DWG NO.
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Synthesizer DWG NO.
2005178C 12-15-71

E FAILURE PROBABILITY ALITY

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| PART/COMPONENT   | Control of the second of the s |      | EFFECT O                  | F FAILURE            | Constitution of the Contract o | CRITIC-  |
|------------------|--|------|---------------------------|----------------------|--|----------|
| SYMBOL           | FAILURE MODE   | (œ)  | ASSEMBLY                  | END ITEM             | FAILURE<br>PROBABILITY<br>Q × 10 <sup>-5</sup>   | ALITY    |
| 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 <b>C34</b> 2 | 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    |
|                  |  |      |                           |                      |  |          |
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ALSEP ARRAY E TTC ATM1005 A

FOR THE PSK Transmitter 2005170E PAGE A17 of 32

ASSY DWS NO. 2005178C 12-15-71

| PART/COMPONENT         |                |      | FICALITY ANALYSIS WOR | ECT OF FAILURE | smitter 200517<br>066 No.<br>er 200517 |   |                  |
|------------------------|----------------|------|-----------------------|----------------|--|---|------------------|
| SYMBOL                 | FAILURE MODE   | (œ)  | ASSEMBLY              | END ITE        |  | FAILURE<br>PROBABILITY<br>Q x 10 <sup>5</sup> | CRITIC-<br>ALITY |
| 48 R327, R328          | SHORT          |      | No Output             | No Output      |  | <b>**</b> *b                                  | Critica          |
| 19                     | OPEN           | .05  | No Output             | No Output      |  | .0342   | Critica          |
| 50                     | DRIFT          | . 95 | Q Point Shift         | None           |  |   | Minor            |
| 1 R329                 | SHORT          |      | Destruction of Q306   | No Output      |  | ;<br>;;                                       | Critic           |
| 52                     | OPEN           | . 05 | No Output             | No Output      |  | .0164   | Critic           |
| 53                     | DRIFT          | . 95 | Q Point Shift         | None           |  | -<br>-  | Minor            |
| Frequency Doubler Q307 | C-B, C-E SHORT | .25  | No Output             | No Output      |  | 24.5243                                       | Gritic           |
| 55                     | OPEN C, E, B   | .75  | No Output             | No Output      |  | 73.5558                                       | :<br>Critic      |
| 66                     | DRIFT          |      | Q Point Shift         | None           |  |   | Mino             |
| 57 C348                | SHORT          | .90  | Destruction of Q307   | No Output      |  | 0.3144  | Critic           |
| 58                     | OPEN           |      | Signal Degeneration   | No Output      |  |   | Criti            |
| 59                     | DRIFT          | . 10 | None                  | None           |  |   | Mino             |
|                        |                |      |                       |                |  |   |                  |
|                        |                |      |                       |                |  | A.<br>F                                       | Rational         |
|                        |                |      |                       |                |  |   |                  |
|                        |                |      |                       |                |  |   |                  |
|                        |                |      |                       |                |  |   |                  |
|                        |                |      |                       |                |  |   |                  |
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|                 | FAILURE MODE, EFFEC  | T & CRI     | ICALITY ANALYSIS WORK     | (SHEET  | ALSEP ARRAY E. SO IIEM PSK Transmitter ASSY Synthesizer  | PEPAZO B<br>TTC<br>DWG NO.<br>20051701<br>DWS NO:<br>20051780 | ATM PAGE A                               | 1001 A   |
|-----------------|--|-------------|---------------------------|---|--|---|--|----------|
| PART/COMPONENT  | FAILURE MODE   |             | EFFE(                     | AND DESCRIPTION OF STREET PROPERTY AND PROPERTY OF STREET | THE RESIDENCE AND ADDRESS OF THE PROPERTY OF T |   | FAILURE PROBABILITY Q × 10 <sup>-5</sup> | CRITIC-  |
| SYMBOL          | er (TOP Commence of the State of Commence of Comme | <u>(or)</u> | ASSEMBLY                  |   | END ITEM   |   |  | ALITY    |
| 160 C346        | SHORT  | .70         | No Output                 | No Outp   | ut   |   | 1.2249                                   | Critical |
| 161             | OPEN   |             | Detuning                  | No Outp   | ut   |   |  | Critical |
| 162             | DRIFT  | .30         | Detuning                  | Low Out   | tput   |   | 0.5245                                   | Major    |
| 163 <b>C345</b> | SHORT  | . 90        | Severe Drain on Regulator | No Outp   | ut   |   | . 0.7867                                 | Critical |
| 164             | OPEN   |             | Possible Instability      | Degrade   | d Performance  |   | · · · · · · · · · · · · · · · · · · ·    | Major    |
| 165             | DRIFT  | . 10        | None                      | None  |  |   |  | Minor    |
