PBLE01

Co-projeto de produtos eletrônicos

Manual

Grupo 3

Rev 1 - Nov/2022

Sumário

Identificação

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Data:

18/11/22

1 Introdução

Este documento tem o intuito de apresentar como foi o desenvolvimento de uma placa de circuito impresso controlada por um microcontrolador. Para o desenvolvimento do esquema elétrico e placa de circuito impresso foi utilizado o Kicad na versão 6.0 e o desenvolvimento do embarcado de validação foi feito em linguagem C. O documento possui instruções de compreensão e desenvolvimento do esquema elétrico, placa de circuito impresso e embarcado de validação para qualquer usuário que faça sua leitura.

2 Requisitos

Tabela 1: Requisitos técnicos do esquema elétrico

Requisitos	Descrição
Alimentação	1 – Suportar tensão de entrada de 7 a 10V (CC); 2 – Empregar conector de alimentação do tipo jack J4; 3 – Possuir proteção contra tensão reversa; 4 – Possuir regulador linear com saída de 5V; 5 – Possuir regulador linear com saída de 3.3V; 6 – Possuir led de indicação de tensão de alimentação.
Operação e atualização do embarcado	1 – Empregar microcontrolador da família LCP1114; 2 – Possuir barra de pinos para gravação no padrão JTAG; 3 – Possuir circuito baseado “jumper” para permitir a gravação serial através de transceptor USB-serial; 4 – Chave táctil de reinício.
Interação com o usuário	1 – Possuir teclado numérico de cinco (5) teclas com disposição de controle (botões direcionais e de confirmação); 2 – Possuir barra de pinos de conexão para visor LCD externo de 16x2 (modo de comunicação de 4 pinos); 3 – Possuir quatro (4) leds para sinalização diversa.
Periféricos e expansão	1 – Empregar relógio de tempo real; 2 – Empregar conversor digital para analógico; 3 – Possuir entrada para sinal analógico diferencial; 4 – Possuir duas barras de expansão independentes cada qual com sinais de comunicação I²C, de referência e de alimentação; 5 – Possuir barra de expansão de sinais para pinos não utilizados do microcontrolador e a contemplar os sinais de alimentação.
Comunicação	1 – Empregar conversor USB–serial.

3 Ambiente de desenvolvimento

Tabela 2: Recursos de desenvolvimento

Recurso	Descrição	Versão
1	Kicad	6.0
2	MPLAB X IDE	6.05
3	PICSimLab	0.8.12_221106

4 Esquema elétrico

Neste tópico, serão abordados os subcircuitos presentes no esquema elétrico do circuito, que neste caso são: alimentação, operação e atualização do embarcado, interação com o usuário, comunicação, periférico e expansão.

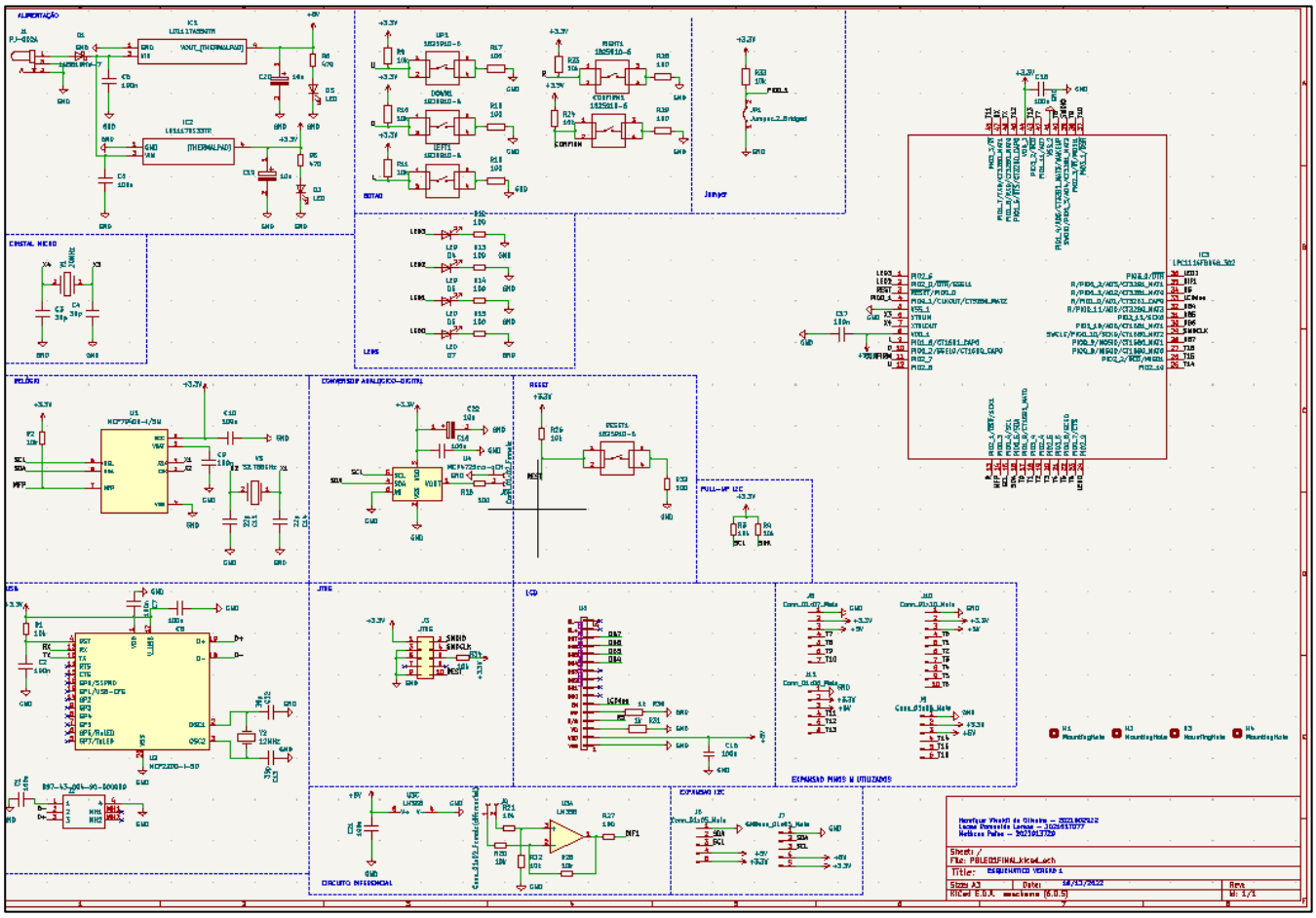


Figura 1: Esquema elétrico completo

4.1 Microcontrolador

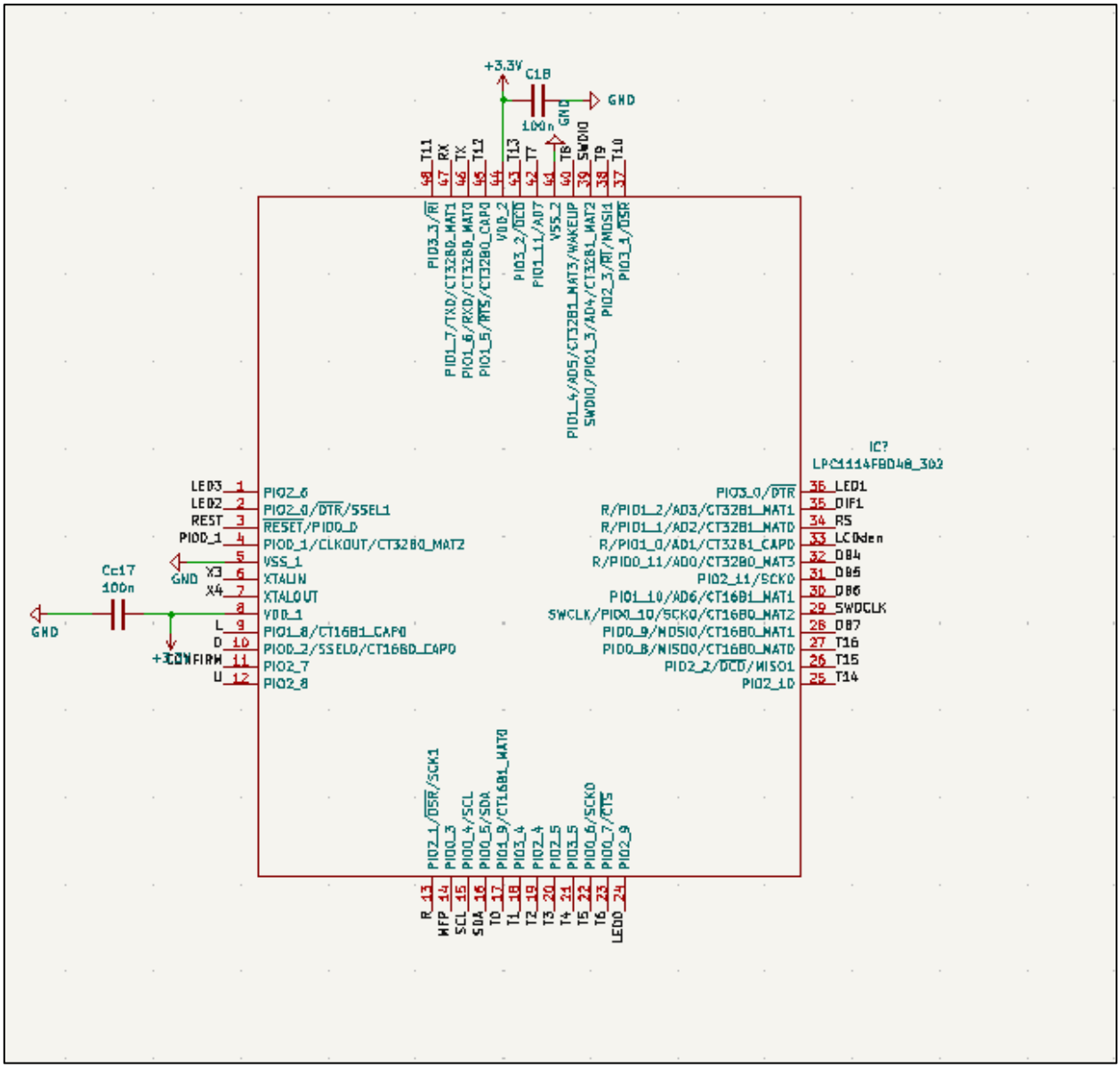


Figura 2: Microcontrolador

4.2 Circuito de alimentação

Para este projeto foram utilizados dois reguladores de tensão, sendo um regulador de 3.3V - LD1117AS33TR e um de 5V - LD1117AS50TR. Espera -se que o circuito opere com tensões entre 7 e 10 V.

Além disso, foi utilizado um diodo retificador- 1N5819HW–7 com o intuito de evitar corrente reversa no circuito. Além do mais, foram utilizados LEDs para indicar o funcionamento dos reguladores de tensão.

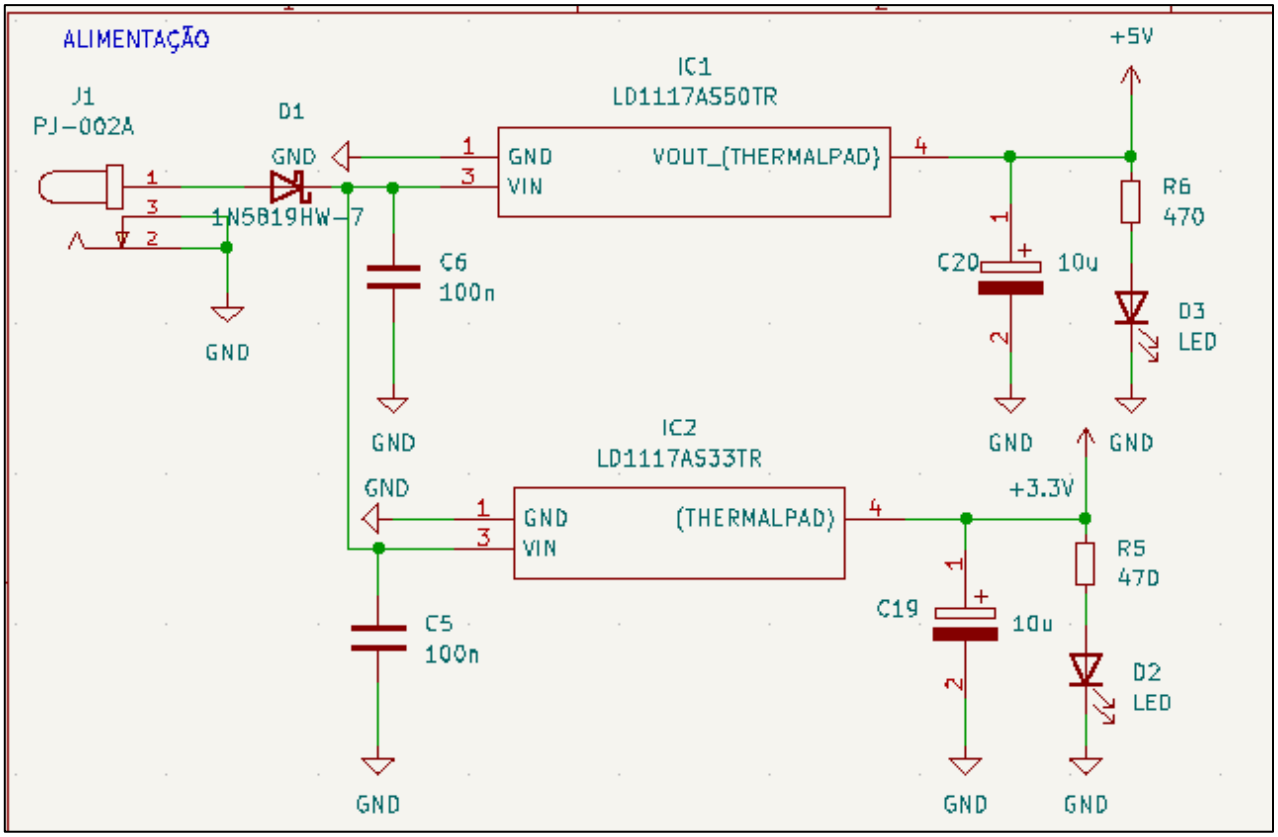


Figura 3: Circuito de alimentação

4.3 Circuito de operação e atualização do embarcado

No subcircuito de operação e atualização do embarcado, está presente o microcontrolador que já foi apresentado anteriormente, um jumper com o intuito de permitir a gravação serial através do transceptor USB-Serial, uma barra de pinos para gravação no estilo JTAG e um botão de reinício do microcontrolador.

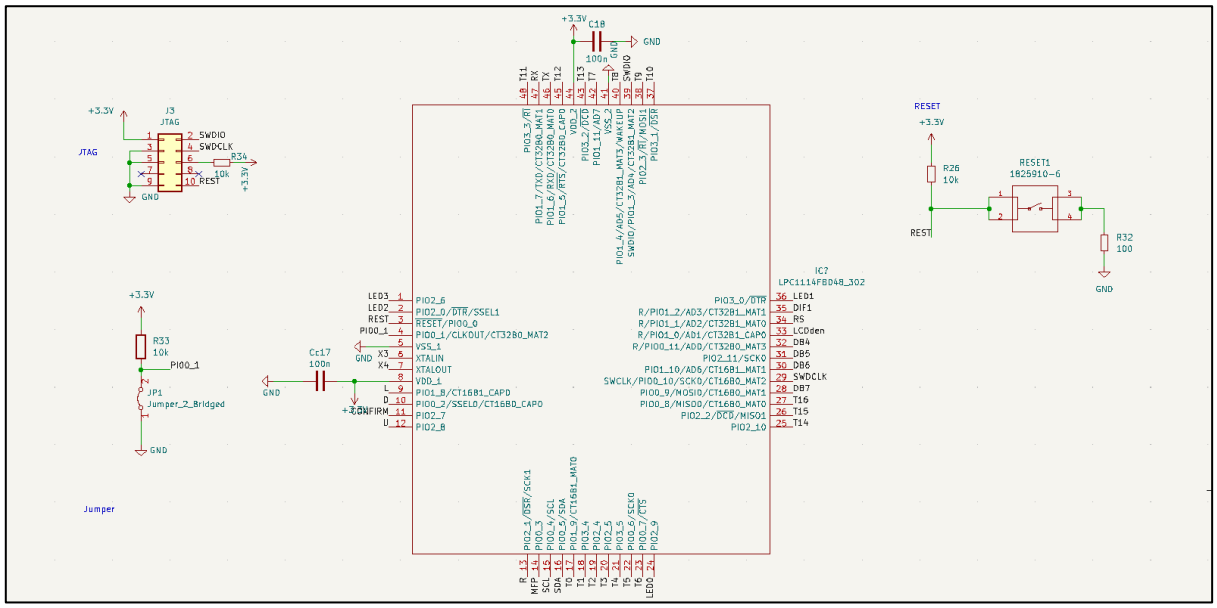


Figura 4: Operação e atualização do embarcado

4.3.1 Circuito Jumper

O circuito jumper apresentado, tem por objetivo permitir a gravação serial através do transceptor USB-Serial.

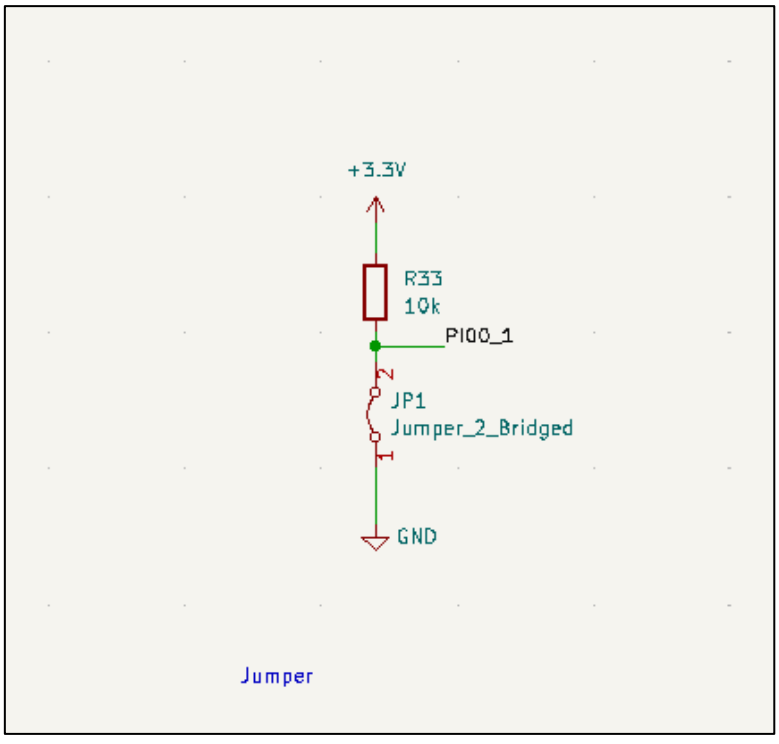


Figura 5: Circuito jumper

4.3.2 Barra de pinos padrão JTAG

Barra de pinos no padrão JTAG para programação do microcontrolador.

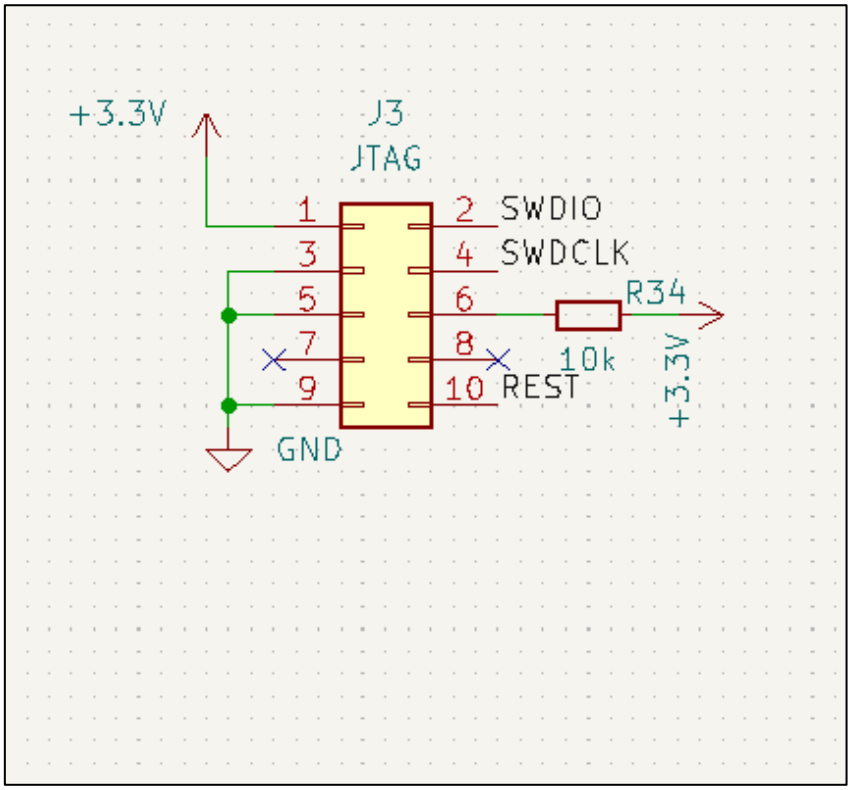


Figura 6: Pinos para JTAG

4.3.3 Circuito de reinício do microcontrolador.

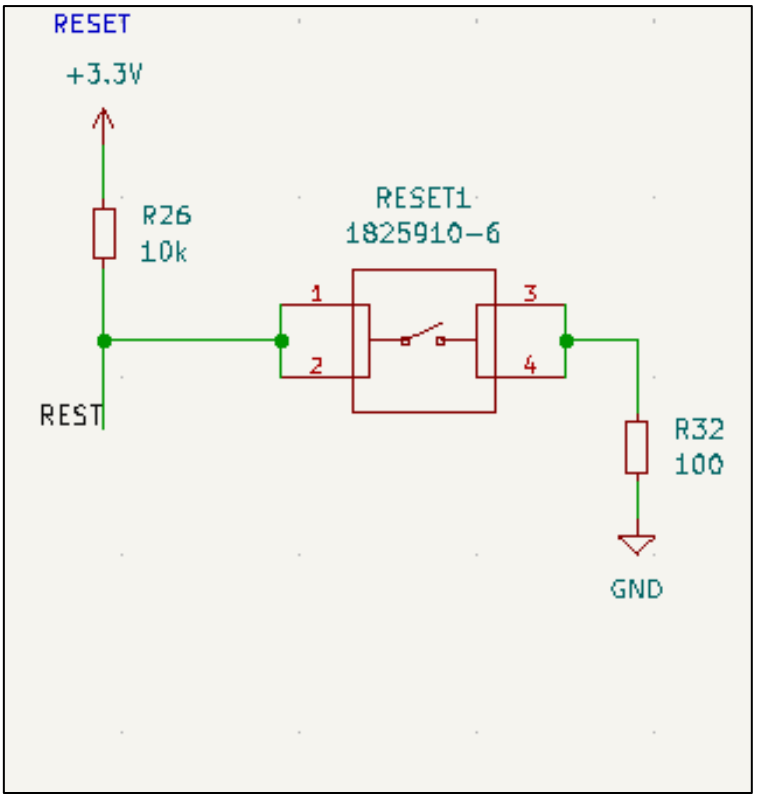


Figura 7: Reset do microcontrolador

4.4 Circuito de interação com o usuário

O circuito de interação com o usuário estão presentes 5 botões que estão conectados no microcontrolador, 4 leds para sinalização a serem definidas e o LCD- JHD162A com 4 pinos de interação.

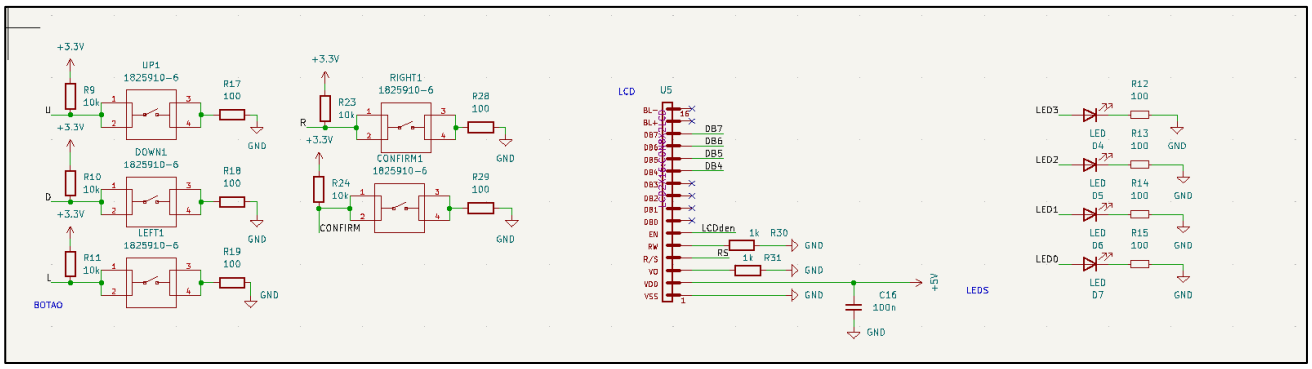


Figura 8: Interação com o usuário

4.4.1 Circuito de botões

Esse circuito apresenta um teclado analógico com 5 botões para ocorrer a interação entre o usuário e o microcontrolador.

