

File E70742
Project 95SC06482

March 5, 1996

REPORT
ON
COMPONENT - WIRING, PRINTED

Sierra Circuits, Inc.
Sunnyvale, California

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DESCRIPTION

PRODUCT COVERED:

USR - Multilayer printed wiring board. See Table I for Type Designations.

CNR - Multilayer printed wiring board. See Table I for Type Designations.

ENGINEERING CONSIDERATIONS (NOT FOR FIELD REPRESENTATIVE'S USE):

USR - United States Recognized.

CNR - Canadian Standards Recognized.

Use - The boards are for use only in electrical equipment where the acceptability of the combination has been determined by Underwriters Laboratories Inc.

Acceptability Conditions - The following are among the considerations to be made in judging the suitability of the boards in the end product.

1. Soldering Limits - The temperature and time specified in Table I shall not be exceeded when the boards are subjected to a wave, flow, dip or an equivalent soldering operation for assembling the components. The maximum time is the cumulative time for all soldering operations when the soldering is done in different steps. These limits do not apply to hand soldering.
2. Temperature Rating - The maximum temperature on the board in the end product shall not exceed the value specified in Table I.
3. Voltage Rating - No voltage rating is assigned. The suitability of the base material as insulation between live-metal parts and dead-metal parts shall be determined in the end product. See Table II for base material identification.
4. Pattern Limits - See Table I. The edge conductor width and conductor width specified in Table I are the minimum acceptable widths. The maximum area diameter is the maximum allowable area of the circle that will cover the largest unpierced section of the conductors.
5. Direct Support of Current-Carrying Parts - A printed wiring board that meets the minimum UL 796 levels of direct-support of current carrying parts is identified to enable the OEM to select appropriate printed wiring boards for use in products. This is indicated in Table II.

6. Comparative Tracking Index (CTI) - the CTI is expressed as that voltage, which causes tracking on a printed wiring board base material after 50 drops of 0.1 percent ammonium chloride solution, has fallen. The results of testing the nominal 3 mm (1/8 in.) thickness are considered representative of the material's performance in any thickness:

CTI Range Tracking Index (TI in Volts)	Assigned PLC
600 and greater	0
400 and up to 600	1
250 and up to 400	2
175 and up to 250	3
100 and up to 175	4
Less than 100	5

For CNR, the actual CTI values are indicated in Table II.

7. Mechanical Strength - The adequacy of the board for the support and replacement of components shall be evaluated.
- *8. **Flammability - The flammability classification for the board is indicated in Table IA for USR and CNR. The classification is based on samples tested with and without nonmetallic permanent coatings (such as solder resist) to be applied by this manufacturer using the UL 94 and CAN/CSA-C22.2 No. 0.17 test methods. Coatings shall not be employed unless so indicated in the specified process. If the board assembler or end product manufacturer applies any coating, the effect of the coating on the flammability of the board is to be determined in the end product. Marking ink and flux are not considered a permanent coating.**
9. Silver Conductors - The minimum spacing between any two silver conductors of opposite polarity must not be less than that indicated in Table IB. The silver conductors have been found suitable only for circuits that do not require a dielectric strength potential greater than that indicated between adjacent parts of opposite polarity. The maximum voltage applied between any two silver conductors must not exceed that listed in Table IB.

- 10 . Other Considerations - The following items shall be considered for insertion into the end-product report:
- A. Minimum required spacing between conductors of different potential and between these conductors and dead-metal parts.
 - B. Pattern Limits. The minimum line width may be the width of the narrowest conductor on the board in the end equipment or the minimum line width specified in this report, depending upon operating temperature or ampacity conditions.
 - C. Thickness of conductors.
 - D. Soldering limits.
 - E. The overall board dimensions.
 - F. Identification marking.
 - G. For flammability rating, identification of coatings applied by user.

GENERAL CHARACTERISTICS:

The printed wiring boards must meet the pattern limits, marking and soldering limits given by Engineering Considerations and Table I.

The printed wiring boards are multilayer in construction, comprising of alternate layers of the laminates and prepregs (bonding sheets) shown in Table II.

