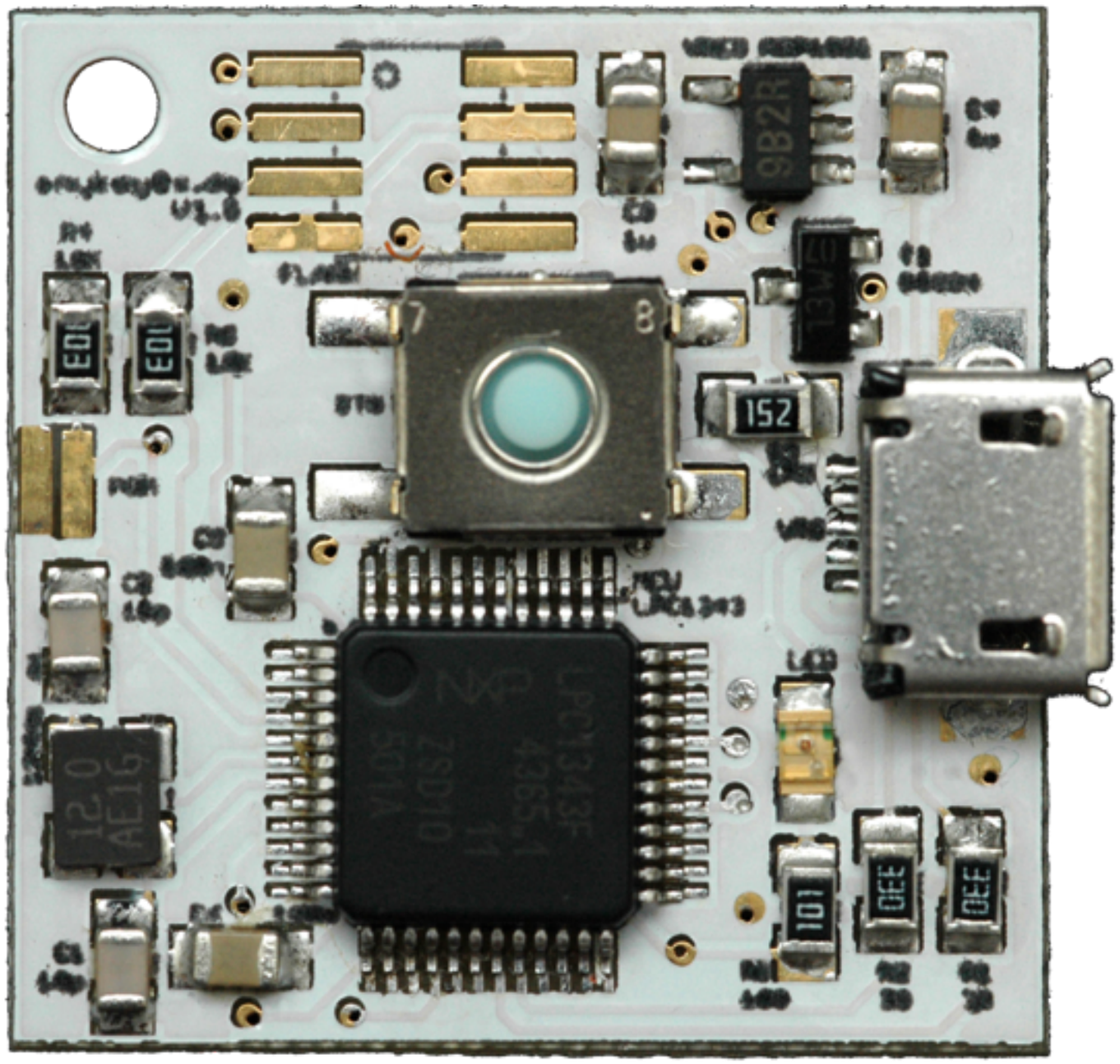


How to Build your own Computer ...

... from Scratch

FrOSCon 25.08.2012

Free and Open Source Software Conference

Matthias Krauß - Tim Becker @anykey0xde www.anykey0x.de

Thursday, August 30, 12

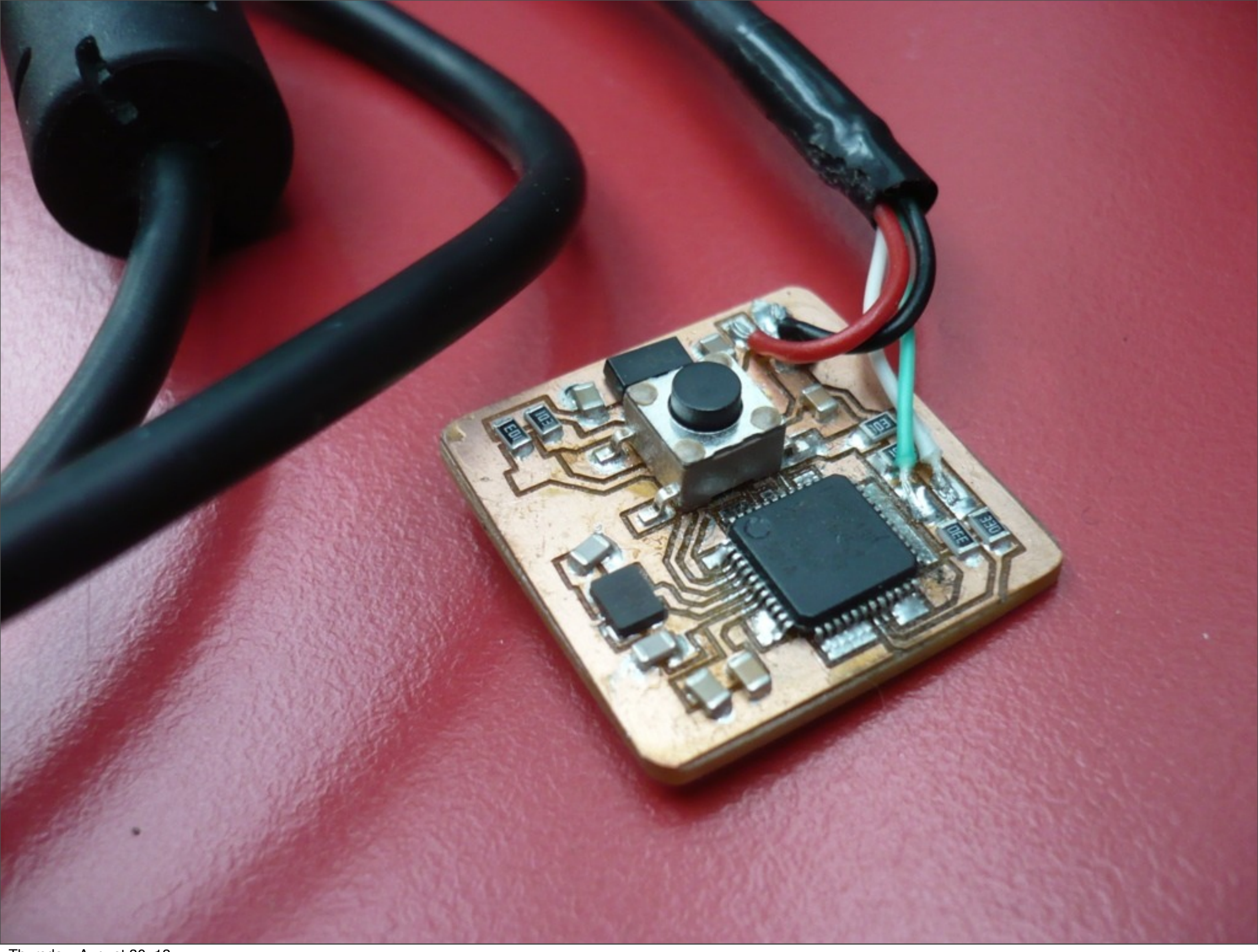

Katzinger
Le Chat
International Cat of Mystery

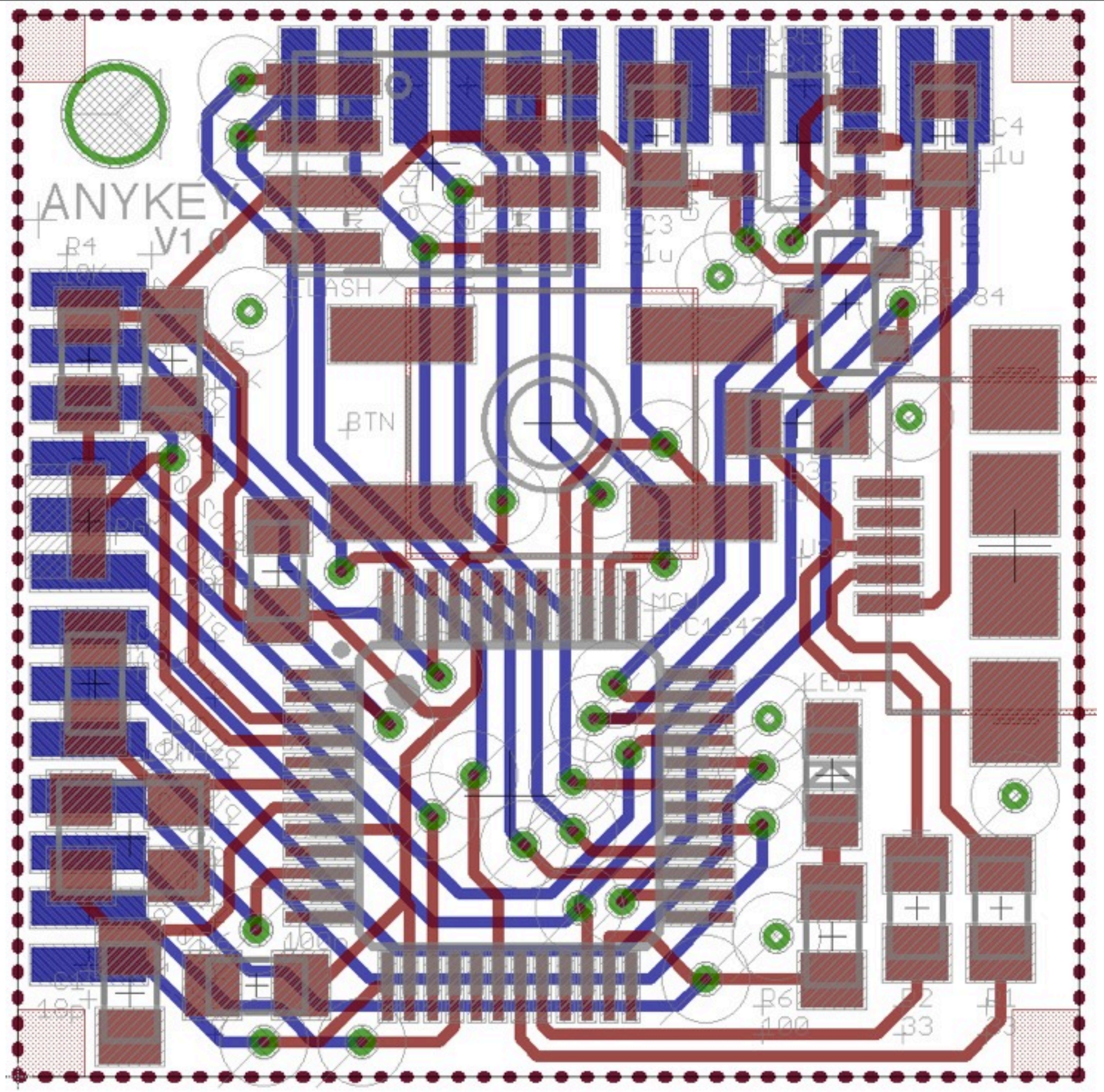

Katzinger
Le Chat
International Cat of Mystery
Zoe


Katzinger
Le Chat
International Cat of Mystery
Zoe


Esc
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
Tab
Alt
Enter
Shift
Alt


ë





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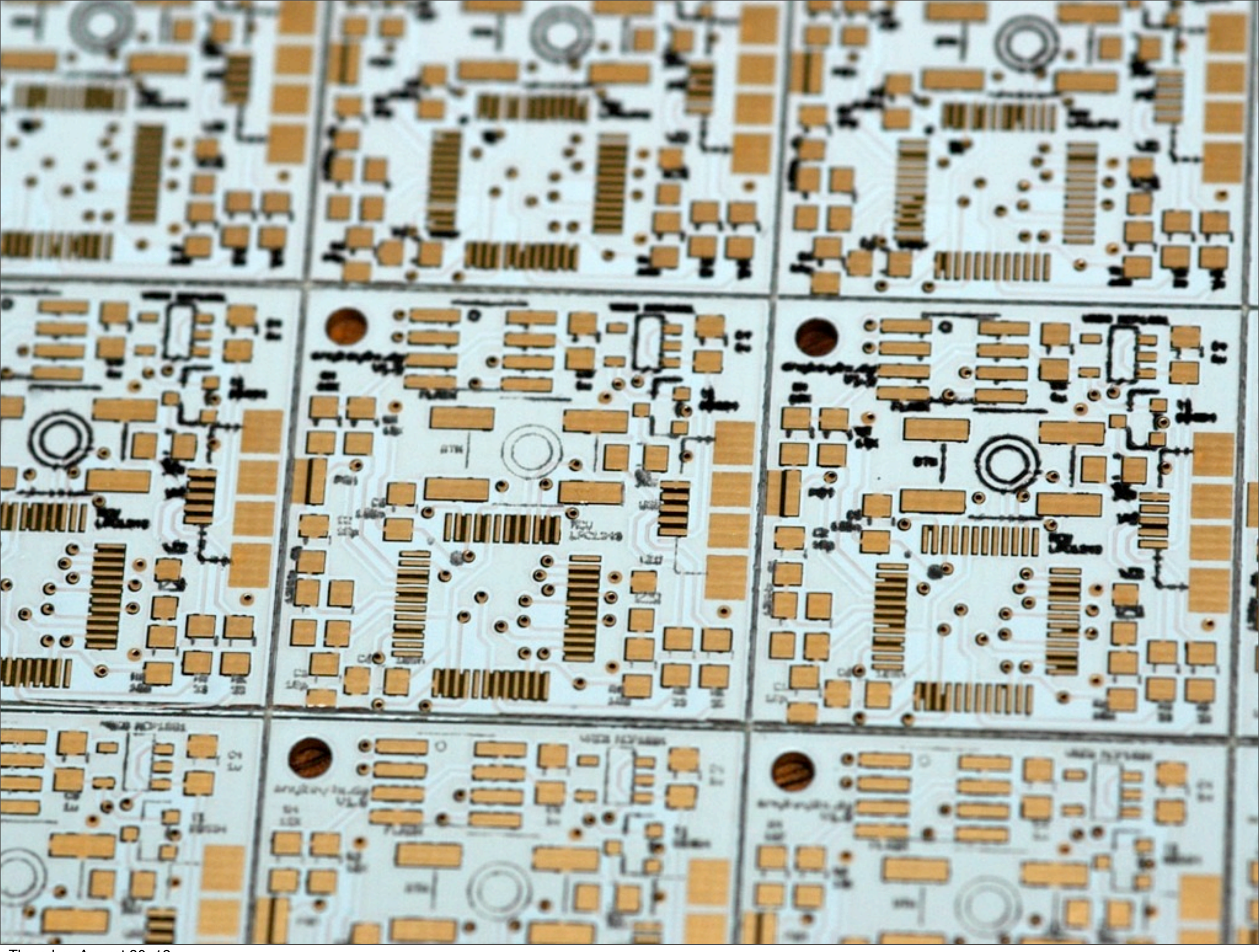

Thursday, August 30, 12

”Just like Arduino...”

