MEAN TIME BETWEEN FAILURES CALCULATION (MTBF)

FOR

WESTINGHOUSE

ON

SINGLE POLE/SEVEN THROW SWITCH PDS24433

AND

TRANSFER RF SWITCH NETWORK PDS24422

TABLE OF CONTENTS

TABLE OF CONTENTS

SYNOPSIS

SINGLE POLE/SEVEN THROW PIN DIODE SWITCH PDS 24433:

MTBF = **495,114** HOURS

TRANSFER RF SWITCH NETWORK PDS 24422:

MTBF = **84,373** HOURS

Mtbf calculations for
SP7T switch
Westinghouse P/N: PDS24433

ENVIRONMENT: GROUND FIXED

AMBIENT TEMPERATURE: +40°C

P 5.1.2.1 MICROELECTRONICS:

$$\lambda_p = \pi_Q(C_1\pi_T\pi_V+C_2\pi_B)\pi_L \text{ FAILURE}/10^6 \text{ HOURS}$$

$\pi_Q = 0.25$
$\pi_L = 1$
$\pi_B = 2.5$
$\pi_T = 0.35$ @ 50° C
$\pi_V = 1.0$
$C_2 = 0.010$ HERMETIC FLATPACKS
$C_1 = 0.01$

$\lambda_p = 7.125X10^{-3}$
N = 2
TOTAL $\lambda_p = 1.425X10^{-02}$

P 5.1.3-1 TRANSISTORS (DISCRETE SEMICONDUCTORS)

$$\lambda_P = \lambda_B(\pi_E x \pi_A x \pi_Q x \pi_R x \pi_{S2} x \pi_C) \text{ FAIL}/10^6 \text{ HRS}$$

GROUP I SILICON

$\lambda_B = .0025$ (NPN; 70° C CASE TEMP; 0.5 POWER STRESS)
$\lambda_B = .0040$ (PNP; 70° C CASE TEMP; 0.5 POWER STRESS)
$\pi_E = 5.8$
$\pi_A = 0.7$
$\pi_Q = 0.12$
$\pi_R = 1.5$
$\pi_{S2} = 0.65$ (50 % DERATED)
$\pi_C = 1.0$

λ_p(NPN) = $1.18755X10^{-3}$
N = 7
TOTAL $\lambda_p = 8.31285X10^{-3}$

λ_p(PNP) = $1.900X10^{-3}$
N = 21
TOTAL $\lambda_p = 3.98982X10^{-2}$

P 5.1.3 DISCRETE SEMICONDUCTORS, PIN DIODES

$$\lambda_P = \lambda_B \times \pi_{B_x}\pi Q \times \pi_R \times \pi A \text{ FAIL}/10^6 \text{ HRS}$$

GROUP VIII

λ_B = .053 (50° C CASE TEMP; 0.5 POWER STRESS)
π_B = 3.9
π_Q = 1.0 (JNTX SCREENED)
π_R = 0.5 (P<10WATTS)
π_A = 1.0

λ_P = 0.10335
N = 14
TOTAL λ_P = 1.4469

P 5.1.3 ZENER DIODE

$$\lambda_P = \lambda_B(\pi_E \times \pi_A \times \pi_s)$$

π_E = 3.9
π_A = 1.0
π_Q = 0.3 (JANTXV SCREENED)
λ_B = .0011 (50C AT .5 POWER STRESS)

$\lambda_P = 1.287X10^{-3}$
N = 1
TOTAL $\lambda_P = 1.287X10^{-3}$

P 5.1.6 RESISTORS (CHIP) THICK FILM CHIP RESISTOR, MIL-R-55342, FAILURE RATE "R", 100mW

$$\lambda_P = \lambda_B(\pi_E \times \pi_R \times \pi_Q)$$

λ_B = .0014 (50C AMBIENT, 0.5 DERATED)
π_E = 2.4
π_R = 1.0 (RESISTANCE UPTO 100K)
π_Q = 0.1 ('R' FAILURE RATED)

$\lambda_P = 3.36X10^{-4}$
N = 72 (RF AND DC)
TOTAL $\lambda_P = 2.42X10^{-2}$

P 5.1.7 CAPACITORS

DC: CERAMIC CHIP, MIL-C-55681, 20% TOLERANCE, FAILURE RATE 'R', 100 VOLT BREAKDOWN.

$$\lambda_P = \lambda_B(\pi_E \times \pi_Q \times \pi_{CV})$$

λ_B = .0038 (50C AMBIENT TEMP, 0.5 DERATED)
π_E = 1.9
π_Q = 0.1 (R FAILURE)
π_{CV} = 0.75 (240 pF CAPACITORS)
π_{CV} = 1.13 (.01 μF CAPACITORS)