| 166 C347        | SHORT  | -90         | No Output                 | No Outp   | ut   |   | 0.7867                                   | Critical |
| 167             | OPEN   |             | Signal Blocking           | No Outp   | ut   |   |  | Critical |
| 68              | DRIFT  | . 10        | Detuning                  | Low Out   | tput   |   | .0864                                    | Major    |
| 69 L314         | SHORT  | . 25        | Detuning                  | No Outp   | ut   |   | .0864                                    | Critical |
| 70              | OPEN   | .25         | No Output                 | No Outp   | ut   |   | .0864                                    | Critical |
| 71              | DRIFT  | .50         | Detuning                  | Low Out   | put  |   | 0.1743                                   | Major    |
| 172 L315        | SHORT  | . 25        | Possible Instability      | Degrade   | ed Performance   |   | .0864                                    | Major    |
| 173             | OPEN   | . 25        | No Output                 | No Outp   | ut   |   | .0864                                    | Critica  |
| 174             | DRIFT  | .50         | None                      | None  |  |   |  | Minor    |
|                 |  |             |                           | ĺ   |  |   |  | 2*111101 |
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| PART/COMPONENT | 1  |            | FEFECT   | PSK Transmitter 2005170  ASSY Synthesizer 2005178  OF FAILURE | Contract Contract of the Contract Contr | -15-71           |
|----------------|--|------------|--|---|--|------------------|
| SYMBOL         | FAILURE MODE   | <u>(α)</u> | ASSEMBLY  Assemble to the contract of the cont | END ITEM  | FAILURE<br>PROBABILITY<br>Q × 10°2   | CRITIC-<br>ALITY |
| 75 C349, C350  | SHORT  | • 90       | Severe Drain on Regulator  | No Output   | 0.6303   | Critical         |
| 76             | OPEN   |            | Possible Instability   | Degraded Performance  |  | Major            |
| 77             | DRIFT  | . 10       | None   | None  |  | Minor            |
| 78 C352        | SHORT  | .90        | Destruction of Q308  | No Output   | 0.3144   | Critical         |
| 79             | OPEN   |            | Signal Degeneration  | No Output   |  | Critical         |
| 80             | DRIFT  | . 10       | None   | None  |  | Minor            |
| 81 C351, C353  | SHORT  | .70        | No Output  | No Output   | 2.4512   | Critica          |
| 82             | OPEN   |            | Detuning   | No Output   |  | Critica          |
| 83             | DRIFT  | .30        | Detuning   | Low Output  | 1.0505   | Major            |
| 84 C354        | SHORT  | .90        | Detuning   | No Output   | 0.7867   | Critica          |
| 85             | OPEN   |            | Signal Blocking  | No Output   | .0864  | Critica          |
| 86             | DRIFT  | . 10       | Detuning   | Low Output  | .0864  | Major            |
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| I                                 | FAILURE MODE, EFFEC | T & CRIT | ICALITY ANALYSIS WORK  | END TIEM PSK Transmitter ASS'Y   | OWG NO.<br>2005170E PAGE A:         | 005 EV. A<br>200f 32 |
|-----------------------------------|---------------------|----------|------------------------|--|-------------------------------------|----------------------|
| PART/COMPONENT                    | FAILURE MODE        |          | EFFEC                  | A STATE OF THE PARTY OF THE PAR | FAILURE                             | -15-71<br>CRITIC-    |
| SYMBOL                            |                     | (a)      | ASSEMBLY               | END ITEM   | PROBABILITY<br>Q × 10 <sup>-5</sup> | ALITY                |
| 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          | <b>No</b> ne   |                                     | Minor                |
| 193 R335                          | SHORT               |          | Destruction of Q308    | No Output  |                                     | Critical             |
| 194                               | OPEN                | .05      | No Output              | No Output  | .0164                               | Critical             |
| 195<br>·                          | DRIFT               | .95      | Q Point Shift          | None   |                                     | Minor                |
| 96 Isolution-Osc/<br>Modul., R345 | SHORT               |          | Loss of 95 MHz Signal  | Lose Output Signal   |                                     | Critical             |
| 97                                | OPEN                | .05      | Degraded 95 MHz Signal | Degraded Output Signal   | .0164                               | Major                |
| 198                               | DRIFT               | .95      | No Effect              | No Effect  | -~                                  | Minor                |
|                                   |                     |          |                        |  |                                     |                      |
|                                   |                     |          |                        |  |                                     |                      |
|                                   |                     | ]        |                        |  |                                     |                      |
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SYSTEM ALSEP ARRAY E SNOTTEM PSK Transmitter ASSYY Synthesizer