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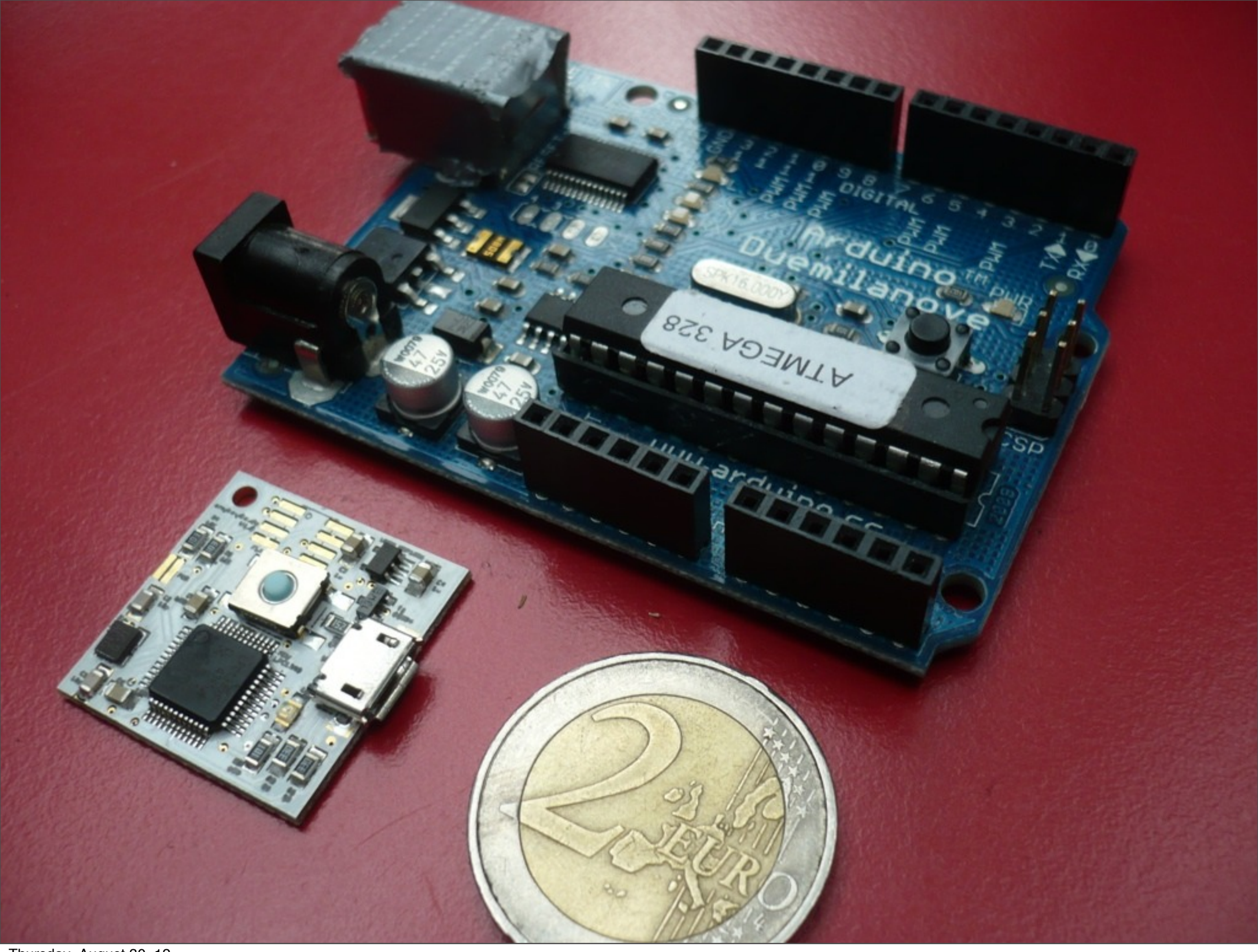
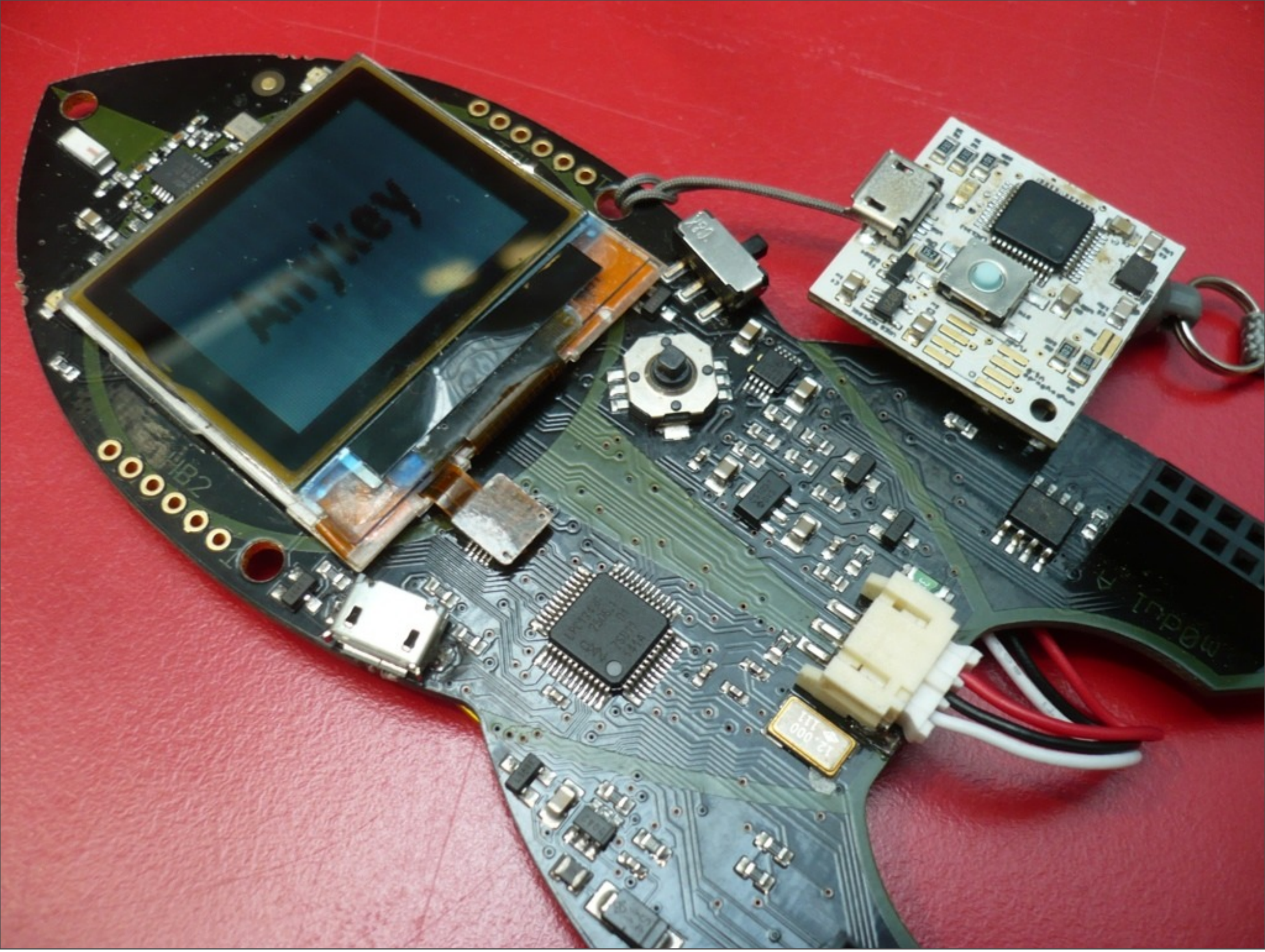

ATMEGA 328
Arduino
Duemilanove
DIGITAL
EURO
2

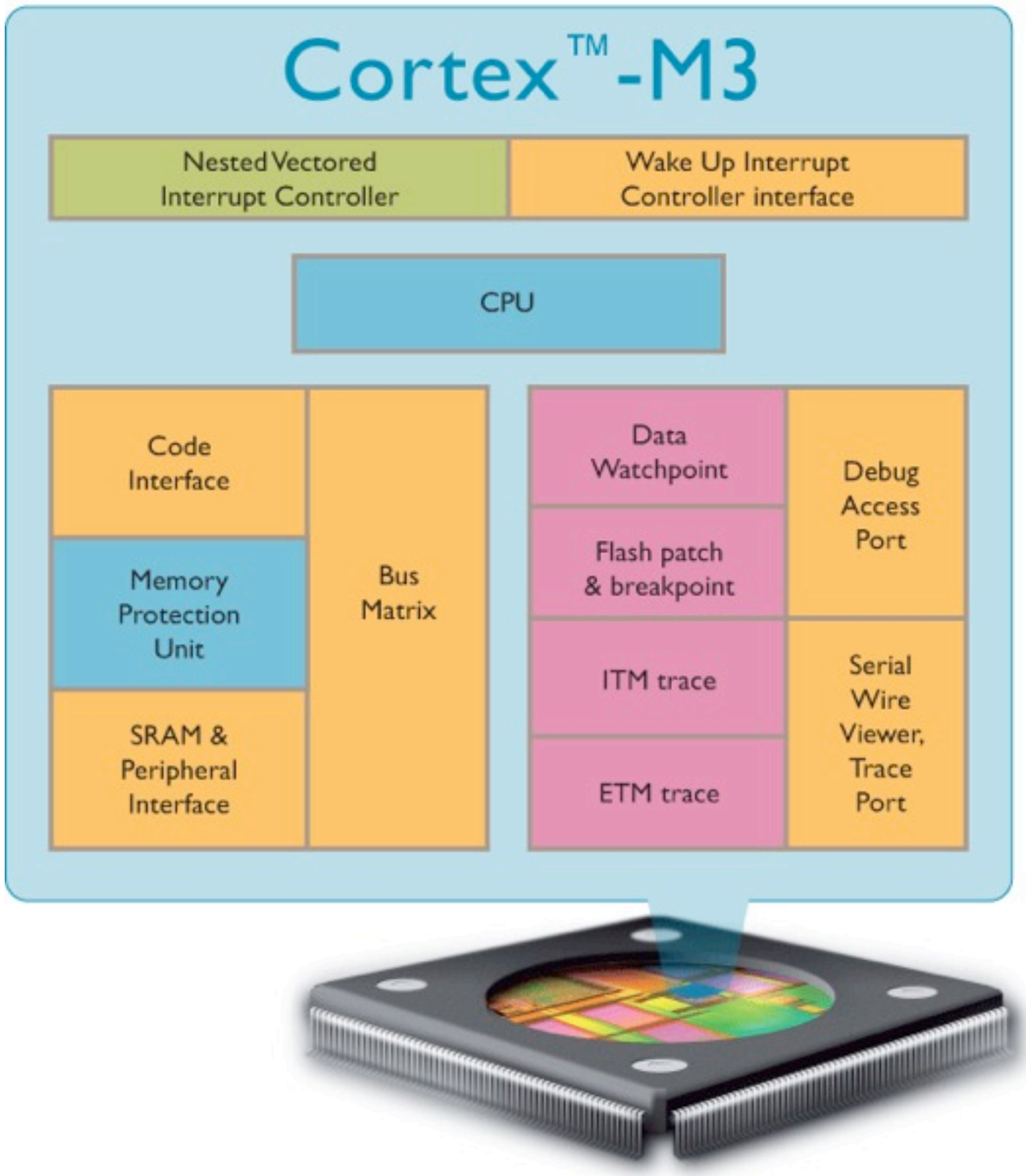
„... only better“

Matthias Krauß - Tim Becker @anykey0xde www.anykey0x.de

	Arduino Uno	**Anykey0x.de**
Microcontroller	ATmega328 (8bit)	LPC1343 (32bit)
Operating Voltage	5V	3.3V
Input Voltage	7-12V	3.5 - 10 V
Digital I/O Pins	14 (6 provide PWM)	23 (16 PWM)
Analog Input Pins	6	8
DC Current per I/O Pin	30mA	45mA
Flash	32 KB (ATmega328) of which 0.5 KB used by bootloader	32KB (no bootloader in flash necessary)
RAM	2KB	8KB
EEPROM	1KB	expandable on board
Clock Speed	16 MHz	72 MHz
USB	FTDI	PHY on chip


Anykey

Initial choice of Processor



STM32 Circle

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ARM doesn't do Silicon

TOSHIBA

Actel®

ATMEL

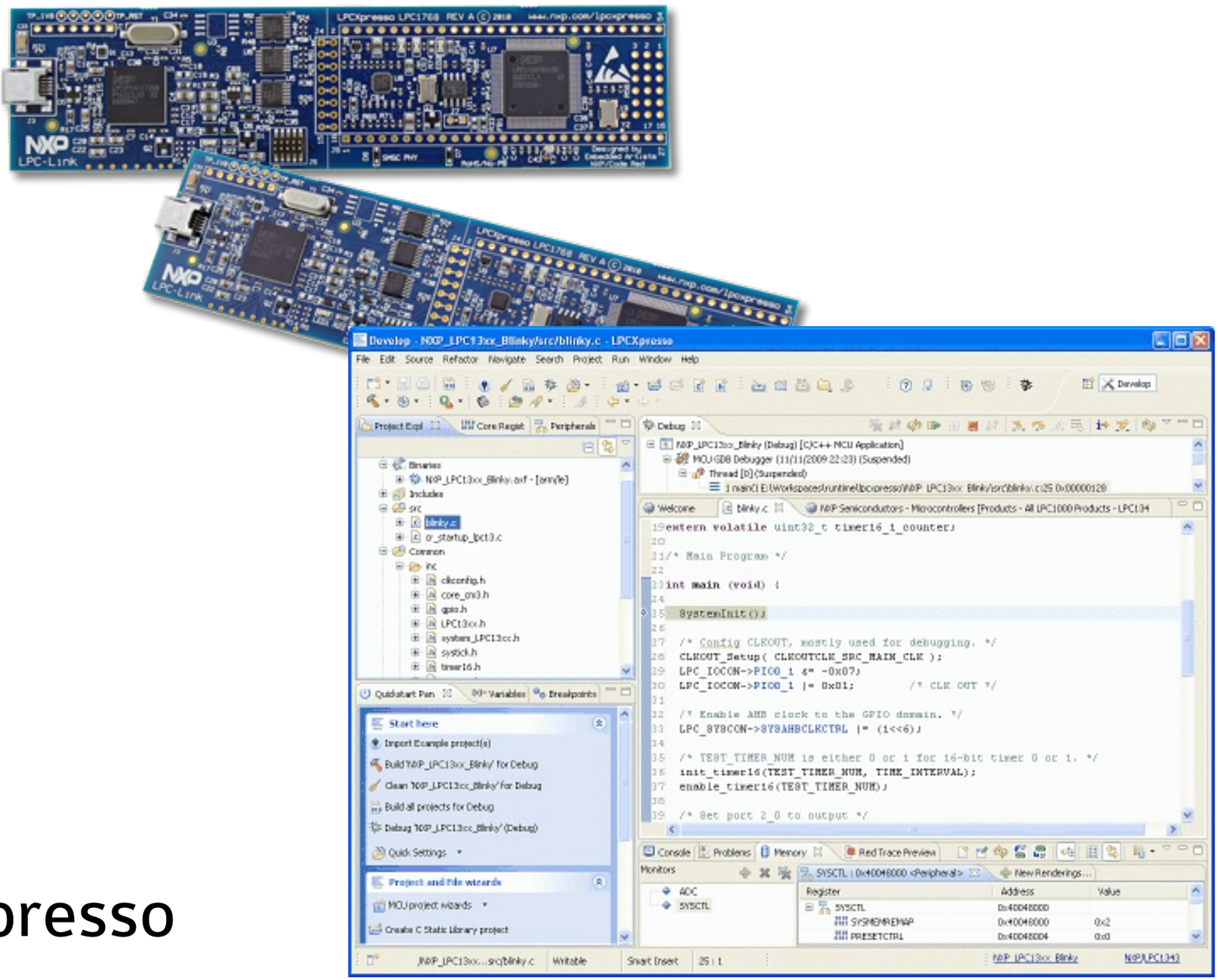
FUJITSU

NXP founded by Philips

CYPRESS

ANALOG DEVICES

Texas Instruments



LPC Expresso

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Multigrad

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Cortex-M3

Parametric filters Save/share selection	Package	Product status	f_{max} [max] (MHz)	FLASH (kB)	RAM (kB)	I/O pins	Nr. USB devices
Reset filtering Reset type numbers **Parametric matches:** Showing **50** products of **76**, please refine your filtering, or download the Excel file.	SOT313-2 (9) SOT314-2 (2) SOT315-1 (6) SOT407-1 (8) SOT459-1 (11) SOT486-1 (6) SOT570-3 (7) SOT740-2 (4) SOT865-3 (10)	Development (14) Production (32) Qualification (30)	180 / 180 / 72 / 72	1024 / 1024 / 0 / 0	200 / 200 / 4 / 4	165 / 165 / 26 / 26	0 (14) 1 (43) 2 (13)
Type number							
LPC1311FHN33	SOT865-3	Production	72	8	4	28	0
LPC1313FBD48	SOT313-2	Production	72	32	8	42	0
LPC1313FHN33	SOT865-3	Production	72	32	8	28	0
LPC1315FBD48	SOT313-2	Qualification	72	32	8	40	0
LPC1315FHN33	SOT865-3	Qualification	72	32	8	28	0
LPC1316FBD48	SOT313-2	Qualification	72	48	8	40	0

• • •

LPC1777FBD208	SOT459-1	Qualification	120	512	96	165	1
LPC1778FBD144	SOT486-1	Production	120	512	96	109	1
LPC1778FBD208	SOT459-1	Production	120	512	96	165	1
LPC1778FET180	SOT570-3	Production	120	512	96	141	1
LPC1778FET208	SOT950-1	Production	120	512	96	165	1
LPC1785FBD208	SOT459-1	Qualification	120	256	80	165	1
LPC1786FBD208	SOT459-1	Qualification	120	256	80	165	1
LPC1787FBD208	SOT459-1	Qualification	120	512	96	165	1
LPC1788FBD144	SOT486-1	Production	120	512	96	109	1
LPC1788FBD208	SOT459-1	Production	120	512	96		1

LPC1343
32bit/72MHz
cheap
usb programming.
pull up and down
bit banding

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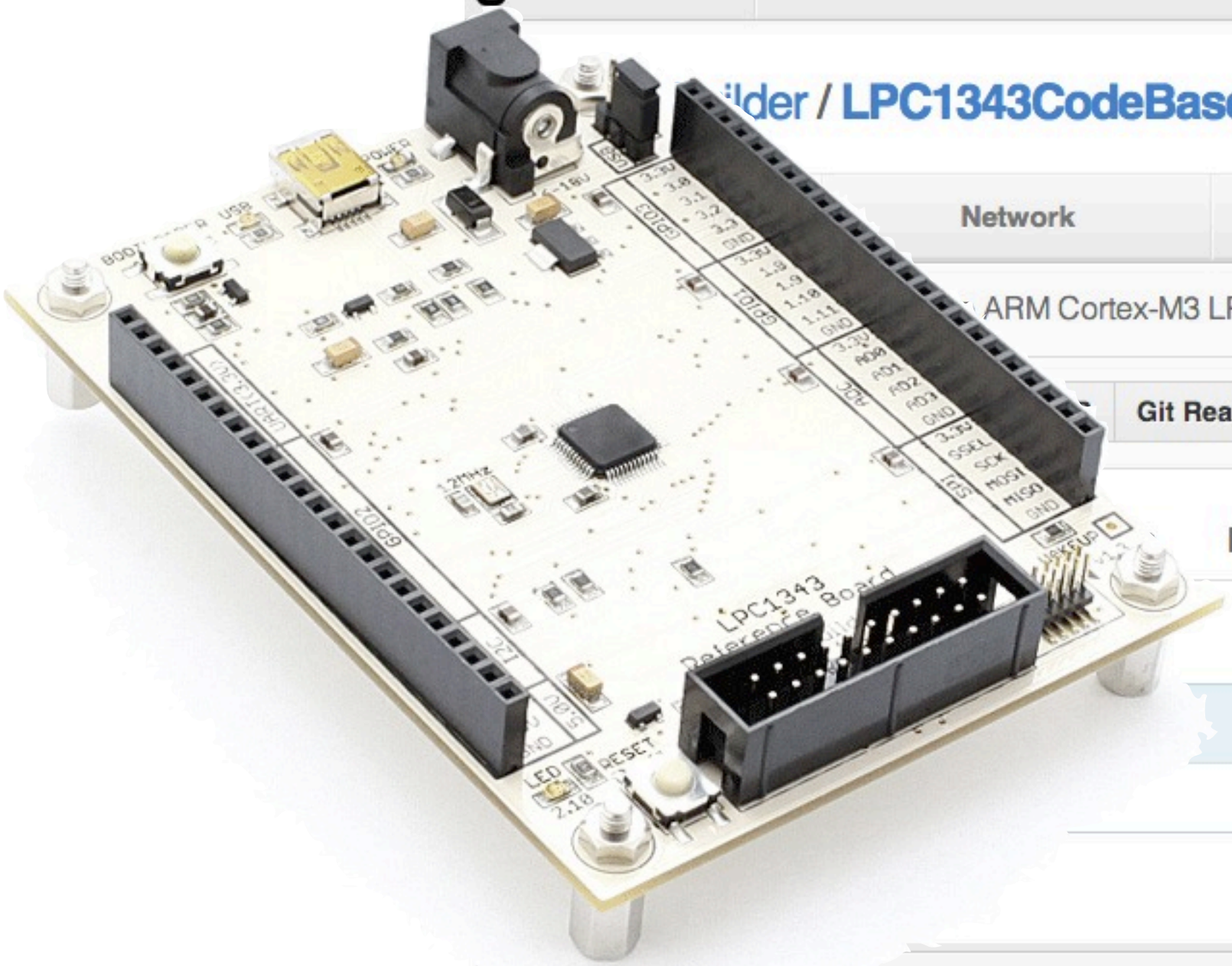

github

Search...