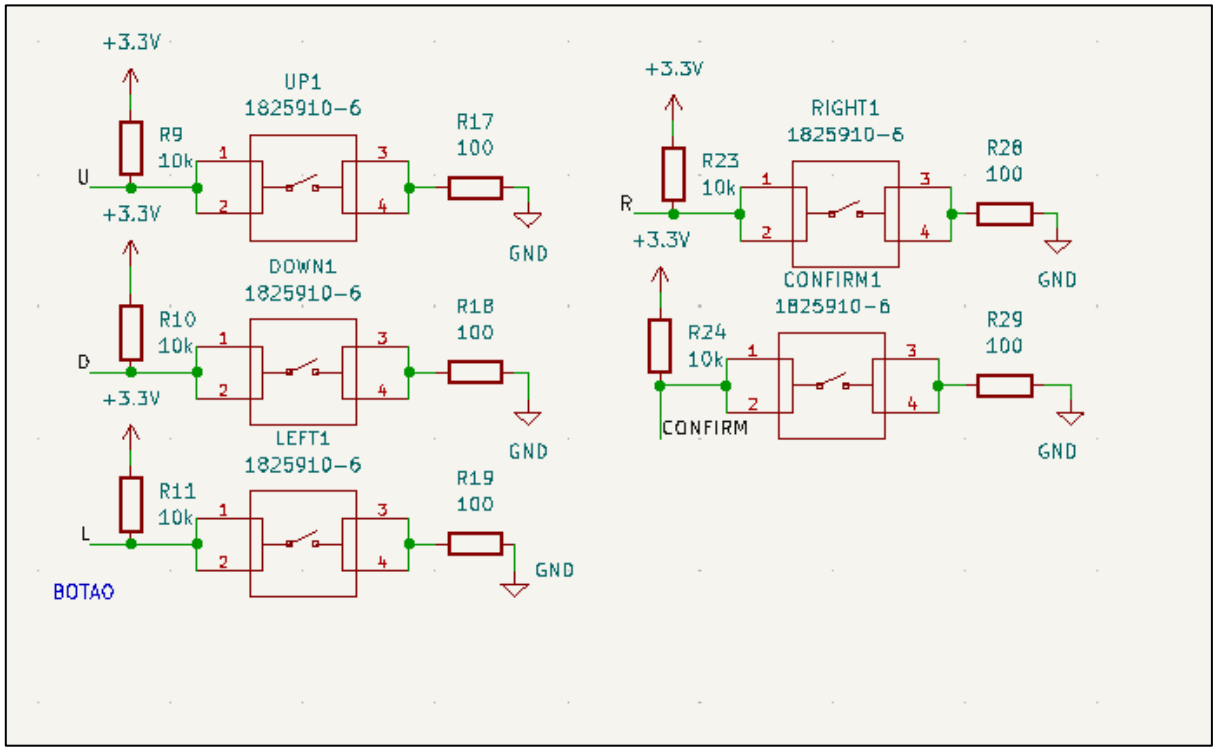


Figura 9: Botões de interação

4.4.2 Circuito de LEDs

Circuito que apresenta 4 leds que devem ser programados e ligados ao microcontrolador.

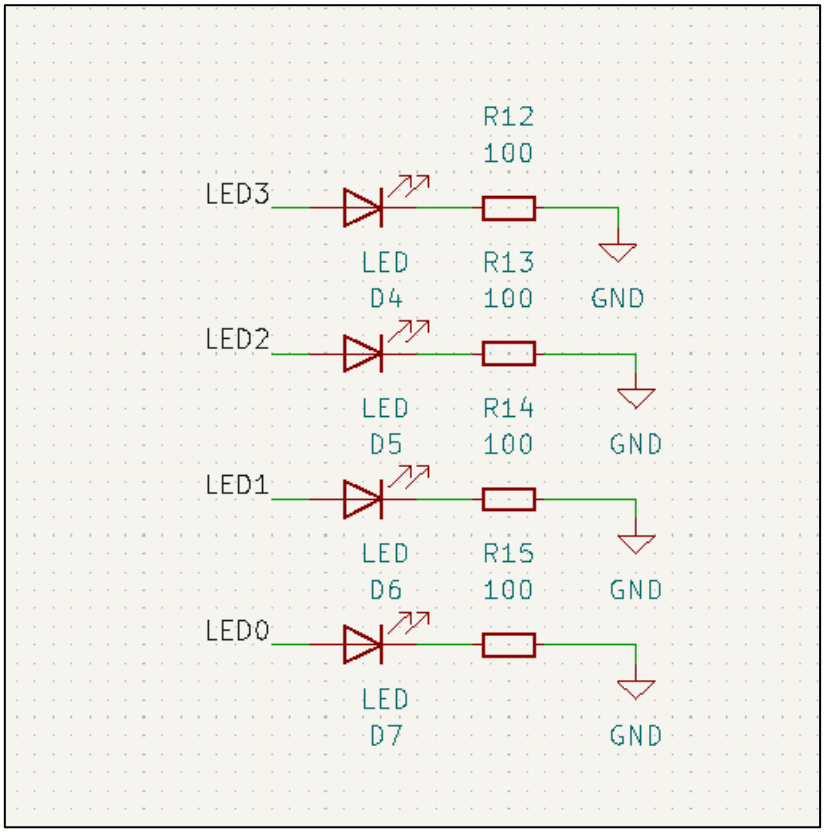


Figura 10: LEDs para sinalização diversa

4.4.3 Circuito do LCD

No circuito LCD, foram utilizados apenas 4 bits para programação, afim de facilitar a montagem da PCI da placa e a programação.

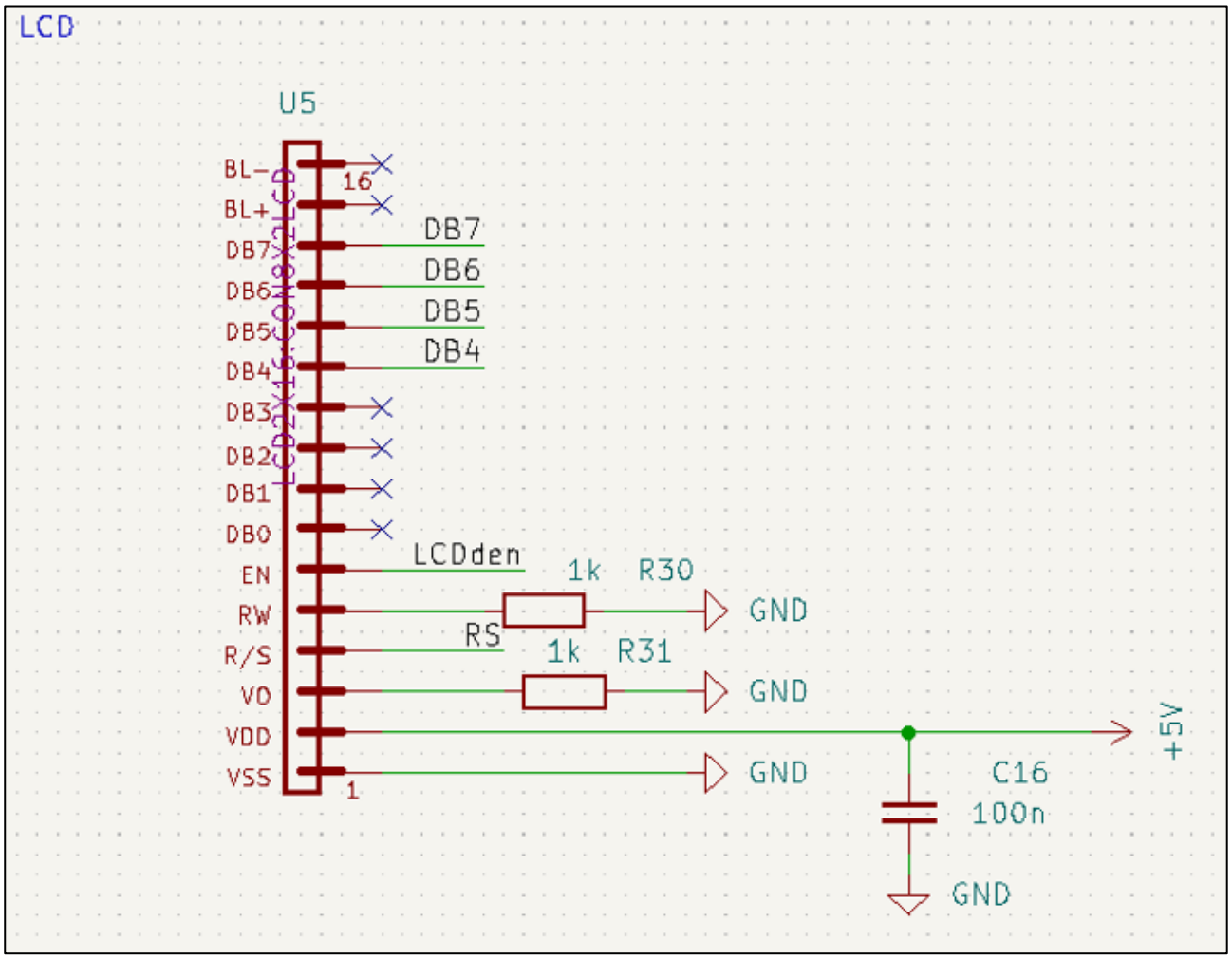


Figura 11: Circuito do LCD

4.5 Circuito de comunicação

O circuito de comunicação da placa utiliza um USB tipo B e um conversor USB serial para fazer a comunicação do mesmo.

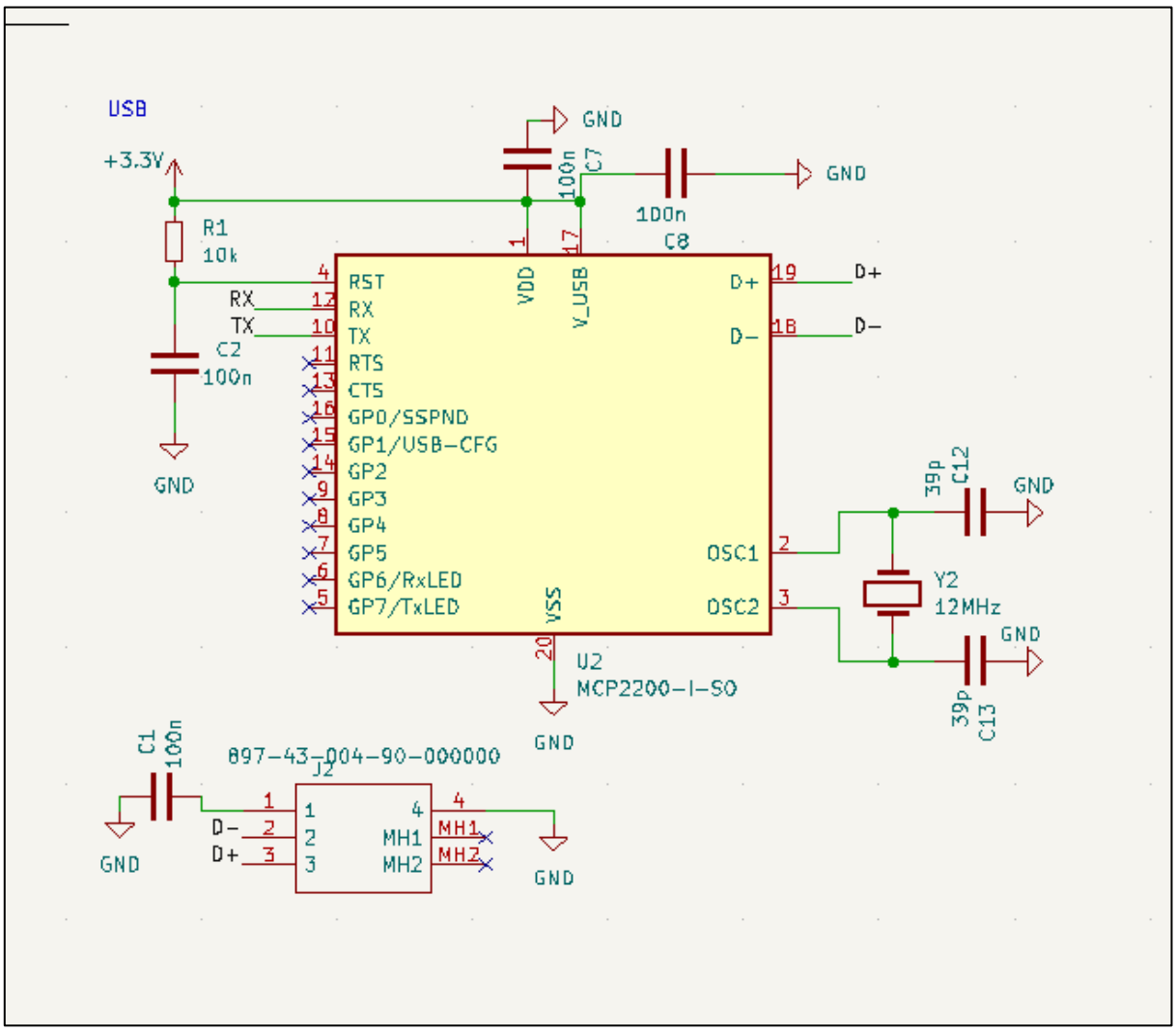


Figura 12: Circuito de comunicação USB

4.6 Circuito de periféricos e expansão

O circuito de periféricos e expansão possui relógio de tempo real, conversor digital para analógico, entrada para sinal analógico diferencial, duas barras de expansão independentes cada qual com sinais de comunicação I²C, barra de expansão de sinais para pinos não utilizados do microcontrolador e a contemplar os sinais de alimentação.

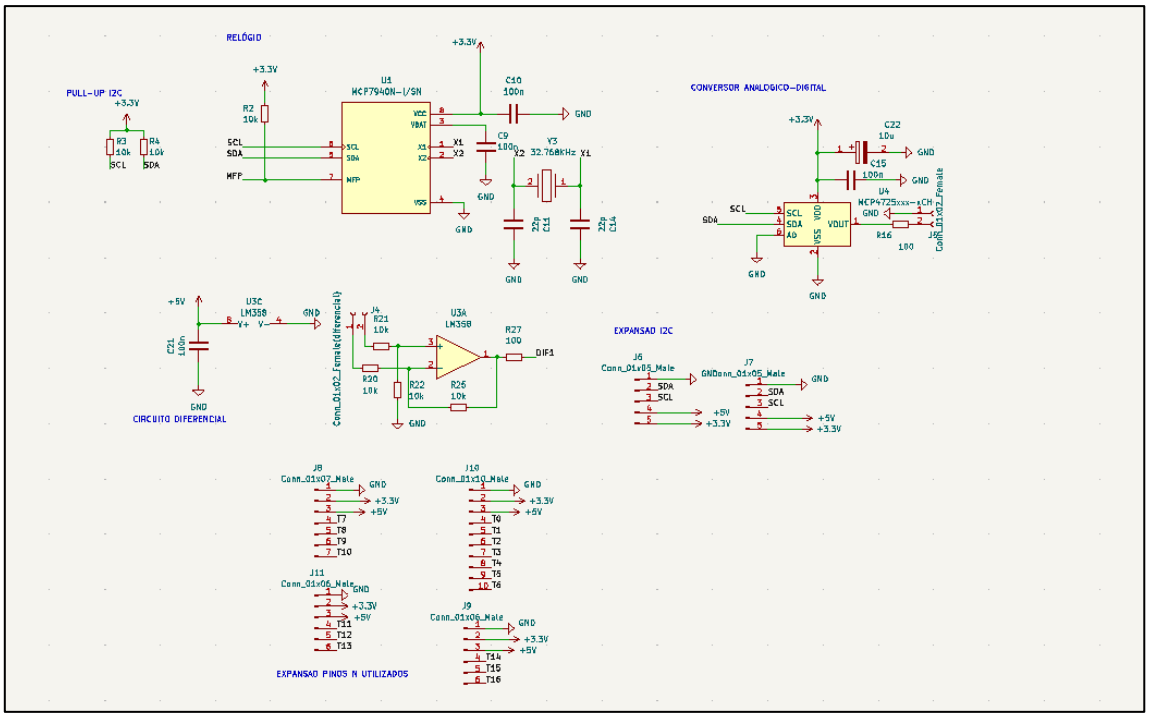


Figura 13: Periféricos e pinos de expansão

4.6.1 Circuito relógio

Circuito com objetivo de mostrar as horas em tempo real ao ser conectado e programado junto ao microcontrolador.

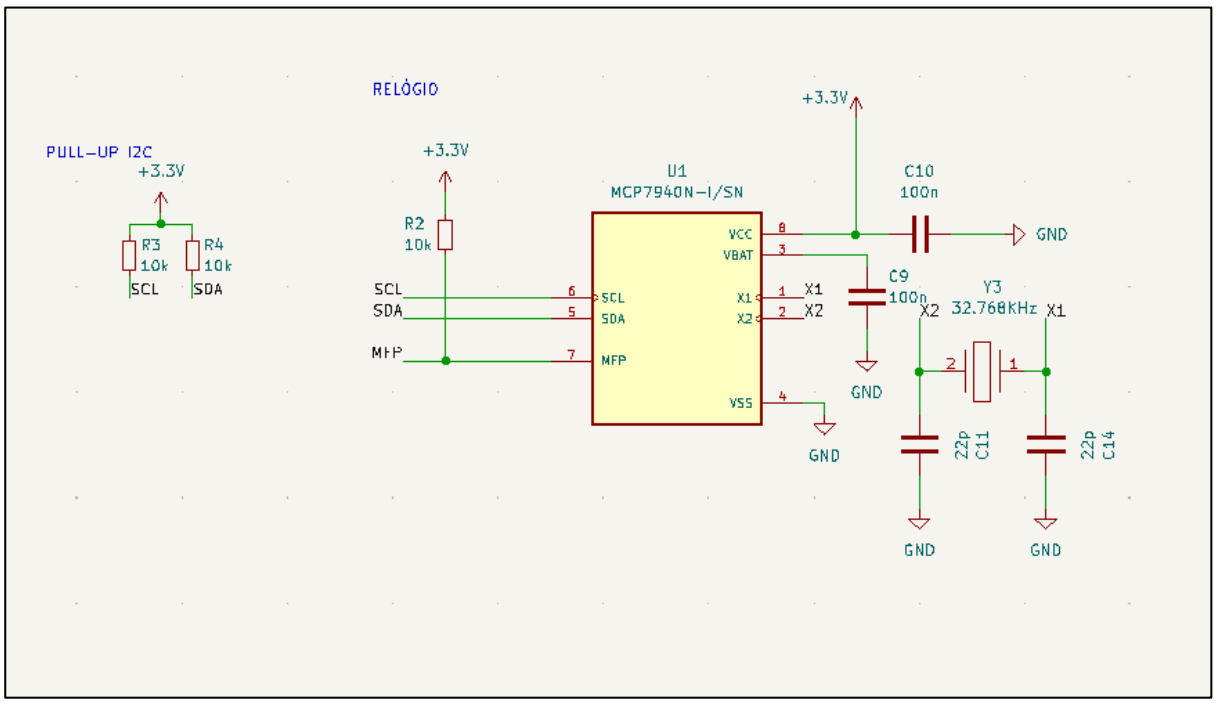


Figura 14: Circuito do relógio

4.6.2 Circuito conversor analógico-digital

O conversor digital analógico pode fazer com que seja implementado a placa periféricos externos não premeditados, para seu funcionamento o modulo I²C necessita um pull up do canal de comunicação e que este seja mantido em nível lógico alto fora dos momentos em que o I²C solicita uma resposta de seus subordinados.

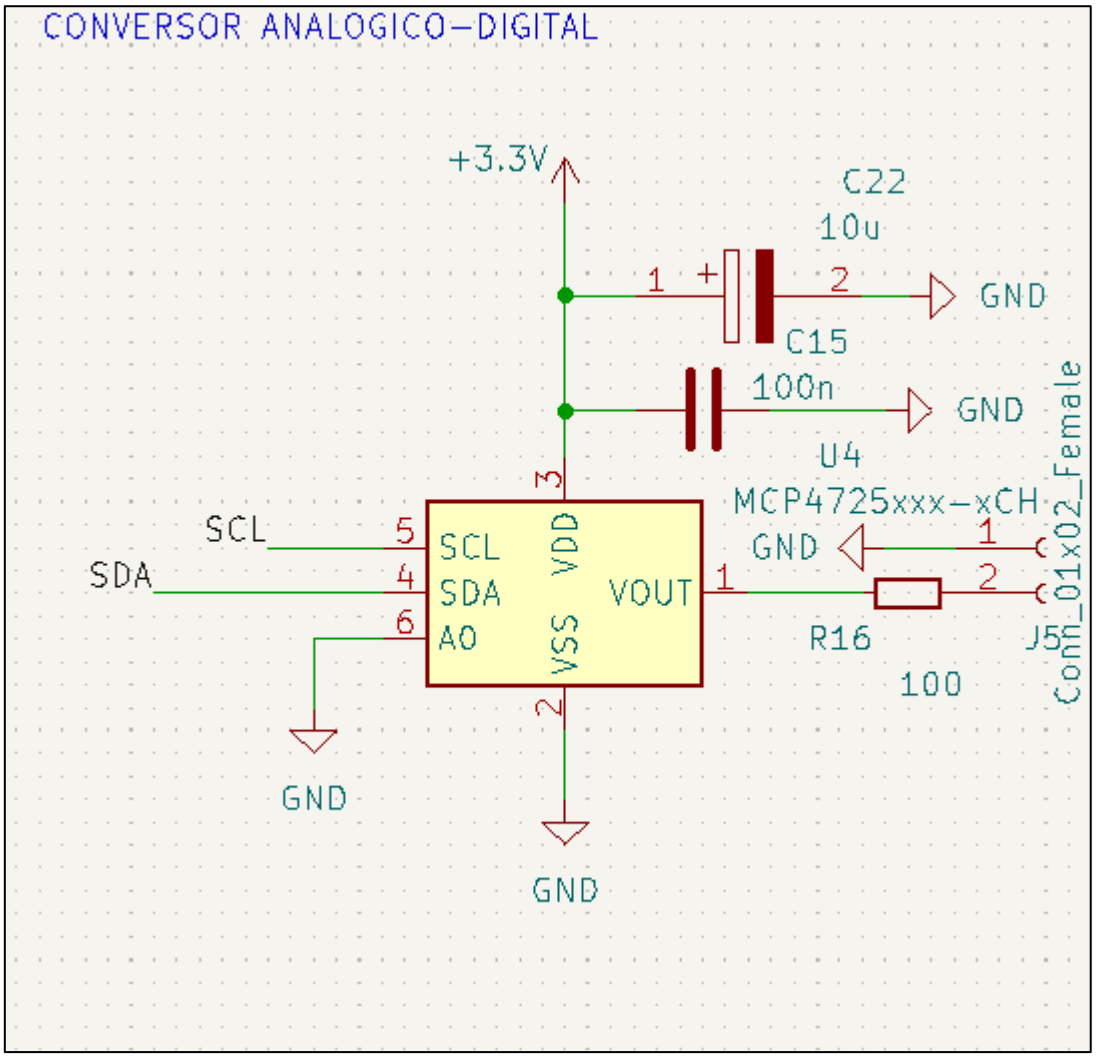


Figura 15: Circuito do conversor analógico-digital

4.6.3 Circuito com barras de expansão I²C

Circuito que possui duas barras de expansão que estão ligadas à terra e duas fontes de tensão (3.3 V e 5V), tem por objetivos colocar mais dispositivos periféricos ao circuito.

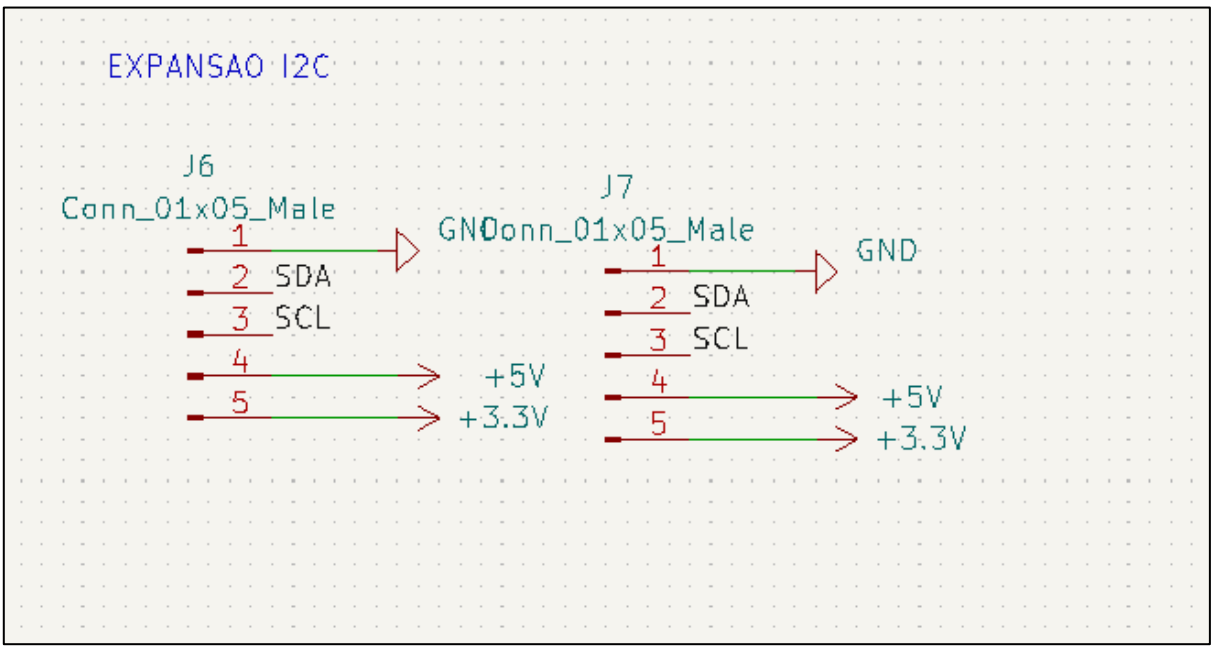


Figura 16: Circuito das barras de expansão I²C

4.6.4 Circuito de barras de expansão de pinos

Circuito que contém barra de expansão para os pinos não utilizados do microcontrolador.