DWG NO. 2005170E DW6 NO. 2005178C

PREPARED BY TTC ATM 1005 REV. A PAGE A21 of 32.

| PART/COMPONENT            |               | Į.   | ICALITY ANALYSIS WORKSHE                     | 178C 12-               |   |                 |
|---------------------------|---------------|--|--|------------------------|---|-----------------|
| SYMBOL                    | FAILURE       | MODE (QL)  | ASSEMBLY                                     | F FAILURE END ITEM     | FAILURE<br>PROBABILITY<br>Q × 10 <sup>5</sup> | CRITIC<br>ALITY |
| 199 R346                  | SHORT         |  | Loss of 95 MHz Signal                        | Lose Output Signal     | 0 × 10 3                                      | Critica         |
| 200                       | OPEN          | .05  | Degraded 95 MHz Signal                       | Degraded Output Signal | .0164   | Major           |
| 201                       | DRIFT         | .95  | No Effect                                    | No Effect              | .010-   | Minor           |
| 202 R347                  | SHORT         |  | Excessive Current Drain; Destruction of Q309 | No Output Signal       |   | Critic          |
| 203                       | OPEN          | .05  | Q309 will not Operate                        | No Output Signal       | .0164   | Critic          |
| 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   | Critic          |
| 207                       | DRIFT         | . 95 No Effect No Effect Lose 95 MHz Signal Lose Output Signal |  |                        |   |                 |
| 208 Q309                  | SHORT         |  |  |                        |   |                 |
| 209                       | OPEN          | .75  | Lose 95 MHz Signal                           | Lose Output Signal     | 73.5558                                       | Critic          |
| 210                       | DRIFT         | [  | No Effect                                    | No Effect              |   | Minor           |
| 211 C361                  | SHORT         | .90  | Destruction of Q309                          | Lose Output Signal     | 0.7867  | Critic          |
| 212                       | OPEN          | ~  | Lose 75 MHz Signal                           | Lose Output Signal     |   | Critic          |
| 213                       | DRIFT         | . 10   | No Effect                                    | No Effect              |   | Minor           |
| 214 Modul. Driver<br>C317 | <b>S</b> HORT | .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 | <b>9.7</b> 867                                | Major           |
| 218                       | OPEN          |  | No Effect                                    | No Effect              |   | Minor           |
| 219                       | DRIFT         | .10  | No Effect                                    | No Effect              |   | Minor           |