The laminates are to be used in conjunction with their respective prepregs. Different manufacturer's materials shall not be used in the same board, unless otherwise specified. Unless more than one grade is specified for the same board, different grades of the same material manufacturer shall not be used.

The overall thickness of the finished board must be equal to or greater than the size indicated in the "Total Build Up" column in Table II excluding surface conductors.

The printed wiring boards are fabricated from the base materials shown in Table II, having a solid copper sheet in the minimum thickness shown bonded to one or both sides of the internal or external laminates, unless otherwise indicated. Maximum conductor thickness of 102 microns (4 mils) may be used unless otherwise indicated.

DIMENSIONS SHOWN IN TABLE II ARE MINIMUM ACCEPTABLE VALUES.

NOTE - There shall be no changes, additions or substitutions made by the manufacturer in his production, to the information shown in Table II, without prior written clearance from Underwriters Laboratories Inc.

Marking - See Section General.

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Revised: 2002-11-15

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TABLE IA - PARAMETER PROFILE INDICES

Type	Pattern Limits			Solder Limits		Maximum Operating Temp. (°C)	UL 94 Flame Class
	Min. Width (in.)	Max. Area Diameter (in.)	Min. Edge Width (in.)	Temp. (°C)	Time (sec.)		
M2	0.002	4.0	0.003	300	30	130	V-0
M3	0.002	4.0	0.002	288	30	130	V-0
M3-1	0.002	4.0	0.002	288	30	130	V-1
M4	0.002	4.0	0.002	288	20	140	V-0
M5	0.002	4.0	0.002	288	30	130	V-0
M6	0.002	4.0	0.002	288	30	130	V-0
M7	0.002	4.0	0.002	288	10	130	V-0
M7-1	0.002	4.0	0.002	288	10	130	V-1
M8	0.002	4.0	0.002	288	30	130	V-1

TABLE IB - SILVER CONDUCTOR LIMITATIONS

Type	Silver Conductor Materials Present (Yes) or (No)	Min. Spacing Between Adjacent Silver Conductors of Different Potential (in.)	Maximum Voltage Withstood Between Silver Conductors (V dc)
M2	Yes (Immersion Silver)	Not Evaluated	Not Evaluated
M3	Yes (Immersion Silver)	Not Evaluated	Not Evaluated
M3-1	Yes (Immersion Silver)	Not Evaluated	Not Evaluated
M4	Yes (Immersion Silver)	Not Evaluated	Not Evaluated.
M5	Yes, (Immersion Silver)	Not Evaluated	Not Evaluated
M6	Yes, (Immersion Silver)	Not Evaluated	Not Evaluated
M7	Yes, (Immersion Silver)	Not Evaluated	Not Evaluated
M7-1	Yes, (Immersion Silver)	Not Evaluated	Not Evaluated
M8	Yes, (Immersion Silver)	Not Evaluated	Not Evaluated

Boards coated with Immersion Silver do not require conductor limitations in accordance with the exception in UL796, 10.2.1.

Note - Reference to silver conductors infers silver conductors and silver plated conductors, for purposes of this report, unless otherwise indicated

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This page replaces Page 7 and 8