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ilder / LPC1343CodeBase

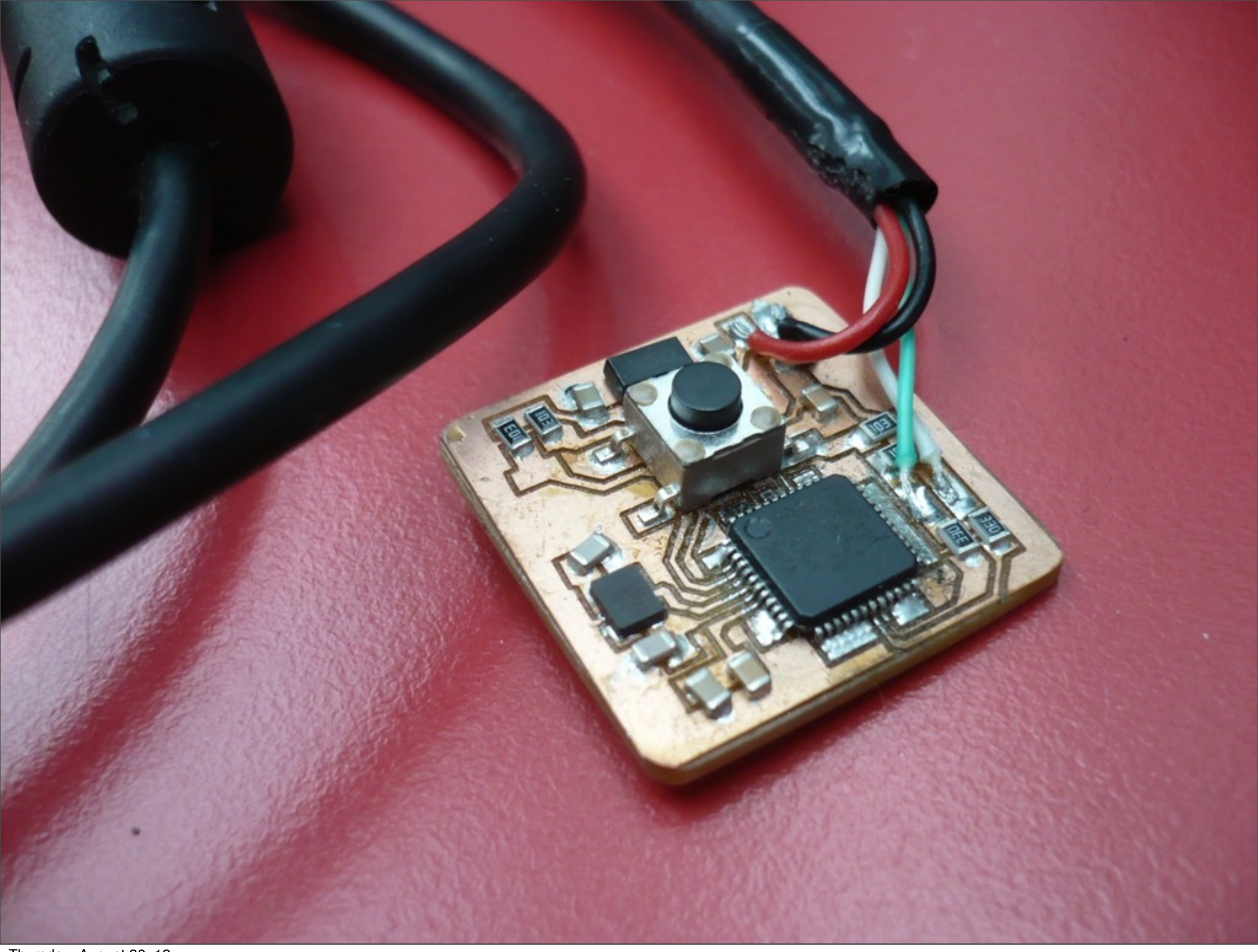
Network | Pull Requests 4 | Issues 4

ARM Cortex-M3 LPC1343 — Read more

Git Read-Only git@github.com:microbuilder/LPC13

Branches 1

	age	message
build	2 months ago	Prep for v1.1.0 [Kevin Townsend]
core	2 months ago	Prep for v1.1.0 [Kevin Townsend]
drivers	2 months ago	Added F to hard float values [Kev
lpc1xxx	a year ago	Initial commit [microbuilder]



LPC1311/13/42/43

32-bit ARM Cortex-M3 microcontroller; up to 32 kB flash and 8 kB SRAM; USB device

Rev. 4 — 20 June 2011 Product data sheet

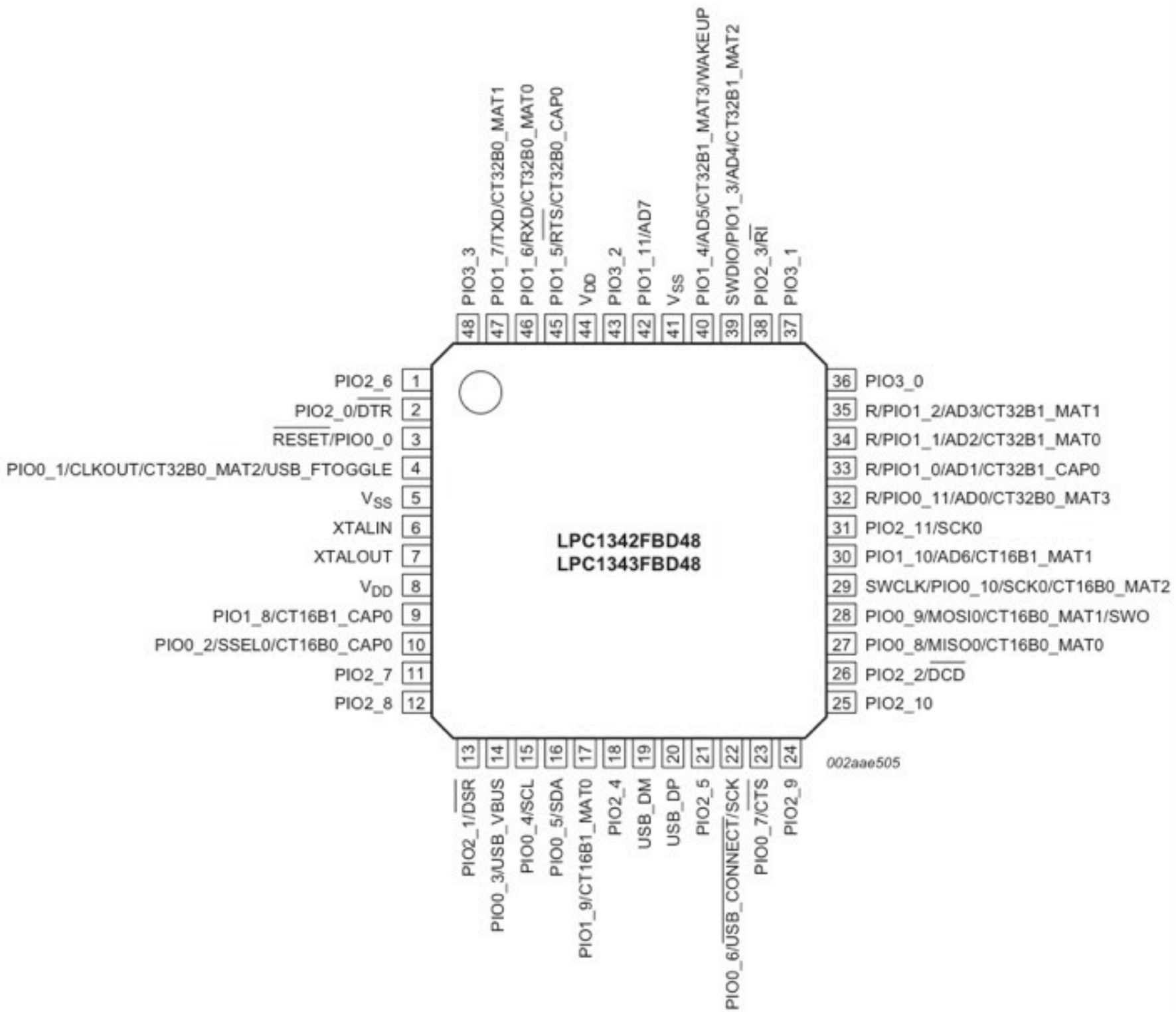


Fig 2. LPC1342/43 LQFP48 package

generous peripherals

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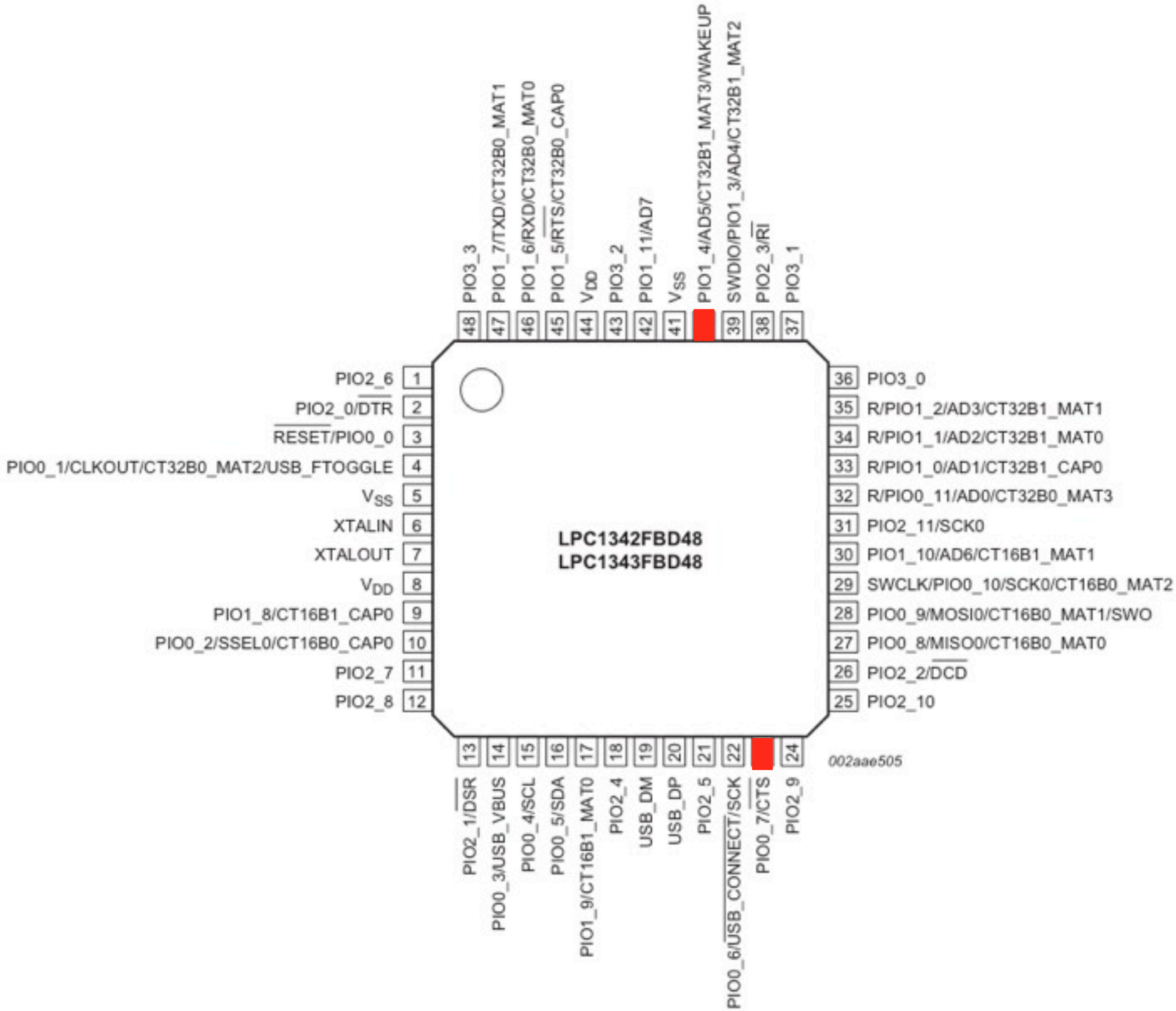
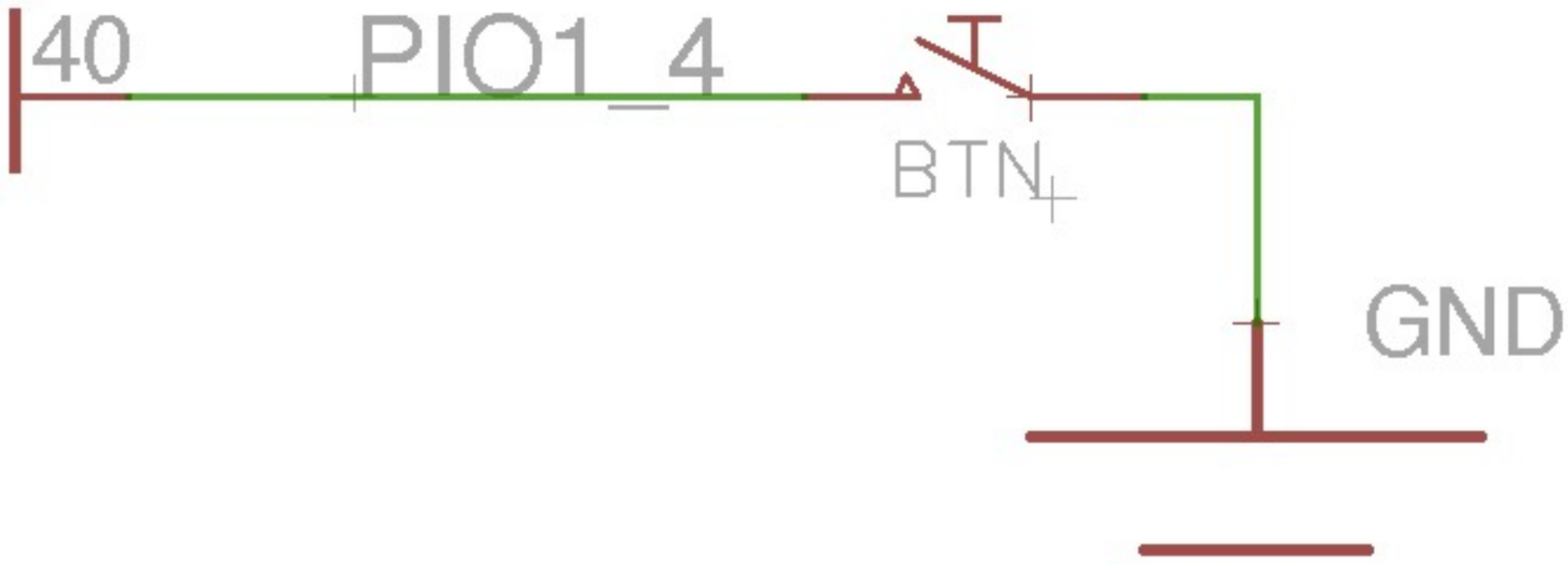