| PART/COMPONENT  |                   |      | CALITY ANALYSIS WOR | KSHEET ASSY Power Ampl. Assy 2005<br>ECT OF FAILURE | FAILURE                             | CRITIC- |
|---|-------------------|------|---------------------|---|-------------------------------------|---------|
| SYMBOL  | FAILURE MODE      | (ox) | ASSEMBLY            | END ITEM  | PROBABILITY<br>Q × 10 <sup>-5</sup> | ALITY   |
| 1 Driver Amplifier<br>Q401  | C-B, B-E<br>SHORT | .10  | No Output           | No Output   | 8.9339                              | Critica |
| 2   | OPEN<br>C, E, B,  | .20  | No Output           | No Output   | 17.8679                             | Critica |
| 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                              | Critica |
| 6   | DRIFT             | . 30 | Detuning            | Low Output  | 0.3666                              | Minor   |
| 7 C402, C403,<br>C412, C413,<br>C425  | SHORT             | .78  | Detuning            | No Output   | 5.4657                              | Critica |
| 8   | OPEN              |      | Detuning            | No Output   |                                     | Critica |
| 9   | DRIFT             | .22  | Detuning            | Low Output  | 1.5408                              | Major   |
| 0 C404, C405,<br>C406, C407   | SHORT             | .90  | Q Point Shift       | Low Output  | <b>3.</b> 1531                      | Major   |
| 11  | OPEN              |      | Instability         | Degraded Performance                                |                                     | Major   |
| 12  | DRIFT             | .10  | None                | None  |                                     | Minor   |
| Si maya di Santa da |                   |      |                     |   |                                     |         |
|   |                   |      |                     |   |                                     |         |
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END ITEM PSK Transmitter ASSY Power Amplifier DWG NO. 2005180C PAGE A23 of 32 FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET DW6 NO. 2005178C 12-15-71 PART/COMPONENT EFFECT OF FAILURE FAILURE PROBABILITY Q × 10<sup>-5</sup> CRITIC-FAILURE MODE SYMBOL ALITY (OL) ASSEMBLY END ITEM 13 C408, C420, C426, C427 SHORT .90 Severe Regulator Drain No Output Critical 2.6315 14 OPEN --Signal Blocking No Output Critical 15 DRIFT . 10 Detuning Low Output 0.2921 Major 16 C410, C411, C423 SHORT Severe Regulator Drain . 90 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 Critical 1.1906 21 DRIFT .70 None None Minor 22 R402 SHORT Destruction of Q401 No Output Critical 23 OPEN No Output .05 No Output Critical 0.7867 24 DRIFT .95 None None Minor

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| PART/COMPONENT   |  | EFFECT C          | THE CONTRACTOR OF THE CONTRACT | A STATE OF THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER, THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER, THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER, THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER, THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER, THE OWNE | 15-71            |
|--|--|-------------------|--|--|------------------|
| SYMBOL   | FAILURE MODE (α  |                   | END ITEM   | FAILURE PROBABILITY Q × 10 <sup>-5</sup>   | CRITIC-<br>ALITY |
| <b>2</b> 5 R <b>4</b> 03   | SHORT  | Q Point Shift     | Low Output   |  | Major            |
| 26   | OPEN .C  | No Output         | No Output  | 0.7867   | Critical         |
| 27   | DRIFT  | 5 None            | None   |  | Minor            |
| 28 L403  | SHORT .2   | 5 Detuning        | No Output  | <b>∤.</b> 0864   | Critica1         |
| 29   | OPEN .2  | No Output         | No Output  | .0864  | Critical         |
| 30   | DRIFT .s   | 0 None            | None   | <b>-</b> -   | Minor            |
| 31 Power Ampli-<br>fier Q402   | C-B, B-E<br>SHORT  | 0 No Output       | No Output  | 10.1603  | Critical         |
| 32   | OPEN<br>C, E, B  | 0 No Output       | No Output  | 20.3192  | Critical         |
| 33   | DRIFT  | Q Point Shift     | None   |  | Minor            |
| 34 C414, L407,<br>C428   | SHORT  | 2 Detuning        | No Output  | 1.8463   | Critical         |
| 35   | OPEN   | 8 Signal Blocking | No Output  | <b>0.2</b> 369   | Critical         |
| 36   | DRIFT  | 0 Detuning        | Low Output   | <b>0.</b> 8925   | Major            |
|  |  |                   |  |  |                  |
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PART/COMPONENT

SYMBOL

37 C415, C416, C417, C424

40 C418, C419

L406

C422

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PREMIER PE SYSTEM ALSEP ARRAY E ATM 1005 REV. END ITEM PSK Transmitter DWG NO. 2005180C PAGE A25of 32 ASSY Power Amplifier FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET DATE 12-15-71 DWS 105178C EFFECT OF FAILURE FAILURE PROBABILITY Q × 10<sup>-5</sup> CRITIC-FAILURE MODE ALITY (OL) ASSEMBLY END ITEM SHORT .90 Severe Drain on Regulator No Output 2.6315 Critical OPEN Instability Degraded Performance Major DRIFT .10 None None Minor 0.2921 SHORT .80 No Output No Output Critical 2.1011 OPEN Detuning No Output Critical DRIFT .20 Detuning Low Output Major 0.5245 SHORT . 25 Detuning No Output Critical .0864 OPEN No Output . 25 No Output Critical .0864 DRIFT .50 None None Minor SHORT .90 Severe Drain on Regulator No Output Critical 0.7867 OPEN Possible Instability Degraded Performance --Major DRIFT None .10 None Minor

