EASYPDKPROG Lite

A simplified version of the EASYPDKPROG that is manufacturable at JLCPCB

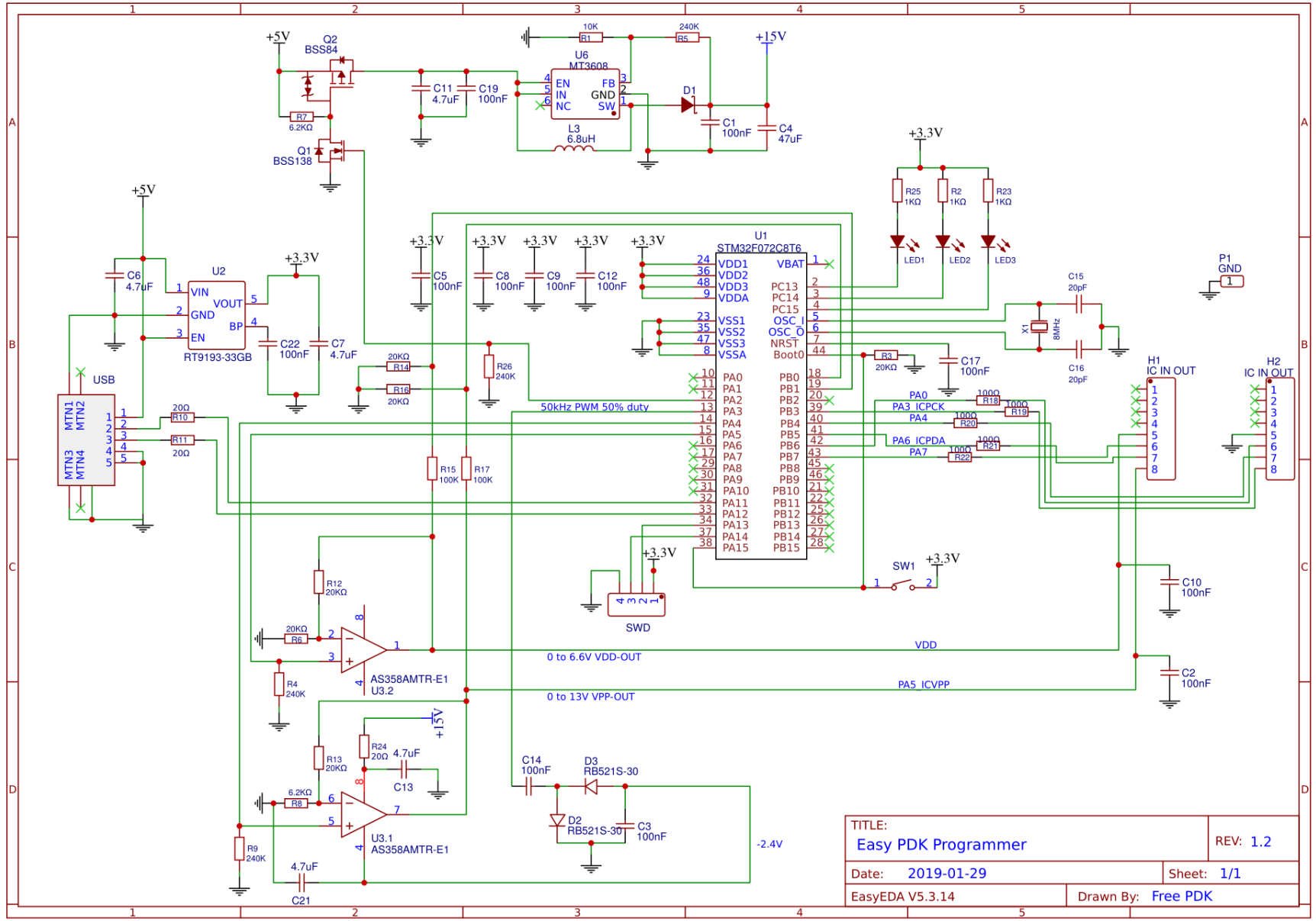
Design goals

1. Retain functionality of the original
2. Reduce types of different components in BOM, whereever possible
3. Try to use only parts from the „Basic“ parts catalogue of JLCPCB
4. Reduce component count whereever possible
5. Allow depop of some parts, e.g. Pushbutton, XTAL
6. Relax spacing between component to ease assembly, especially for USB connector
7. Add silk screen

Schematic of original

easypdkprog_schematic12.pdf

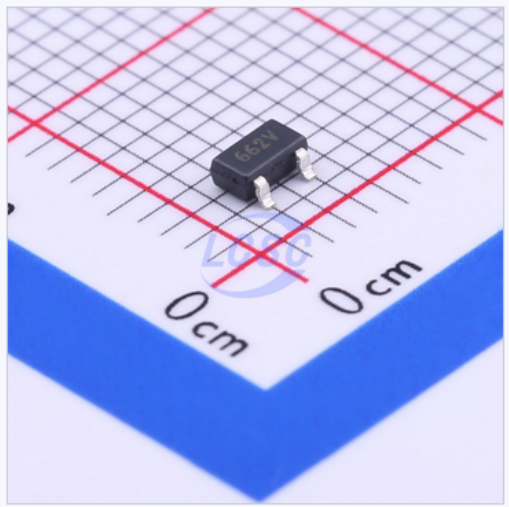
easypdkprog_easyedaproject12.zip



Ideas

- Remove negative power supply to OPAMPS -> output can go 20mV to ground, this should be sufficient
- Remove input switch from DC-DC converter -> Opamps can do power gating
- Remove additional RC filter for OPAMP supply -> loop gain should be high enough to tolerate some power noise. PSRR of opamp is xx dB anyways.
- Replace step-up converter with one from basic components at JLCPCB
- Replace inductor with SMD type (or two?) from basic selection. -> there is no suitable power inductor.
- Extra clearance for USB connector to allow for easier soldering
- More regular layout for resistors with more spacing
- Remove XTAL? -> no, needs adaption of software