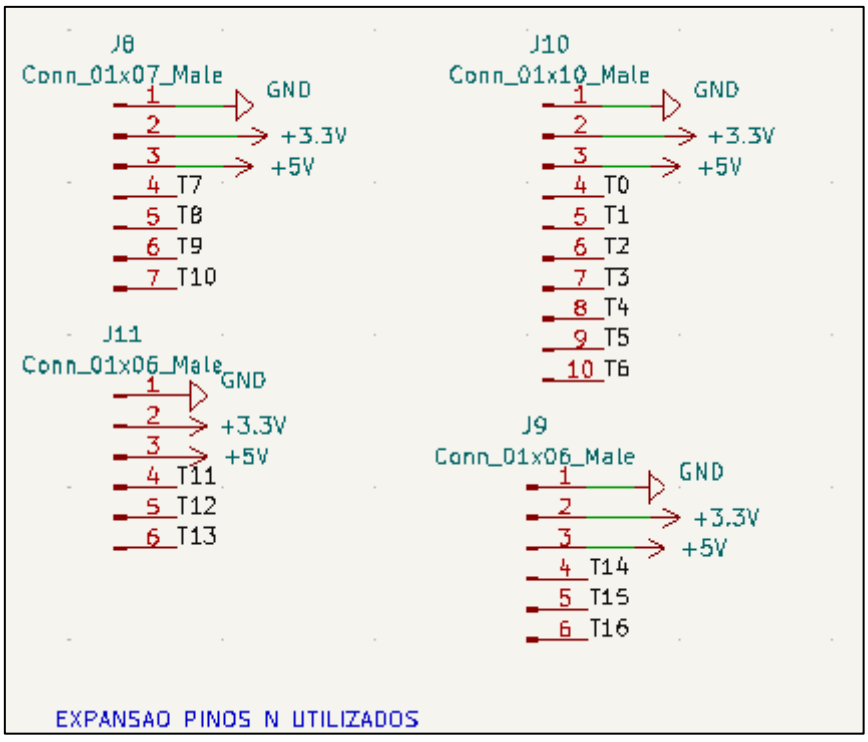


Figura 17: Circuito de barras de expansão de pinos não utilizados

4.6.5 Circuito com entrada diferencial

Circuito que utiliza um amplificador operacional e projetado para que sua saída saia entre 0 e 3.3V.

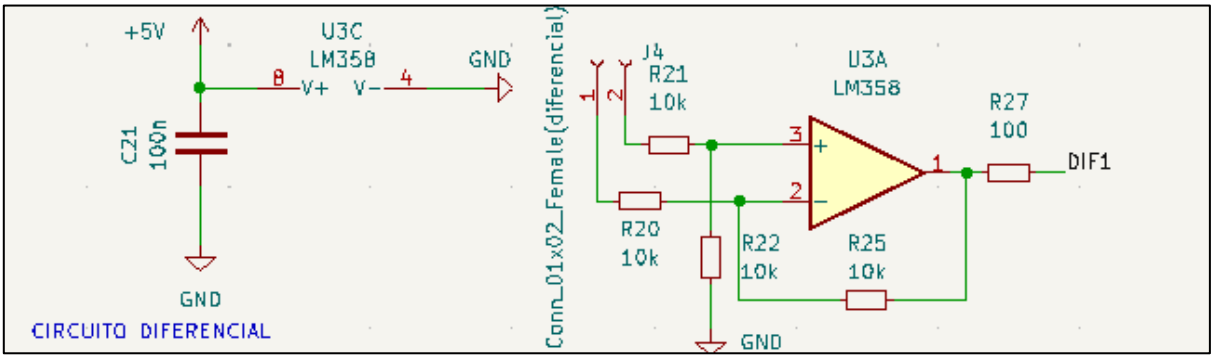


Figura 18: Circuito de entrada diferencial com amplificador operacional

4.7 Relatório de verificação de erros de projeto elétrico

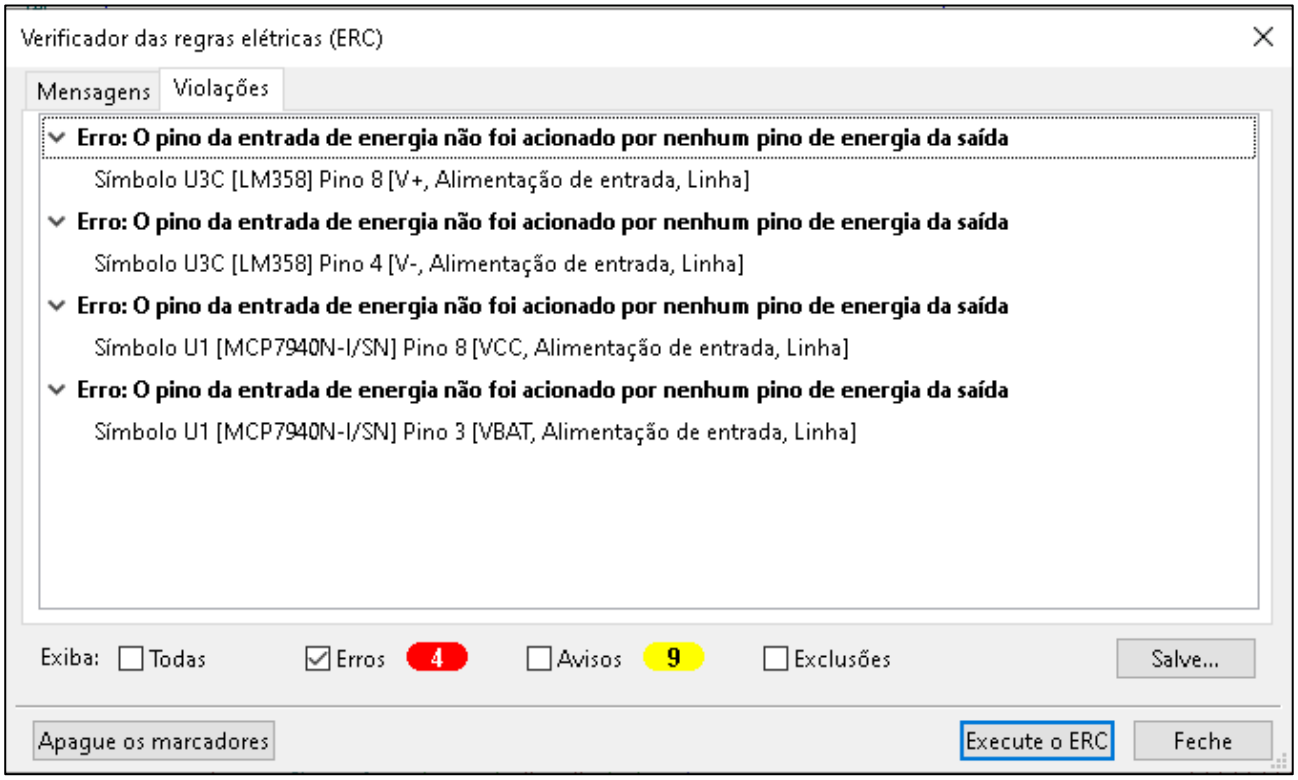


Figura 19: Relatório de erros ERC

5 Placa de circuito impresso

A placa de circuito impresso foi desenvolvida de forma a contemplar todos requisitos mínimos estabelecidos e facilitar a montagem e soldagem dos componentes na placa física. Além disso teve-se o intuito de facilitar a utilização do usuário posicionando qualquer tipo de interação física nas extremidades da placa.

Tabela 3: Requisitos técnicos da placa de circuito impresso

Requisitos	Descrição
Característica gerais da PCI	1 – Ter dimensões de até 7 x 7 cm2; 2 – Possuir dupla face de condução; 3 – Utilizar a face inferior como plano de terra; 4 – Possuir identificação dos componentes; 5 – Possuir identificação do grupo de desenvolvimento; 6 – Possuir identificação do pino de referência para conectores de programação e de alimentação; 7 – Possuir identificação de pinos para demais conectores; 8 – Possuir quadro furos de fixação dispostos nos cantos; 9 – Possuir capacitores de supressão de tensão para todos os circuitos integrados.
Espaçamento e dimensões de trilhas	1 – Mínima largura para trilhas de sinais: 8 mils; 2 – Mínima largura para trilhas de alimentação: 12 mils; 3 – Mínimo espaçamento entre trilhas, furos e ilhas: 8 mils; 4 – Mínimo diâmetro de furo de vias: 12 mils; 5 – Mínimo diâmetro de ilhas de vias: 25 mils; 6 – Não utilizar microvias.

Tabela 4: Identificação dos componentes disponibilizados

Item	Modelo	Fabricante
Processador	LPC1114FBD48/302	NXP
Relógio de tempo real	MCP7940N-I/SN	Microchip
Transceptor USB-serial	MCP2200-I/SO	Microchip
Conversor digital para analógico	MCP4725A0T-E/CH	Microchip
Resistores diversos (100, 470, 1k, 4k7, 10k, 100k e 1M)	SMD 0805	-
Capacitores cerâmicos (22 e 39 pF, 10nF, 100nF e 220 nF)	SMD 0805	-
Capacitores (regulador de tensão)	710-865090368008	Wurth Elektronik
Trimpot de 10k	P160KN-0QC15B100K	TT Eletronics
Trimmer de 10k	3296W-1-103RLF	Bourns Inc.
Barra de pinos	PPTC101LFBN-RC	Sullins Connector Solutions
Conector de energia	PJ-002ª	CUI Devices
Diodos emissores de luz	LTST-C150GKT	Lite On
Amplificador operacional	LM358DR/LM358DG	On Semi
Conector USB	897-43-004-90-000000	Mil-Max
Chaves tácteis	1825910-6	TE Connectivity
Reguladores de tensão	LD1117AS33TR (3.3V) e LD1117AS50TR (5.0V)	STMicroeletronics
Cristal de 32.768 kHz	AB38T-32.768KHZ	ABRACON
Cristal de 20 MHz	ATS20A	CTS Electronic Components
Cristal de 12 MHz	ATS12A	CTS Electronic Components
Conector para entradas diferenciais	OSTTA024163	On Shore Technology Inc.
Conector para barra de expansão	3-644456-2	TE Connectivity
Diodo retificador	1N5819HW-7	Diodes Incorporated
Visor de 16x2 pontos	JHD162A	-
Conector JTAG (SWD)	70246-1002	Molex

5.1 Desenho da placa de circuito impresso

5.1.1 Visualização da placa de circuito impresso no Kicad 6.0

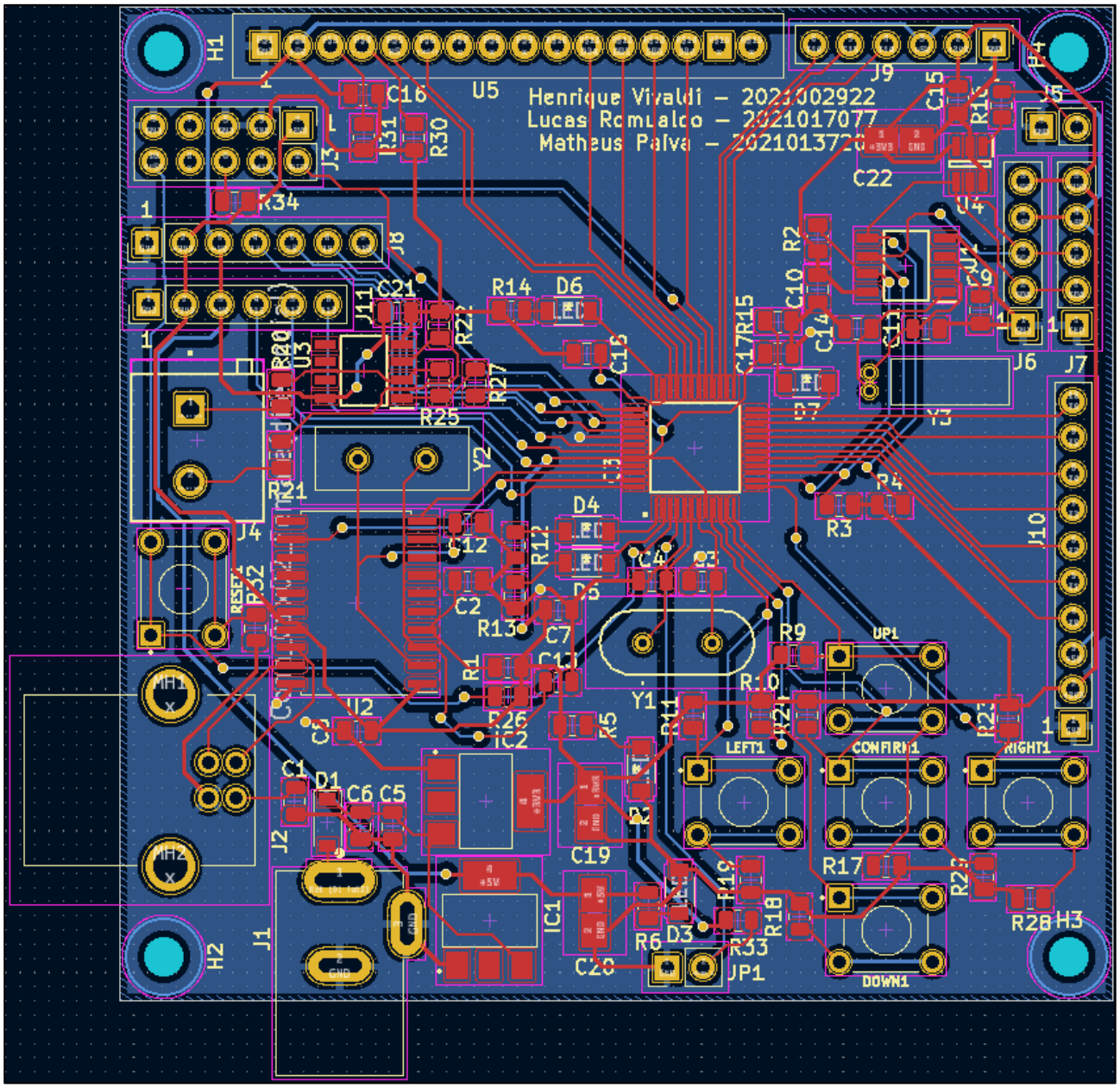


Figura 20: Placa PCI com o plano terra

Para melhor visualização das trilhas que passam na parte inferior da placa, o plano terra foi removido.