240 PF AND LOWER
$\lambda_P = 5.415X10^{-4}$
N = 21
TOTAL $\lambda_P = 1.137X10^{-2}$

.01UF AND LOWER
$\lambda_P = 8.1586X10^{-4}$
N = 2
TOTAL $\lambda_P = 1.631X10^{-3}$

RF:

$$\lambda_P = \lambda_B(\pi_E \times \pi_Q \times \pi_{CV})$$

λ_B = .0038 (50C AMBIENT TEMP, 0.5 DERATED)
π_E = 2.4
π_Q = 3.0 (NON-ESTABLISHED RELIABILITY)
π_{CV} = 0.75 (C<240 pF CAPACITORS)

$\lambda_P = 1.6245X10^{-2}$
N = 15
TOTAL λ_P = 0.243675

5.1.12.2 PRINTED CIRCUIT BOARD MULTI-PIN CONNECTOR

$$\lambda_P = \lambda_B (\pi_E \times \pi_P \times \pi_K)$$

λ_B = 0.00047 (50C)
π_E = 3.4
π_P = 3.28 (15 PIN MULTI PIN)
π_K = 1.0

TOTAL $\lambda_P = 5.24144X10^{-3}$

P 5.1.2.9.3 INTERCONNECTIONS IN DC

$\lambda_I = 0.000650$
$N_I = 91$

$\lambda_P = N_I \times \lambda_I$

$\lambda_P = 5.915X10^{-2}$
$N = 1$

P 5.1.12 COAXIAL RF CONNECTORS

$\lambda_P = \lambda_B(\pi_E \times \pi_P \times \pi_K)$

$\lambda_B = 0.0059$ (OPERATING TEMP 50 C)
$\pi_E = 3.4$
$\pi_P = 1.0$
$\pi_K = 1.0$

$\lambda_P = 2.006X10^{-2}$
$N = 8$
TOTAL $\lambda_P = 0.1605$

SUMMARY

$\lambda_{TOTAL} = \Sigma_{TOTAL}\ \lambda_P = 2.02$ FAILURES/MILLION HOURS

$MTBF = \lambda_{TOTAL}/1X106 = 2.02/1X106$

495.114 HOURS BETWEEN FAILURES

MTBF CALCULATION FOR
TRANSFER RF SWITCH NETWORK
WESTINGHOUSE P/N: PDS24422

ENVIRONMENT: GROUND FIXED

AMBIENT TEMPERATURE: +40°C

SW-2181-2AT PIN DIODE SWITCH

P 5.2.1.9 RF HYBRID

$$\text{RF HYBRID } \lambda_P = \left\{ \Sigma N_C \lambda_C \pi_Q + [N_R \lambda_R + \Sigma N_I \lambda_I + \lambda_S] \pi_F \pi_E \right\} \pi_Q \pi_D$$

P 5.1.2.9.1 $\Sigma N_C \lambda_C \pi_Q$ ACTIVE COMPONENTS AND CAPACITORS

N_C = NUMBER OF EACH PARTICULAR PART
λ_C = FAILURE CONTRIBUTION OF EACH PART
π_Q = DIE AND CAPACITOR CORRECTION FACTORS

PIN DIODES:

BEAM LEAD DIODES (SAMPLE CALCULATION):

P 5.1.3 DISCRETE SEMICONDUCTORS, PIN DIODES

$$\lambda_P = \lambda_B \times \pi_E \times \pi_Q \times \pi_R \times \pi_A \text{ FAIL}/10^6 \text{ HRS}$$

GROUP VIII

λ_B = .053 (50° C CASE TEMP; 0.5 POWER STRESS)
π_E = 3.9
π_Q = 0.5 (JNTXV SCREENED)
π_R = 0.5 (P<10WATTS)
π_A = 1.0

$$\lambda_P = 5.1675 \times 10^{-2}$$

CHIP DIODES(SAMPLE CALCULATION):

P 5.1.3 DISCRETE SEMICONDUCTORS, PIN DIODES

$$\lambda_P = \lambda_B \times \pi_B \times \pi_Q \times \pi_R \times \pi_A \text{ FAIL}/10^6 \text{ HRS}$$

GROUP VIII

λ_B = .053 (50° C CASE TEMP; 0.5 POWER STRESS)
π_B = 3.9
π_Q = 25 (UN-SCREENED)
π_R = 0.5 (P<10WATTS)
π_A = 1.0

$$\lambda_P = 2.58375$$

PIN DIODES:

BEAM LEADS:
$\lambda_C = 5.1675X10^{-2}$
$N_C = 6$
$\pi_Q = 0.2$

CHIP DIODES:

$\lambda_C = 2.58375$
$N_C = 4$
$\pi_Q = 0.2$

RF CAPACITORS
$\lambda_C = 8.55X10^{-3}$
$N_C = 12$
$\pi_Q = 0.8$

$$\sum N_C \lambda_C \pi_Q = 2.21109$$

P 5.1.2.9.2 CHIP AND SUBSTRATE RESISTORS

λ_R = .00015
N_R = 7

P 5.1.2.9.3 INTERCONNECTIONS

N_I = 48
λ_I = 0.000650

P 5.1.2.9-7 PACKAGE FAILURE RATE

$S = 3.5$"
$\lambda_s = .0323$ (50C, FROM TABLE 5.1.2.9-4)

ENVIRONMENTAL π_E

$\pi_E = 0.78$

QUALITY π_Q

$\pi_Q = 1.0$ (B-1 SCREENED MIL-STD-883 METHOD 5008)

DENSITY FACTOR π_D

$\pi_D = 1.31$

RF HYBRID $\lambda_P = 2.99425$

DC COMPONENTS

P 5.1.3-1 TRANSISTORS (DISCRETE SEMICONDUCTORS)

$$\lambda_P = \lambda_B(\pi_E \times \pi_A \times \pi_Q \times \pi_R \times \pi_S \times \pi_C) \text{ FAIL}/10^6 \text{ HRS}$$

GROUP I SILICON

$\lambda_B = .0025$ (NPN; 70° C CASE TEMP; 0.5 POWER STRESS)
$\lambda_B = .0040$ (PNP; 70° C CASE TEMP; 0.5 POWER STRESS)
$\pi_E = 5.8$
$\pi_A = 0.7$
$\pi_Q = 0.12$
$\pi_R = 1.5$
$\pi_S = 0.65$ (50 % DERATED)
$\pi_C = 1.0$

λ_P(NPN) = 1.18755×10^{-3}
N = 2
TOTAL $\lambda_P = 2.3751 \times 10^{-3}$

λ_P(PNP) = 1.900×10^{-3}
N = 6
TOTAL $\lambda_P = 1.14 \times 10^{-2}$

P 5.1.3 ZENER DIODE

$$\lambda_P = \lambda_B(\pi_E \times \pi_A \times \pi_s)$$

$\pi_E = 3.9$
$\pi_A = 1.0$
$\pi_Q = 0.3$ (JANTXV SCREENED)
$\lambda_B = .0011$ (50C AT .5 POWER STRESS)

$$\lambda_P = 1.287X10^{-3}$$
$$N = 1$$

P 5.1.6 RESISTORS (CHIP) THICK FILM CHIP RESISTOR, MIL-R-55342, FAILURE RATE "R", 100mW

$$\lambda_P = \lambda_B(\pi_E \times \pi_R \times \pi_Q)$$

$\lambda_B = .0014$ (50C AMBIENT, 0.5 DERATED)
$\pi_E = 2.4$
$\pi_R = 1.0$ (RESISTANCE UPTO 100K)
$\pi_Q = 0.1$ ('R' FAILURE RATED)

$$\lambda_P = 3.36X10^{-4}$$
$$N = 58$$
$$\text{TOTAL } \lambda_P = 1.948X10^{-2}$$

P 5.1.7 CAPACITORS

DC: CERAMIC CHIP, MIL-C-55681, 20% TOLERANCE, FAILURE RATE 'R', 100 VOLT BREAKDOWN.

$$\lambda_P = \lambda_B(\pi_E \times \pi_Q \times \pi_{CV})$$

$\lambda_B = .0038$ (50C AMBIENT TEMP, 0.5 DERATED)
$\pi_E = 1.9$
$\pi_Q = 0.1$ (R FAILURE)
$\pi_{CV} = 0.75$ (240 pF CAPACITORS)
$\pi_{CV} = 1.13$ (.01 μF CAPACITORS)

$$\lambda_P = 5.415X10^{-4}$$
$$N = 6$$
$$\text{TOTAL } \lambda_P = 1.14X10^{-2}$$

$$\lambda_P = 8.1586X10^{-4}$$
$$N = 2$$
$$\text{TOTAL } \lambda_P = 1.631X10^{-3}$$