TABLE II - BASE MATERIALS

Type	Base Material†								Total Build-Up Thk. (in.)	Conductor Thk.# (mils)	Meets UL746 E Dir. Sup.	CTI Volts (PLC)	PWB Mfg. Proc.
	Individual Laminate Matl.				Individual Bonding Sheet Matl.								
	UL/ANSI Grade	Mfr @	Grade	Min. Thk. (mils)	UL/ANSI Grade	Mfr @	Grade	Min. Thk. (mils)					
M2	FR-4.0	NY	NP-155FR, NP-155FTL, NP-175FR, NP-175FTL, NP-180FR, NP-180FTL	2.0	FR-4.0	NY	NP-155FB, NP-175FB, NP-180FB	2.0	0.015	E: 0.33 I: 4.02	Yes	175 (3)	J
M2	FR-4.0 (IT14)	PE	N4103-13-**, N4^^-13RF-**, N4103-13EP**	2.0	FR-4.0 (IT14)	PE	N4203-13-**, N4203-13EP**	2.0	0.015	E: 0.33 I: 4.02	Yes	175 (3)	J
*M3	FR-4.1	NY	NPG-R, NPG-170R, NPG-TL, NPG-170TL, NPG-170DR, NPG-170DTL, NPG-170INR, NPG-170INTL, NPG-150DR, NPG-150DTL, NPG-170, NPG-151, NPG-171, NPGN-150LKHD, NPG-150N, NPG-170N	2.0	FR-4.1	NY	NPG-B, NPG-170B, NPG-170DB, NPG-170INB, NPG-150DB, NPG-151B, NPG-171B, NPGN-150LKHDB, NPG-150NB, NPG-170NB	2.0	0.015	E: 0.33 I: 4.02	Yes	318 (2)	J
M3-1	FR-4.1	NY	NPG-R, NPG-170R, NPG-TL, NPG-170TL, NPG-170DR, NPG-170DTL, NPG-170INR, NPG-170INTL, NPG-150DR, NPG-150DTL, NPG-170, NPG-151, NPG-171, NPGN-150LKHD, NPG-150N, NPG-170N	2.0	FR-4.1	NY	NPG-B, NPG-170B, NPG-170DB, NPG-170INB, NPG-150DB, NPG-151B, NPG-171B, NPGN-150LKHDB, NPG-150NB, NPG-170NB	2.0	0.015	E: 0.33 I: 4.02	Yes	318 (2)	J

*

& - Recognized Component, (QMTS2)

- I: Maximum internal thickness, E: Minimum external thickness

+ - NY: Nan Ya [E98983]; I: Isola (E41625); PE: Park Electrochemical (E36295)

(IT14) - UL Internal Tracking

TABLE II - BASE MATERIALS

Type	Base Material [‡]								Total Build-Up Thk. (in.)	Conductor Thk.# (mils)	Meets UL746E Dir. Sup.	CTI Volts (PLC)	PWB Mfg. Proc.
	Individual Laminate Matl.				Individual Bonding Sheet Matl.								
	UL/ANSI Grade	Mfr. @	Grade	Min. Thk. (mils)	UL/ANSI Grade	Mfr. @	Grade	Min. Thk. (mils)					
M4	GPY	I	P96	2.0	GPY	I	P26	2.0	0.015	E: 0.67 I: 3.9	Yes	100 (4)	J
M4	GPY	V	VT-901	2.0	GPY	V	VT-901PP	2.0	0.015	E: 0.67 I: 3.9	Yes	100 (4)	J
M5	-	P	N4805-20-***	2.0	-	P	N4802-20-***	2.0	0.015	E: 0.35 I: 4.05	Yes	175 (3)	J
M6	FR-4.0	I	IS400, IS400HR, PCL-FR-254, PCL-FR-370HR, PCL-FR-370 Turbo, PCL-FR-250HR, 185HR	2.0	FR-4.0	I	IS400++, IS400HR++, PCL-FRP-254, PCL-FRP-370HR, PCL-FRP-370 Turbo, PCL-FRP-250HR, 185HR	2.0	0.015	E: 0.35 I: 5.35	Yes	175 (3)	J
M6	FR-4.0	N	N4105-11-**, N4105-29-**	2.0	FR-4.0	N	N4205-11-**, N4205-29-**	2.0	0.015	E: 0.67 I: 5.35	Yes	175 (3)	J
M6	FR-4.0	V	VT-47, VT-47TC, VT-481, VT-481TC, VT-575, VT-5A2, VT-585	2.0	FR-4.0	V	VT-47PP, VT-481PP, VT-575PP, VT-5A2PP, VT-585PP	2.0	0.015	E: 0.35 I: 5.35	Yes	175 (3)	J
M6	FR-4.0	I	FR406, FR406N, FR406BC, PCL-FR-370	2.0	FR-4.0	I	FR406++, FR406N++, PCL-FRP-370	2.0	0.015	E: 0.33 I: 4.02	Yes	175 (3)	J
M6	FR-4.0	I	FR408, FR408HR, IS415, IS811, I-Speed	2.0	FR-4.0	I	FR408++, FR408HR++, IS415++, IS811++, I-Speed	2.0	0.019	E: 0.33 I: 4.02	Yes	175 (3)	J
M6	FR-4.0	I	FR408HR	2.0	FR-4.0	I	FR408HR++	2.0	0.019	E: 0.33 I: 5.35	Yes	175 (3)	J
M6	FR-4.0	IT	IT-180ATC	2.0	FR-4.0	I	IT-18A0BS	2.0	0.015	E: 0.67 I: 5.35	Yes	175 (3)	J
M6	FR-4.0	8.5N Y	NP-155FR, NP-155FTL, NP-175FR, NP-175FTL, NP-180FR, NP-180FTL	2.0	FR-4.0	V	VT-47PP, VT-481PP, VT-575PP, VT-5A2PP, VT-585PP	2.0	0.015	E: 0.67 I: 4.02	Yes	175 (3)	J