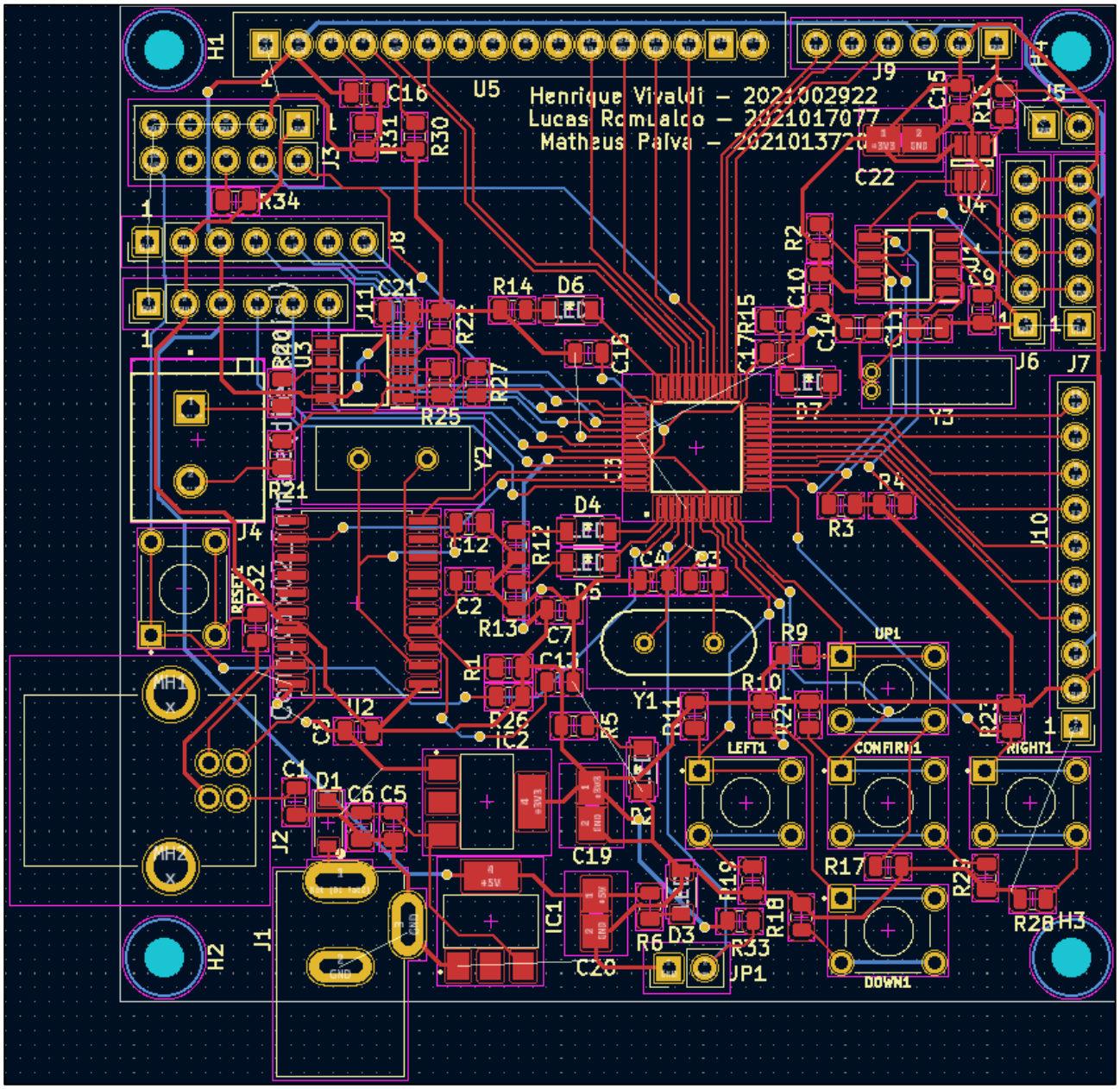


Figura 21: Placa PCI sem plano terra

5.1.2 Visualização 3D da placa de circuito impresso

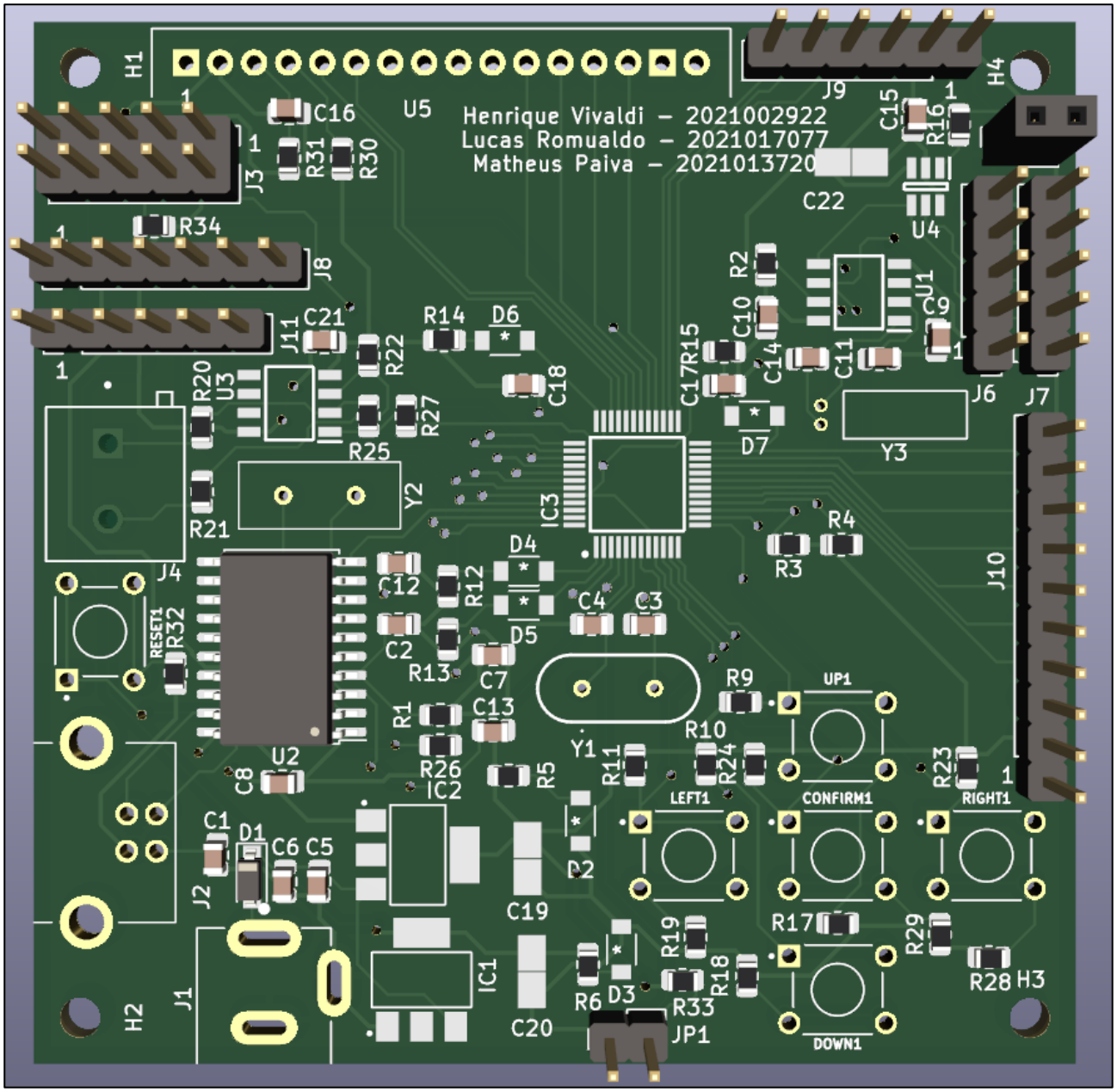


Figura 22: Visualização superior 3D da placa de circuito impresso

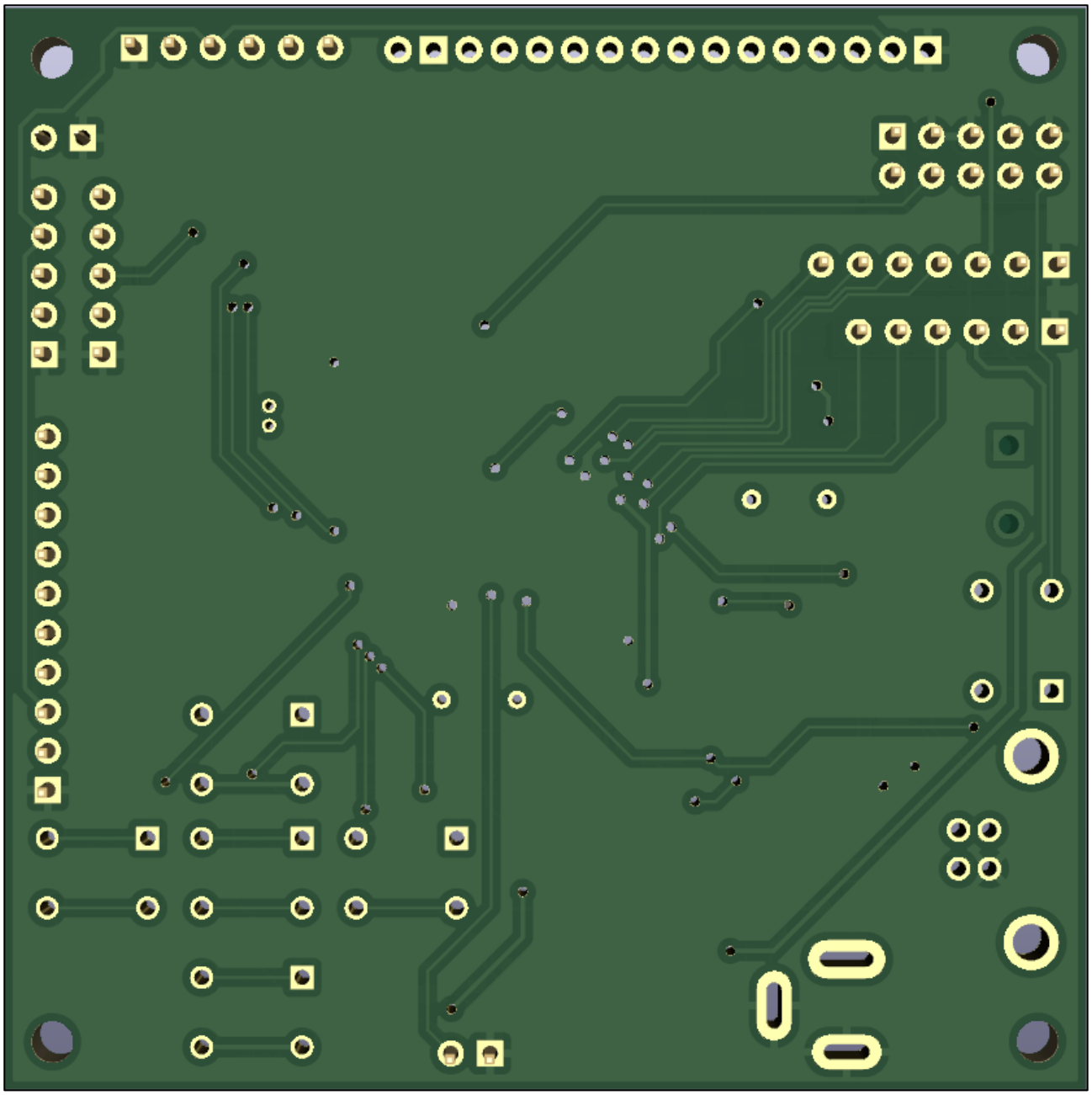


Figura 23: Visualização inferior 3D da placa de circuito impresso

5.2 Relatório de verificação de erros de projeto

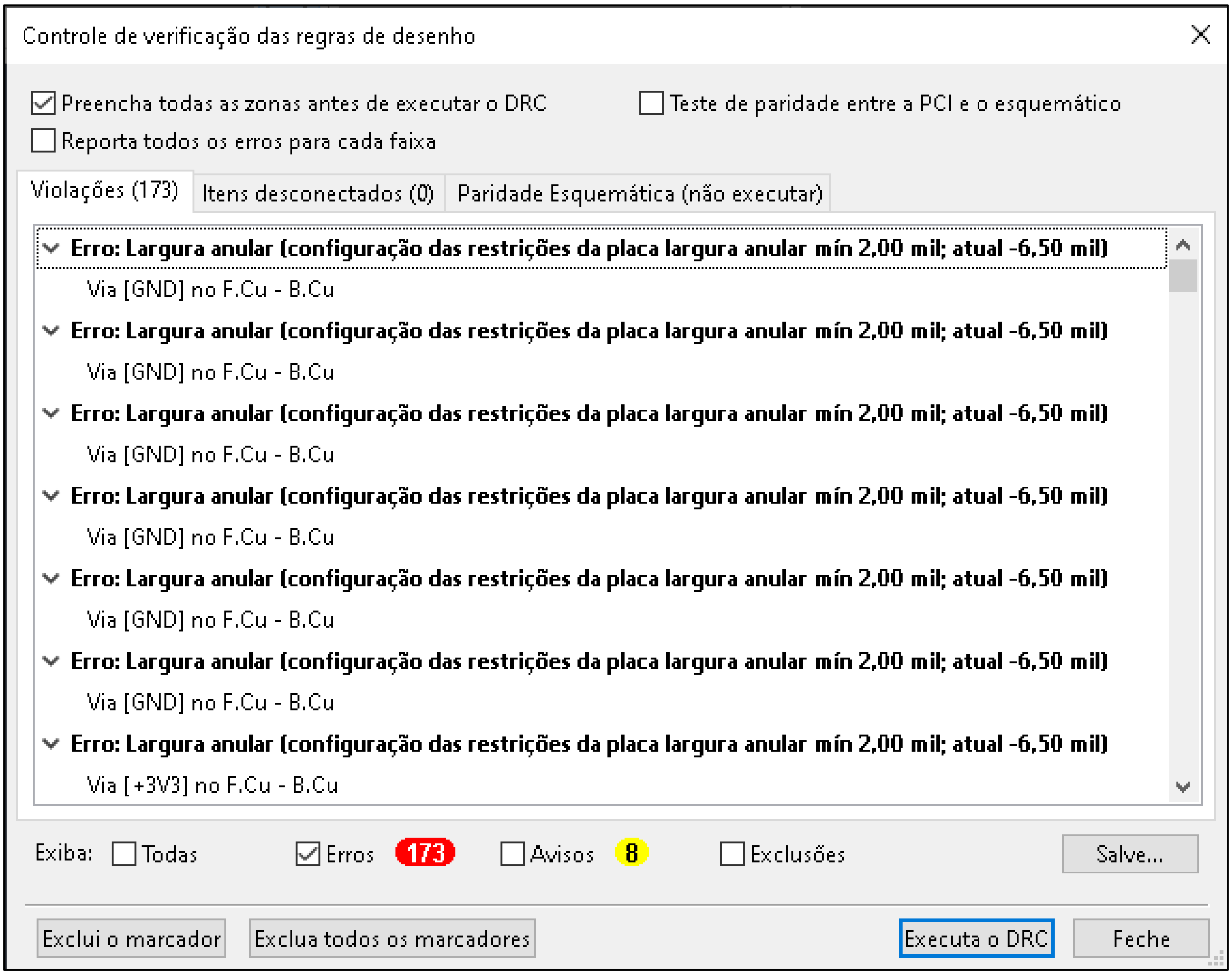


Figura 24: Relatório de erros DRC

6 Características gerais

6.1 Mapas de pinos

6.1.1 Microcontrolador

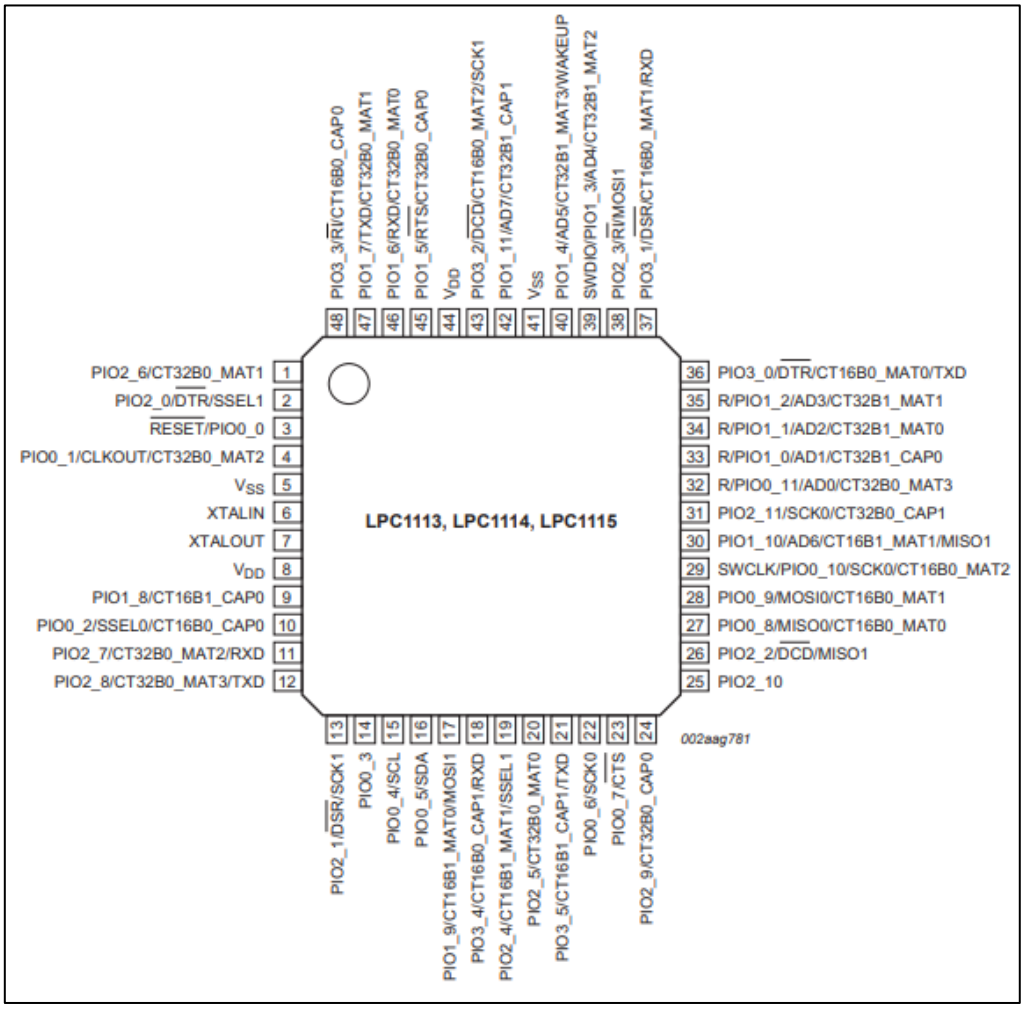


Figura 25: Microcontrolador LPC1114FBD48/302

Tabela 5: Identificação de pinos do microcontrolador

Pino	Conexão	Pino	Conexão	Pino	Conexão	Pino	Conexão
1	LED3	13	R	25	T14	37	T10
2	LED2	14	MFP	26	T15	38	T9
3	REST	15	SCL	27	T16	39	SWDIO
4	PI00_1	16	SDA	28	DB7	40	T8
5	GND	17	T0	29	SWDCLK	41	GND
6	X3	18	T1	30	DB6	42	T7
7	X4	19	T2	31	DB5	43	T13
8	3.3V	20	T3	32	DB4	44	3.3V
9	L	21	T4	33	LCDen	45	T12
10	D	22	T5	34	RS	46	TX
11	CONFIRM	23	T6	35	DIF1	47	RX
12	U	24	LED0	36	LED1	48	T11

6.1.2 Interface

Tabela 6: Interface PJ002-A

Componente	Nome do pino	Conexão(polaridade)
PJ002-A (J1)	-	1 (+)
	-	2 (-)

Tabela 7: Conector USB

Componente	Nome do pino	Conexão(polaridade)
897–43–004–90–000000 (J2)	1	1
	2	D- (-)
	3	D+ (+)
	4	GND
	MH1	Sem conexão
	MH2	Sem conexão

Tabela 8: Conector JTAG

Componente	Nome do pino	Conexão(polaridade)
70246-100 (J3)	1	3.3V(+)
	2	SWDIO
	3	GND(-)
	4	SWDCLK
	5	GND(-)
	6	R34
	7	Sem conexão
	8	Sem conexão
	9	GND(-)
	10	REST

Tabela 9: Conector amplificador diferencial

Componente	Nome do pino	Conexão(polaridade)
OSTTA024163 (J4)	1	R20(+)
	2	R21(-)

Tabela 10: Conector do conversor analógico-digital

Componente	Nome do pino	Conexão(polaridade)
Conn_01x02_Female (J5)	1	GND(-)
	2	R16(+)

Tabela: 11 Conectores de expansão I²C

Componente	Nome do pino	Conexão(polaridade)
Conn_01x05_Male (J6)	1	GND(-)
	2	SDA
	3	SCL
	4	5V(+)
	5	3.3V(+)
Conn_01x05_Male (J7)	1	GND(-)
	2	SDA
	3	SCL
	4	5V(+)
	5	3.3V(+)

Tabela 12: Conectores de expansão do microcontrolador

Componente	Nome do pino	Conexão(polaridade)
Conn_01x07_Male (J8)	1	GND(-)
	2	3.3V(+)
	3	5V(+)
	4	T7
	5	T8
	6	T9
	7	T10
Conn_01x06_Male (J9)	1	GND(-)
	2	3.3V(+)
	3	5V(+)
	4	T14
	5	T15
	6	T16
Conn_01x10_Male (J10)	1	GND(-)
	2	3.3V(+)
	3	5V(+)
	4	T0
	5	T1
	6	T2
	7	T3
	8	T4
	9	T5
	10	T6
Conn_01x06_Male (J11)	1	GND(-)
	2	3.3V(+)
	3	5V(+)
	4	T11
	5	T12
	6	T13

Tabela 13: Conector para LCD

Componente	Nome do pino	Conexão(polaridade)
LCD2X16:CON8X2LCD (U5)	1	GND(-)
	2	5V(+)
	3	R31
	4	RS
	5	R30
	6	LCDen
	7	Sem conexão
	8	Sem conexão
	9	Sem conexão
	10	Sem conexão
	11	DB4
	12	DB5
	13	DB6
	14	DB7
	15	Sem conexão
	16	Sem conexão

6.2 Alimentação e consumo

A placa projetada deve ser alimentada com tensões entre 9 V e 12V, sendo com corrente contínua.

De acordo com o datasheet do microcontrolador, a corrente máxima suportada é de 20mA por entrada, como o LPC1114FBD48/302 possui 48 portas, a corrente máxima suportada é de 960mA, já a potência é de aproximadamente 3 W.

O conversor digital -analógico MCP4725A0T-E/CH precisa ser alimentado por uma tensão de 3.3 V, consome corrente elétrica em cerca de 400 uA, e a potência é de aproximadamente 0.6mW

O LCD do circuito- JHD162A tem como corrente de operação 3mA, é alimentado por uma tensão de 5V, e sua potência é de aproximadamente 0.5mW.

Os reguladores de tensão da família LD1117 possuem capacidade de corrente para até 800mA, tendo como potência dissipada aproximadamente 12W, o que dá margem de segurança para o funcionamento do circuito, já que o circuito atual, da maneira que foi projetado possui como potência dissipada cerca de 7W.

7 Programa embarcado de validação

O objetivo do programa embarcado de validação é testar as funcionalidades microcontroladas da placa desenvolvida, validando a configuração das portas do microcontrolador, os drivers utilizados e o funcionamento correto dos componentes da PCI, como os LEDs, botões e displays.

7.1 Modelo de operação geral

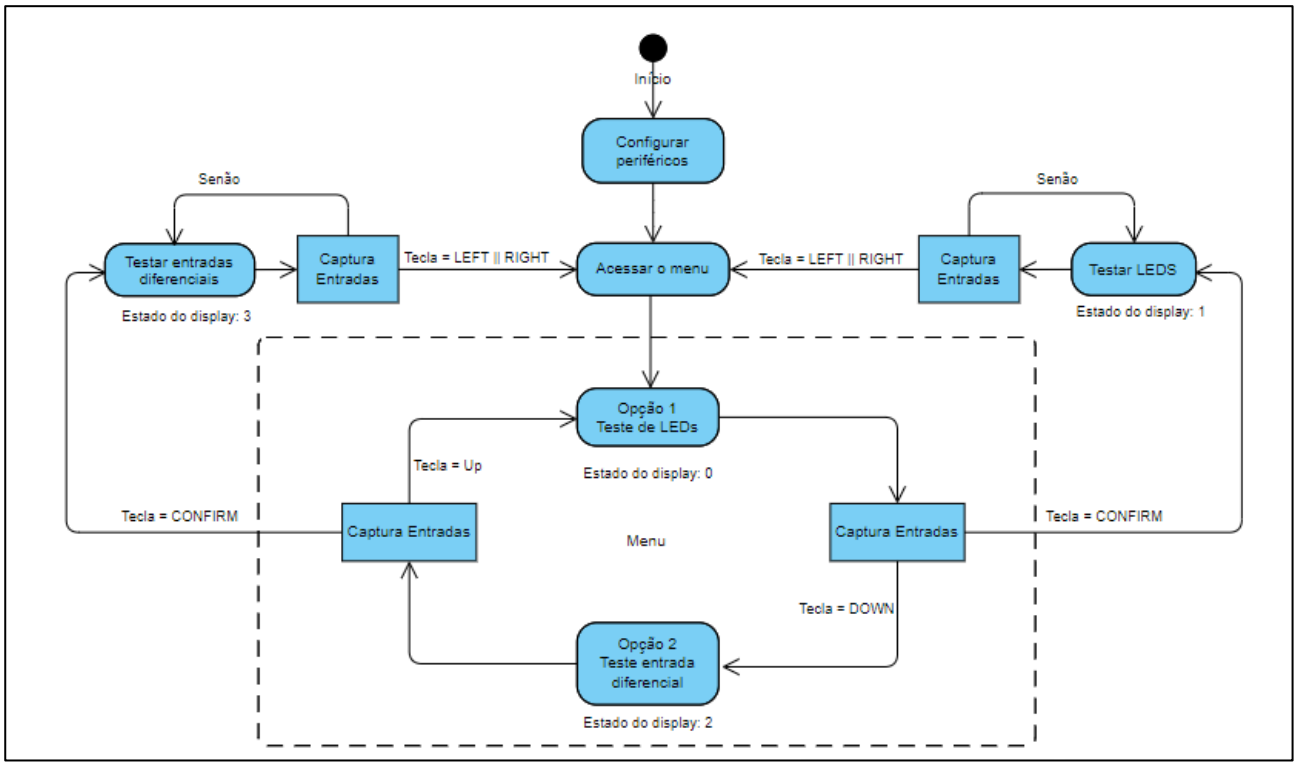


Figura 26: Diagrama de estados do programa embarcado de validação

7.2 Arquitetura

O programa é composto por 2 blocos principais,

1. Inicializar
   A função do bloco inicializar é realizar a inicialização e configuração das bibliotecas e drivers utilizadas no programa, este bloco é representado pelo arquivo main.c, onde são executados os seguintes procedimentos:
   - displayInit(): Inicializando as bibliotecas display e lcd, que controlam as informações apresentadas no display LCD;
   - timerInit(): inicializando a biblioteca timer, que é responsável por gerar intervalos de tempo no código;
   - kpInit(): inicializando as bibliotecas keypad, so e io, responsáveis por capturar os cliques nos botões “UP”, “RIGHT”, “DOWN, “LEFT” e “SELECT”;
   - differentialInit(): Inicializando as bibliotecas differential e adc, responsável por receber os valores enviados ao conversor analógico digital pelo circuito comparador e apresentá-los no display LCD;

Após serem inicializadas as bibliotecas, o programa procede para um loop, onde é definido o intervalo de tempo gerado biblioteca timer, através da função timerReset(), o parâmetro da função é o intervalo de tempo desejado em milissegundos. Em seguida, é acessado o loop da função de menu, que compreende o segundo bloco funcional da aplicação;

2. Menu

O bloco Menu é responsável por gerenciar os estados da aplicação e controlar os testes a serem realizados pelo embarcado, que consiste em uma função loop e 2 variáveis globais, option e ledTrigger;

- Option representa o estado atual da aplicação e
- ledTrigger representa o estado atual do teste dos leds.

O loop executa constantemente a função kpread, parte da biblioteca keypad, que retorna o valor da tecla pressionada. O valor retornado pela função kpread é testado em uma estrutura de decisão switch case, onde o valor da tecla é testado em relação ao estado atual do embarcado. O programa possui 4 estados, definidos pela variável “option”.

- Option = 0: Enquanto estiver no estado 0, o programa estará aguardando até que a tecla “CONFIRM” seja pressionada, o que colocará o programa no estado 1, caso a tecla “DOWN” seja pressionada, o estado será alterado para 2, alterando a mensagem exibida no display;

Figura 27:Display LCD no estado 0

- Option = 1: Enquanto o programa estiver no estado 1, o programa de teste de LEDs será executado continuamente até que sejam pressionadas as teclas “LEFT” ou “RIGHT”;

Figura 28: Display LCD no estado 1

- Option = 2: Enquanto estiver no estado 2, o programa estará aguardando até que a tecla “CONFIRM” seja pressionada, o que colocará o programa no estado 3, caso a tecla “UP” seja pressionada, o estado será alterado para 0, alterando a mensagem exibida no display;

Figura 29: Display LCD no estado 2

- Option = 3: Enquanto o programa estiver no estado 3, o programa de teste do comparador diferencial será executado continuamente até que sejam pressionadas as teclas “LEFT” ou “RIGHT”;

Figura 30: Display LCD no estado 3

Caso o programa esteja no estado 1, a função ledTest será executada juntamente ao looping principal do menu, ela é parte da biblioteca led test e é responsável por ativar e desativar os LEDs 1, 2, 3, e 4 da PCI. Os LEDs acesos são controlados pela variável ledTrigger.

Caso o programa esteja no estado 2, a função getDifference, será executada juntamente ao looping principal do menu, ela é parte da biblioteca differential, e é responsável por obter os dados convertidos no conversor analógico digital conectado ao circuito comparador, realizar os cálculos necessários, e exibi-los no display LCD.

7.3 Casos de uso

O embarcado possui dois testes programados

- Teste dos LEDs:
    1. O programa se inicia no estado 0, apresentando no display LCD a seguinte mensagem: “Testar LEDs:”;
        a. Caso a mensagem “Test. Comparador” esteja sendo apresentada no display, significa que o programa está no estado 2, pressione a tecla “UP” no teclado direciona para retornar ao estado 0;
    2. Pressione a tecla “CONFIRM”, no centro do teclado direcional;
    3. O programa entrará no estado 1, iniciando o teste dos LEDs 1,2,3 e 4;
    4. Para encerrar o teste dos LEDs e retornar ao menu inicial, pressione a tecla “LEFT” ou a tecla “RIGHT” no teclado diferencial;

- Teste do comparador diferencial:
    1. O programa se inicia no estado 0, apresentando no display LCD a seguinte mensagem: “Testar LEDs:”;
    2. Para acessar o teste das entradas diferenciais, pressione a tecla “DOWN” no teclado diferencial;
    3. O programa entrará no estado 2, apresentando no display LCD a seguinte mensagem: “Test. Comparador”;
    4. Pressione a tecla "CONFIRMA", no centro do teclado direcional;
    5. O programa entrará no estado 3, iniciando o teste do comparador diferencial, os dados exibidos no display são gerados pelo circuito comparador analógico e convertidos pelo conversor analógico digital;
    6. Para encerrar o teste do comparador e retornar ao menu inicial, pressione a tecla “LEFT” ou a tecla “RIGHT” no teclado diferencial;

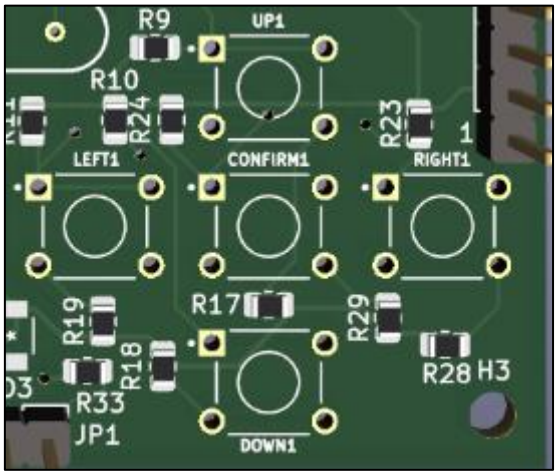


Figura 31: Teclado diferencial para referência

8 Custos

8.1 Materiais

Componente	Nome na placa	Fornecedor	Custo
LPC1114FBD48/302	IC3	https://br.mouser.com/ProductDetail/NXP-Semiconductors/LPC1114FBD48-3021?qs=5XzWkq3%2FTOpFCNP2poI2JQ%3D%3D	$6,45
MCP7940N–I/SN	U1	https://br.mouser.com/ProductDetail/Microchip-Technology-Atmel/MCP7940N-I-SN?qs=o%2FJG-MiCJeCOTsMP4nrR5Uw%3D%3D	$0,86
MCP2200–I/SO	U2	https://br.mouser.com/ProductDetail/Microchip-Technology-Atmel/MCP2200-I-SO?qs=kI7nsUnms46fN8L9VZlJCA%3D%3D	$2,62
MCP4725A0T-E/CH	U4	https://br.mouser.com/ProductDetail/Microchip-Technology-Atmel/MCP4725A0T-E-CH?qs=vkMqrgFpRaje-QECZ3goc0A%3D%3D	$1,29
710-865090368008	C12, C15, C18	https://br.mouser.com/ProductDetail/Wurth-Elektronik/865090368008?qs=I7cgNqFNU1hI2Lri8dDC9g%3D%3D	3x $0,31
PJ–002A	J1	https://br.mouser.com/ProductDetail/CUI-Devices/PJ-002A?qs=WyjlAZoYn51CKfAix9Mngw%3D%3D	$0,77
LTST–C150GKT	D2-D7	https://www.digikey.com/en/products/detail/liteon/LTST-C150GKT/269216	6x $0,31
LM358DR	U3A	https://br.mouser.com/ProductDetail/Texas-Instruments/LM358DR?qs=Zu35EjizYSSY6pJ37yjmHA%3D%3D	$0,37
897–43–004–90–000000	J2	https://br.mouser.com/ProductDetail/Mill-Max/897-43-004-90-000000?qs=x6EjVpvqMVNM0AotjG3j0A%3D%3D	$1,70
1825910–6	UP1, DOWN1, LEFT1, RIGHT1, CONFIRM1 e RESET1	https://www.digikey.com.br/pt/products/detail/te-connectivity-alcoswitch-switches/1825910-6/1632536	6x $0,13
LD1117AS33TR	IC2	https://br.mouser.com/ProductDetail/STMicroelectronics/LD1117AS33TR?qs=C3bf%2FVrkE5CoDDd7wyn%252BaQ%3D%3D	$0,90
LD1117AS50TR	IC1	https://br.mouser.com/ProductDetail/STMicroelectronics/LD1117S50TR?qs=eQN2Ig5lfEwsh0kTXN%2FkTg%3D%3D	$0,67
AB38T–32.768KHZ	Y3	https://br.mouser.com/ProductDetail/ABRACON/AB38T-32.768KHZ?qs=m%252BUhWDcpCfbdp9ovMbeW3g%3D%3D	$0,17
ATS20A	Y1	https://br.mouser.com/ProductDetail/CTS-Electronic-Components/ATS20A?qs=tjlMjqRIEYSf%252BN4zUqLZuw%3D%3D	$0,36
ATS12A	Y2	https://br.mouser.com/ProductDetail/CTS-Electronic-Components/ATS12A?qs=tjlMjqRIEYSiVgznX15DJQ%3D%3D	$0,36