Fig 2. LPC1342/43 LQFP48 package



Button
GPIO User manual
Button Programming

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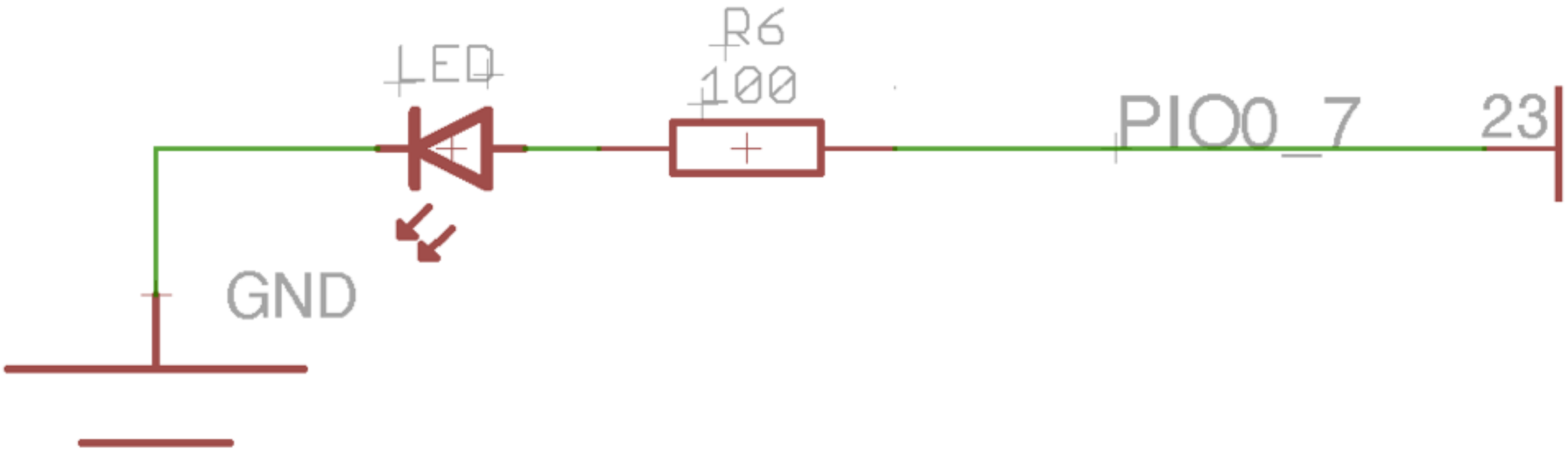

LED
LED Datasheet
Calculate Resistor
LED Programming

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Selection Guide

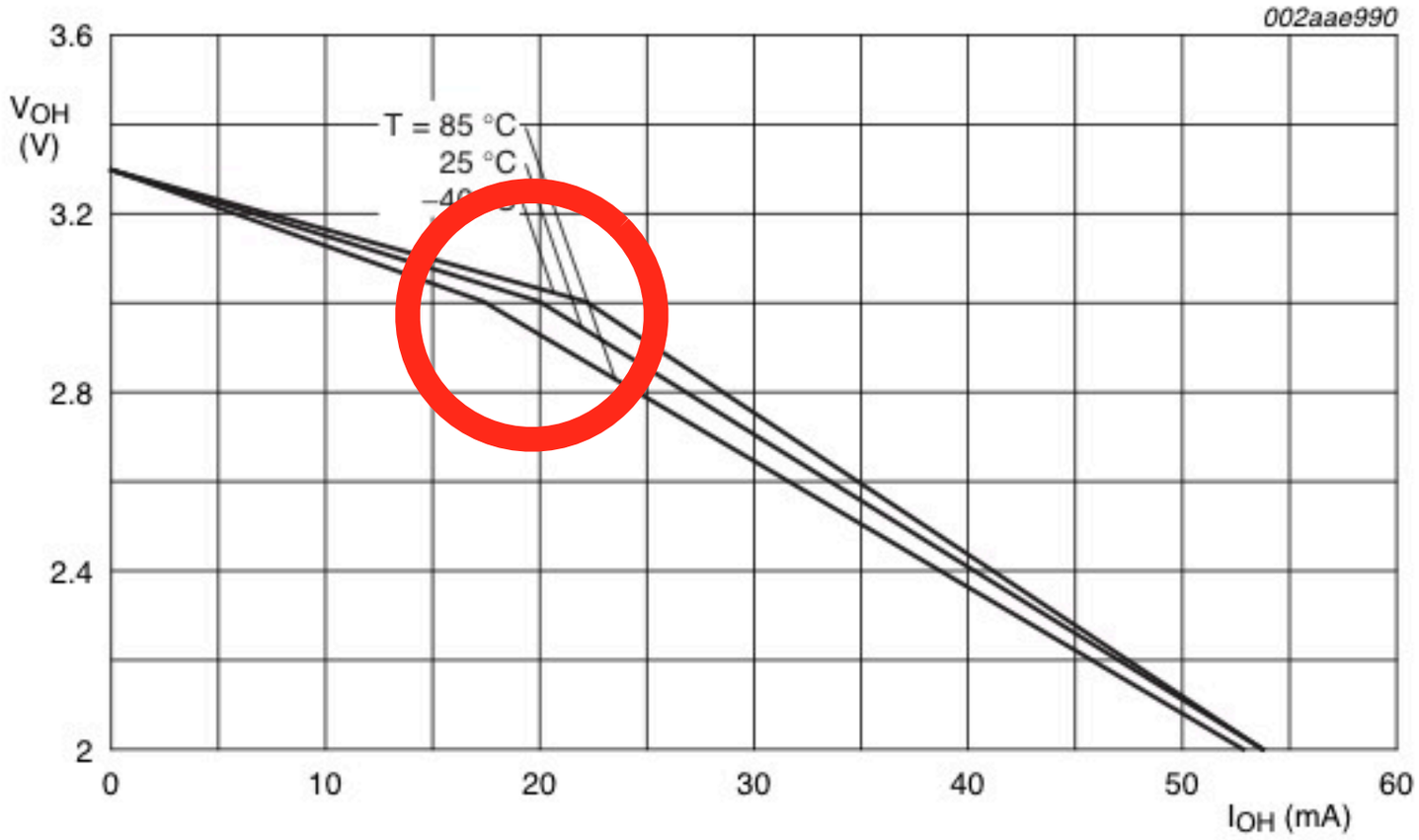
Part No.	Dice	Lens Type	Iv (mcd) @ 20mA		Viewing Angle
			Min.	Typ.	2 θ 1/2
APT2012SYC	SUPER BRIGHT YELLOW (InGaAlP)	WATER CLEAR	36	150	120°

Note:
1. θ1/2 is the angle from optical centerline where the luminous intensity is 1/2 the optical centerline value.

Electrical / Optical Characteristics at T_A=25°C

Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
λpeak	Peak Wavelength	Super Bright Yellow	590		nm	I_F=20mA
λD	Dominant Wavelength	Super Bright Yellow	588		nm	I_F=20mA
Δλ1/2	Spectral Line Half-width	Super Bright Yellow			nm	I_F=20mA
C	Capacitance	Super Bright Yell	25		pF	V_F=0V;f=1MHz
V_F	Forward Voltage	Super Bright Ye w	2.0	.5	V	I_F=20mA
I_R	Reverse Current	Super Bright Yel		10	uA	V_R = 5V

9.6 Electrical pin characteristics



Conditions: V_{DD} = 3.3 V; on pin PIO0_7.

Fig 19. High-drive output: Typical HIGH-level output voltage V_{OH} versus HIGH-level output current I_{OH}.

20mA (LED typical current)
3.0 V (IO) - 2.0V(forward Voltage)= ~1.0V

20mA (LED typical current)
3.0 V (IO) - 2.0V(forward Voltage)= ~1.0V

Ohm´s Law R=V/I
1.0V/0.02A = 50Ω

20mA (LED typical current)
3.0 V (IO) - 2.0V(forward Voltage)= ~1.0V

Ohm´s Law R=V/I
1.0V/0.02A = 50Ω

100 Ohm (to be on the safe side)

Red LEDs have less Voltage drop

So how do you turn it on?

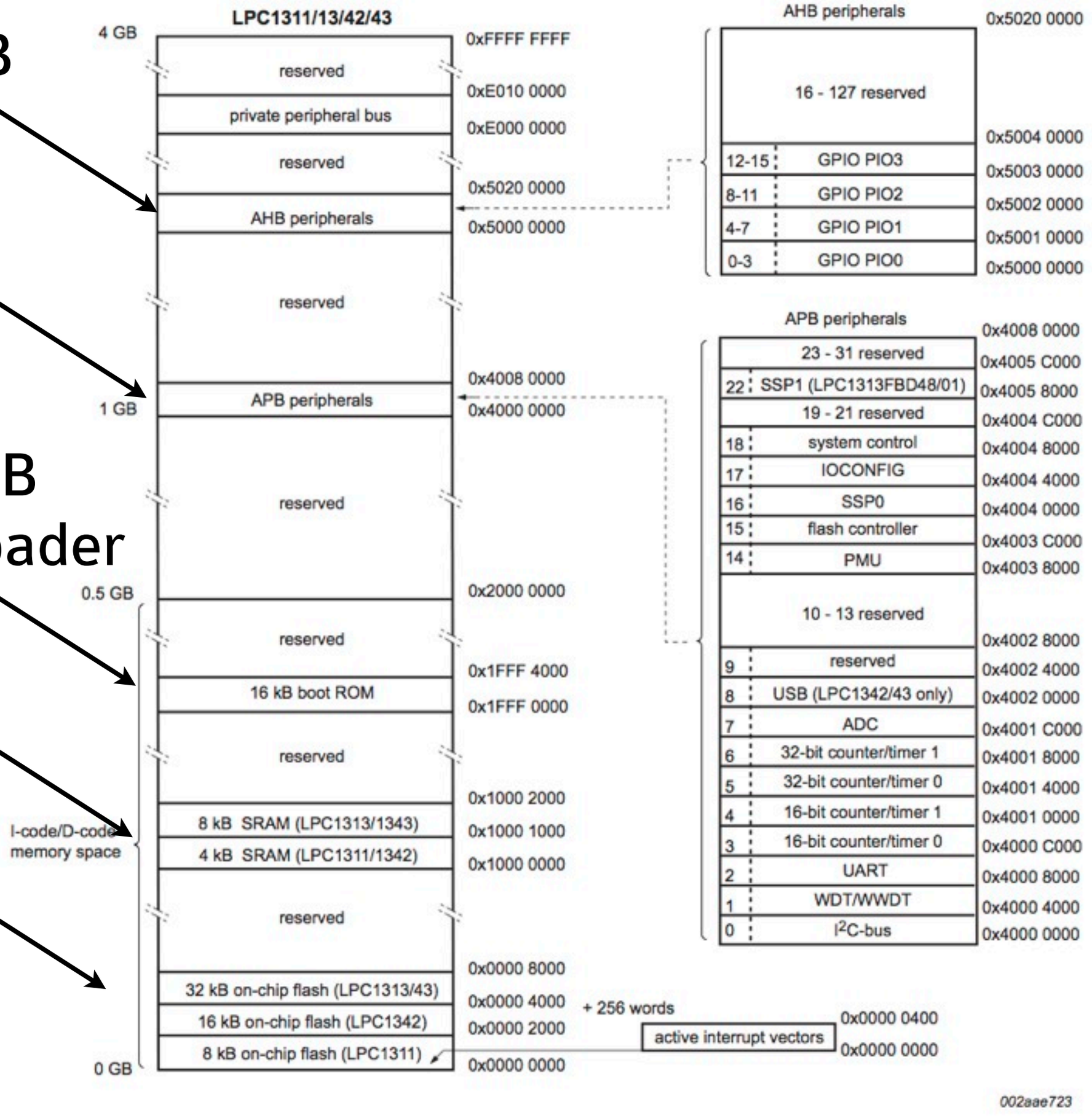
AHB

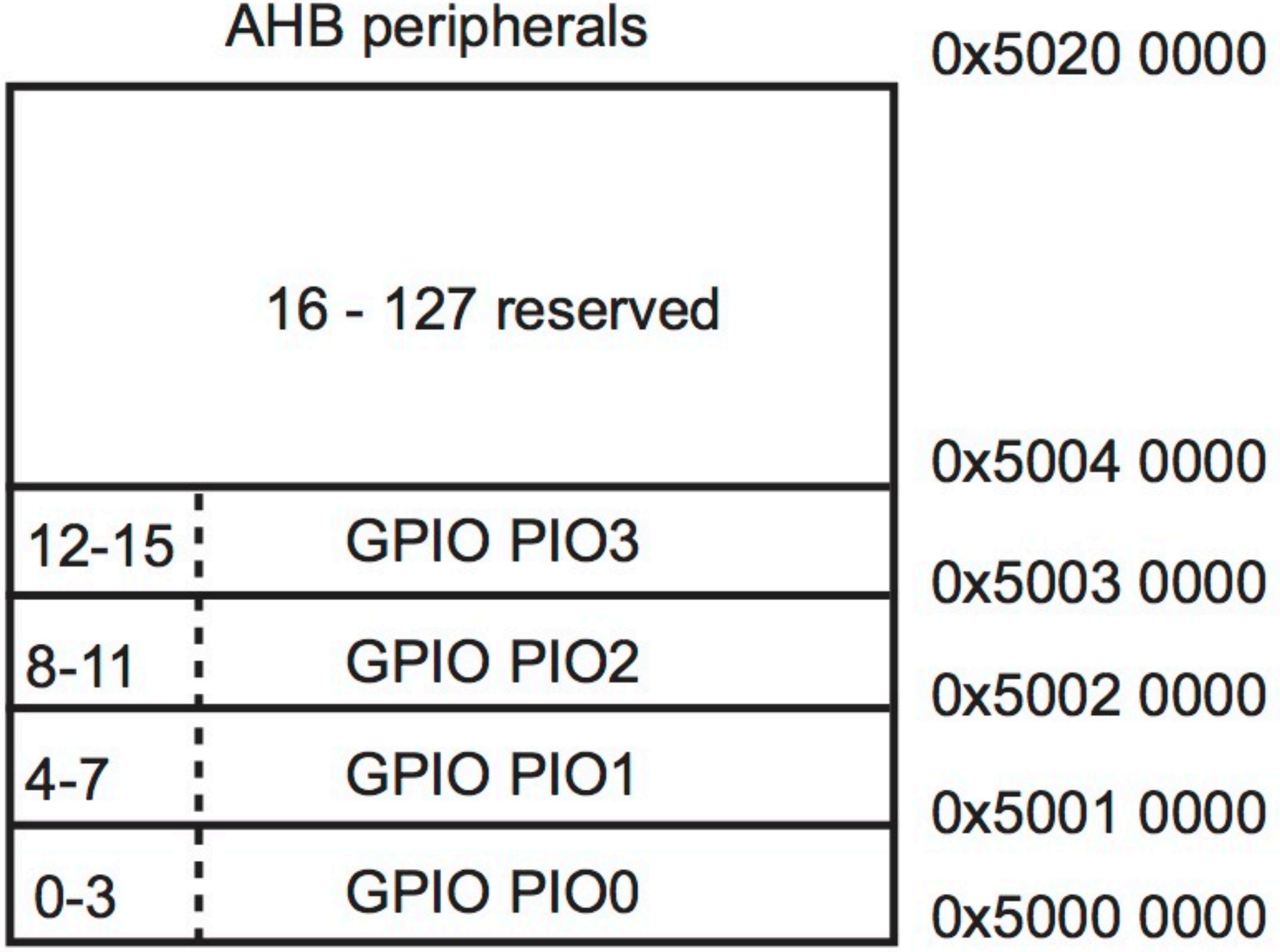
APB

USB Bootloader

RAM

ROM




AHB peripherals
0x5020 0000
16 - 127 reserved
0x5004 0000
12-15
GPIO PIO3
0x5003 0000
8-11
GPIO PIO2
0x5002 0000
4-7
GPIO PIO1
0x5001 0000
0-3
GPIO PIO0
0x5000 0000

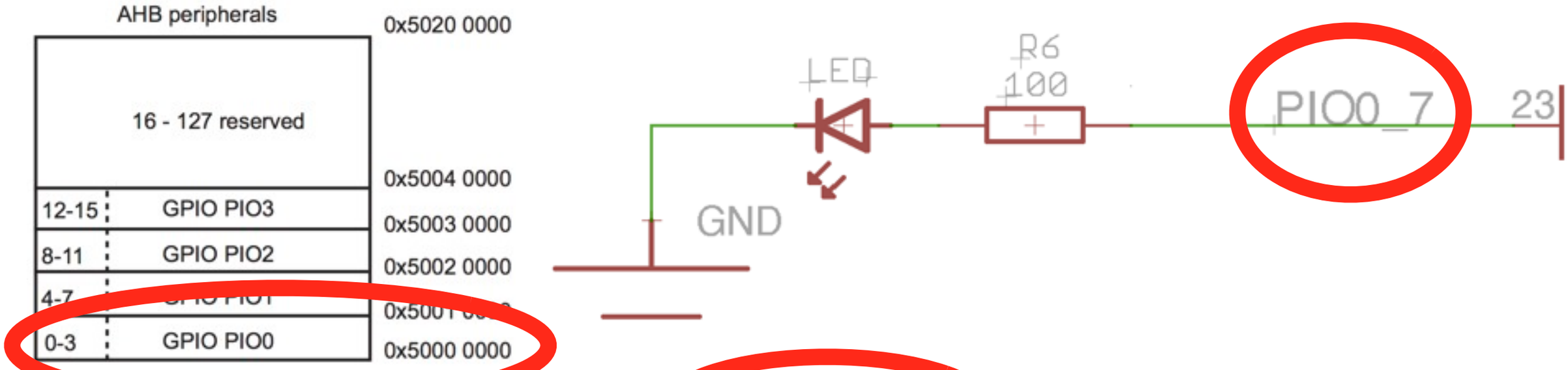
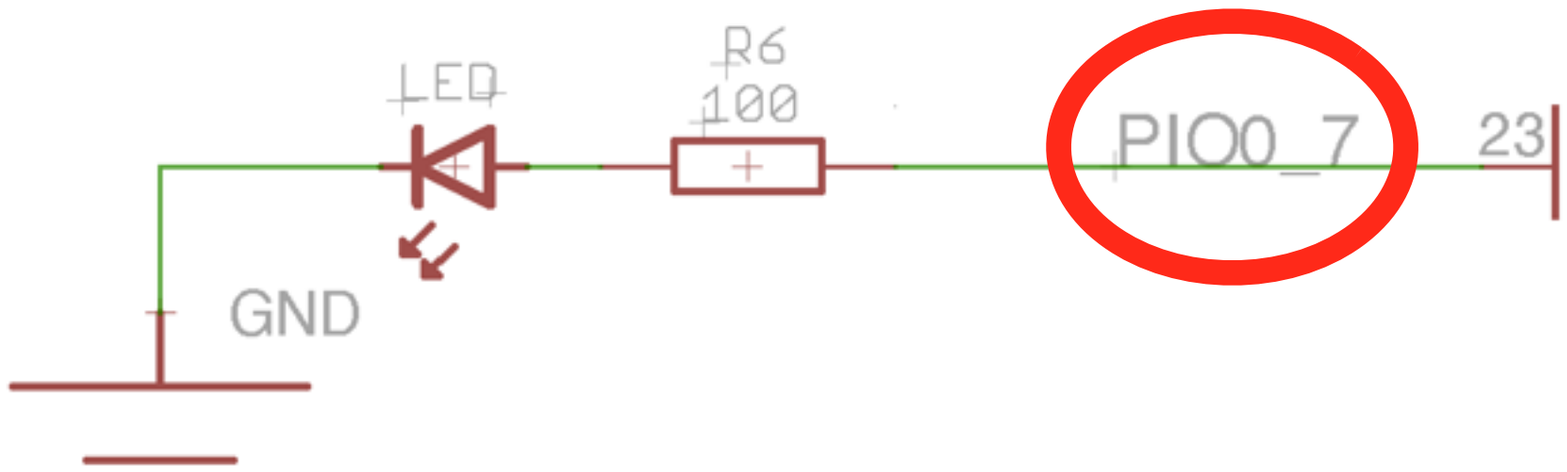