P 5.1.2.9.3 INTERCONNECTIONS IN DC

$\lambda_I = 0.000650$
$N_I = 27$

$$\lambda_P = N_I \times \lambda_I$$

$$\lambda_P = 1.755X10^{-2}$$

P 5.1.12 COAXIAL RF CONNECTORS

$$\lambda_P = \lambda_B(\pi_E \times \pi_P \times \pi_K)$$

$\lambda_B = 0.0059$ (OPERATING TEMP 50 C)
$\pi_E = 3.4$
$\pi_P = 1.0$
$\pi_K = 1.0$

$$\lambda_P = 2.006X10^{-2}$$
$$N = 3$$
$$\text{TOTAL } \lambda_P = 6.018X10^{-2}$$

SUMMARY

$\lambda_{TOTAL} = \Sigma_{TOTAL}\ \lambda_P = 2.34$ FAILURES/MILLION HOURS

MTBF = $\lambda_{TOTAL}/1X10^6 = 2.34/1X10^6$

428,027 HOURS BETWEEN FAILURES

MTBF CALCULATION FOR
TRANSFER RF SWITCH NETWORK
WESTINGHOUSE P/N: PDS24422

SW-2181-TRA PIN DIODE SWITCH (MONOLITHIC CHIP)

P 5.1.2.2 MOS LINEAR, MONOLITHIC DEVICE

$$\lambda_P = \pi_Q(C_1 \times \pi_T \times \pi_V + C_2 \times \pi_B)\pi_L$$

π_Q = 2.0 (MIL-883-(B-1) SCREENED)
π_L = 10.0 (NEW TECHNOLOGY)
π_B = 2.5
π_T = 0.76
π_V = 1.0
C_2 = 0.0026
C_1 = 0.06

TOTAL λ_P = 1.042

SUMMARY

$\lambda_{TOTAL} = \Sigma_{TOTAL}\ \lambda_P$ = 1.042 FAILURES/MILLION HOURS

MTBF = $1X10^6/\lambda_{TOTAL}$ = $1X10^6/1.042$

959,693 HOURS BETWEEN FAILURES

MTBF CALCULATION FOR
TRANSFER RF SWITCH NETWORK
WESTINGHOUSE P/N: PDS24422

SP6T PIN DIODE SWITCH

P 5.1.2.1 MICROELECTRONICS:

$$\lambda_p = \pi_Q(C_1\pi_T\pi_V + C_2\pi_E)\pi_L \text{ FAILURE}/10^6 \text{ HOURS}$$

$\pi_Q = 0.25$
$\pi_L = 1$
$\pi_E = 2.5$
$\pi_T = 0.35$ @ 50° C
$\pi_V = 1.0$
$C_2 = 0.010$ HERMETIC FLATPACKS
$C_1 = 0.01$

$$\lambda_p = 7.125X10^{-3}$$
$$N = 2$$
$$\text{TOTAL } \lambda_p = 1.425X10^{-2}$$

P 5.1.3-1 TRANSISTORS (DISCRETE SEMICONDUCTORS)

$$\lambda_p = \lambda_B(\pi_{Bx}\pi_{Ax}\pi_{Qx}\pi_{Rx}\pi_{S2x}\pi_C) \text{ FAIL}/10^6 \text{ HRS}$$

GROUP I SILICON

$\lambda_B = .0025$ (NPN; 70° C CASE TEMP; 0.5 POWER STRESS)
$\pi_E = 5.8$
$\pi_A = 0.7$
$\pi_Q = 0.12$
$\pi_R = 1.5$
$\pi_{S2} = 0.65$ (50 % DERATED)
$\pi_C = 1.0$

$$\lambda_p(\text{NPN}) = 1.18755X10^{-3}$$
$$N = 12$$
$$\text{TOTAL } \lambda_p = 1.425X10^{-2}$$

P 5.1.3 DISCRETE SEMICONDUCTORS, PIN DIODES

$$\lambda_P = \lambda_B \times \pi_E \times \pi_Q \times \pi_R \times \pi_A \text{ FAIL}/10^6 \text{ HRS}$$

GROUP VIII

λ_B = .053 (50° C CASE TEMP; 0.5 POWER STRESS)
π_E = 3.9
π_Q = 1.0 (JNTX SCREENED)
π_R = 0.5 (P<10WATTS)
π_A = 1.0

λ_P = 0.10335
N = 12
TOTAL λ_P = 1.2402

P 5.1.6 RESISTORS (CHIP) THICK FILM CHIP RESISTOR, MIL-R-55342, FAILURE RATE "R", 100mW

$$\lambda_P = \lambda_B(\pi_E \times \pi_R \times \pi_Q)$$

λ_B = .0014 (50C AMBIENT, 0.5 DERATED)
π_E = 2.4
π_R = 1.0 (RESISTANCE UPTO 100K)
π_Q = 0.1 ('R' FAILURE RATED)