OSTTA024163	J4	https://www.digikey.com/en/products/detail/on-shore-technology-inc/OSTTA024163/614529	$0,73
1N5819HW–7	D1	https://br.mouser.com/ProductDetail/Diodes-Incorporated/1N5819HW-7-F?qs=NQ47qNm99eDyW-TEd07miYA%3D%3D	$0,45
JHD162A	U5	https://www.alibaba.com/product-detail/1602-16-2-Lcd-16x2-High_1600527207522.html?spm=a2700.7735675.normal_offer.d_title.640f29c0uCN8Ri&s=p	$1,40
70246-1002	J3	https://br.mouser.com/ProductDetail/Molex/70246-1002?qs=L7RdmAxh%252BcOF%2FzUAVPnsXg%3D%3D	$2,57
342-10-106-00-594000	J9	https://www.digikey.com.br/pt/products/detail/mill-max-manufacturing-corp/342-10-106-00-594000/4455950	$3,23
342-10-107-00-591000	J8	https://www.digikey.com.br/pt/products/detail/mill-max-manufacturing-corp/342-10-107-00-591000/4455951	$1,56
342-10-105-00-594000	J6 e J7	https://www.digikey.com.br/pt/products/detail/mill-max-manufacturing-corp/342-10-105-00-594000/4455947	$2,69
342-10-110-00-593000	J11	https://www.digikey.com.br/pt/products/detail/mill-max-manufacturing-corp/342-10-110-00-593000/4455961	$3,79
XR2P-1641	U5	https://www.digikey.com.br/pt/products/detail/omron-electronics-inc-emc-div/XR2P-1641/1829613	$3,25
CHP0805AFX-1000ELF	R9-R16, R16-R19, R24, R27-R29	https://br.mouser.com/ProductDetail/Bourns/CHP0805AFX-1000ELF?qs=BJlw7L4Cy7%252BkJgcu88J9nA%3D%3D	12x $0,64
ERJ-U06J471V	R3 e R4	https://br.mouser.com/ProductDetail/Panasonic/ERJ-U06J471V?qs=Yyy8avaXIlsqmmWmyUFRRw%3D%3D	2x $0,13
RQ73C2A1K0BTDF	R25 e R26	https://br.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/RQ73C2A1K0BTDF?qs=sGAEpiMZZMvd-Gkrng054t7z4BkURc4LzHaAW0clZmtxqo%252BvEm-GRFfA%3D%3D	2x $1.16
CHP0805-FX-1002ELF	R1, R2, R5-R8, R17-R23, R30-R32	https://br.mouser.com/ProductDetail/Bourns/CHP0805-FX-1002ELF?qs=lc2O%252BfHJPVaDI6gsPdDtfw%3D%3D	16x $0,47
C0603C220K3RACAUTO	C11 e C16	https://br.mouser.com/ProductDetail/KEMET/C0603C220K3RACAUTO?qs=hzBznG4dWXWmxitsebgAlw%3D%3D	2x $0,15
CBR04C390J5GACAUTO	C3, C4, C13, C14	https://br.mouser.com/ProductDetail/KEMET/CBR04C390J5GACAUTO?qs=By6Nw2ByBD3fqIHD3dZXxQ%3D%3D	4x $0,29
VJ1206Y104KXAMT	C1, C2, C5-C10, C17, C19-C22	https://br.mouser.com/ProductDetail/Vishay-Vitramon/VJ1206Y104KXAMT?qs=sGAEpiMZZMvsSlwiRhF8qqavgVTr5bEwUDYc1a3dLYA%3D	16x $0,52

Dessa forma o preço total dos materiais é de $67,32

9 Apêndice

9.1 Memorial de cálculos

Cálculo circuito comparador diferencial:

$$V_+ = V_- = V_0$$

$$V_0 = \frac{V_{cc} \cdot R}{R_{LDR} + R}$$

$$R = 10k\Omega$$

Cálculo para resistor dos leds:

$$2{,}6 = R \cdot 20mA$$

$$R = 130\Omega$$

9.2 Código-fonte do programa de validação

9.2.1 Código do arquivo main.c

```
#include <xc.h>
#include "config.h"
#include <pic18f4520.h>
#include "timer.h"
#include "display.h"
#include "keypad.h"
#include "bits.h"
#include "menu.h"
#include "differential.h"
void main(void) {
    //Inicialização das bibliotecas
    displayInit();
    timerInit();
    kpInit();
    differentialInit();
    for (;;) {
        //Definindo delay
        timerReset(5000);
```

```
        //Loop principal
        menuLoop();
        timerWait();
    }
}
```

9.2.2 Código do arquivo menu.h

```
#ifndef MENU_H
#define MENU_H
void menuLoop(void);
#endif
```

9.2.3 Código do arquivo menu.c

```
#include "menu.h"
#include "ledtest.h"
#include "display.h"
#include "differential.h"
#include "timer.h"
#include "keypad.h"
static int option = 0;
static int ledTrigger = 0;
//Tela de menu
//Teclas UP e DOWN selecionam a funcionalidade
//Teclas LEFT e RIGHT retornam ao menu
//Tecla SELECT seleciona a função e executa o teste selecionado
//Opcao 0 e 2 -> Telas de menu
//Opcao 1 e 3 -> Testes
void menuLoop() {
    int tecla;
    for (;;) {
        //Verificando se houve clique
        if (kpRead() != tecla) {
            tecla = kpReadKey();
```

```
switch (tecla) {
    case 'U':
        //UP
        if (option == 2) {
            option = 0;
            displayPrint(option);
        }
        break;
    case 'D':
        //DOWN
        if (option == 0) {
            option = 2;
            displayPrint(option);
        }
        break;
    case 'L':
        //LEFT
        if (option == 1 || option == 3) {
            option = 0;
        }
        displayPrint(option);
        break;
    case 'R':
        //RIGHT
        if (option == 1 || option == 3) {
            option = 0;
        }
        displayPrint(option);
        break;
    case 'S':
        //SELECT
```

```
                switch (option) {
                    case 0:
                        option = 1;
                        displayPrint(option);
                        break;
                    case 2:
                        option = 3;
                        displayPrint(option);
                        break;
                }
                break;
            }
        }
        timerWait();
        kpDebounce();
        //Teste AD
        if (option == 3) {
            getDifference();
        }
        //Teste LEDs
        if (option == 1) {
            if (ledTrigger == 80) {
                ledTrigger = 0;
            } else {
                ++ledTrigger;
            }
            ledTest(ledTrigger);
        }
    }
}
```

10 Anexo

Additional Resources: Product Page | 3D Model | PCB Footprint

CUI DEVICES

date 10/30/2019
page 1 of 3

MODEL: PJ-002A | **DESCRIPTION:** DC POWER JACK

FEATURES
- 2.0 mm center pin
- 2.5 A rating
- right-angle orientation
- through hole

RoHS

SPECIFICATIONS

parameter	conditions/description	min	typ	max	units
rated input voltage			24		Vdc
rated input current				2.5	A
contact resistance[1]	between terminal and mating plug between terminal in a closed circuit			50 30	mΩ mΩ
insulation resistance	at 500 Vdc	100			MΩ
voltage withstand	at 50/60Hz for 1 minute			500	Vac
insertion/withdrawal force		0.3		3	kg
terminal strength	any direction for 10 seconds			500	g
operating temperature		-25		85	°C
life			5,000		cycles
flammability rating	UL94V-0				
RoHS	yes				

Note: 1. When measured at a current of less than 100 mA/1 kHz

SOLDERABILITY

parameter	conditions/description	min	typ	max	units
wave soldering	dipped in solder pot for 5 ±0.5 seconds	255	260	265	°C

Figura 32: PJ002-A

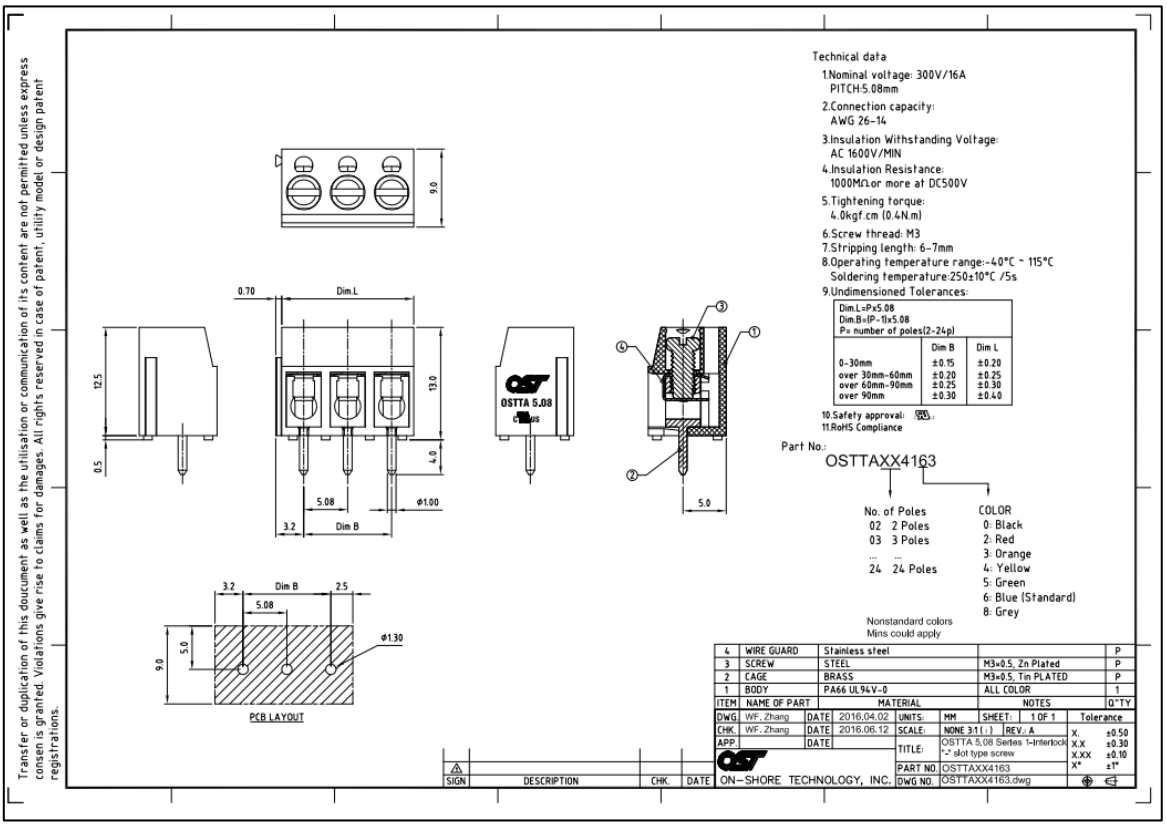
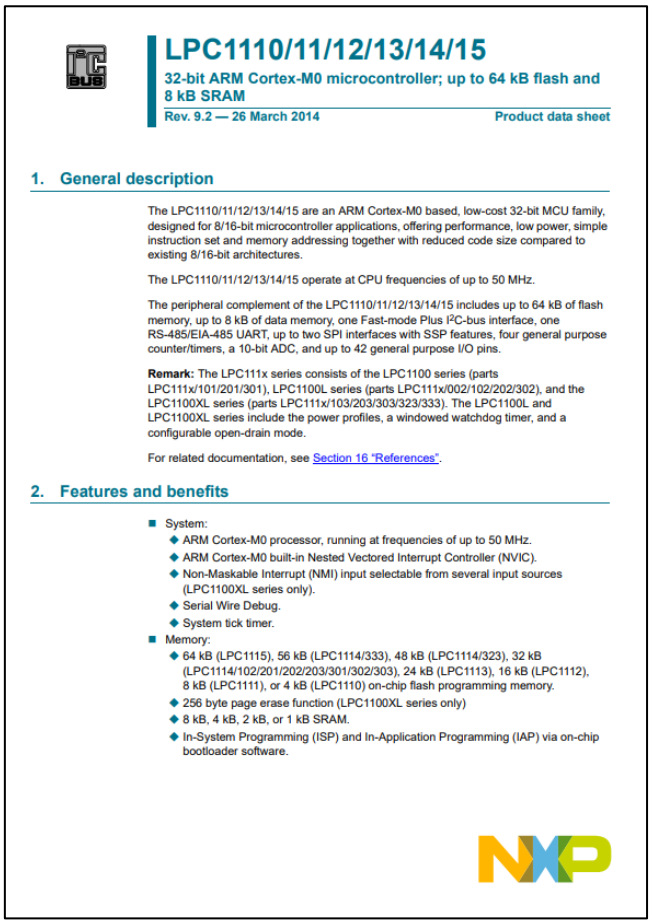


Figura 33: OSTTA024163



LPC1110/11/12/13/14/15

32-bit ARM Cortex-M0 microcontroller; up to 64 kB flash and 8 kB SRAM

Rev. 9.2 — 26 March 2014 Product data sheet

1. General description

The LPC1110/11/12/13/14/15 are an ARM Cortex-M0 based, low-cost 32-bit MCU family, designed for 8/16-bit microcontroller applications, offering performance, low power, simple instruction set and memory addressing together with reduced code size compared to existing 8/16-bit architectures.

The LPC1110/11/12/13/14/15 operate at CPU frequencies of up to 50 MHz.

The peripheral complement of the LPC1110/11/12/13/14/15 includes up to 64 kB of flash memory, up to 8 kB of data memory, one Fast-mode Plus I²C-bus interface, one RS-485/EIA-485 UART, up to two SPI interfaces with SSP features, four general purpose counter/timers, a 10-bit ADC, and up to 42 general purpose I/O pins.

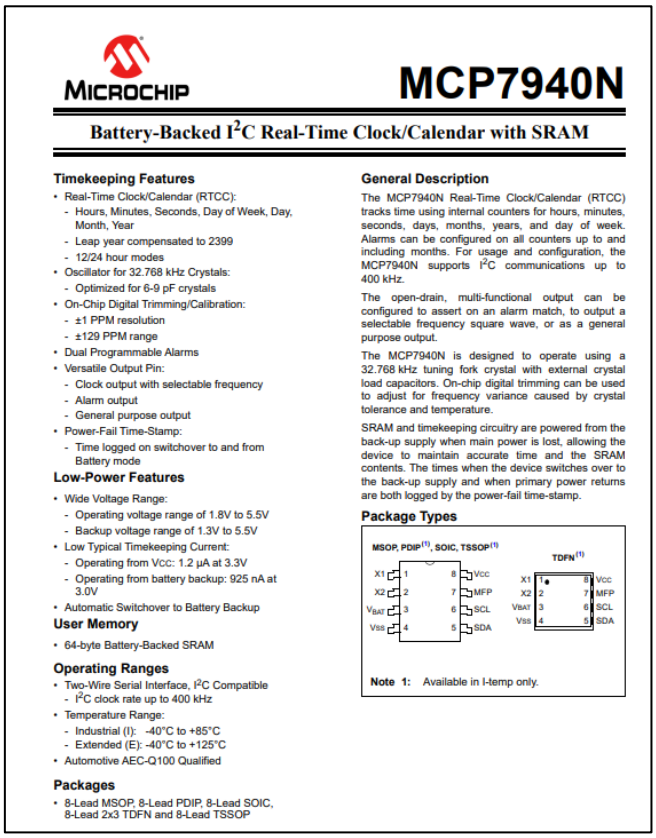
Remark: The LPC111x series consists of the LPC1100 series (parts LPC111x/101/201/301), LPC1100L series (parts LPC111x/002/102/202/302), and the LPC1100XL series (parts LPC111x/103/203/303/323/333). The LPC1100L and LPC1100XL series include the power profiles, a windowed watchdog timer, and a configurable open-drain mode.

For related documentation, see Section 16 "References".

2. Features and benefits

- System:
  - ARM Cortex-M0 processor, running at frequencies of up to 50 MHz.
  - ARM Cortex-M0 built-in Nested Vectored Interrupt Controller (NVIC).
  - Non-Maskable Interrupt (NMI) input selectable from several input sources (LPC1100XL series only).
  - Serial Wire Debug.
  - System tick timer.
- Memory:
  - 64 kB (LPC1115), 56 kB (LPC1114/333), 48 kB (LPC1114/323), 32 kB (LPC1114/102/201/202/203/301/302/303), 24 kB (LPC1113), 16 kB (LPC1112), 8 kB (LPC1111), or 4 kB (LPC1110) on-chip flash programming memory.
  - 256 byte page erase function (LPC1100XL series only)
  - 8 kB, 4 kB, 2 kB, or 1 kB SRAM.
  - In-System Programming (ISP) and In-Application Programming (IAP) via on-chip bootloader software.

Figura 34: LPC1114FBD48/302



MICROCHIP

MCP7940N

Battery-Backed I²C Real-Time Clock/Calendar with SRAM

Timekeeping Features

- Real-Time Clock/Calendar (RTCC):
  - Hours, Minutes, Seconds, Day of Week, Day, Month, Year
  - Leap year compensated to 2399
  - 12/24 hour modes
- Oscillator for 32.768 kHz Crystals:
  - Optimized for 6-9 pF crystals
- On-Chip Digital Trimming/Calibration:
  - ±1 PPM resolution
  - ±129 PPM range
- Dual Programmable Alarms
- Versatile Output Pin:
  - Clock output with selectable frequency
  - Alarm output
  - General purpose output
- Power-Fail Time-Stamp:
  - Time logged on switchover to and from Battery mode

Low-Power Features

- Wide Voltage Range:
  - Operating voltage range of 1.8V to 5.5V
  - Backup voltage range of 1.3V to 5.5V
- Low Typical Timekeeping Current:
  - Operating from VCC: 1.2 µA at 3.3V
  - Operating from battery backup: 925 nA at 3.0V
- Automatic Switchover to Battery Backup

User Memory

- 64-byte Battery-Backed SRAM

Operating Ranges

- Two-Wire Serial Interface, I²C Compatible
  - I²C clock rate up to 400 kHz
- Temperature Range:
  - Industrial (I): -40°C to +85°C
  - Extended (E): -40°C to +125°C
- Automotive AEC-Q100 Qualified

Packages

- 8-Lead MSOP, 8-Lead PDIP, 8-Lead SOIC, 8-Lead 2x3 TDFN and 8-Lead TSSOP

General Description

The MCP7940N Real-Time Clock/Calendar (RTCC) tracks time using internal counters for hours, minutes, seconds, days, months, years, and day of week. Alarms can be configured on all counters up to and including months. For usage and configuration, the MCP7940N supports I²C communications up to 400 kHz.

The open-drain, multi-functional output can be configured to assert on an alarm match, to output a selectable frequency square wave, or as a general purpose output.

The MCP7940N is designed to operate using a 32.768 kHz tuning fork crystal with external crystal load capacitors. On-chip digital trimming can be used to adjust for frequency variance caused by crystal tolerance and temperature.

SRAM and timekeeping circuitry are powered from the back-up supply when main power is lost, allowing the device to maintain accurate time and the SRAM contents. The times when the device switches over to the back-up supply and when primary power returns are both logged by the power-fail time-stamp.

Package Types

MSOP, PDIP(1), SOIC, TSSOP(1)

TDFN(1)

Note 1: Available in I-temp only.

Figura 35: MCP7940N–I/SN

MICROCHIP

MCP2200

USB 2.0 to UART Protocol Converter with GPIO

Features

Universal Serial Bus (USB)

- Supports Full-Speed USB (12 Mb/s)
- Implements USB Protocol Composite Device:
  - Communication Device Class (CDC) for Communications and Configuration
  - Human Interface Device (HID) for I/O control
- 128-Byte Buffer to Handle Data Throughput at Any UART Baud Rate:
  - 64-byte transmit
  - 64-byte receive
- Fully Configurable VID and PID Assignments and String Descriptors
- Bus-Powered or Self-Powered
- USB 2.0 Compliant: TID 40001150

USB Driver and Software Support

- Uses Standard Windows® Drivers for Virtual Com Port (VCP): Windows XP (SP2 or later), Windows Vista, Windows 7, Windows 8, Windows 8.1 and Windows 10
- Configuration Utility for Initial Configuration

Universal Asynchronous Receiver/Transmitter (UART)

- Responds to `SET_LINE_CODING` Commands to Dynamically Change Baud Rates
- Supports Baud Rates: 300-1000k
- Hardware Flow Control
- UART Signal Polarity Option

General Purpose Input/Output (GPIO) Pins

- Eight General Purpose I/O pins

EEPROM

- 256 Bytes of User EEPROM

Other

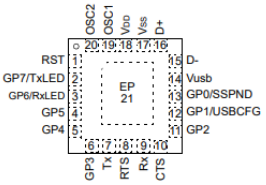
- USB Activity LED Outputs (TxLED and RxLED)
- SSPND Output Pin
- USBCFG Output Pin (indicates when the enumeration is completed)
- Operating Voltage: 3.0V-5.5V
- Oscillator Input: 12 MHz
- Electrostatic Discharge (ESD) Protection: >4 kV Human Body Model (HBM)
- Industrial (I) Operating Temperature: –40°C to +85°C
- Passes Automotive AEC-Q100 Reliability Testing

Package Types

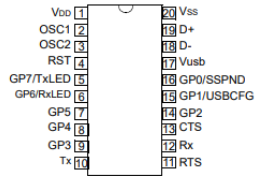
The device is offered in the following packages:

- 20-lead VQFN (5x5 mm)
- 20-lead SOIC
- 20-lead SSOP

MCP2200
5x5 VQFN*



MCP2200
SOIC, SSOP



* Includes Exposed Thermal Pad (EP); see Table 1-1.

Figura 36: MCP2200–I/SO

MICROCHIP

MCP4725

12-Bit Digital-to-Analog Converter with EEPROM Memory

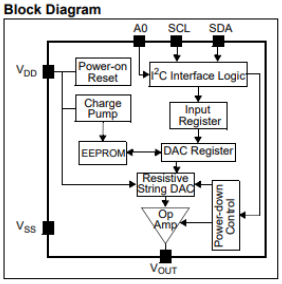
Features

- 12-Bit Resolution
- On-Board Nonvolatile Memory (EEPROM)
- ±0.2 LSB DNL (typical)
- External A0 Address Pin
- Normal or Power-Down Mode
- Fast Settling Time: 6 µs (typical)
- External Voltage Reference (V_{DD})
- Rail-to-Rail Output
- Low Power Consumption
- Single-Supply Operation: 2.7V to 5.5V
- I^2C Interface:
  - Eight Available Addresses
  - Standard (100 kbps), Fast (400 kbps), and High-Speed (3.4 Mbps) Modes
- Small 6-Lead SOT-23 and DFN Package Options
- Extended Temperature Range: -40°C to +125°C

Applications

- Set Point or Offset Trimming
- Sensor Calibration
- Closed-Loop Servo Control
- Low Power Portable Instrumentation
- PC Peripherals
- Data Acquisition Systems

Block Diagram



General Description

The MCP4725 is a low-power, high accuracy, single channel, 12-bit buffered voltage output Digital-to-Analog Converter (DAC) with nonvolatile memory (EEPROM). Its on-board precision output amplifier allows it to achieve rail-to-rail analog output swing.

The DAC input and configuration data can be programmed to the nonvolatile memory (EEPROM) by the user using I^2C interface command. The nonvolatile memory feature enables the DAC device to hold the DAC input code during power-off time, and the DAC output is available immediately after power-up. This feature is very useful when the DAC device is used as a supporting device for other devices in the network.

The device includes a Power-on-Reset (POR) circuit to ensure reliable power-up and an on-board charge pump for the EEPROM programming voltage. The DAC reference is driven from V_{DD} directly. In power-down mode, the output amplifier can be configured to present a known low, medium, or high resistance output load.

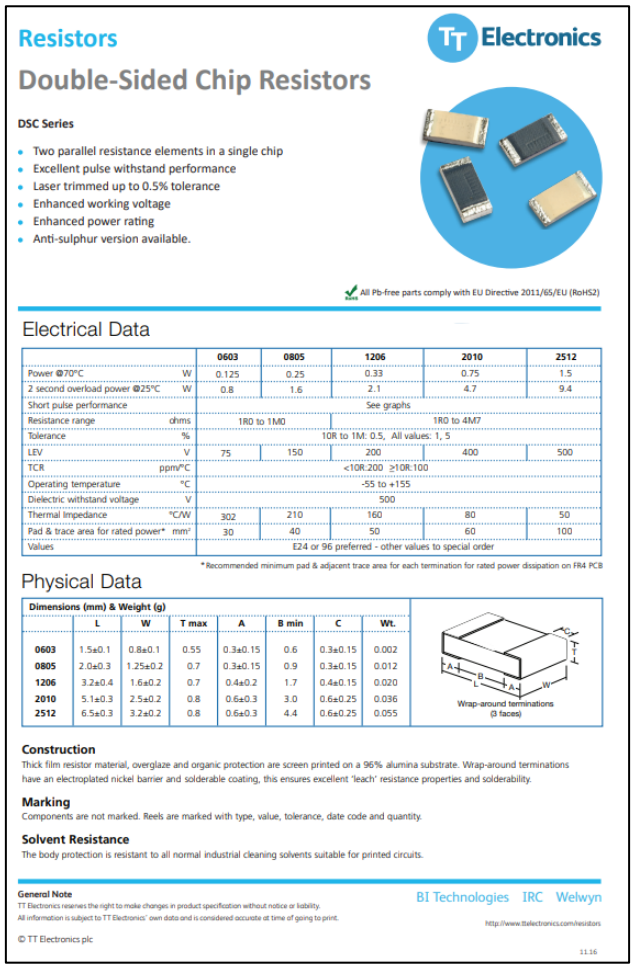
The MCP4725 has an external A0 address bit selection pin. This A0 pin can be tied to V_{DD} or V_{SS} of the user's application board.

The MCP4725 has a two-wire I^2C compatible serial interface for standard (100 kHz), fast (400 kHz), or high speed (3.4 MHz) mode.

The MCP4725 is an ideal DAC device where design simplicity and small footprint is desired, and for applications requiring the DAC device settings to be saved during power-off time.