Table 148. Register overview: GPIO (base addres[s] port 0: 0x5000 0000; po[r]t 1: 0x5001 0000, port 2: 0x5002 0000; port 3: 0x5003 0000)

Name	Access	Address offset	Description	Reset value
GPIODATAMASK	R/W	0x0000 to 0x3FF8	Port n data address masking register locations for pins PIOn_0 to PIOn_11 (see Section 9.5.1)	n/a
GPIODATA	R/W	0x3FFC	Port n data register for pins PIOn_0 to PIOn_11	n/a
-	-	0x4000 to 0x7FFC	Reserved	-
GPIODIR	R/W	0x8000	Data direction register for port n	0x00
GPIOIS	R/W	0x8004	Interrupt sense register for port n	0x00
GPIOIBE	R/W	0x8008	Interrupt both edges register for port n	0x00
GPIOIEV	R/W	0x800C	Interrupt event register for port n	0x00
GPIOIE	R/W	0x8010	Interrupt mask register for port n	0x00
GPIORIS	R	0x8014	Raw interrupt status register for port n	0x00
GPIOMIS	R	0x8018	Masked interrupt status register for port n	0x00
GPIOIC	W	0x801C	Interrupt clear register for port n	0x00
-	-	0x8020 - 0xFFFF	Reserved	0x00




```
#include "pressanykey/pressanykey.h"

#define LED_PORT 0
#define LED_PIN 7

GPIO_SetDir(LED_PORT, LED_PIN, GPIO_Output);

GPIO_WriteOutput(LED_PORT, LED_PIN, true);
```

```
void GPIO_SetDir(
        uint8_t port,
        uint8_t pin,
        GPIO_Direction dir)
{
   switch (dir) {
      case GPIO_Input:
         GPIO[port].DIR &= ~(1<<pin);
         break;
      case GPIO_Output:
         GPIO[port].DIR |= (1<<pin);
         break;
   }
}
```

pressanykey/gpio.c

```
void GPIO_SetDir(
        uint8_t port,
        uint8_t pin,
        GPIO_Direction dir)
{
   switch (dir) {
      case GPIO_Input:
         GPIO[port].DIR &= ~(1<<pin);
         break;
      case GPIO_Output:
         GPIO[port].DIR |= (1<<pin);
         break;
   }
}
```

pressanykey/gpio.c

```
typedef struct {
   HW_RW MASKED_DATA[0xfff];
   HW_RW DATA;
   HW_RS RESERVED1[0x1000];
   HW_RW DIR;
        (...)
   HW_RO RIS;
   HW_RO MIS;
   HW_WO IC;
   HW_RS RESERVED2[0x3f8];
   HW_UU UNUSED[0x1c00];
} GPIO_STRUCT;

// GPIO bank bases can be accessed via GPIO[i]
#define GPIO ((GPIO_STRUCT*)(0x50000000))
```

pressanykey/memorymap.h

```
typedef struct {
   HW_RW MASKED_DATA[0xfff];
   HW_RW DATA;
   HW_RS RESERVED1[0x1000];
   HW_RW DIR;
        (...)
   HW_RO RIS;
   HW_RO MIS;
   HW_WO IC;
   HW_RS RESERVED2[0x3f8];
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pressanykey/memorymap.h

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   HW_RW DATA;
   HW_RS RESERVED1[0x1000];
   HW_RW DIR;
         (...)
   HW_RO RIS;
   HW_RO MIS;
   HW_WO IC;
   HW_RS RESERVED2[0x3f8];
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pressanykey/memorymap.h

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  HW_RW DATA;
  HW_RS RESERVED1[0x1000];
  HW_RW DIR;
        (...)
  HW_RO RIS;
  HW_RO MIS;
  HW_WO IC;
  HW_RS RESERVED2[0x3
  HW_UU UNUSED[0x1c00
} GPIO_STRUCT;

// GPIO bank bases can be accessed via GPIO[i]
#define GPIO ((GPIO_STRUCT*)(0x50000000))
```
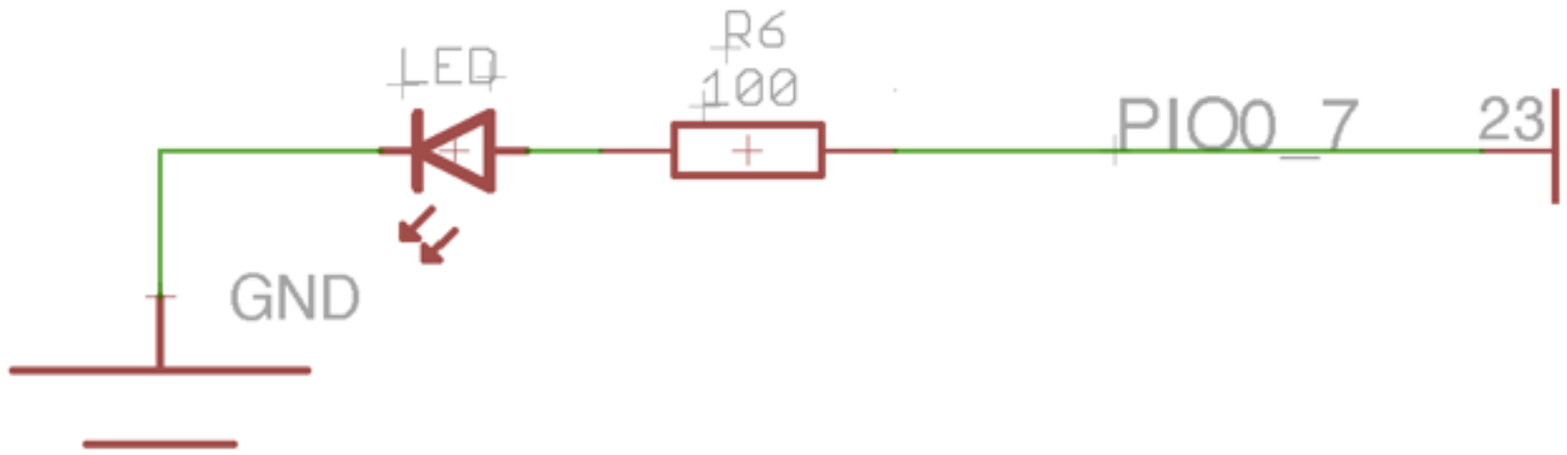

Table 148. Register overview: GPIO (base address port 0: 0x5000 0000; port 1: 0x5001 0000, port 2: port 3: 0x5003 0000)

Name	Access	Address offset	Description
GPIODATAMASK	R/W	0x0000 to 0x3FF8	Port n data address masking register locations for pins PIOn_0 to PIOn_1 Section 9.5.1)
-	R/W	0x3FFC	Port n data register for pins PIOn_0 PIOn_11
GPIODATA	-	0x4000 to 0x7FFC	Reserved
-	R/W	0x8000	Data direction register for port n
GPIODIR	R/W	0x8004	Interrupt sense register for port n
GPIOIS	R/W	0x8008	Interrupt both edges register for
GPIOIBE	R/W	0x800C	Interrupt event register for port
GPIOIEV	R/W	0x8010	Interrupt mask register for port
GPIOIE	R	0x8014	Raw interrupt status register fo
GPIORIS	R	0x8018	Masked interrupt status regist
GPIOMIS	W	0x801C	Interrupt clear register for por
GPIOIC	-	0x8020 - 0xFFFF	Reserved
-			

pressanykey/memorymap.h




```
#include "pressanykey/pressanykey.h"

#define LED_PORT 0
#define LED_PIN 7

GPIO_SetDir(LED_PORT, LED_PIN, GPIO_Output);

GPIO_WriteOutput(LED_PORT, LED_PIN, true);
```

```
void GPIO_WriteOutput(
    uint8_t port,
    uint8_t pin,
    bool value)
{
  GPIO[port].MASKED_DATA[1<<pin] =
    value ? 0x3fff : 0x0000;
}
```

Power Supply / Decoupling

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Integrated Circuits (ICs)

- Interface - Drivers, Receivers, Transceivers (30 items)
- Linear - Amplifiers - Audio (10 items)
- Linear - Amplifiers - Instrumentation, OP Amps, Buffer Amps (11 items)
- Logic - Translators (15 items)
- PMIC - Battery Management (128 items)
- PMIC - Display Drivers (2 items)
- PMIC - LED Drivers (397 items)
- PMIC - MOSFET, Bridge Drivers - External Switch (2 items)
- PMIC - Motor and Fan Controllers, Drivers (6 items)
- PMIC - Power Distribution Switches (16 items)
- PMIC - Power Management - Specialized (336 items)
- PMIC - Power Supply Controllers, Monitors (7 items)
- PMIC - Voltage Reference (3 items)
- PMIC - Voltage Regulators - Linear (LDO) (37858 items)
- PMIC - Voltage Regulators - Linear + Switching (1134 items)
- PMIC - Voltage Regulators - Linear Transistor Driver (3 items)
- PMIC - Voltage Regulators - Special Purpose (157 items)

Integrated Circuits (ICs)

- Interface - Drivers, Receivers, Transceivers (30 items)
- Linear - Amplifiers - Audio (10 items)
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- Logic - Translators (15 items)
- PMIC - Battery Management (128 items)
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- PMIC - LED Drivers (397 items)
- PMIC - MOSFET, Bridge Drivers - External Switch (2 items)
- PMIC - Motor and Fan Controllers, Drivers (6 items)
- PMIC - Power Distribution Switches (16 items)
- PMIC - Power Management - Specialized (336 items)
- PMIC - Power Supply Controllers, Monitors (7 items)
- PMIC - Voltage Reference (3 items)
- PMIC - Voltage Regulators - Linear (LDO) (37858 items)
- PMIC - Voltage Regulators - Linear + Switching (1124 items)
- PMIC - Voltage Regulators - Linear Transistor Driver (3 items)
- PMIC - Voltage Regulators - Special Purpose (157 items)

Voltage Regulator
size/footprint
Voltage drop
capacitor requirements
input range (Voltage)

price/availability

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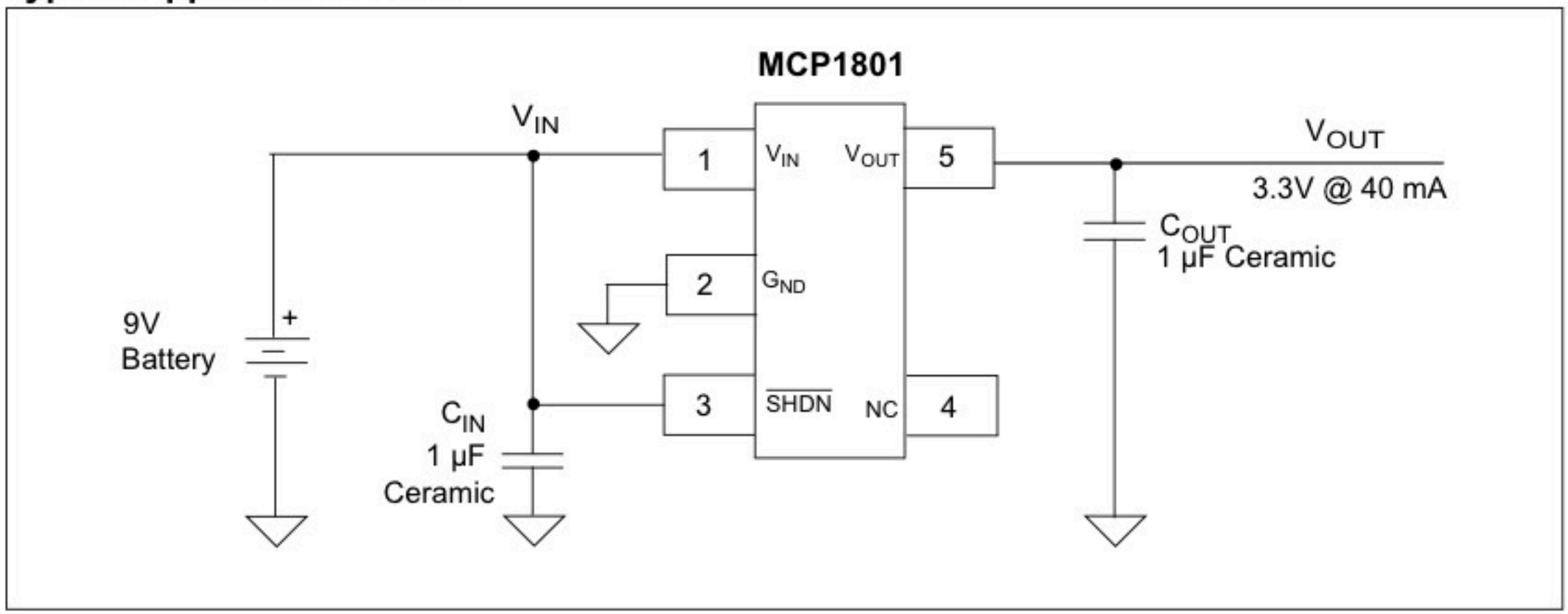
Typical Application Circuit



MCP 1801 Datasheet

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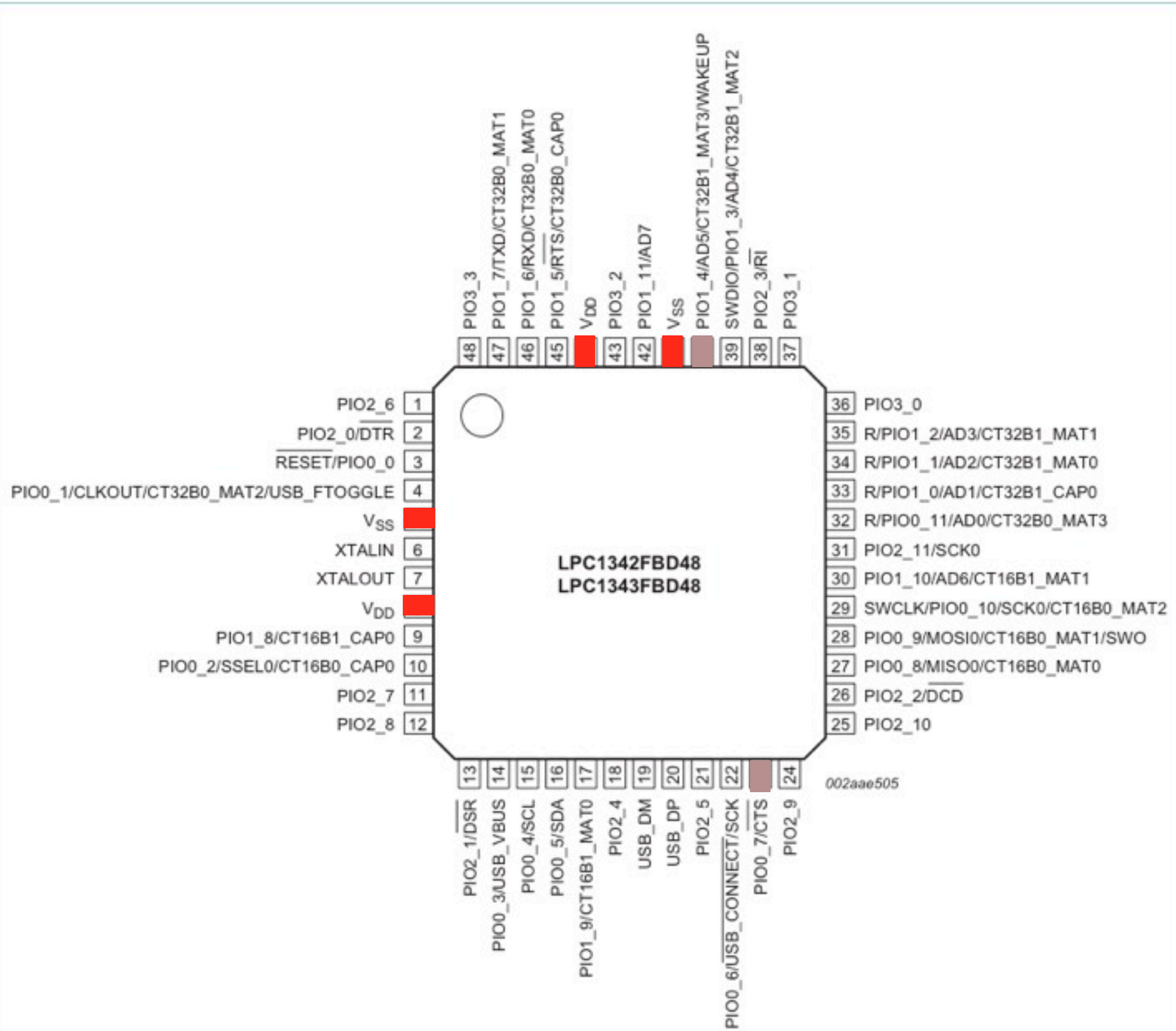
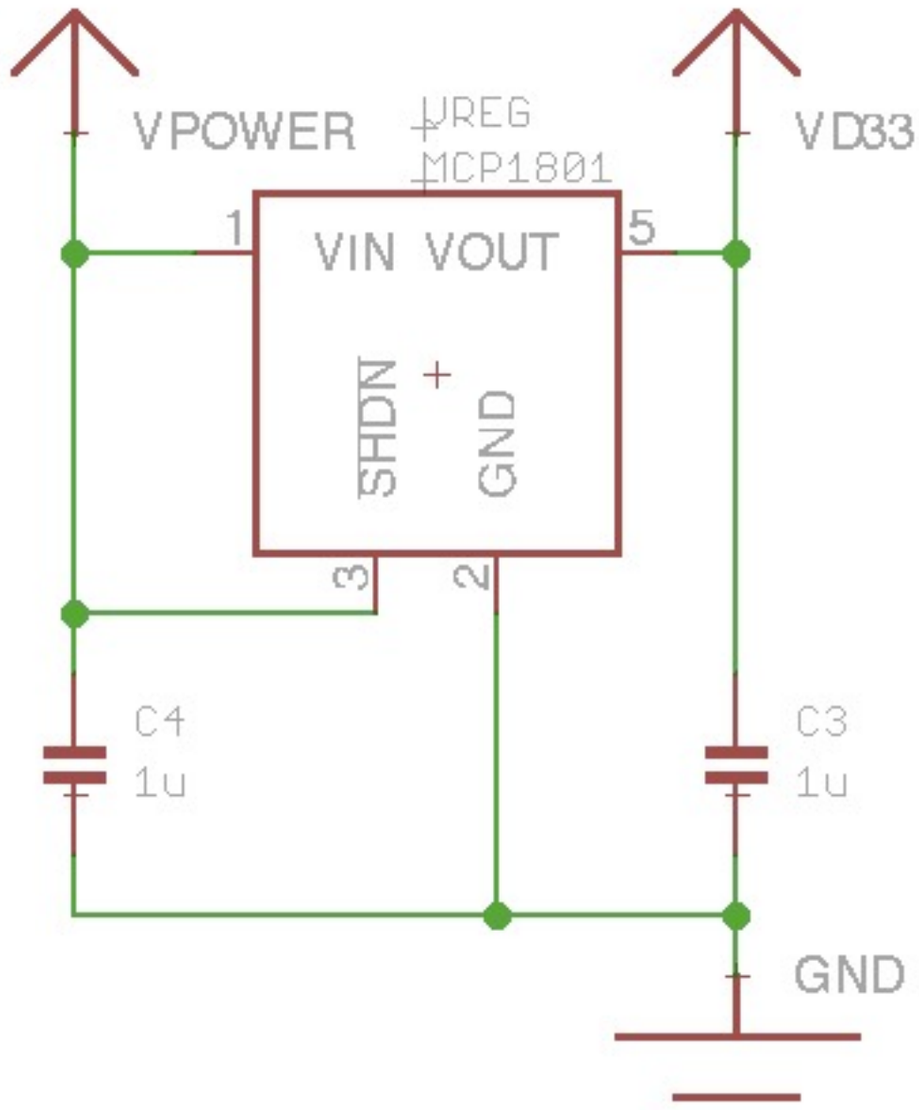