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BY ITEM
PSK Transmitter
ASS'Y DWG NO. 2005180 C PAGE A26 of

| FAILURE MODE, EFFECT & C | RITICALITY ANALYSIS WORKSHE                             | Power Amplifier 200517   | 178C 12-15-7;  |  |  |  |
|--------------------------|---|--|--|--|--|--|
| EATILIDE MODE            | EFFECT O  | F FAILURE  | 1 FAILURE  | CRITIC-  |  |  |
| (a                       | ) ASSEMBLY  | END ITEM   | PROBABILITY<br>Q × 10 <sup>5</sup>   | ALITY  |  |  |
| SHORT .1                 | No Output   | No Output  | 1.1206   | Critical   |  |  |
| OPEN .2                  | No Output   | No Output  | 2.2411   | Critical   |  |  |
| DRIFT .7                 | None  | None   | 7.8477   | Minor  |  |  |
|                          | Improper Temperature Indication                         | None   |  | Minor  |  |  |
| OPEN                     | Improper Temperature Indication                         | None   |  | Minor  |  |  |
| DRIFT                    | Improper Temperature Indication                         | None   |  | Minor  |  |  |
|                          | Not an actual part.<br>These are transistor base leads. |  |  | <del></del>  |  |  |
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|                          |   |  |  | transfer (constitution)  |  |  |
|                          | SHORT .10 OPEN .20 DRIFT .70 SHORT OPEN DRIFT           | FAILURE MODE  (C)  ASSEMBLY  SHORT  OPEN  .10  No Output  OPEN  .70  None  SHORT  Improper Temperature Indication  OPEN  DRIFT  Improper Temperature Indication  DRIFT  Improper Temperature Indication  Not an actual part. | FAILURE MODE  (C)  ASSEMBLY  END ITEM  SHORT  .10  No Output  No Output  No Output  No Output  No Output  None  SHORT  .70  None  Improper Temperature Indication  OPEN  Improper Temperature Indication  None  DRIFT  Improper Temperature Indication  None  None  None  None  None  None  None  None  None | FAILURE MODE  (OC)  ASSEMBLY  END ITEM  PROBABILITY  Q x 10 <sup>5</sup> SHORT  .10 No Output  No Output  No Output  No Output  No Output  DRIFT  .70 None  Improper Temperature Indication  DRIFT  . Improper Temperature Indication  DRIFT  . Improper Temperature Indication  None  . Improper Temperature Indication  None |  |  |

ALSEP ARRAY E

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PSK Transmitter

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OVER 1800

PAGE A27 of 32

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET

| PART/COMPONENT | FAILURE MODE  |               | EFFECT  | The second secon |  | CRITIC- |
|----------------|---|---------------|---|--|--|---------|
| SYMBOL         | FAILURE MODE  | ( <b>a</b> c) | ASSEMBLY  | END ITEM   | FAILURE<br>PROBABILITY<br>Q x 10 <sup>-5</sup> | ALITY   |
| 56 C429        | SHORT   | .90           | Improper Temp. Indication   | None   |  | Minor   |
| 57             | OPEN  |               | tr tr tr  | 11   |  | "       |
| 58             | DRIFT   | . 10          | D 0 D   | tr .   |  | 11      |
| 59 C430        | SHORT   | . 90          | и и п   | 11   |  | ,,      |
| 60             | OPEN  |               | и и и   | " These are TLM  |  | ,,      |
| 61             | DRIFT   | . 10          | п п п   | components that  |  | .,      |
| 62 C431        | SHORT   | .90           | n n   | do not affect re-<br>quired operation.   |  | "       |
| 63             | OPEN  |               | и и п   | n  |  |         |
| 64             | DRIFT   | .10           | 11 11 11  | **   |  |         |
| 65 C422        | SHORT   | . 90          | 11 11 11  | · n  |  |         |
| . <b>6</b> 6   | OPEN  |               | n a n   | 11   |  | .,      |
| 67             | DRIFT   | .10           | tt 11 ft  | п  |  |         |
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SYSTEM ALSEP Array E TTC ATM1005 A