The device is available in a small 6-pin SOT-23 and DFN package.

Figura 37: MCP4725A0T-E/CH



Resistors

TT Electronics

Double-Sided Chip Resistors

DSC Series

- Two parallel resistance elements in a single chip
- Excellent pulse withstand performance
- Laser trimmed up to 0.5% tolerance
- Enhanced working voltage
- Enhanced power rating
- Anti-sulphur version available.

All Pb-free parts comply with EU Directive 2011/65/EU (RoHS2)

Electrical Data

		0603	0805	1206	2010	2512
Power @70°C	W	0.125	0.25	0.33	0.75	1.5
2 second overload power @25°C	W	0.8	1.6	2.1	4.7	9.4
Short pulse performance		See graphs				
Resistance range	ohms	1R0 to 1M0		1R0 to 4M7		
Tolerance	%	10R to 1M: 0.5, All values: 1, 5				
LEV	V	75	150	200	400	500
TCR	ppm/°C	<10R:200 ≥10R:100				
Operating temperature	°C	-55 to +155				
Dielectric withstand voltage	V	500				
Thermal Impedance	°C/W	302	210	160	80	50
Pad & trace area for rated power*	mm²	30	40	50	60	100
Values		E24 or 96 preferred - other values to special order				

*Recommended minimum pad & adjacent trace area for each termination for rated power dissipation on FR4 PCB

Physical Data

Dimensions (mm) & Weight (g)

	L	W	T max	A	B min	C	Wt.
0603	1.5±0.1	0.8±0.1	0.55	0.3±0.15	0.6	0.3±0.15	0.002
0805	2.0±0.3	1.25±0.2	0.7	0.3±0.15	0.9	0.3±0.15	0.012
1206	3.2±0.4	1.6±0.2	0.7	0.4±0.2	1.7	0.4±0.15	0.020
2010	5.1±0.3	2.5±0.2	0.8	0.6±0.3	3.0	0.6±0.25	0.036
2512	6.5±0.3	3.2±0.2	0.8	0.6±0.3	4.4	0.6±0.25	0.055

Wrap-around terminations (3 faces)

Construction

Thick film resistor material, overglaze and organic protection are screen printed on a 96% alumina substrate. Wrap-around terminations have an electroplated nickel barrier and solderable coating, this ensures excellent 'leach' resistance properties and solderability.

Marking

Components are not marked. Reels are marked with type, value, tolerance, date code and quantity.

Solvent Resistance

The body protection is resistant to all normal industrial cleaning solvents suitable for printed circuits.

General Note

TT Electronics reserves the right to make changes in product specification without notice or liability.
All information is subject to TT Electronics' own data and is considered accurate at time of going to print.

BI Technologies IRC Welwyn

http://www.ttelectronics.com/resistors

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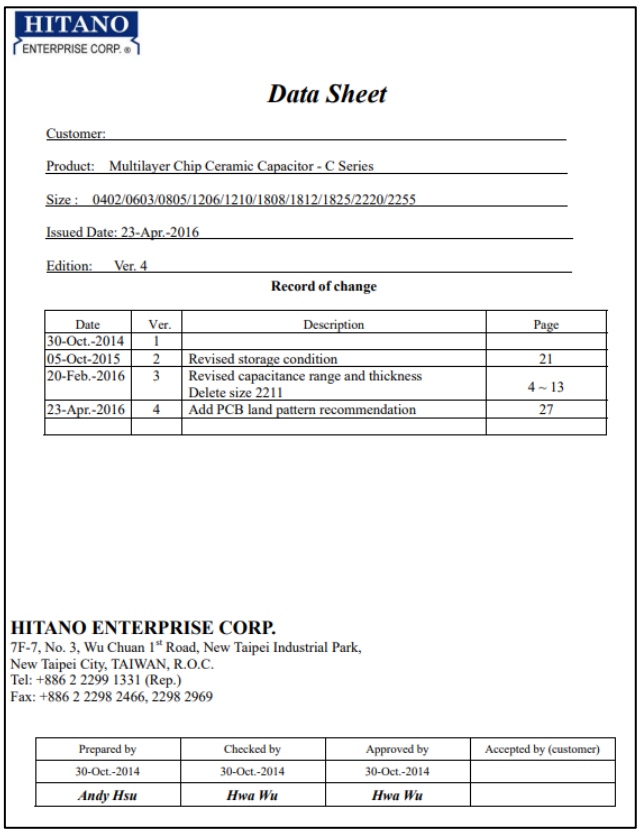
11.16

Figura 38: Resistores SMD 0805



HITANO ENTERPRISE CORP.

Data Sheet

Customer:

Product: Multilayer Chip Ceramic Capacitor - C Series

Size : 0402/0603/0805/1206/1210/1808/1812/1825/2220/2255

Issued Date: 23-Apr.-2016

Edition: Ver. 4

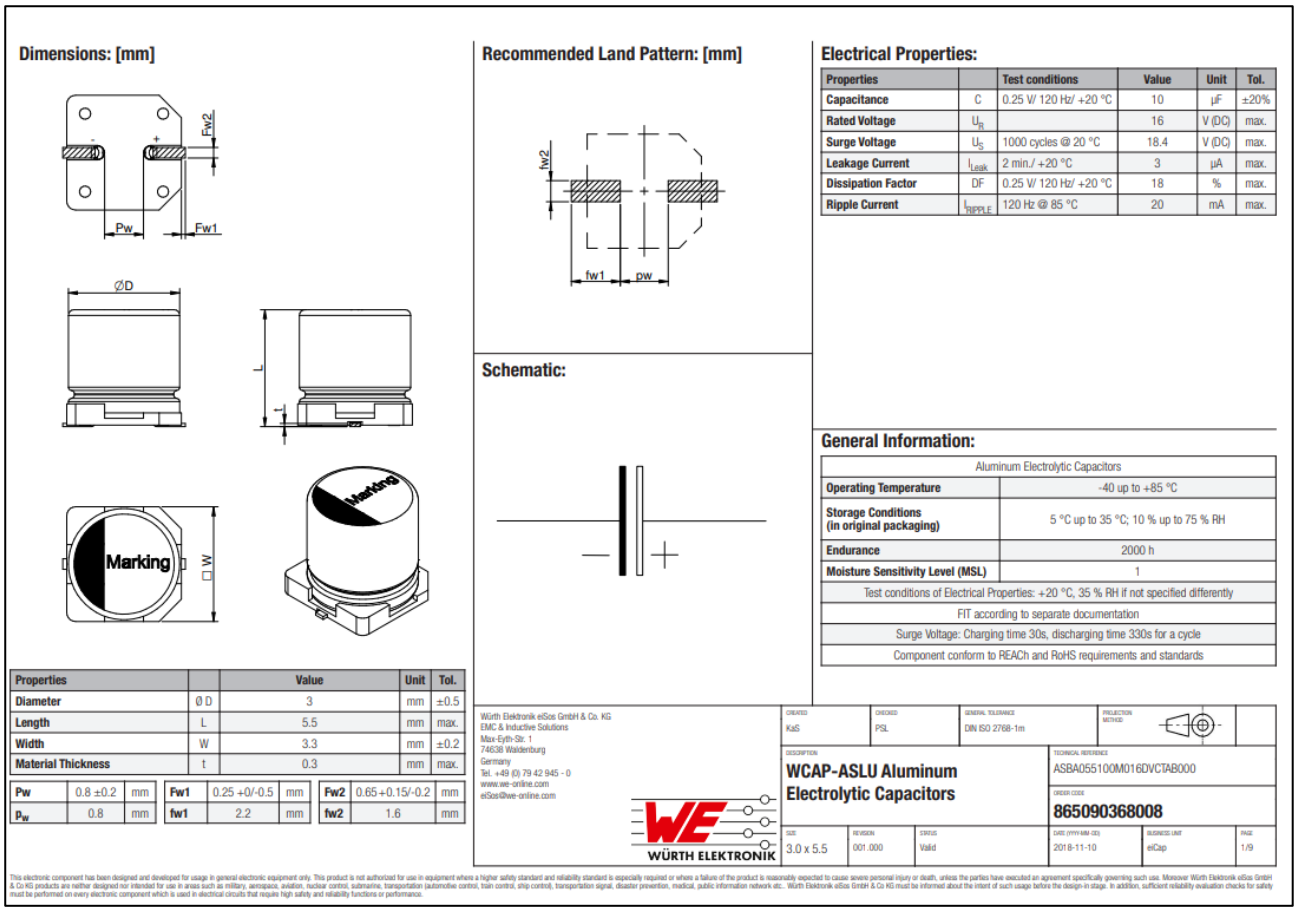
Record of change

Date	Ver.	Description	Page
30-Oct.-2014	1		
05-Oct-2015	2	Revised storage condition	21
20-Feb.-2016	3	Revised capacitance range and thickness Delete size 2211	4 ~ 13
23-Apr.-2016	4	Add PCB land pattern recommendation	27

HITANO ENTERPRISE CORP.
7F-7, No. 3, Wu Chuan 1st Road, New Taipei Industrial Park,
New Taipei City, TAIWAN, R.O.C.
Tel: +886 2 2299 1331 (Rep.)
Fax: +886 2 2298 2466, 2298 2969

Prepared by	Checked by	Approved by	Accepted by (customer)
30-Oct.-2014	30-Oct.-2014	30-Oct.-2014	
Andy Hsu	*Hwa Wu*	*Hwa Wu*	

Figura 39: Capacitores SMD 0805



Properties		Value	Unit	Tol.
Diameter	Ø D	3	mm	±0.5
Length	L	5.5	mm	max.
Width	W	3.3	mm	±0.2
Material Thickness	t	0.3	mm	max.

Pw	0.8 ±0.2	mm	Fw1	0.25 +0/-0.5	mm	Fw2	0.65 +0.15/-0.2	mm
p_w	0.8	mm	fw1	2.2	mm	fw2	1.6	mm

Properties		Test conditions	Value	Unit	Tol.
Capacitance	C	0.25 V/ 120 Hz/ +20 °C	10	µF	±20%
Rated Voltage	U_R		16	V (DC)	max.
Surge Voltage	U_S	1000 cycles @ 20 °C	18.4	V (DC)	max.
Leakage Current	I_{Leak}	2 min./ +20 °C	3	µA	max.
Dissipation Factor	DF	0.25 V/ 120 Hz/ +20 °C	18	%	max.
Ripple Current	I_{RIPPLE}	120 Hz @ 85 °C	20	mA	max.

Aluminum Electrolytic Capacitors	
Operating Temperature	-40 up to +85 °C
Storage Conditions (in original packaging)	5 °C up to 35 °C; 10 % up to 75 % RH
Endurance	2000 h
Moisture Sensitivity Level (MSL)	1
Test conditions of Electrical Properties: +20 °C, 35 % RH if not specified differently	
FIT according to separate documentation	
Surge Voltage: Charging time 30s, discharging time 330s for a cycle	
Component conform to REACh and RoHS requirements and standards	

Würth Elektronik eiSos GmbH & Co. KG
EMC & Inductive Solutions
Max-Eyth-Str. 1
74638 Waldenburg
Germany
Tel. +49 (0) 79 42 945 - 0
www.we-online.com
eiSos@we-online.com

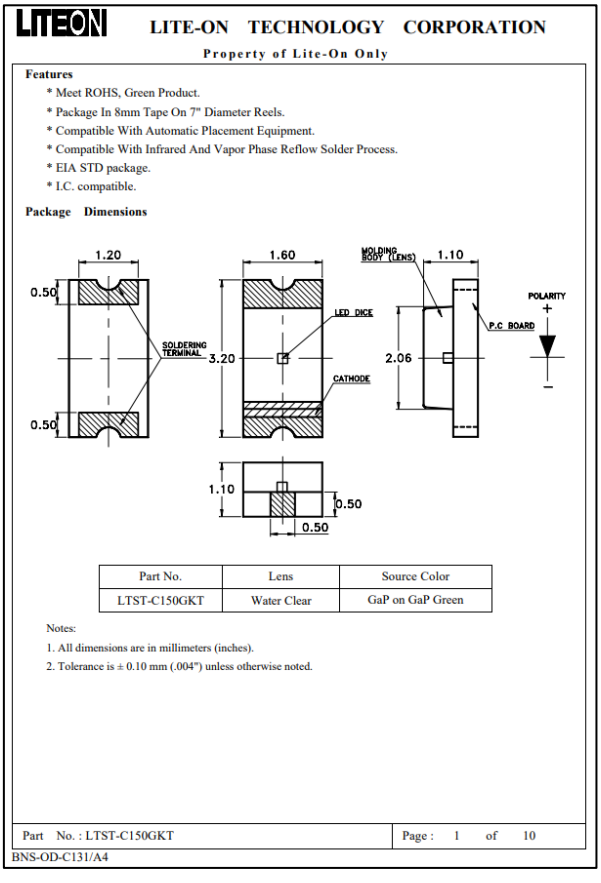
CREATED	CHECKED	GENERAL TOLERANCE	PROJECTION METHOD
KaS	PSL	DIN ISO 2768-1m	

DESCRIPTION: WCAP-ASLU Aluminum Electrolytic Capacitors
TECHNICAL REFERENCE: ASBA055100M016DVCTAB000
ORDER CODE: 865090368008

SIZE	REVISION	STATUS	DATE (YYYY-MM-DD)	BUSINESS UNIT	PAGE
3.0 x 5.5	001.000	Valid	2018-11-10	eiCap	1/9

This electronic component has been designed and developed for usage in general electronic equipment only. This product is not authorized for use in equipment where a higher safety standard and reliability standard is especially required or where a failure of the product is reasonably expected to cause severe personal injury or death, unless the parties have executed an agreement specifically governing such use. Moreover Würth Elektronik eiSos GmbH & Co KG products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Würth Elektronik eiSos GmbH & Co KG must be informed about the intent of such usage before the design-in stage. In addition, sufficient reliability evaluation checks for safety must be performed on every electronic component which is used in electrical circuits that require high safety and reliability functions or performance.

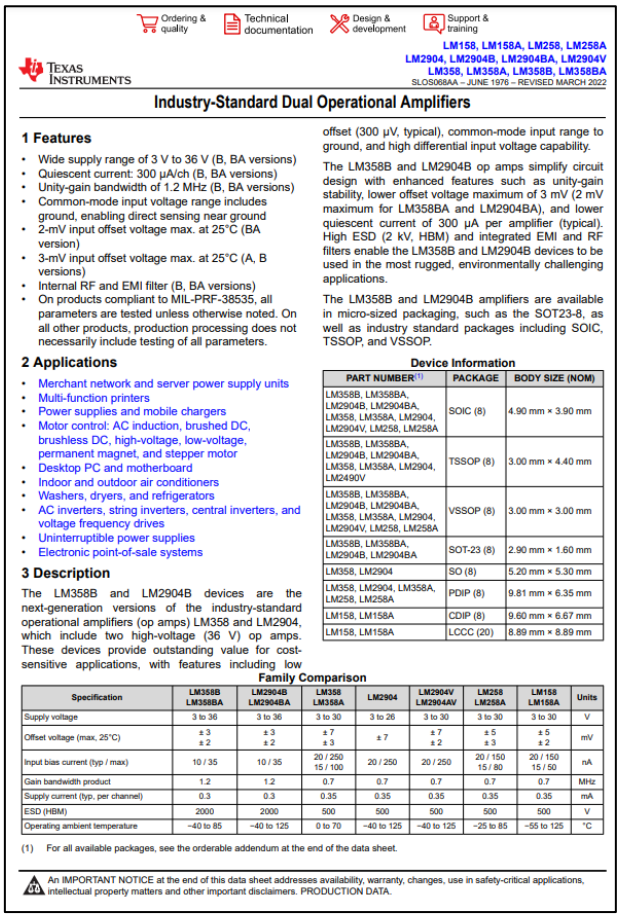
Figura 40: Capacitores de 10uF 710-865090368008



Part No.	Lens	Source Color
LTST-C150GKT	Water Clear	GaP on GaP Green

Notes:
1. All dimensions are in millimeters (inches).
2. Tolerance is ± 0.10 mm (.004") unless otherwise noted.

Figura 41: LTST–C150GKT



Ordering & quality | Technical documentation | Design & development | Support & training

TEXAS INSTRUMENTS

LM158, LM158A, LM258, LM258A
LM2904, LM2904B, LM2904BA, LM2904V
LM358, LM358A, LM358B, LM358BA
SLOS068AA – JUNE 1976 – REVISED MARCH 2022

Industry-Standard Dual Operational Amplifiers

1 Features

- Wide supply range of 3 V to 36 V (B, BA versions)
- Quiescent current: 300 µA/ch (B, BA versions)
- Unity-gain bandwidth of 1.2 MHz (B, BA versions)
- Common-mode input voltage range includes ground, enabling direct sensing near ground
- 2-mV input offset voltage max. at 25°C (BA version)
- 3-mV input offset voltage max. at 25°C (A, B versions)
- Internal RF and EMI filter (B, BA versions)
- On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

2 Applications

- Merchant network and server power supply units
- Multi-function printers
- Power supplies and mobile chargers
- Motor control: AC induction, brushed DC, brushless DC, high-voltage, low-voltage, permanent magnet, and stepper motor
- Desktop PC and motherboard
- Indoor and outdoor air conditioners
- Washers, dryers, and refrigerators
- AC inverters, string inverters, central inverters, and voltage frequency drives
- Uninterruptible power supplies
- Electronic point-of-sale systems

3 Description

The LM358B and LM2904B devices are the next-generation versions of the industry-standard operational amplifiers (op amps) LM358 and LM2904, which include two high-voltage (36 V) op amps. These devices provide outstanding value for cost-sensitive applications, with features including low offset (300 µV, typical), common-mode input range to ground, and high differential input voltage capability.

The LM358B and LM2904B op amps simplify circuit design with enhanced features such as unity-gain stability, lower offset voltage maximum of 3 mV (2 mV maximum for LM358BA and LM2904BA), and lower quiescent current of 300 µA per amplifier (typical). High ESD (2 kV, HBM) and integrated EMI and RF filters enable the LM358B and LM2904B devices to be used in the most rugged, environmentally challenging applications.

The LM358B and LM2904B amplifiers are available in micro-sized packaging, such as the SOT23-8, as well as industry standard packages including SOIC, TSSOP, and VSSOP.

Device Information

PART NUMBER(1)	PACKAGE	BODY SIZE (NOM)
LM358B, LM358BA, LM2904B, LM2904BA, LM358, LM358A, LM2904, LM2904V, LM258, LM258A	SOIC (8)	4.90 mm × 3.90 mm
LM358B, LM358BA, LM2904B, LM2904BA, LM358, LM358A, LM2904, LM2490V	TSSOP (8)	3.00 mm × 4.40 mm
LM358B, LM358BA, LM2904B, LM2904BA, LM358, LM358A, LM2904, LM2904V, LM258, LM258A	VSSOP (8)	3.00 mm × 3.00 mm
LM358B, LM358BA, LM2904B, LM2904BA	SOT-23 (8)	2.90 mm × 1.60 mm
LM358, LM2904	SO (8)	5.20 mm × 5.30 mm
LM358, LM2904, LM358A, LM258, LM258A	PDIP (8)	9.81 mm × 6.35 mm
LM158, LM158A	CDIP (8)	9.60 mm × 6.67 mm
LM158, LM158A	LCCC (20)	8.89 mm × 8.89 mm

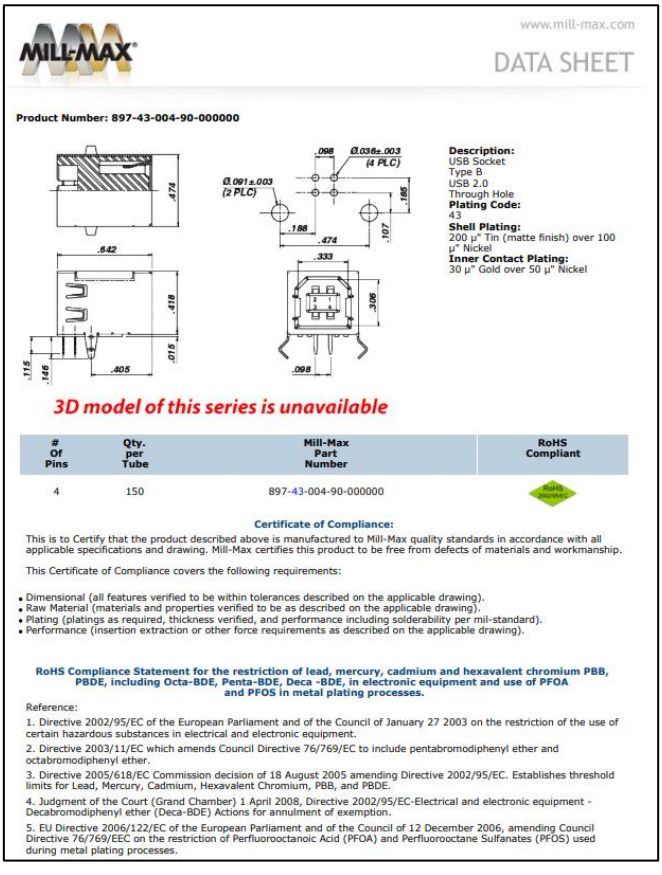
Family Comparison

Specification	LM358B LM358BA	LM2904B LM2904BA	LM358 LM358A	LM2904	LM2904V LM2904AV	LM258 LM258A	LM158 LM158A	Units
Supply voltage	3 to 36	3 to 36	3 to 30	3 to 26	3 to 30	3 to 30	3 to 30	V
Offset voltage (max, 25°C)	± 3 ± 2	± 3 ± 2	± 7 ± 3	± 7	± 7 ± 2	± 5 ± 3	± 5 ± 2	mV
Input bias current (typ / max)	10 / 35	10 / 35	20 / 250 15 / 100	20 / 250	20 / 250	20 / 150 15 / 80	20 / 150 15 / 50	nA
Gain bandwidth product	1.2	1.2	0.7	0.7	0.7	0.7	0.7	MHz
Supply current (typ, per channel)	0.3	0.3	0.35	0.35	0.35	0.35	0.35	mA
ESD (HBM)	2000	2000	500	500	500	500	500	V
Operating ambient temperature	−40 to 85	−40 to 125	0 to 70	−40 to 125	−40 to 125	−25 to 85	−55 to 125	°C

(1) For all available packages, see the orderable addendum at the end of the data sheet.

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Figura 42: LM358DR



MILL-MAX

www.mill-max.com

DATA SHEET

Product Number: 897-43-004-90-000000

Description:
USB Socket
Type B
USB 2.0
Through Hole
Plating Code:
43
Shell Plating:
200 µ" Tin (matte finish) over 100 µ" Nickel
Inner Contact Plating:
30 µ" Gold over 50 µ" Nickel

3D model of this series is unavailable

# Of Pins	Qty. per Tube	Mill-Max Part Number	RoHS Compliant
4	150	897-43-004-90-000000	

Certificate of Compliance:

This is to Certify that the product described above is manufactured to Mill-Max quality standards in accordance with all applicable specifications and drawing. Mill-Max certifies this product to be free from defects of materials and workmanship.

This Certificate of Compliance covers the following requirements:

- Dimensional (all features verified to be within tolerances described on the applicable drawing).
- Raw Material (materials and properties verified to be as described on the applicable drawing).
- Plating (platings as required, thickness verified, and performance including solderability per mil-standard).
- Performance (insertion extraction or other force requirements as described on the applicable drawing).

RoHS Compliance Statement for the restriction of lead, mercury, cadmium and hexavalent chromium PBB, PBDE, including Octa-BDE, Penta-BDE, Deca -BDE, in electronic equipment and use of PFOA and PFOS in metal plating processes.

Reference:

1. Directive 2002/95/EC of the European Parliament and of the Council of January 27 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
2. Directive 2003/11/EC which amends Council Directive 76/769/EC to include pentabromodiphenyl ether and octabromodiphenyl ether.
3. Directive 2005/618/EC Commission decision of 18 August 2005 amending Directive 2002/95/EC. Establishes threshold limits for Lead, Mercury, Cadmium, Hexavalent Chromium, PBB, and PBDE.
4. Judgment of the Court (Grand Chamber) 1 April 2008, Directive 2002/95/EC-Electrical and electronic equipment - Decabromodiphenyl ether (Deca-BDE) Actions for annulment of exemption.
5. EU Directive 2006/122/EC of the European Parliament and of the Council of 12 December 2006, amending Council Directive 76/769/EEC on the restriction of Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfanates (PFOS) used during metal plating processes.