‡ - Recognized Component, (QMTS2)

- I: Maximum internal thickness, E: Minimum external thickness

+ - RO: Rogers [E102763]; I: Isola (E41625); V: Ventec (E214381); P: Park (E36295); V: Ventec (E214381); IT: ITEQ (E178114); NY: Nan Ya (E98983)

TABLE II - BASE MATERIALS

Type	Base Material [†]								Total Build-Up Thk. (in.)	Conductor Thk.# (mils)	Meets UL746 E Dir. Sup.	CTI Volts (PLC)	PWB Mfg. Proc.
	Individual Laminate Matl.				Individual Bonding Sheet Matl.								
	UL/ANSI Grade	Mfr. @	Grade	Min. Thk. (mils)	UL/ANSI Grade	Mfr. @	Grade	Min. Thk. (mils)					
*M7	-	RO	RO4350B, RO4535	4.0	-	RO	RO4450B, RO4450F	3.54	0.027	E: 0.65 I: 2.6	Yes	600 (0)	J
*M7	FR-4.0	I	IS400, IS400HR , PCL-FR-254, PCL-FR-370HR, PCL-FR-370 Turbo, PCL-FR-250HR, 185HR	2.0	FR-4.0	I	IS400++, IS400HR++ , PCL-FRP-254, PCL-FRP-370HR, PCL-FRP-370 Turbo, PCL-FRP-250HR, 185HR	2.0	0.027	E: 0.65 I: 2.6	Yes	175 (3)	J
*M7	-	RO	RO4350B, RO4535	4.0	-	RO	RO4450B, RO4450F	3.54	0.027	E: 0.65 I: 2.6	Yes	175 (3)	J
	FR-4.0	I	IS400, IS400HR , PCL-FR-254, PCL-FR-370HR, PCL-FR-370 Turbo, PCL-FR-250HR, 185HR	2.0	FR-4.0	I	IS400++, IS400HR++ , PCL-FRP-254, PCL-FRP-370HR, PCL-FRP-370 Turbo, PCL-FRP-250HR, 185HR	2.0					

& - Recognized Component, (QMTS2)
 # - I: Maximum internal thickness, E: Minimum external thickness
 + - RO: Rogers [E102763]; I: Isola (E41625)