FIG. 115M PSK Transmitter 2005160A PAGE A28 of 32

ASSY
Regulator Assy. 2005178C PLE/15/71

| PART/COMPONENT   | The second secon |               | EFFECT OF                     | THE RESIDENCE OF THE PROPERTY | Dates to the annual control of the state of | E                               |
|--|--|---------------|-------------------------------|---|---|---------------------------------|
| SYMBOL   | FAILURE MODE   | ( <b>o</b> c) | ASSEMBLY                      | END ITEM  | FAILURE<br>PROBABILITY<br>Q x 10 <sup>5</sup>   | CRITIC-<br>ALITY                |
|  | and the second of the second o |               |                               | heart ( ) heart | G × 10.5  | and the second                  |
| 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                           |
|  |  |               |                               |   |   |                                 |
| Remonstrative.   |  |               |                               |   |   |                                 |
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| Birkittukon  |  |               |                               |   |   |                                 |
| *Microelectric   |  |               |                               |   |   |                                 |
| Modular Assembly   | 7  |               |                               |   |   | مادر بن بوستار <sub>ال</sub> جا |
|  |  |               |                               |   |   |                                 |

| PART/COMPONENT   | FAILURE MODE |          | Officers or | EFFECT OF FAILURE  |   |   |      |                                   | FAILURE  | CRITIC-<br>ALITY |
|--|--------------|----------|---|--|---|---|------|-----------------------------------|--|------------------|
| SYMBOL   | (α)          |          | AS  | SEMBL  | .Y  | ang erhanagantaur pangkatak magantah pangkan da |      | END ITEM                          | FAILURE<br>PROBABILITY<br>Q × 10 <sup>-5</sup> | ALITY            |
| 13 R 517   | Short        | Incorrec | t voltag  | ge or c  | urrent  | idication                                       | None |                                   |  | Minor            |
| 14   | Open         | 11       | 11  | ti   | "   | 21  | ,,   |                                   |  | l:               |
| 15   | Drift        | 11       | 11  | 11   | 11  | **  | 11   |                                   |  | ı,               |
| 16 R 518   | Short        | 11       | 11  | "  | 11  | *11   | "    |                                   |  | t r              |
| 17   | Open         | ,,       | 11  | 11   | 17  | 11  | 11   | These are                         |  | n                |
| 18   | Drift        | "        | 11  | 11   | 11  | 11  | "    | TLM Components that               |  | 11               |
| 19 R 519   | Short        |          | tt  | 11   | 11  | n   | "    | do not affect required operation. |  | ŧŧ               |
| 20   | Open         | ,,       | ft  | 11   | 11  | ti .  | 11   | - •                               |  | ,,               |
| 21   | Drift        | ,,       | ***   | "  | 11  | 11  | 11   | •                                 |  | ŧr               |
| 22 R 520   | Short        | - 11     | ff  | †1   |   | *1  | tt   |                                   |  | ş.,              |
| <b>23</b>  | Open         | "        | 11 ,  | **   | *1  | 11  | rı . |                                   |  | #1<br>-          |
| 24   | Drift        | 11       | 11  | 11   | 11  | 11  | ,,   |                                   |  | 81               |
|  |              |          |   |  |   |   |      |                                   |  |                  |
|  |              | l        |   |  |   |   |      |                                   |  |                  |
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| regulations and  |              |          |   |  |   |   |      |                                   |  |                  |
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ASSIVE Regulator Assy. 2005178C PASE 12/15/71

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS WORKSHEET PART/COMPONENT EFFECT OF FAILURE FAILURE PROBABILITY Q × 10<sup>5</sup> CRITIC-FAILURE MODE SYMBOL ALITY (OL) ASSEMBLY END ITEM 25 R 521 Short Incorrect voltage or current idication None Minor 26 Open Drift 28 R 522 Short 29 Open These are 30 Drift TLMComponents 31 CR 501 Short that do not affect required 32 Open operations 33 Drift 34 CR 502 Short 35 Open 36 Drift

SISTEM ALSEP Array E END ITEM PSK Transmitter ASSY Regulator Assy.