Figura 43: 897–43–004–90–000000

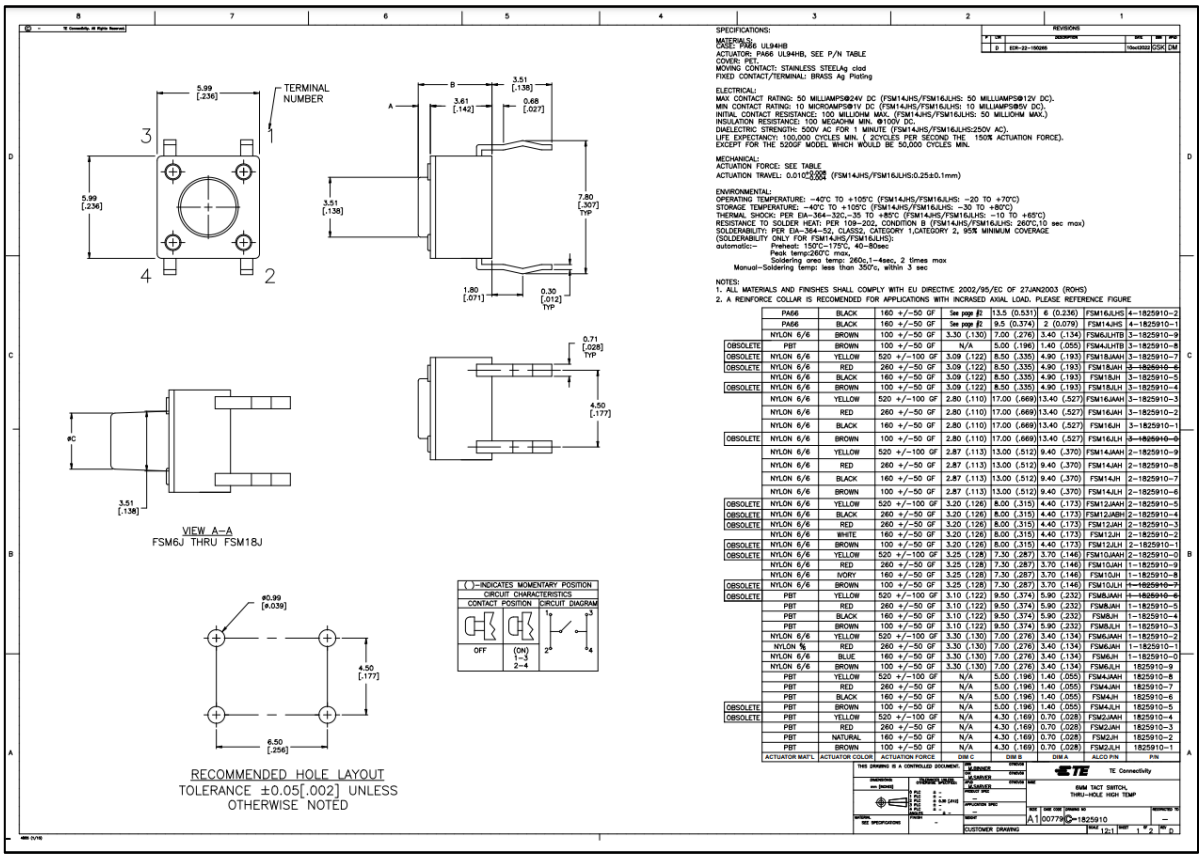


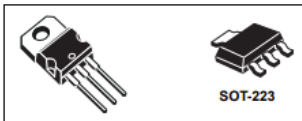
Figura 44: 1825910–6

LD1117A

life.augmented

Low drop fixed and adjustable positive voltage regulators

Datasheet - production data



- Available in ± 2% (at 25 °C) and 4% in full temperature range
- High supply voltage rejection:
  - 80 dB typ. (at 25 °C)
- Temperature range: 0 °C to 125 °C

Features

- Low dropout voltage:
  - 1.15 V typ. @ I_{OUT} = 1 A, 25 °C
- Very low quiescent current:
  - 5 mA typ. @ 25 °C
- Output current up to 1 A
- Fixed output voltage of:
  - 1.2 V, 1.8 V, 3.3 V
- Adjustable version availability (V_{REF} = 1.25 V)
- Internal current and thermal limit
- Only 10 µF for stability

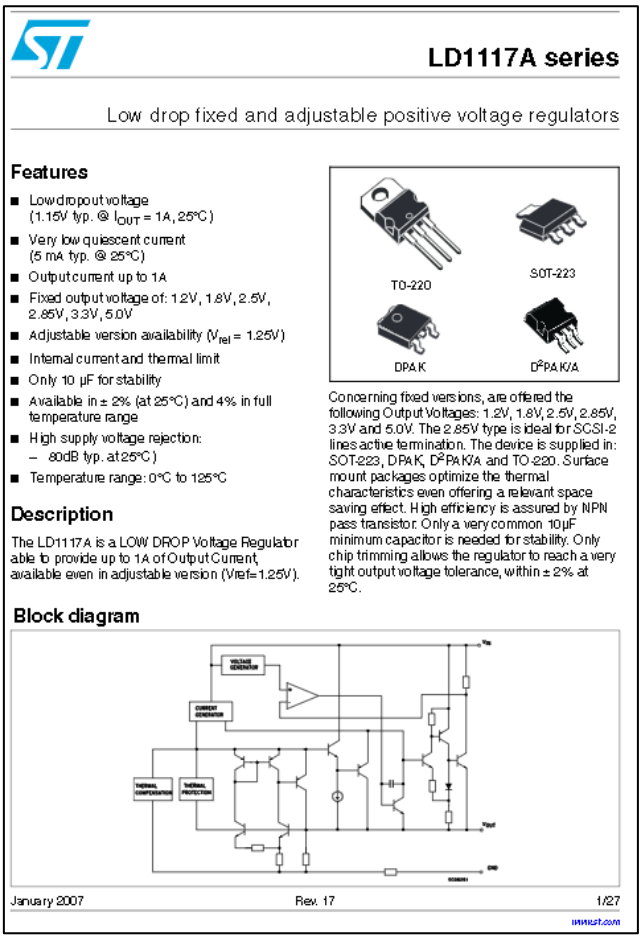
Description

The LD1117A is a low drop voltage regulator able to provide up to 1 A of output current, available also in adjustable versions (V_{REF} = 1.25 V). In fixed versions, the following output voltages are offered: 1.2 V, 1.8 V, and 3.3 V. The device is supplied in: SOT-223, DPAK and TO-220. Surface mounted packages optimize the thermal characteristics while offering a relevant space saving advantage. High efficiency is assured by an NPN pass transistor. Only a very common 10 µF minimum capacitor is needed for stability. Chip trimming allows the regulator to reach a very tight output voltage tolerance, within ± 2% at 25 °C.

Table 1. Device summary

Order codes			Output voltage
SOT-223	DPAK	TO-220	
LD1117AS12TR	LD1117ADT12TR		1.2 V
LD1117AS18TR	LD1117ADT18TR		1.8 V
LD1117AS33TR	LD1117ADT33TR	LD1117AV33	3.3 V
LD1117ASTR	LD1117ADT-TR		Adjustable from 1.25 V

Figura 45: LD1117AS33TR



LD1117A series

Low drop fixed and adjustable positive voltage regulators

Features

- Low dropout voltage (1.15V typ. @ I_{OUT} = 1A, 25°C)
- Very low quiescent current (5 mA typ. @ 25°C)
- Output current up to 1A
- Fixed output voltage of: 1.2V, 1.8V, 2.5V, 2.85V, 3.3V, 5.0V
- Adjustable version availability (V_{ref} = 1.25V)
- Internal current and thermal limit
- Only 10 µF for stability
- Available in ± 2% (at 25°C) and 4% in full temperature range
- High supply voltage rejection: – 80dB typ. at 25°C)
- Temperature range: 0°C to 125°C

TO-220 SOT-223 DPAK D^2PAK/A

Concerning fixed versions, are offered the following Output Voltages: 1.2V, 1.8V, 2.5V, 2.85V, 3.3V and 5.0V. The 2.85V type is ideal for SCSI-2 lines active termination. The device is supplied in: SOT-223, DPAK, D^2PAK/A and TO-220. Surface mount packages optimize the thermal characteristics even offering a relevant space saving effect. High efficiency is assured by NPN pass transistor. Only a very common 10µF minimum capacitor is needed for stability. Only chip trimming allows the regulator to reach a very tight output voltage tolerance, within ± 2% at 25°C.

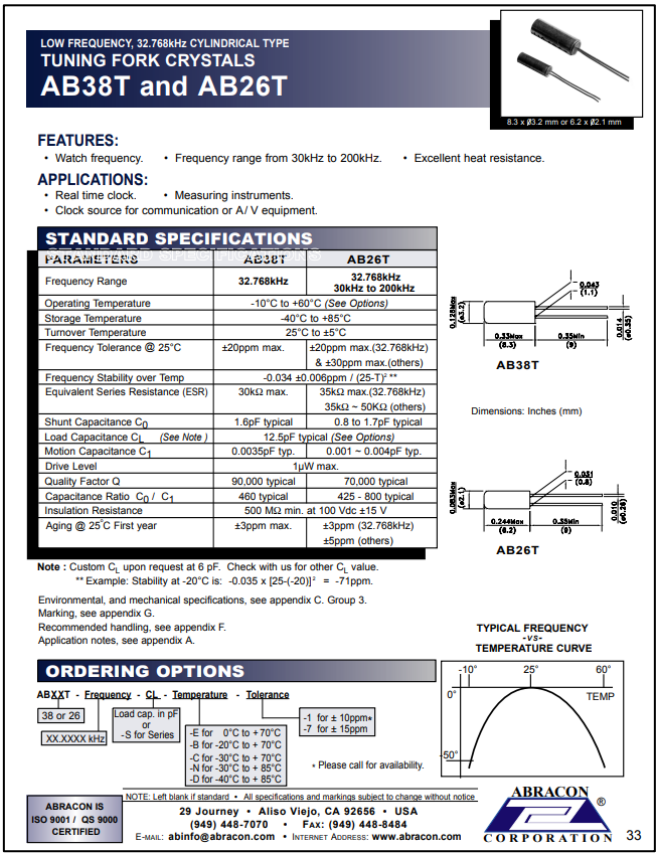
Description

The LD1117A is a LOW DROP Voltage Regulator able to provide up to 1A of Output Current, available even in adjustable version (Vref=1.25V).

Block diagram

January 2007 Rev. 17 1/27

Figura 46: LD1117AS50TR



LOW FREQUENCY, 32.768kHz CYLINDRICAL TYPE
TUNING FORK CRYSTALS
AB38T and AB26T

8.3 x ⌀3.2 mm or 6.2 x ⌀2.1 mm

FEATURES:
• Watch frequency. • Frequency range from 30kHz to 200kHz. • Excellent heat resistance.

APPLICATIONS:
• Real time clock. • Measuring instruments.
• Clock source for communication or A/V equipment.

STANDARD SPECIFICATIONS

PARAMETERS	AB38T	AB26T
Frequency Range	32.768kHz	32.768kHz 30kHz to 200kHz
Operating Temperature	-10°C to +60°C *(See Options)*	
Storage Temperature	-40°C to +85°C	
Turnover Temperature	25°C to ±5°C	
Frequency Tolerance @ 25°C	±20ppm max.	±20ppm max.(32.768kHz) & ±30ppm max.(others)
Frequency Stability over Temp	-0.034 ±0.006ppm / (25-T)² **	
Equivalent Series Resistance (ESR)	30kΩ max.	35kΩ max.(32.768kHz) 35kΩ ~ 50KΩ (others)
Shunt Capacitance C_0	1.6pF typical	0.8 to 1.7pF typical
Load Capacitance C_L *(See Note)*	12.5pF typical *(See Options)*	
Motion Capacitance C_1	0.0035pF typ.	0.001 ~ 0.004pF typ.
Drive Level	1µW max.	
Quality Factor Q	90,000 typical	70,000 typical
Capacitance Ratio C_0 / C_1	460 typical	425 - 800 typical
Insulation Resistance	500 MΩ min. at 100 Vdc ±15 V	
Aging @ 25°C First year	±3ppm max.	±3ppm (32.768kHz) ±5ppm (others)

AB38T

Dimensions: Inches (mm)

AB26T

Note : Custom C_L upon request at 6 pF. Check with us for other C_L value.
** Example: Stability at -20°C is: -0.035 x [25-(-20)]² = -71ppm.

Environmental, and mechanical specifications, see appendix C. Group 3.
Marking, see appendix G.
Recommended handling, see appendix F.
Application notes, see appendix A.

TYPICAL FREQUENCY -vs- TEMPERATURE CURVE

-10° 25° 60° 0° TEMP -50°

ORDERING OPTIONS

ABXXT - Frequency - CL - Temperature - Tolerance

38 or 26 | XX.XXXX kHz | Load cap. in pF or -S for Series | -E for 0°C to +70°C, -B for -20°C to +70°C, -C for -30°C to +70°C, -N for -30°C to +85°C, -D for -40°C to +85°C | -1 for ± 10ppm•, -7 for ± 15ppm

• Please call for availability.

NOTE: Left blank if standard. • All specifications and markings subject to change without notice.

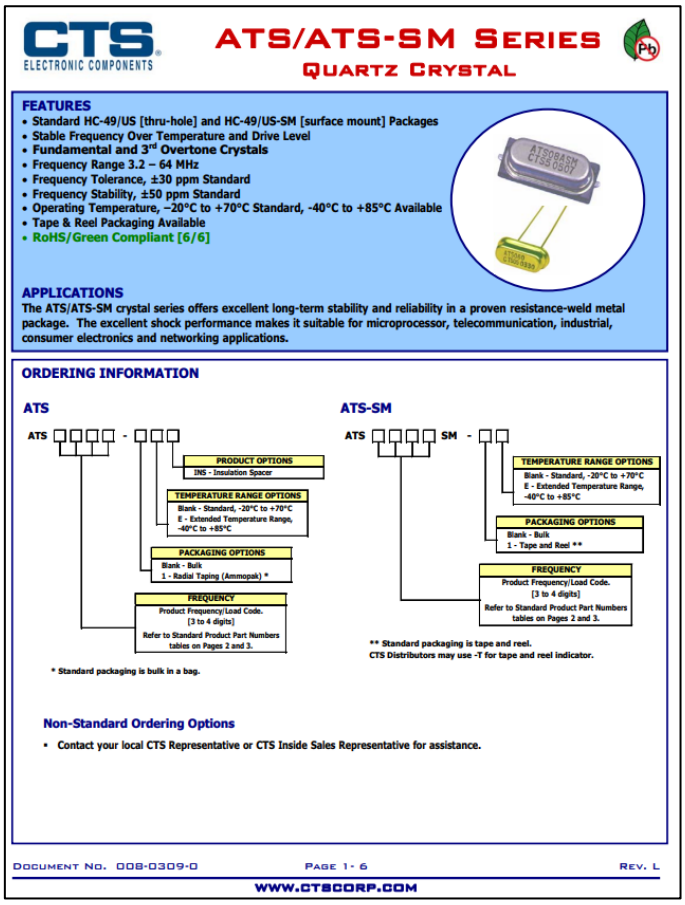
ABRACON IS ISO 9001 / QS 9000 CERTIFIED

29 Journey • Aliso Viejo, CA 92656 • USA
(949) 448-7070 • Fax: (949) 448-8484
E-mail: abinfo@abracon.com • Internet Address: www.abracon.com

ABRACON CORPORATION

33

Figura 47: AB38T–32.768KHZ



CTS ELECTRONIC COMPONENTS

ATS/ATS-SM Series

Quartz Crystal

FEATURES

- Standard HC-49/US [thru-hole] and HC-49/US-SM [surface mount] Packages
- Stable Frequency Over Temperature and Drive Level
- **Fundamental and 3rd Overtone Crystals**
- Frequency Range 3.2 – 64 MHz
- Frequency Tolerance, ±30 ppm Standard
- Frequency Stability, ±50 ppm Standard
- Operating Temperature, –20°C to +70°C Standard, -40°C to +85°C Available
- Tape & Reel Packaging Available
- RoHS/Green Compliant [6/6]

APPLICATIONS

The ATS/ATS-SM crystal series offers excellent long-term stability and reliability in a proven resistance-weld metal package. The excellent shock performance makes it suitable for microprocessor, telecommunication, industrial, consumer electronics and networking applications.

ORDERING INFORMATION

ATS

ATS □□□□ - □□□

- PRODUCT OPTIONS: INS - Insulation Spacer
- TEMPERATURE RANGE OPTIONS: Blank - Standard, -20°C to +70°C; E - Extended Temperature Range, -40°C to +85°C
- PACKAGING OPTIONS: Blank - Bulk; 1 - Radial Taping (Ammopak) *
- FREQUENCY: Product Frequency/Load Code. [3 to 4 digits] Refer to Standard Product Part Numbers tables on Pages 2 and 3.

* Standard packaging is bulk in a bag.

ATS-SM

ATS □□□□ SM - □□

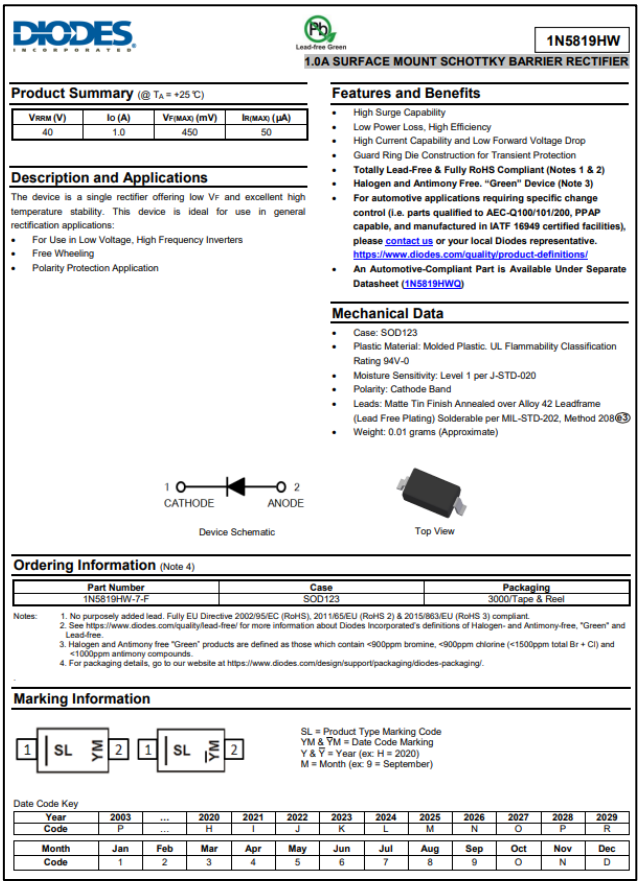
- TEMPERATURE RANGE OPTIONS: Blank - Standard, -20°C to +70°C; E - Extended Temperature Range, -40°C to +85°C
- PACKAGING OPTIONS: Blank - Bulk; 1 - Tape and Reel **
- FREQUENCY: Product Frequency/Load Code. [3 to 4 digits] Refer to Standard Product Part Numbers tables on Pages 2 and 3.

** Standard packaging is tape and reel.
CTS Distributors may use -T for tape and reel indicator.

Non-Standard Ordering Options

- Contact your local CTS Representative or CTS Inside Sales Representative for assistance.

Figura 48: ATS20A e ATS12A



DIODES INCORPORATED

Lead-free Green

1N5819HW

1.0A SURFACE MOUNT SCHOTTKY BARRIER RECTIFIER

Product Summary (@ T_A = +25°C)

V_{RRM} (V)	I_O (A)	$V_{F(MAX)}$ (mV)	$I_{R(MAX)}$ (μA)
40	1.0	450	50

Description and Applications

The device is a single rectifier offering low V_F and excellent high temperature stability. This device is ideal for use in general rectification applications:

- For Use in Low Voltage, High Frequency Inverters
- Free Wheeling
- Polarity Protection Application

Features and Benefits

- High Surge Capability
- Low Power Loss, High Efficiency
- High Current Capability and Low Forward Voltage Drop
- Guard Ring Die Construction for Transient Protection
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**
- **An Automotive-Compliant Part is Available Under Separate Datasheet (1N5819HWQ)**

Mechanical Data

- Case: SOD123
- Plastic Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Polarity: Cathode Band
- Leads: Matte Tin Finish Annealed over Alloy 42 Leadframe (Lead Free Plating) Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.01 grams (Approximate)

1 CATHODE — 2 ANODE

Device Schematic

Top View

Ordering Information (Note 4)

Part Number	Case	Packaging
1N5819HW-7-F	SOD123	3000/Tape & Reel

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen and Antimony free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

1 SL YM 2 1 SL YM 2

SL = Product Type Marking Code
YM & $\overline{YM}$ = Date Code Marking
Y & $\overline{Y}$ = Year (ex: H = 2020)
M = Month (ex: 9 = September)

Date Code Key

Year	2003	...	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Code	P	...	H	I	J	K	L	M	N	O	P	R

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Code	1	2	3	4	5	6	7	8	9	O	N	D

Figura 49: 1N5819HW–7

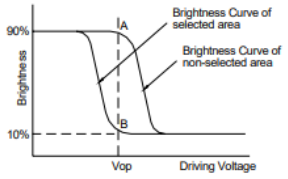
LCD MOUDULE SPECIFICATION FOR APPROVAL	DATE	18/03/04
	VER.	1.0
JHD162A	PAGE	4

5. ELECTRO-OPTICAL CHARACTERISTICS

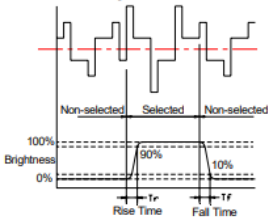
ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT	NOTE
Contrast ratio	K	ϕ=0	1.4	4	-	-	1
Response time (rise)	Tr	ϕ=1	-	130	-	ms	2
Response time (fall)	Tf	ϕ=2		130	-	ms	2
Viewing angle	ϕ	K ⩾1.4	10 — +30			deg.	3
	θ		-30 — +30				

Note 1: Definition of Contrast Ratio "K"

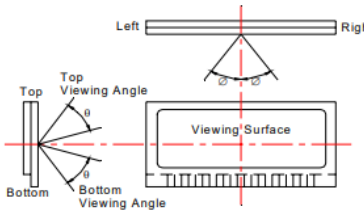
K= Brightness of non-selected segment(A) / Brightness of selected segment(B)



Note 2: Definition of Optical Response Time



Note 3: Definition of Viewing Angle



Please select either top or bottom viewing angle

Figura 50: JHD162A

molex
one company > a world of innovation

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PLEASE CHECK WWW.MOLEX.COM FOR LATEST PART INFORMATION

Part Number: 0702461002
Status: Active
Overview: C-Grid Connector Products
Description: 2.54mm Pitch C-Grid Header, Low Profile, Dual Row, Vertical, Shrouded, 10 Circuits, 0.76µm Gold (Au) Selective Plating, Tin (Sn) PC Tail Plating

Series image - Reference only

Documents:
Drawing (PDF)
3D Model
3D Model (PDF)
Product Specification PS-70246-100-001 (PDF)
Application Specification 713080001-AS-000 (PDF)
Packaging Specification PK-87835-001-001 (PDF)
RoHS Certificate of Compliance (PDF)

Agency Certification

CSA	LR19980
UL	E29179

General

Product Family	PCB Headers
Series	70246
Application	Signal, Wire-to-Board
Overview	C-Grid Connector Products
Product Name	C-Grid
UPC	822348487332

Physical

Breakaway	No
Circuits (Loaded)	10
Circuits (maximum)	10
First Mate / Last Break	No
Flammability	94V-0
Glow-Wire Capable	No
Guide to Mating Part	No
Keying to Mating Part	None
Lock to Mating Part	None
Material - Plating Mating	Gold
Material - Plating Termination	Tin
Net Weight	1.467/g
Number of Rows	2
Orientation	Vertical
PC Tail Length	3.43mm
PCB Locator	No
PCB Retention	None
PCB Thickness - Recommended	1.60mm
Packaging Type	Tray
Pitch - Mating Interface	2.54mm
Pitch - Termination Interface	2.54mm
Plating min - Mating	0.762µm
Plating min - Termination	1.905µm
Polarized to Mating Part	Center Slot
Polarized to PCB	No
Shrouded	Fully
Stackable	No
Surface Mount Compatible (SMC)	No
Temperature Range - Operating	-55° to +120°C
Termination Interface: Style	Through Hole

Electrical

EU ELV
Not Relevant

EU RoHS | **China RoHS**
Compliant

REACH SVHC
Not Contained Per - D(2021)4569-DC (8 July 2021)

Halogen-Free Status
Not Low-Halogen

For more information, please visit Contact US

China ROHS	Green Image
ELV	Not Relevant
RoHS Phthalates	Not Contained

Search Parts in this Series
70246 Series

Mates With
70450 SL Crimp Housing, 70058 SL Crimp Terminal

Figura 51: 70246-1002

Surface Mount Multilayer Ceramic Chip Capacitors (SMD MLCCs)

X7R Dielectric, 6.3 – 250 VDC (Automotive Grade)

KEMET a YAGEO company

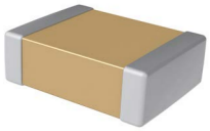
Overview

The KEMET Automotive Grade Surface Mount Capacitors in X7R dielectric are suited for a variety of applications requiring proven, reliable performance in harsh environments. Whether underhood or in-cabin, these devices emphasize the vital and robust nature of capacitors required for mission and safety of critical automotive circuits. Stricter testing protocol and inspection criteria have been established for automotive grade products in recognition of potentially harsh environmental conditions. KEMET automotive grade capacitors meet the demanding Automotive Electronics Council's AEC-Q200 qualification requirements.

X7R dielectric features a 125°C maximum operating temperature and is considered temperature stable. The Electronics Industries Alliance (EIA) characterizes X7R dielectric as a Class II material. Components of this classification are fixed, ceramic dielectric capacitors, suited for bypass and decoupling applications, or for frequency discriminating circuits, where Q and stability of capacitance characteristics are not critical. X7R exhibits a predictable change in capacitance with respect to time and voltage, and boasts a minimal change in capacitance with reference to ambient temperature. Capacitance change is limited to ±15% from −55°C to +125°C.

Benefits

- AEC–Q200 automotive qualified
- −55°C to +125°C operating temperature range
- Lead (Pb)-free, RoHS and REACH compliant
- Temperature stable dielectric
- EIA 0402, 0603, 0805, 1206, 1210, 1808, 1812, 1825, and 2220 case sizes
- DC voltage ratings of 6.3 V, 10 V, 16 V, 25 V, 50 V, 100 V, 200 V and 250 V
- Capacitance offerings ranging from 10 pF to 22 µF
- Available capacitance tolerances of ±5%, ±10% and ±20%
- Non-polar device, minimizing installation concerns
- 100% pure matte tin-plated termination finish, allowing for excellent solderability



Applications

Typical applications include decoupling, bypass, filtering and transient voltage suppression.