Fig 2. LPC1342/43 LQFP48 package



Anykey Eagle Schematics

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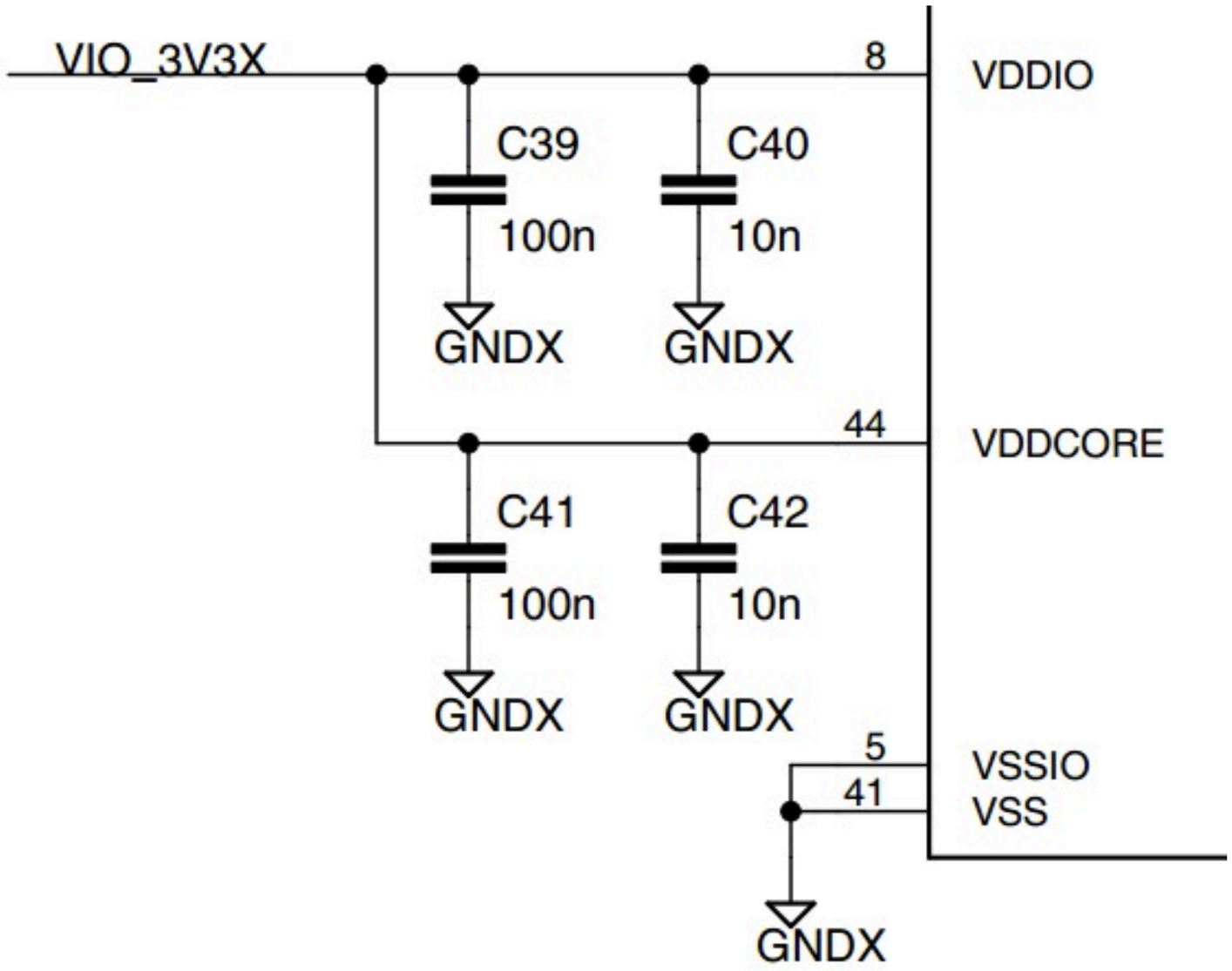

LPC Expresso 1343

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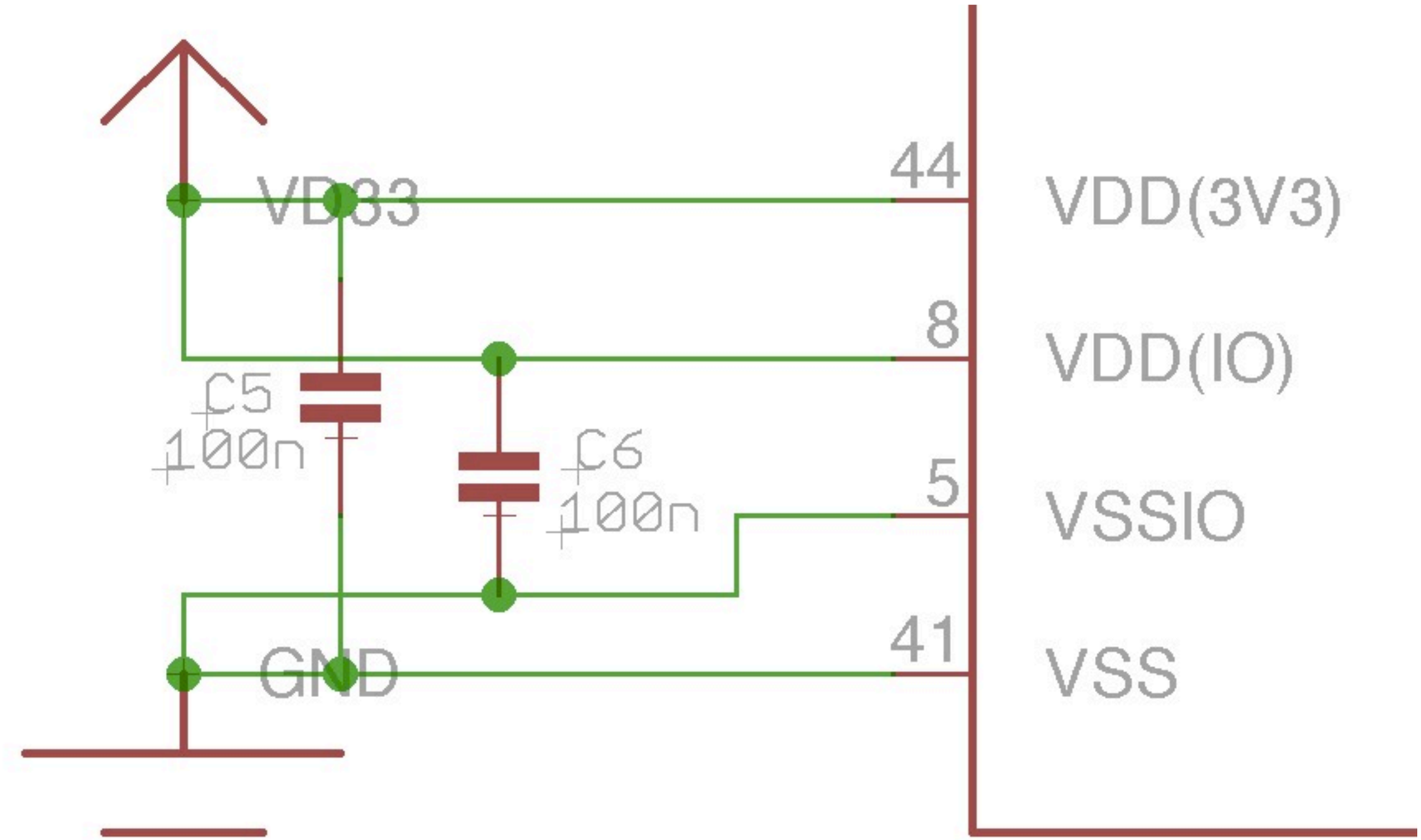
VDD3
44
VDD(3V3)
8
VDD(IO)
C5
100n
C6
100n
5
VSSIO
41
VSS
GND

Oscillator

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Table 21. Recommended values for C_{X1}/C_{X2} in oscillation mode (crystal and external components parameters) low frequency mode

Fundamental oscillation frequency F_{OSC}	Crystal load capacitance C_L	Maximum crystal series resistance R_S	External load capacitors C_{X1}, C_{X2}
1 MHz - 5 MHz	10 pF	< 300 Ω	18 pF, 18 pF
	20 pF	< 300 Ω	39 pF, 39 pF
	30 pF	< 300 Ω	57 pF, 57 pF
5 MHz - 10 MHz	10 pF	< 300 Ω	18 pF, 18 pF
	20 pF	< 200 Ω	39 pF, 39 pF
	30 pF	< 100 Ω	57 pF, 57 pF
10 MHz - 15 MHz	10 pF	< 160 Ω	18 pF, 18 pF
	20 pF	< 60 Ω	39 pF, 39 pF
15 MHz - 20 MHz	10 pF	< 80 Ω	18 pF, 18 pF

LPC 1343 Datasheet

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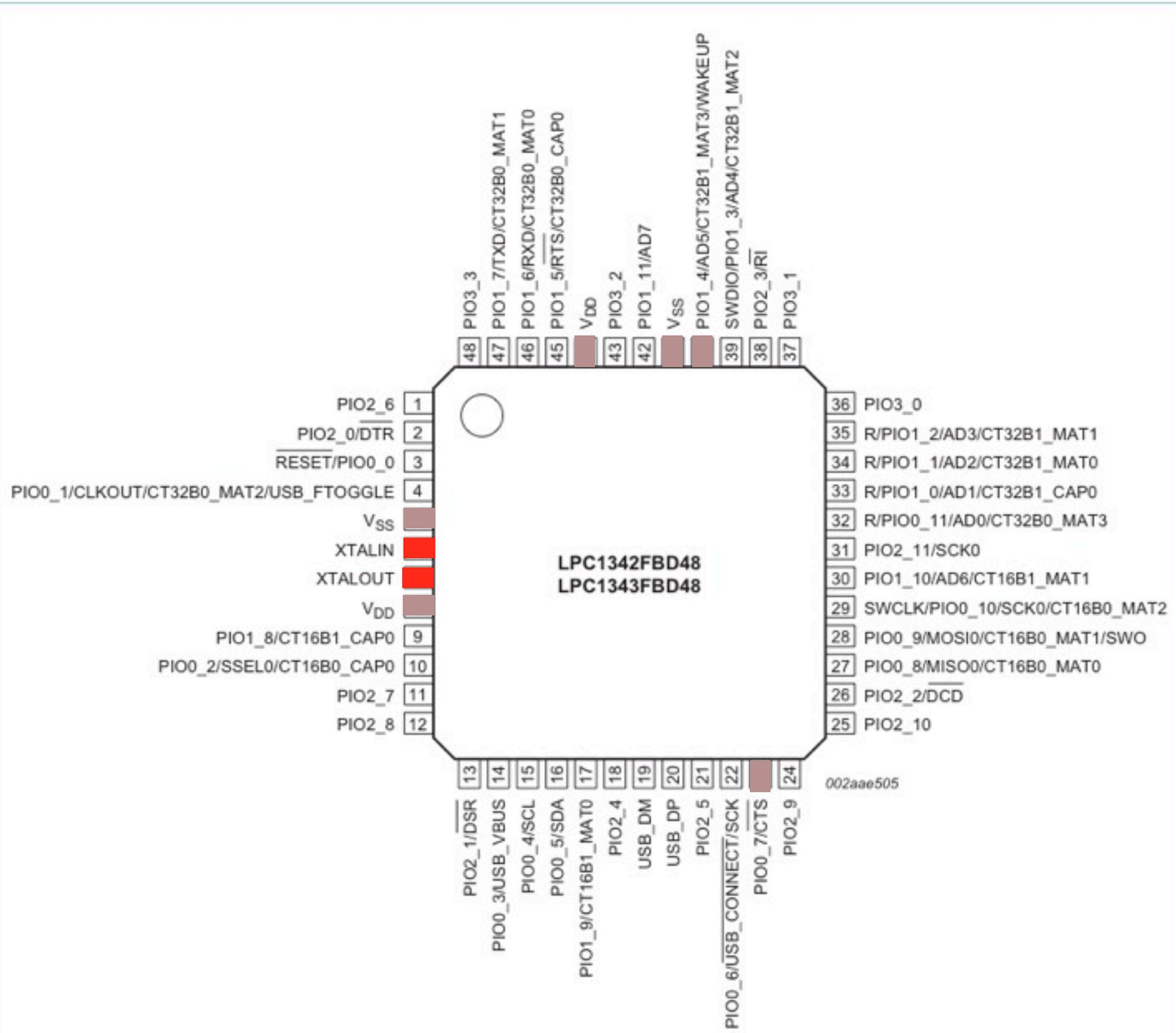
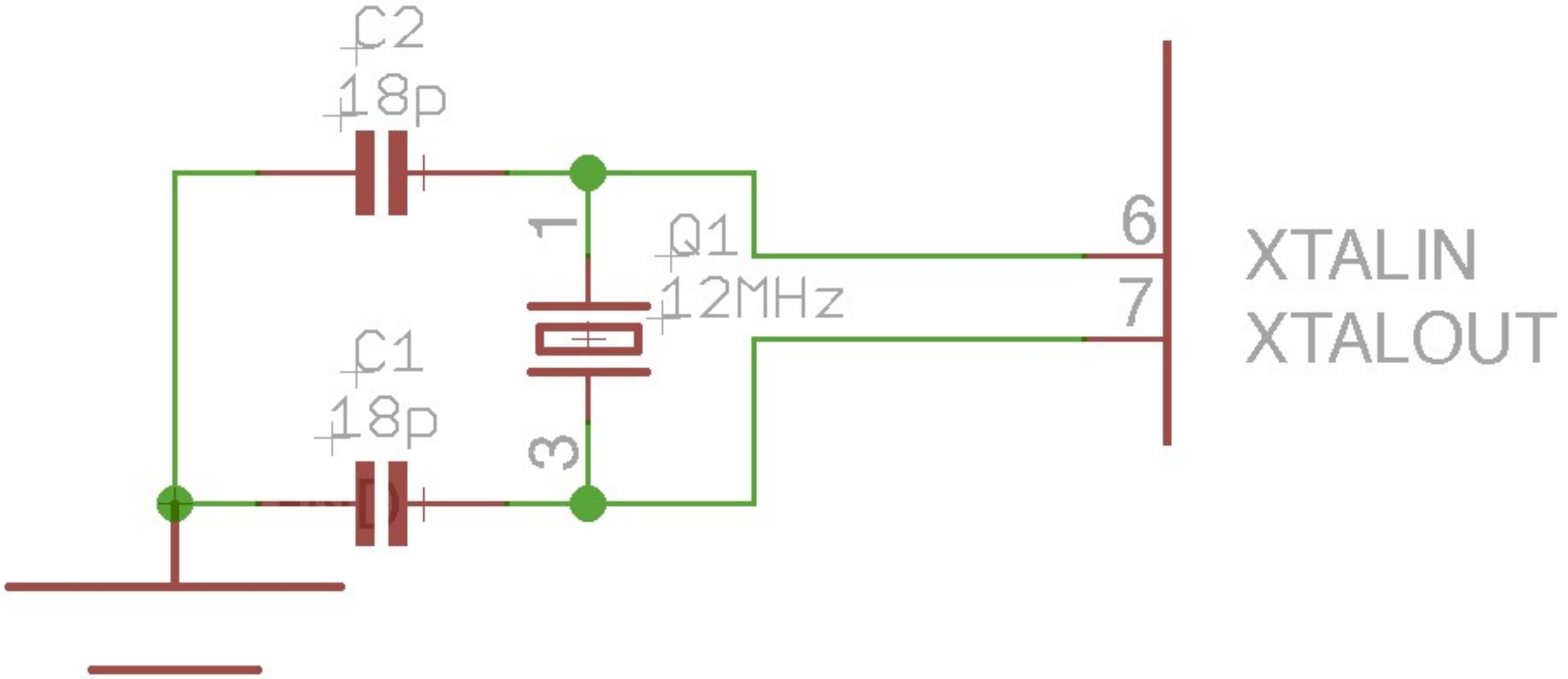