TABLE II - BASE MATERIALS

Type	Base Material [‡]								Total Build -Up Thk. (in.)	Conductor Thk.# (mils)	Meets UL746E Dir. Sup.	CTI Volts (PLC)	PWB Mfg. Proc.
	Individual Laminate Matl.				Individual Bonding Sheet Matl.								
	UL/ANSI Grade	Mfr. @	Grade	Min. Thk. (mils)	UL/ANSI Grade	Mfr. @	Grade	Min. Thk. (mils)					
M7-1	-	RO	RO4350B, RO4535	4.0	-	RO	RO4450B, RO4450F	3.54	0.027	E: 0.65 I: 2.6	Yes	600 (0)	J
M7-1	FR-4.0	I	IS400, IS400HR++, PCL-FR-254, PCL-FR-370HR, PCL-FR-370 Turbo, PCL-FR-250HR, 185HR	2.0	FR-4.0	I	IS400++, IS400HR++, PCL-FRP-254, PCL-FRP-370HR, PCL-FRP-370 Turbo, PCL-FRP-250HR, 185HR	2.0	0.027	E: 0.65 I: 2.6	Yes	175 (3)	J
M7-1	-	RO	RO4350B, RO4535	4.0	-	RO	RO4450B, RO4450F	3.54	0.027	E: 0.65 I: 2.6	Yes	175 (3)	J
	FR-4.0	I	IS400, IS400HR, PCL-FR-254, PCL-FR-370HR, PCL-FR-370 Turbo, PCL-FR-250HR, 185HR	2.0	FR-4.0	I	IS400++, PIS400HR++, PCL-FRP-254, PCL-FRP-370HR, PCL-FRP-370 Turbo, PCL-FRP-250HR, 185HR	2.0					
M8	FR-4.1	NY	NPG-R, NPG-170R, NPG-TL, NPG-170TL, NPG-170DR, NPG-170DTL, NPG-170INR, NPG-170INTL, NPG-150DR, NPG-150DTL, NPG-170, NPG-151, NPG-171, NPGN-150LKHD, NPG-150N, NPG-170N	2.0	FR-4.0	V	VT-47PP, VT-481PP, VT-575PP, VT-5A2PP, VT-585PP	2.0	0.015	E: 0.33 I: 4.02	Yes	3	J

& - Recognized Component, (QMTS2)

- I: Maximum internal thickness, E: Minimum external thickness

+ - RO: Rogers [E102763]; I: Isola (E41625); Nan Ya [E98983]; V: Ventec [E214381]

MANUFACTURING PROCESS:

1. Machining, cleaning, rinsing, air-drying and similar operations may be performed by the manufacturer, but are not listed in the following process description(s).
2. If not listed below, temperatures exceeding 100°C (212°F) or the maximum operating temperature of the type, whichever is greater, shall not be used in the following process description(s).
3. Any of the steps in the following process description may be omitted from the manufacturing process at the manufacturer's option, unless the process step is noted as a MUST step.
4. There shall be no changes, additions or substitutions by the manufacturer to the manufacturing process, as listed in the following process description(s), without prior written clearance from UL LLC.
5. Critical steps (including, but not limited to, process steps with temperatures over 100°C or MOT, whichever is greater) can be performed by an outside facility indicated in the Section General, if footnoted in the following process descriptions(s). Documentation is to be provided by the original manufacturing location to the subcontractor (see Appendix D for the service/work (traveler) instructions). This documentation is to be returned with the finished boards only to the original manufacturer.
6. Non-critical steps (including, but not limited to, process steps with temperatures below 100°C or MOT) may be performed by any outside facility. Documentation is to be provided by the original manufacturing location to the subcontractor (see Appendix D for the service/work (traveler) instructions). This documentation is to be returned with the finished boards only to the original manufacturer.
7. For any process steps in the following process description(s) performed at an alternate manufacturing location (as described in the Authorization Page or Supplement), documentation is to be provided by the original manufacturing location to the alternate manufacturer (see Appendix D for the service/work (traveler) instructions). This documentation is to be returned to the original manufacturer.

PROCESS:

See next page.

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This page replaces Page 10 through 24.