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|                          | FAILURE MODE, EFFEC  | T & CRIT | ICALITY   | ANALY      | SIS W   | ORKSHEE    |           | PSK Transmitter 200516 ASSY Regulator Assy. 200517   | 0A PAGE A3  8C 72/15   | 31 of 32<br>5/71 |
|--------------------------|--|----------|-----------|------------|---------|------------|-----------|--|--|------------------|
| PART/COMPONENT<br>SYMBOL | FAILURE MODE   | (a)      |           | ASSEMBL    |         | EFFECT OF  | FAILURE   | END ITEM   | FAILURE<br>PROBABILITY<br>Q × 10 <sup>5</sup>  | CRITIC-<br>ALITY |
| 37 C 501                 | Short  |          | Incorrect | voltage or | current | indication | None      | and the state of t | Anna Carlotte Control of the C | Minor            |
| 38                       | Open   |          | 11        | 11 11      | ti      | 11         | 11        |  |  | ,,               |
| 39                       | Drift  |          | **        | f1 f1      | fi      | 11         | 11        |  |  | "                |
| 40 C 502                 | Short  |          | *1        | ** **      | 11      | н          | H         | These are  |  | "                |
| 41                       | Open   |          | 11        | f1 11      | 11      | 11         | 11        | TLM<br>Components  |  | 11               |
| 42                       | Drift  |          | 11        | t7 15      | 1 11    | 11         | <b>F1</b> | that do not<br>affect required   |  | .,               |
| 43 C 504                 | Short  |          | fi .      | 1) 12      | 11      | 11         | 11        | operation.   |  | 11               |
| <b>4</b> 4               | Open   |          | 11        | 11 11      | **      | ,,         | 11        |  |  | .,               |
| 45                       | Drift  |          | ti        | 1) 11      | **      | ti .       | 11        |  |  | 11               |
|                          |  |          |           |            |         |            |           |  |  |                  |
|                          | ,  |          |           |            |         |            |           |  |  |                  |
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|                          | - K <sup>a</sup> ap (Dag Gag Cally |          |           |            |         | į          |           |  |  |                  |

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ASSY
Multiplier-Isofilter 2005178C ATM 1005 A

| and the first and the contract part of the form of the first of the state and the contract the c | FAILURE MODE, EFFEC | T& CRI       | TICALITY ANALYSIS WORKSHE | PSK Transmitter 2005190  ASSY Multiplier-Isofilter 2005178 | B PAGE A3  | 2 of 32<br>15/71  |
|--|---------------------|--------------|---------------------------|--|--|---|
| PART/COMPONENT<br>SYMBOL   | FAILURE MODE        | (∞)          |                           | F FAILURE END ITEM   | FAILURE<br>PROBABILITY<br>Q × 10 <sup>-5</sup>   | CRITIC-<br>ALITY  |
| 1 C601, C602,<br>C605, C604  | SHORT               | .90          | Detuning                  | No Output  | 0.6303   | Critical  |
| 2  | OPEN                |              | Detuning                  | No Output  |  | Critical  |
| 3  | DRIFT               | . 10         | Detuning                  | Low Output   | l  | Major   |
| 4 C603, L601,<br>L602  | SHORT               | .47          | No Output                 | No Output  | 0.4113   | Critical  |
| 5  | OPEN                | . 16         | Signal Blocking           | No Output  | <b>0.138</b> 6   | Critical  |
| 6  | DRIFT               | . 37         | Defuning                  | Low Output   | 0.3234   | Major   |
| 7 CR601  | SHORT               | . 05         | No Output                 | No Output  | 1.4007   | Critical  |
| 8  | OPEN                | <b>. 0</b> 5 | 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   |
|  |                     |              |                           |  | And the second s |   |
|  |                     |              |                           |  |  |   |
|  |                     |              |                           |  | **************************************   |   |
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| New York (Marriage 1991)   | <u> </u>            |              | <u>.</u>                  |  |  |   |