Fig 2. LPC1342/43 LQFP48 package



12 * 4 = 48 MHz (USB)
12 * 6 = 72 MHz (max)

USB

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USB

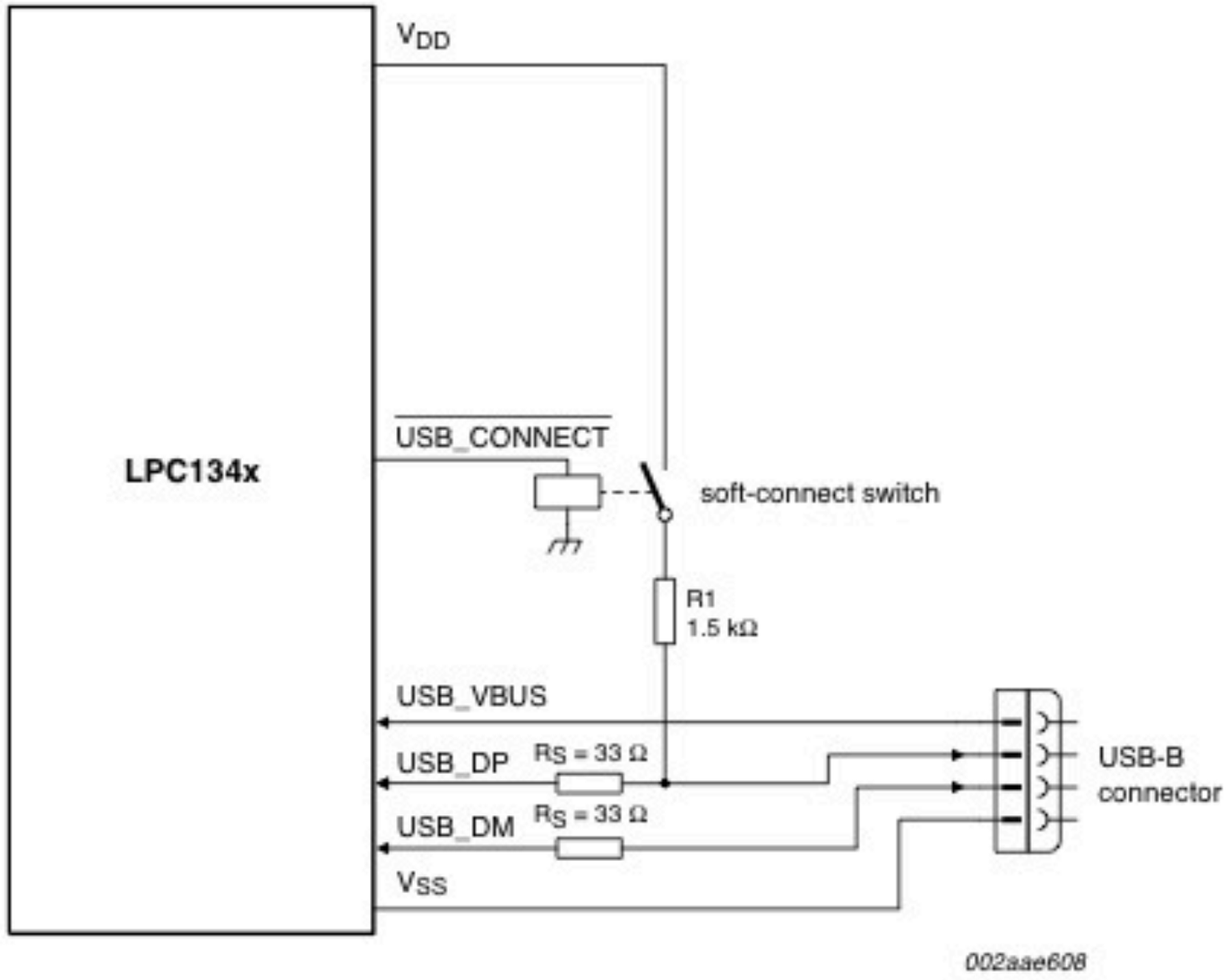


Fig 32. LPC1342/43 USB interface on a self-powered device

LPC 1343 Datasheet

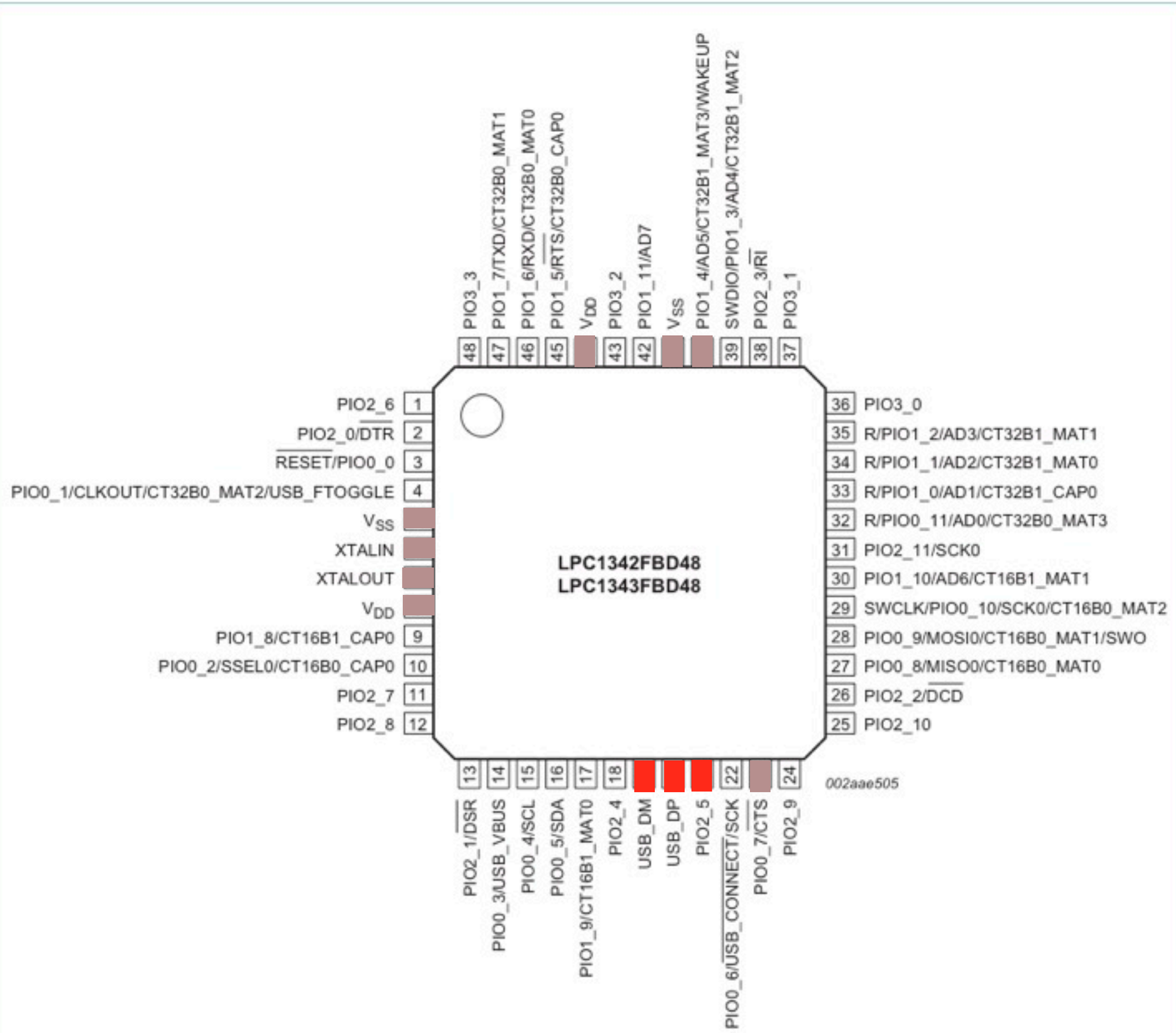
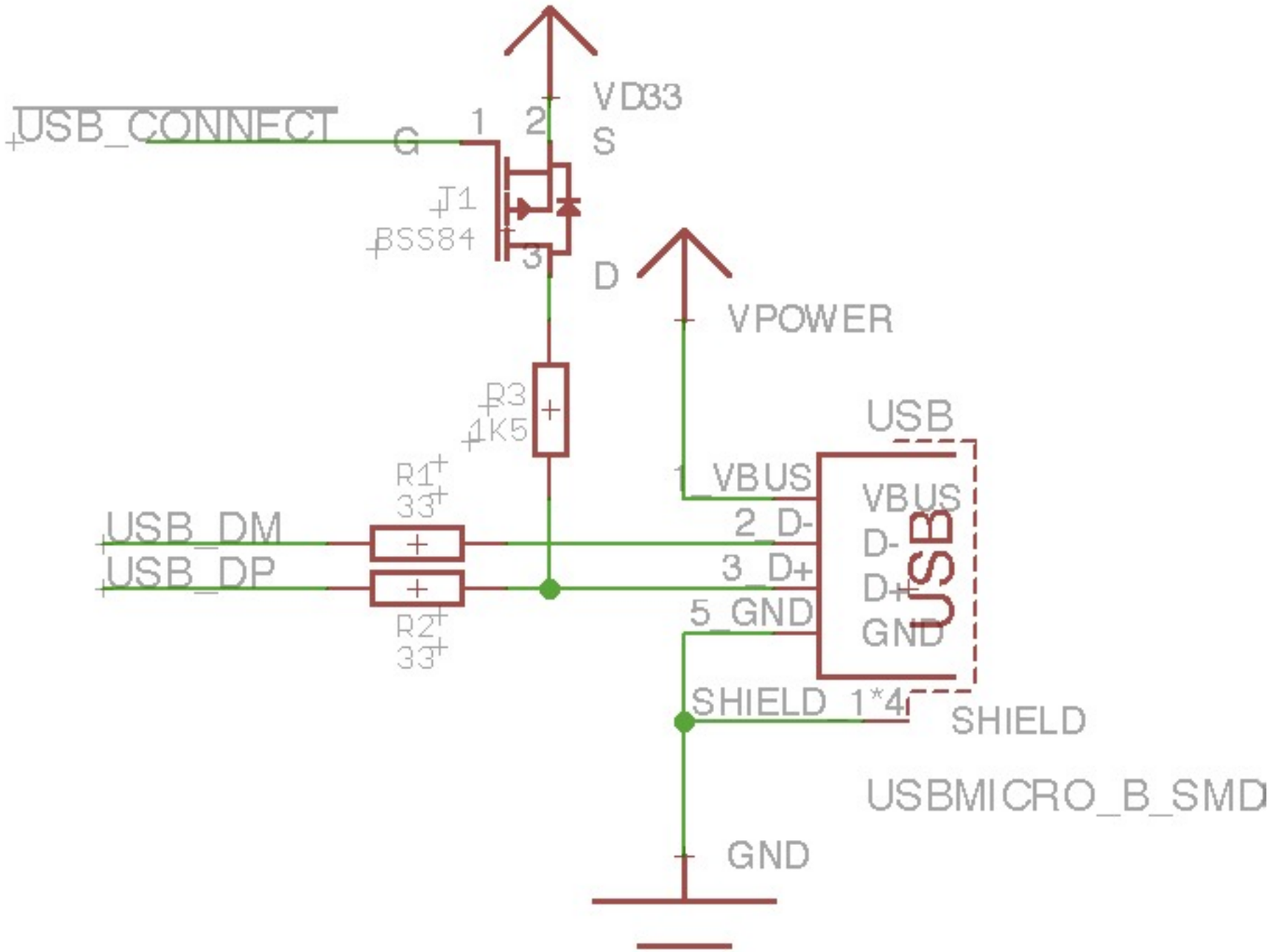


Fig 2. LPC1342/43 LQFP48 package



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reset / programming

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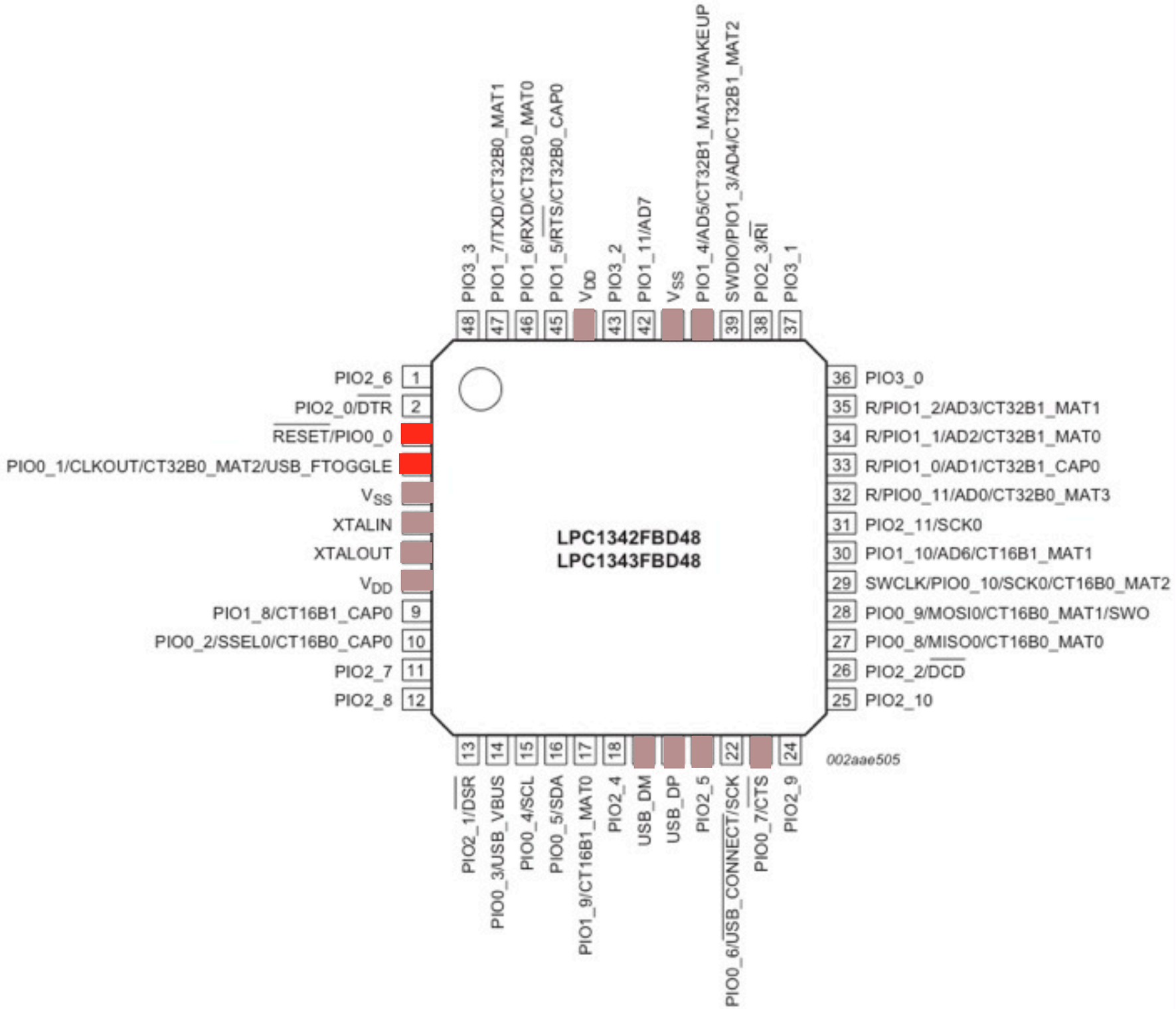
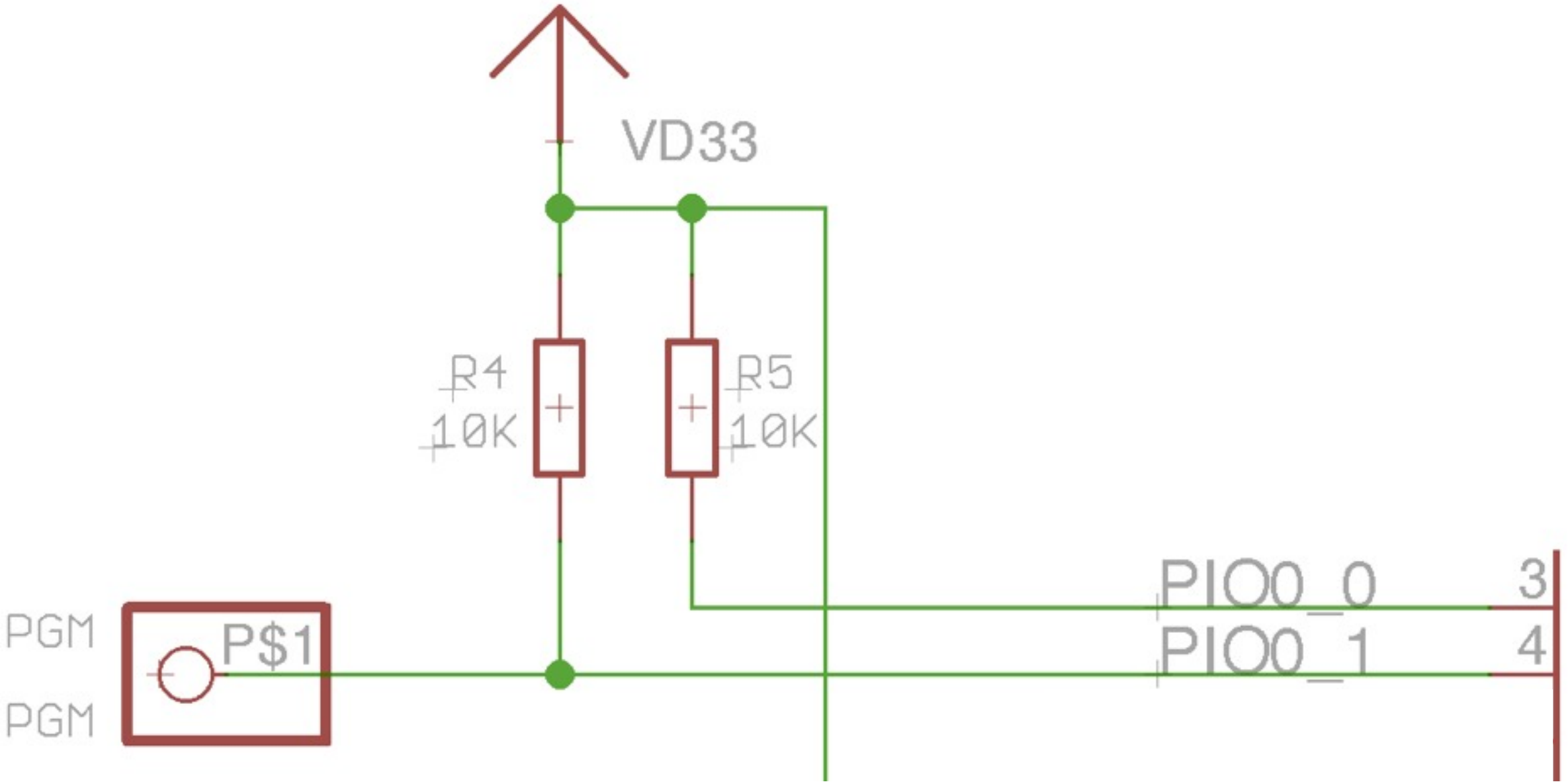