$\lambda_P = 3.36 \times 10^{-4}$
N = 20 (RF AND DC)
TOTAL $\lambda_P = 6.72 \times 10^{-3}$

P 5.1.7 CAPACITORS

DC: CERAMIC CHIP, MIL-C-55681, 20% TOLERANCE, FAILURE RATE 'R', 100 VOLT BREAKDOWN.

$$\lambda_P = \lambda_B(\pi_E \times \pi_Q \times \pi_{CV})$$

$\lambda_B = .0038$ (50C AMBIENT TEMP, 0.5 DERATED)
$\pi_E = 1.9$
$\pi_Q = 0.1$ (R FAILURE)
$\pi_{CV} = 0.75$ (240 pF CAPACITORS)
$\pi_{CV} = 1.13$ (.01 µF CAPACITORS)

240 PF CAPACITORS
$\lambda_P = 5.415X10^{-4}$
N = 13 (RF AND DC)
TOTAL $\lambda_P = 7.0395X10^{-3}$

.01 UF CAPACITORS
$\lambda_P = 8.1586X10^{-4}$
N = 2
TOTAL $\lambda_P = 1.631X10^{-3}$

P 5.1.2.9.3 INTERCONNECTIONS

$$\lambda_P = N_I \times \lambda_I$$

$\lambda_I = 0.000650$
$N_I = 73$

$\lambda_P = 4.745X10^{-2}$

P 5.1.12 COAXIAL RF CONNECTORS

$$\lambda_P = \lambda_B(\pi_E \times \pi_P \times \pi_K)$$

$\lambda_B = 0.0059$ (OPERATING TEMP 50 C)
$\pi_E = 3.4$
$\pi_P = 1.0$
$\pi_K = 1.0$

$\lambda_P = 2.006X10^{-2}$
N = 7
TOTAL $\lambda_P = 0.14042$

SUMMARY

$\lambda_{TOTAL} = \Sigma_{TOTAL}\ \lambda_p = 1.472$ FAILURES/MILLION HOURS

MTBF = $1X10^6/\lambda_{TOTAL} = 1X10^6/1.472$

679,366 HOURS BETWEEN FAILURES

MTBF CALCULATION FOR
TRANSFER RF SWITCH NETWORK
WESTINGHOUSE P/N: PDS24422

PD-1000-2

P 5.1.12 COAXIAL RF CONNECTORS

$$\lambda_P = \lambda_B(\pi_E \times \pi_P \times \pi_K)$$

$\lambda_B = 0.0059$ (OPERATING TEMP 50 C)
$\pi_E = 3.4$
$\pi_P = 1.0$
$\pi_K = 1.0$

$\lambda_P = 2.006 \times 10^{-2}$
N = 3
TOTAL $\lambda_P = 6.018 \times 10^{-2}$

P 5.1.8.1 INDUCTIVE DEVICES, TRANSFORMERS

$$\lambda_P = \lambda_B(\pi_E \times \pi_Q)$$

$\pi_Q = 12.0$ (RF TRANSFORMERS, MIL SPEC)
$\pi_E = 5.7$
$T_{HS} = 73°$ (FROM 5.1.8.3.2 WHERE $T_A = 40°C$; $\Delta T = 30°C$)
$\lambda_B = 0.0108$ (MAXIMUM OPERATING TEMP = 85°C;)

$\lambda_P = 0.739$
N = 2
TOTAL $\lambda_P = 1.477$

SUMMARY

$\lambda_{TOTAL} = \sum_{TOTAL} \lambda_P = 1.53718$ FAILURES/MILLION HOURS

MTBF = $1X10^6/\lambda_{TOTAL}$ = $1X10^6/1.53718$

650,541 HOURS BETWEEN FAILURES

MTBF CALCULATION FOR
TRANSFER RF SWITCH NETWORK
WESTINGHOUSE P/N: PDS24422

SYSTEM SUMMARY

COMPONENT	QUANTITY	λ_{TOTAL} OF COMPONENT	MTBF
SW-2181-2AT	2	2.34	428,027
XFER SWITCH	4	1.04	959,693
SP6T SWITCH	1	1.472	679,366
PD-1000-2 POWER DIVIDER	1	1.54	650,541

OVERALL λ_{TOTAL} = 11.852

MTBF = $1X10^6/11.852$

84,373 HOURS