Figura 52: Capacitor SMD 0805 22pF

Surface Mount Multilayer Ceramic Capacitors (SMD MLCCs) for High Frequency Applications

HiQ-CBR Automotive Series, C0G Dielectric, Low ESR, 50 VDC, 1 MHz – 50 GHz (RF & Microwave)

KEMET a YAGEO company

Overview

KEMET's HiQ CBR Automotive RF Capacitor Series features a copper electrode BME (Base Metal Electrode) system that offers ultra-low ESR and High Q in the VHF, UHF, and microwave frequency bands. Low ESR allows for higher RF currents which are ideal for applications such as V2X, safety systems, power train and automotive communication systems.

CBR Series capacitors exhibit no change in capacitance with respect to time and voltage, and boast a negligible change in capacitance with reference to ambient temperature.

HiQ-CBR RF & MICROWAVE

KEMET's HiQ CBR RF capacitors are characterized using Modelithics™ substrate scalable models and is available in most EDA software. Contact KEMET Sales for details on accessing models.

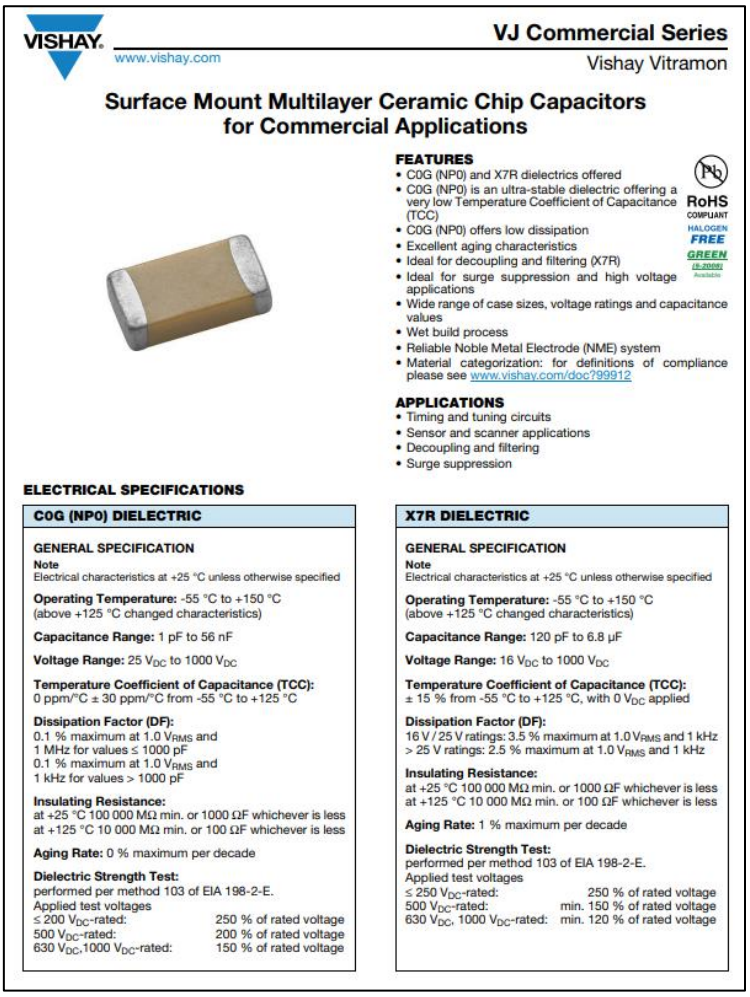
Benefits

- AEC-Q200 Qualified
- Ultra-low ESR and High Q
- High SRF
- High thermal stability
- 1 MHz to 50 GHz frequency range
- Operating temperature range of −55°C to +125°C
- Base metal electrode (BME) dielectric system
- Pb-free and RoHS compliant
- 0402 and 0603 case sizes (inches)
- DC voltage rating of 50 V
- Capacitance offerings ranging from 0.1 pF up to 100 pF
- Available capacitance tolerances of ±0.05 pF, ±0.1 pF, ±0.25 pF, ±0.5 pF, ±1%, ±2%, and ±5%
- Negligible capacitance change with respect to temperature
- 100% pure matte tin-plated termination finish allowing for excellent solderability

Applications

- V2X
- Safety Systems
- Power Train
- Automotive Communication Systems
- Bypass, coupling, filtering, impedance matching, DC blocking

Figura 53: Capacitor SMD 0805 39pF



VISHAY
www.vishay.com

VJ Commercial Series
Vishay Vitramon

Surface Mount Multilayer Ceramic Chip Capacitors for Commercial Applications

FEATURES
- C0G (NP0) and X7R dielectrics offered
- C0G (NP0) is an ultra-stable dielectric offering a very low Temperature Coefficient of Capacitance (TCC)
- C0G (NP0) offers low dissipation
- Excellent aging characteristics
- Ideal for decoupling and filtering (X7R)
- Ideal for surge suppression and high voltage applications
- Wide range of case sizes, voltage ratings and capacitance values
- Wet build process
- Reliable Noble Metal Electrode (NME) system
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

RoHS COMPLIANT
HALOGEN FREE
GREEN (5-2008)

APPLICATIONS
- Timing and tuning circuits
- Sensor and scanner applications
- Decoupling and filtering
- Surge suppression

ELECTRICAL SPECIFICATIONS

C0G (NP0) DIELECTRIC

GENERAL SPECIFICATION
Note
Electrical characteristics at +25 °C unless otherwise specified

Operating Temperature: -55 °C to +150 °C
(above +125 °C changed characteristics)

Capacitance Range: 1 pF to 56 nF

Voltage Range: 25 V_{DC} to 1000 V_{DC}

Temperature Coefficient of Capacitance (TCC):
0 ppm/°C ± 30 ppm/°C from -55 °C to +125 °C

Dissipation Factor (DF):
0.1 % maximum at 1.0 V_{RMS} and 1 MHz for values ≤ 1000 pF
0.1 % maximum at 1.0 V_{RMS} and 1 kHz for values > 1000 pF

Insulating Resistance:
at +25 °C 100 000 MΩ min. or 1000 ΩF whichever is less
at +125 °C 10 000 MΩ min. or 100 ΩF whichever is less

Aging Rate: 0 % maximum per decade

Dielectric Strength Test:
performed per method 103 of EIA 198-2-E.
Applied test voltages

≤ 200 V_{DC}-rated:	250 % of rated voltage
500 V_{DC}-rated:	200 % of rated voltage
630 V_{DC},1000 V_{DC}-rated:	150 % of rated voltage

X7R DIELECTRIC

GENERAL SPECIFICATION
Note
Electrical characteristics at +25 °C unless otherwise specified

Operating Temperature: -55 °C to +150 °C
(above +125 °C changed characteristics)

Capacitance Range: 120 pF to 6.8 µF

Voltage Range: 16 V_{DC} to 1000 V_{DC}

Temperature Coefficient of Capacitance (TCC):
± 15 % from -55 °C to +125 °C, with 0 V_{DC} applied

Dissipation Factor (DF):
16 V / 25 V ratings: 3.5 % maximum at 1.0 V_{RMS} and 1 kHz
> 25 V ratings: 2.5 % maximum at 1.0 V_{RMS} and 1 kHz

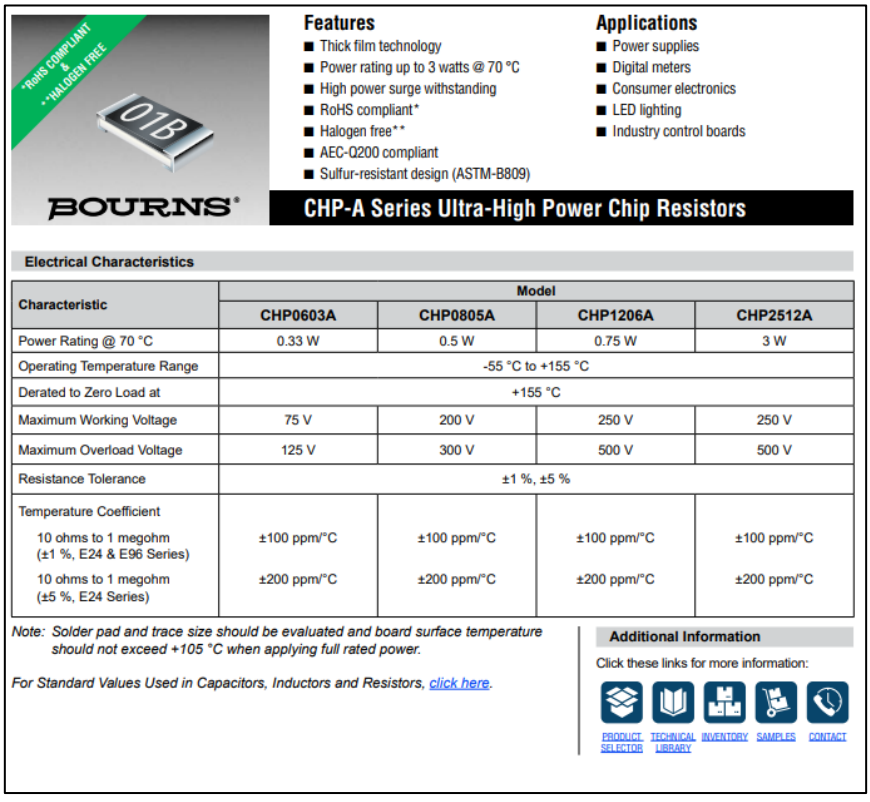
Insulating Resistance:
at +25 °C 100 000 MΩ min. or 1000 ΩF whichever is less
at +125 °C 10 000 MΩ min. or 100 ΩF whichever is less

Aging Rate: 1 % maximum per decade

Dielectric Strength Test:
performed per method 103 of EIA 198-2-E.
Applied test voltages

≤ 250 V_{DC}-rated:	250 % of rated voltage
500 V_{DC}-rated:	min. 150 % of rated voltage
630 V_{DC}, 1000 V_{DC}-rated:	min. 120 % of rated voltage

Figura 54: Capacitor SMD 0805 100nF



*RoHS COMPLIANT & **HALOGEN FREE

01B

BOURNS®

Features
- Thick film technology
- Power rating up to 3 watts @ 70 °C
- High power surge withstanding
- RoHS compliant*
- Halogen free**
- AEC-Q200 compliant
- Sulfur-resistant design (ASTM-B809)

Applications
- Power supplies
- Digital meters
- Consumer electronics
- LED lighting
- Industry control boards

CHP-A Series Ultra-High Power Chip Resistors

Electrical Characteristics

Characteristic	Model			
	CHP0603A	CHP0805A	CHP1206A	CHP2512A
Power Rating @ 70 °C	0.33 W	0.5 W	0.75 W	3 W
Operating Temperature Range	-55 °C to +155 °C			
Derated to Zero Load at	+155 °C			
Maximum Working Voltage	75 V	200 V	250 V	250 V
Maximum Overload Voltage	125 V	300 V	500 V	500 V
Resistance Tolerance	±1 %, ±5 %			
Temperature Coefficient				
10 ohms to 1 megohm (±1 %, E24 & E96 Series)	±100 ppm/°C	±100 ppm/°C	±100 ppm/°C	±100 ppm/°C
10 ohms to 1 megohm (±5 %, E24 Series)	±200 ppm/°C	±200 ppm/°C	±200 ppm/°C	±200 ppm/°C

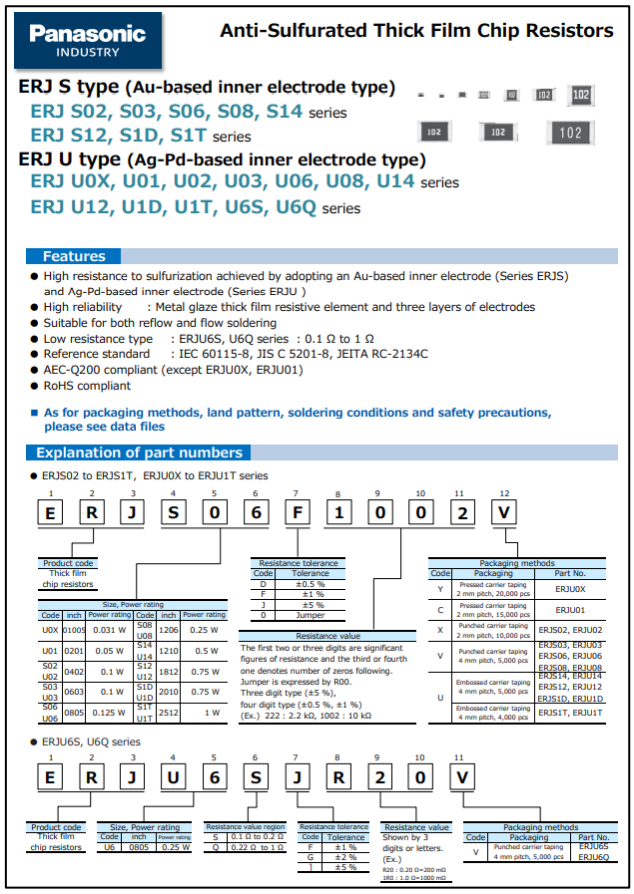
Note: Solder pad and trace size should be evaluated and board surface temperature should not exceed +105 °C when applying full rated power.

For Standard Values Used in Capacitors, Inductors and Resistors, click here.

Additional Information
Click these links for more information:

PRODUCT SELECTOR | TECHNICAL LIBRARY | INVENTORY | SAMPLES | CONTACT

Figura 55: Resistor SMD 0805 100Ω



Panasonic INDUSTRY

Anti-Sulfurated Thick Film Chip Resistors

ERJ S type (Au-based inner electrode type)

ERJ S02, S03, S06, S08, S14 series

ERJ S12, S1D, S1T series

ERJ U type (Ag-Pd-based inner electrode type)

ERJ U0X, U01, U02, U03, U06, U08, U14 series

ERJ U12, U1D, U1T, U6S, U6Q series

Features

- High resistance to sulfurization achieved by adopting an Au-based inner electrode (Series ERJS) and Ag-Pd-based inner electrode (Series ERJU)
- High reliability : Metal glaze thick film resistive element and three layers of electrodes
- Suitable for both reflow and flow soldering
- Low resistance type : ERJU6S, U6Q series : 0.1 Ω to 1 Ω
- Reference standard : IEC 60115-8, JIS C 5201-8, JEITA RC-2134C
- AEC-Q200 compliant (except ERJU0X, ERJU01)
- RoHS compliant

■ As for packaging methods, land pattern, soldering conditions and safety precautions, please see data files

Explanation of part numbers

● ERJS02 to ERJS1T, ERJU0X to ERJU1T series

1	2	3	4	5	6	7	8	9	10	11	12
E	R	J	S	0	6	F	1	0	0	2	V

Product code: Thick film chip resistors

Size, Power rating

Code	inch	Power rating	Code	inch	Power rating
U0X	01005	0.031 W	S08 U08	1206	0.25 W
U01	0201	0.05 W	S14 U14	1210	0.5 W
S02 U02	0402	0.1 W	S12 U12	1812	0.75 W
S03 U03	0603	0.1 W	S1D U1D	2010	0.75 W
S06 U06	0805	0.125 W	S1T U1T	2512	1 W

Resistance tolerance

Code	Tolerance
D	±0.5 %
F	±1 %
J	±5 %
G	Jumper

Resistance value

The first two or three digits are significant figures of resistance and the third or fourth one denotes number of zeros following.
Jumper is expressed by R00.
Three digit type (±5 %),
four digit type (±0.5 %, ±1 %)
(Ex.) 222 : 2.2 kΩ, 1002 : 10 kΩ

Packaging methods

Code	Packaging	Part No.
Y	Pressed carrier taping 2 mm pitch, 20,000 pcs	ERJU0X
C	Pressed carrier taping 2 mm pitch, 15,000 pcs	ERJU01
X	Punched carrier taping 2 mm pitch, 10,000 pcs	ERJS02, ERJU02
V	Punched carrier taping 4 mm pitch, 5,000 pcs	ERJS03, ERJU03 ERJS06, ERJU06 ERJS08, ERJU08
U	Embossed carrier taping 4 mm pitch, 5,000 pcs	ERJS14, ERJU14 ERJS12, ERJU12 ERJS1D, ERJU1D
	Embossed carrier taping 4 mm pitch, 4,000 pcs	ERJS1T, ERJU1T

● ERJU6S, U6Q series

1	2	3	4	5	6	7	8	9	10	11
E	R	J	U	6	S	J	R	2	0	V

Product code: Thick film chip resistors

Size, Power rating

Code	inch	Power rating
U6	0805	0.25 W

Resistance value region

S	0.1 Ω to 0.2 Ω
Q	0.22 Ω to 1 Ω

Resistance tolerance

Code	Tolerance
F	±1 %
G	±2 %
J	±5 %

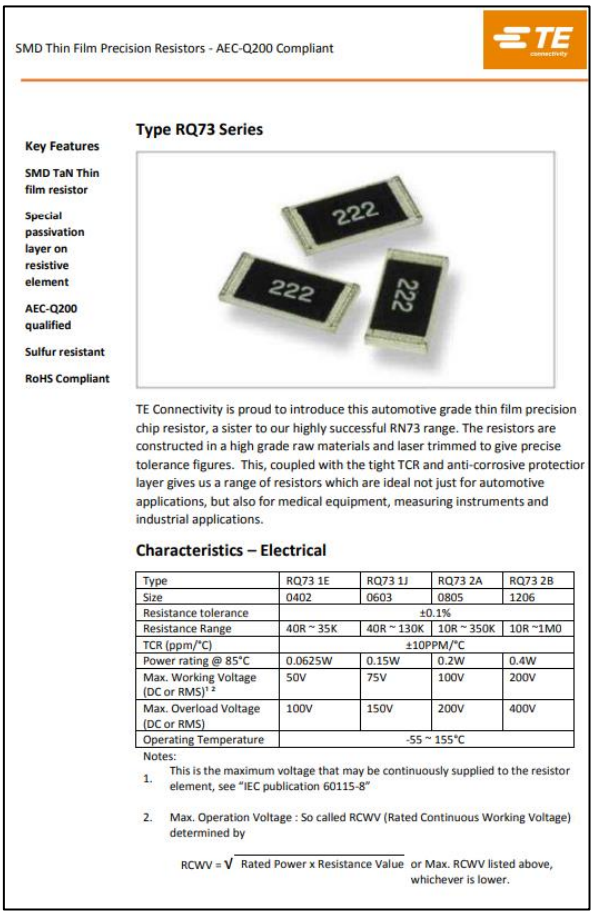
Resistance value: Shown by 3 digits or letters. (Ex.)

R20 : 0.20 Ω=200 mΩ
1R0 : 1.0 Ω=1000 mΩ

Packaging methods

Code	Packaging	Part No.
V	Punched carrier taping 4 mm pitch, 5,000 pcs	ERJU6S ERJU6Q

Figura 56: Resistor SMD 0805 470Ω



SMD Thin Film Precision Resistors - AEC-Q200 Compliant

TE connectivity

Type RQ73 Series

Key Features

SMD TaN Thin film resistor

Special passivation layer on resistive element

AEC-Q200 qualified

Sulfur resistant

RoHS Compliant

TE Connectivity is proud to introduce this automotive grade thin film precision chip resistor, a sister to our highly successful RN73 range. The resistors are constructed in a high grade raw materials and laser trimmed to give precise tolerance figures. This, coupled with the tight TCR and anti-corrosive protectior layer gives us a range of resistors which are ideal not just for automotive applications, but also for medical equipment, measuring instruments and industrial applications.

Characteristics – Electrical

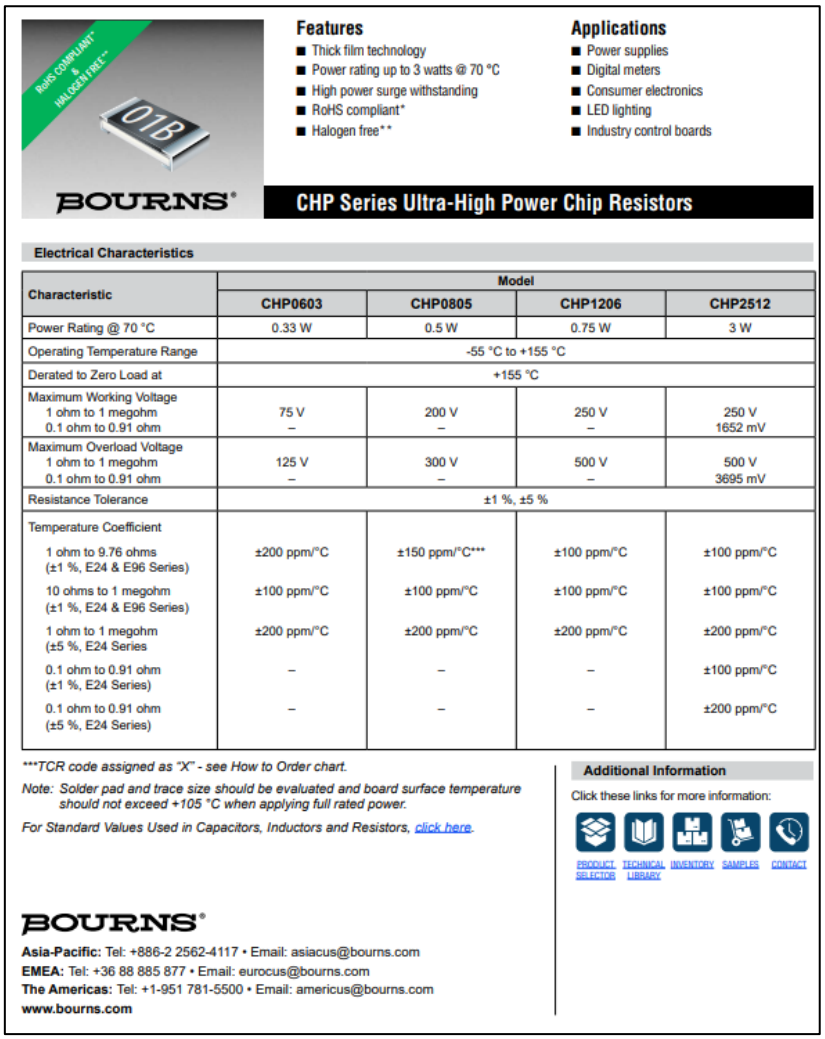
Type	RQ73 1E	RQ73 1J	RQ73 2A	RQ73 2B
Size	0402	0603	0805	1206
Resistance tolerance	±0.1%			
Resistance Range	40R ~ 35K	40R ~ 130K	10R ~ 350K	10R ~1M0
TCR (ppm/°C)	±10PPM/°C			
Power rating @ 85°C	0.0625W	0.15W	0.2W	0.4W
Max. Working Voltage (DC or RMS)[1,2]	50V	75V	100V	200V
Max. Overload Voltage (DC or RMS)	100V	150V	200V	400V
Operating Temperature	-55 ~ 155°C			

Notes:

1. This is the maximum voltage that may be continuously supplied to the resistor element, see "IEC publication 60115-8"
2. Max. Operation Voltage : So called RCWV (Rated Continuous Working Voltage) determined by

$$RCWV = \sqrt{\text{Rated Power x Resistance Value}}$$ or Max. RCWV listed above, whichever is lower.

Figura 57: Resistor SMD 0805 1kΩ



Features
- Thick film technology
- Power rating up to 3 watts @ 70 °C
- High power surge withstanding
- RoHS compliant*
- Halogen free**

Applications
- Power supplies
- Digital meters
- Consumer electronics
- LED lighting
- Industry control boards

BOURNS®

CHP Series Ultra-High Power Chip Resistors

Electrical Characteristics

Characteristic	Model			
	CHP0603	CHP0805	CHP1206	CHP2512
Power Rating @ 70 °C	0.33 W	0.5 W	0.75 W	3 W
Operating Temperature Range	-55 °C to +155 °C			
Derated to Zero Load at	+155 °C			
Maximum Working Voltage 1 ohm to 1 megohm 0.1 ohm to 0.91 ohm	75 V –	200 V –	250 V –	250 V 1652 mV
Maximum Overload Voltage 1 ohm to 1 megohm 0.1 ohm to 0.91 ohm	125 V –	300 V –	500 V –	500 V 3695 mV
Resistance Tolerance	±1 %, ±5 %			
Temperature Coefficient				
1 ohm to 9.76 ohms (±1 %, E24 & E96 Series)	±200 ppm/°C	±150 ppm/°C***	±100 ppm/°C	±100 ppm/°C
10 ohms to 1 megohm (±1 %, E24 & E96 Series)	±100 ppm/°C	±100 ppm/°C	±100 ppm/°C	±100 ppm/°C
1 ohm to 1 megohm (±5 %, E24 Series	±200 ppm/°C	±200 ppm/°C	±200 ppm/°C	±200 ppm/°C
0.1 ohm to 0.91 ohm (±1 %, E24 Series)	–	–	–	±100 ppm/°C
0.1 ohm to 0.91 ohm (±5 %, E24 Series)	–	–	–	±200 ppm/°C

****TCR code assigned as "X" - see How to Order chart.*

Note: Solder pad and trace size should be evaluated and board surface temperature should not exceed +105 °C when applying full rated power.

For Standard Values Used in Capacitors, Inductors and Resistors, click here.

Additional Information

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Figura 58: Resistor SMD 0805 10kΩ