Fig 2. LPC1342/43 LQFP48 package


VD33
R4
10K
R5
10K
PIO0_0
3
PIO0_1
4
PGM
P$1
PGM

flash (experimental)

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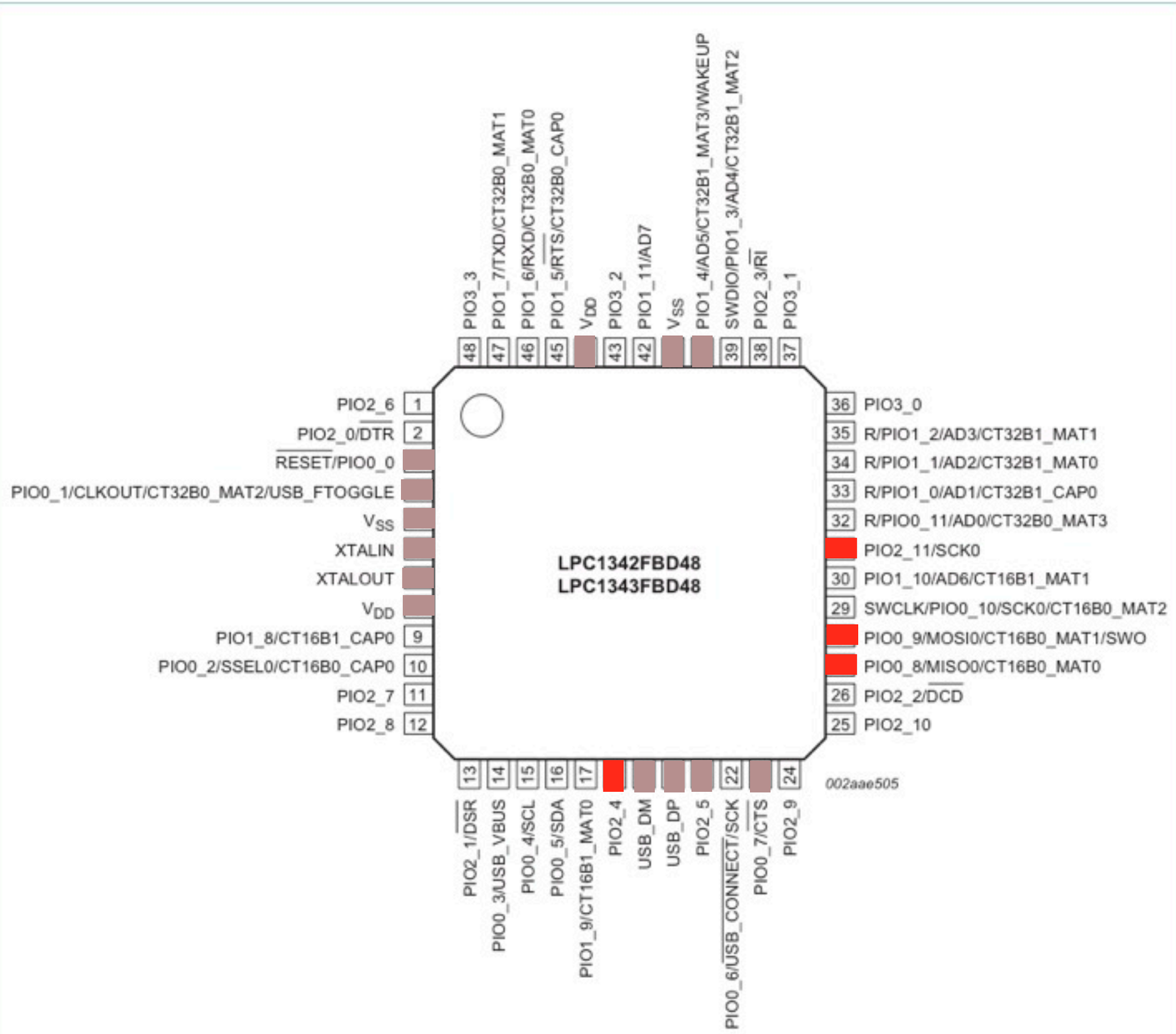
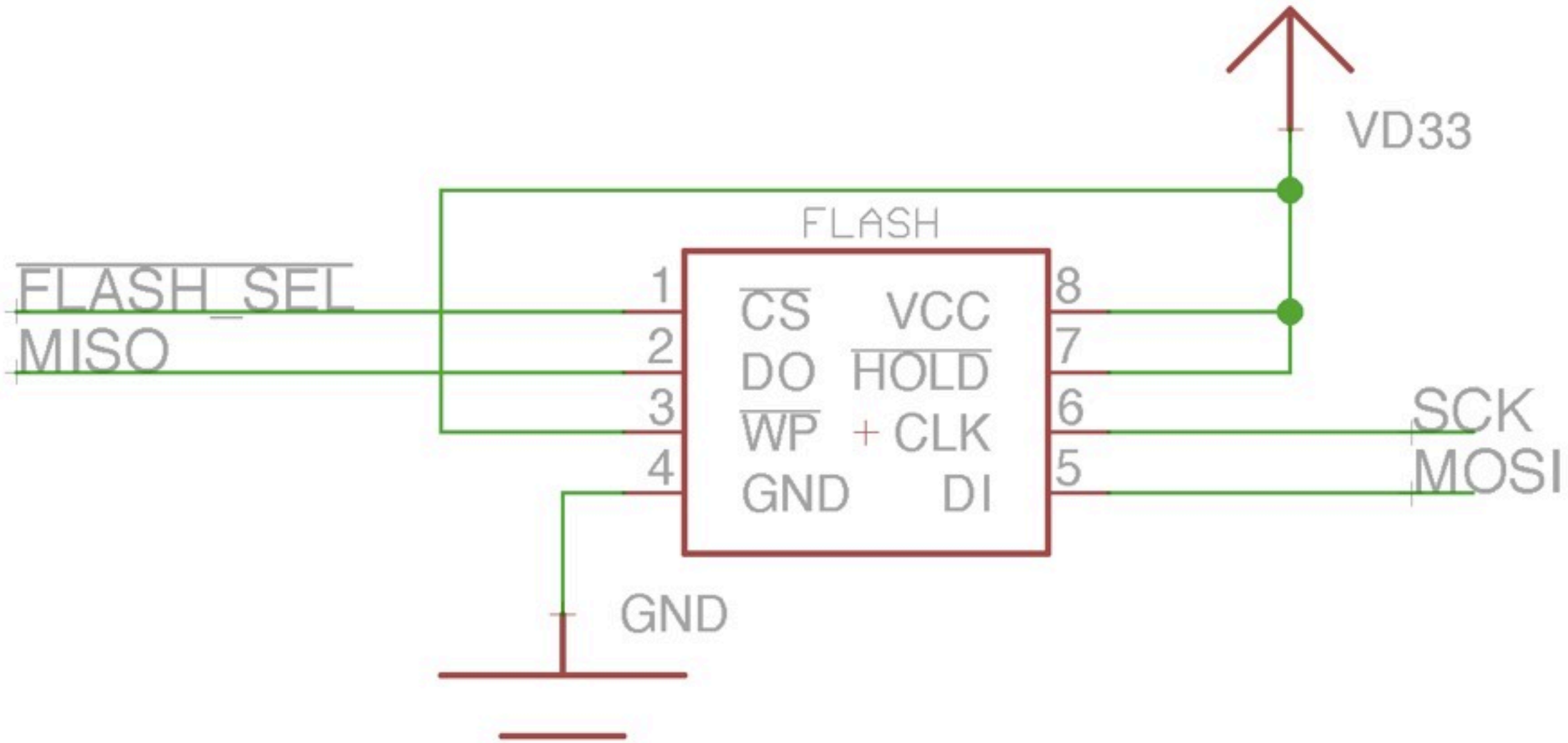


Fig 2. LPC1342/43 LQFP48 package


VD33
FLASH
FLASH_SEL
MISO
1
2
3
4
CS
DO
WP
GND
VCC
HOLD
CLK
DI
8
7
6
5
SCK
MOSI
GND

Resources

Datasheets
Digikey Wikipedia Loop
other people's designs

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Vielen Dank!
Fragen?

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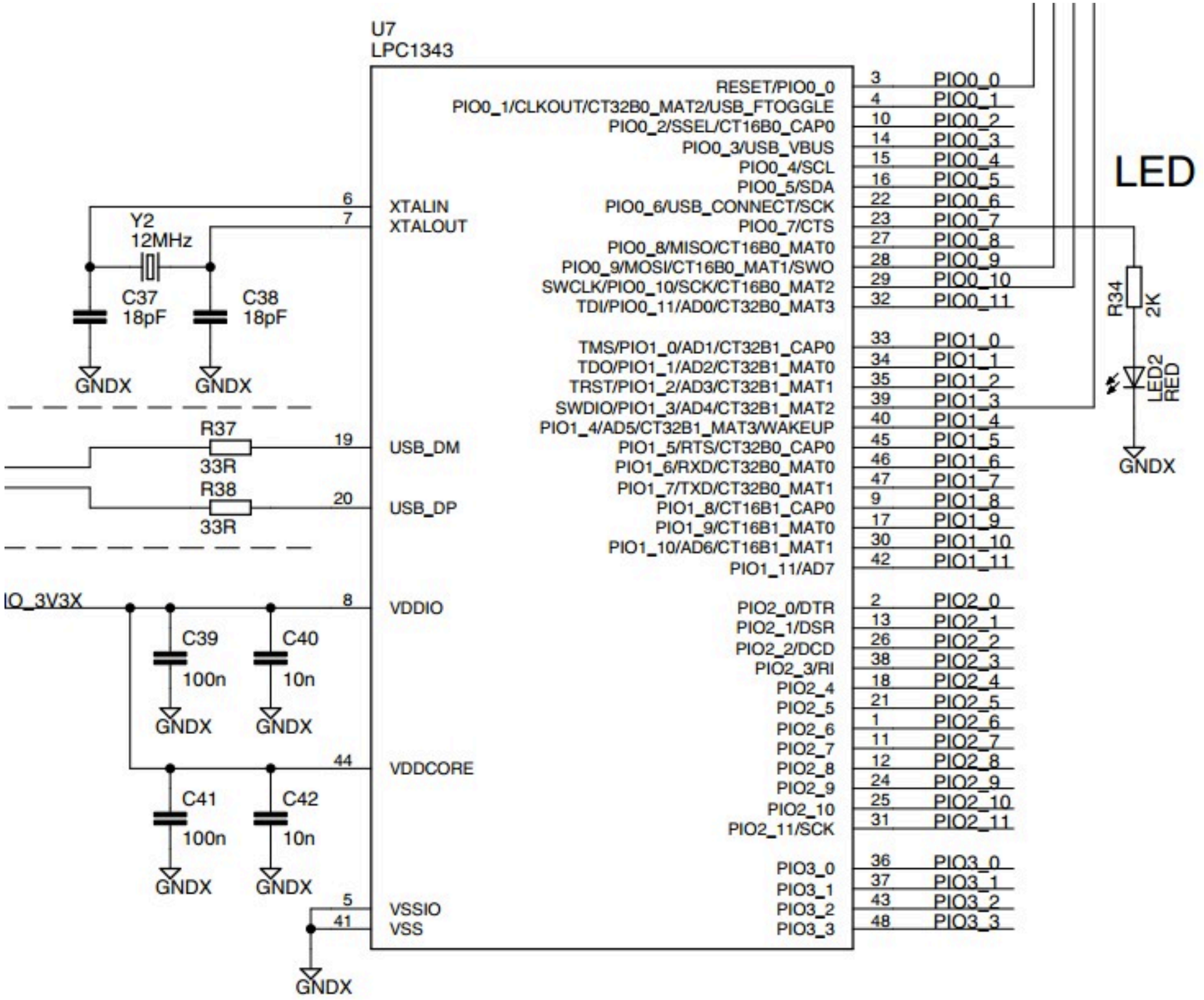
U7
LPC1343
RESET/PIO0_0
PIO0_1/CLKOUT/CT32B0_MAT2/USB_FTOGGLE
PIO0_2/SSEL/CT16B0_CAP0
PIO0_3/USB_VBUS
PIO0_4/SCL
PIO0_5/SDA
PIO0_6/USB_CONNECT/SCK
PIO0_7/CTS
PIO0_8/MISO/CT16B0_MAT0
PIO0_9/MOSI/CT16B0_MAT1/SWO
SWCLK/PIO0_10/SCK/CT16B0_MAT2
TDI/PIO0_11/AD0/CT32B0_MAT3
TMS/PIO1_0/AD1/CT32B1_CAP0
TDO/PIO1_1/AD2/CT32B1_MAT0
TRST/PIO1_2/AD3/CT32B1_MAT1
SWDIO/PIO1_3/AD4/CT32B1_MAT2
PIO1_4/AD5/CT32B1_MAT3/WAKEUP
PIO1_5/RTS/CT32B0_CAP0
PIO1_6/RXD/CT32B0_MAT0
PIO1_7/TXD/CT32B0_MAT1
PIO1_8/CT16B1_CAP0
PIO1_9/CT16B1_MAT0
PIO1_10/AD6/CT16B1_MAT1
PIO1_11/AD7
PIO2_0/DTR
PIO2_1/DSR
PIO2_2/DCD
PIO2_3/RI
PIO2_4
PIO2_5
PIO2_6
PIO2_7
PIO2_8
PIO2_9
PIO2_10
PIO2_11/SCK
PIO3_0
PIO3_1
PIO3_2
PIO3_3
3 PIO0_0
4 PIO0_1
10 PIO0_2
14 PIO0_3
15 PIO0_4
16 PIO0_5
22 PIO0_6
23 PIO0_7
27 PIO0_8
28 PIO0_9
29 PIO0_10
32 PIO0_11
33 PIO1_0
34 PIO1_1
35 PIO1_2
39 PIO1_3
40 PIO1_4
45 PIO1_5
46 PIO1_6
47 PIO1_7
9 PIO1_8
17 PIO1_9
30 PIO1_10
42 PIO1_11
2 PIO2_0
13 PIO2_1
26 PIO2_2
38 PIO2_3
18 PIO2_4
21 PIO2_5
1 PIO2_6
11 PIO2_7
12 PIO2_8
24 PIO2_9
25 PIO2_10
31 PIO2_11
36 PIO3_0
37 PIO3_1
43 PIO3_2
48 PIO3_3
LED
R34
2K
LED2
RED
GNDX
6 XTALIN
7 XTALOUT
Y2
12MHz
C37
18pF
C38
18pF
GNDX
GNDX
R37
33R
19 USB_DM
R38
33R
20 USB_DP
IO_3V3X
8 VDDIO
C39
100n
C40
10n
GNDX
GNDX
44 VDDCORE
C41
100n
C42
10n
GNDX
GNDX
5 VSSIO
41 VSS
GNDX

Thumb