Multilayer PROCESS J

Step	Description
1.	May clean inner layers.
2.	May coat with dry film photo resist, expose, and develop inner layers.
3.	May etch inner layers in any enchant except chromic sulfuric.
4.	May oxide-bake at 250°F maximum for 90 minutes maximum.
5.	May laminate layers at 450 F maximum for 4.5 hours maximum at 400lb./in. ² maximum. (May perform lamination cycle 5 times maximum). For Types 21 and 22, an alternate lamination process is used - May laminate layers at 370°F maximum for 180 minutes maximum at 350 lb./in. ² maximum. (May perform lamination cycle 5 times maximum).
6.	May post bake at 450°F maximum for 6 hours maximum.
7.	May drill boards.
8.	May bake prior to plasma operation at 250°F maximum for 30 minutes maximum and then may plasma desmear or etch back with temp of 212°F maximum for 3 hours maximum.
9.	May print/coat plating resist.
10.	May plate any of the following metals:
A.	Electroless copper, Electrolytic copper, solder, tin/nickel, nickel, hard gold, soft gold, immersion white tin.
B.	Electroless Nickel, Electroless palladium, Immersion Gold (ENEPIG)
C.	Electroless nickel/Immersion gold (ENIG)
D.	Immersion silver
Note:	May bake at 300°F maximum for 2 hours maximum after the metal plating.
11.	May plug holes with either conductive material which must always be encapsulated in copper or non-conductive hole plugging materials listed in the table on the following page. Boards may then be baked at 325°F maximum for 90 minutes maximum after hole plugging operation. When holes are plugged with material not detailed in the Hole-Plugging Material table the holes MUST be capped with Cu plating in step 12 to fully encapsulate the plugged hole.
12.	May apply electroless Cu and flash plate to cap plugged holes.
13.	May etch in any enchant except chromic sulfuric.
14.	May be coated in any solder resists. 94V-rated types maybe coated with the resist indicated in the following pages. Boards then are dried at 180°F maximum for 1 hour maximum then cured at 325°F maximum for 90 minutes maximum
*15.	Non-flame and HB rated boards may be coated with any solder resist. V rated boards may be coated with the solder resist materials listed in the table on the following pages. Boards may then be dried at 180°F maximum for 1 hour maximum then cured at 325°F maximum for 90 minutes maximum.

Step	Description
*16.	May add legend marking to be cured at 325°F maximum for 90 minutes maximum.
*17.	May plate contact fingers on any part of the board with nickel, and/or palladium, and/or gold. Then may bake after nickel, palladium, gold plating operation with a temp of 300°F maximum for 60 minutes maximum.
*18.	May bake prior to surface finish at 325°F maximum for 6 hours maximum.
17.	May hot air level with solder at 518°F maximum for 15 seconds maximum.
	OR
*18A.	May hot air level with Lead Free solder at 572°F maximum, for 15 seconds maximum.
*19.	No other plating operations performed and no other temperatures over 212°F or the maximum operating temperature of the board, whichever is greater, are encountered.

SOLDER RESISTS

Types	Process	Solder Resists [®]
M2	J	1, 3, 4, 5
M3	J	3, 4, 6
M3-1	J	1, 3, 4, 5
M4	J	1, 2, 7
M5	J	1, 3, 4, 5
M6	J	1, 3, 4, 5
M7	J	1, 3, 4, 5
M7-1	J	1, 5
M8	J	1, 4

HOLE PLUGGING/SOLDER RESIST COMBINATIONS

Types	Process	Hole Plugging Material and Solder Resist [®]
M2	J	Not Recognized for use with coating combinations
M3	J	A/-, A/1, A/3, B/-, B/1, B/3
M3-1	J	Not Recognized for use with coating combinations
M4	J	Not Recognized for use with coating combinations
M5	J	A/-, A/1, A/3, A/4, B/-, B/1
M6	J	B, B/1
M7	J	B/1
M7-1	J	B/1, A/-, A/1
M8	J	Not Recognized for use with coating combinations

@ - Solder Resist and Hole Plugging Grades (Recognized Component, QMJU2):

No.	Hole Plugging Material		
	Manufacturer	Grade	File Number
A.	San-Ei	PHP-900 IR-6P or PHP-900 IR-6PW	E70678
B.	Taiyo America	PSR-4000BN/CA-40BN or PSR-4000HG/CA-40HG	E166421

No.	Solder Resist		
	Manufacturer	Grade	File Number
1.	Taiyo America	PSR-4000BN/CA-40BN or PSR-4000HG/CA-40HG	E166421
2.	Taiyo Ink	PSR-4000BN/CA-40BN	E69262
3.	Taiyo America	PSR-4000MP/CA-40MP	E166421
4.	Taiyo America	PSR-4000JA/CA-40JA	E166421
5.	Sierra Circuits	LDI 100/20@	E70742 (QMJU3)
6.	San-Ei	PHP-900 IR-6P or PHP-900 IR-6PW	E70678
7.	Taiyo Ink	PSR-4000BN/CA-40BN	E69262

@ - LDI 100/20 is mixed from a 100:20 custom blend of Taiyo (E166421) PSR-4000JA/CA-40JA (GN) and PSR-4000MP/CA-40MP (GN) only.

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