XC6206P332MR		LOW DROPOUT REGULATORS(LDO) POSITIVE FIXED 68(	Basic Part	TOREX SEMICON	50542	1+ $0.0948



Torex Semicon XC6206P332MR **JLCPCB Warehouse**

Manufacturer	Torex Semicon
MFR.Part #	XC6206P332MR
LCSC Part #	C5446
Package	SOT-23-3L
Description	LOW DROPOUT REGULATORS(LDO) POSITIVE FIXED 680MV @ 100MA 6V 3.3V 200MA SOT-23-3L ROHS
Datasheet	Torex-Semicon-XC6206P332MR_C5446.pdf
EasyEDA Libraries:	EasyEDA

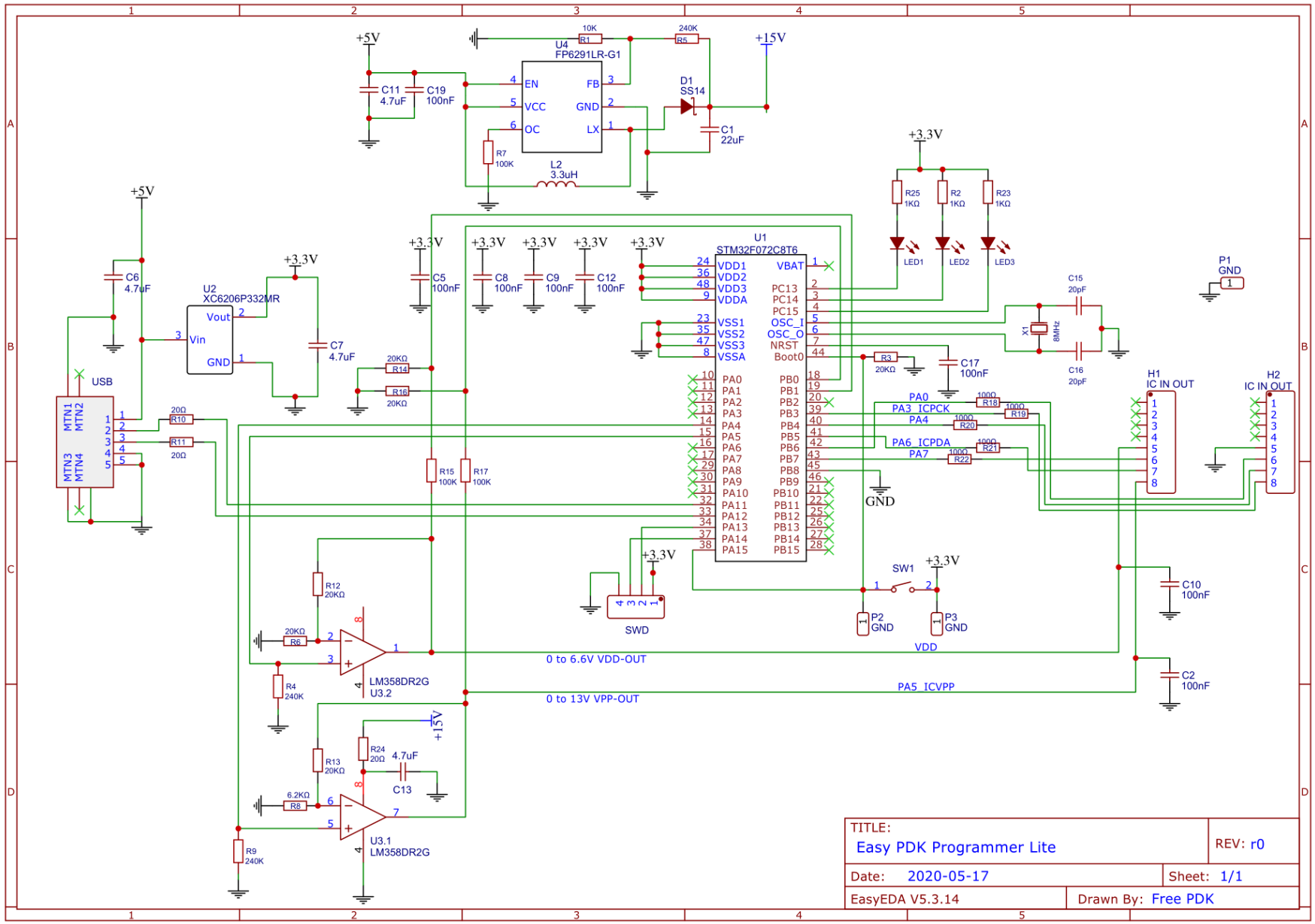
Sales Unit: Piece Full Reel: 50542

Qty.	Unit Price
1+	$0.0948
100+	$0.0562

Change log original -> r0

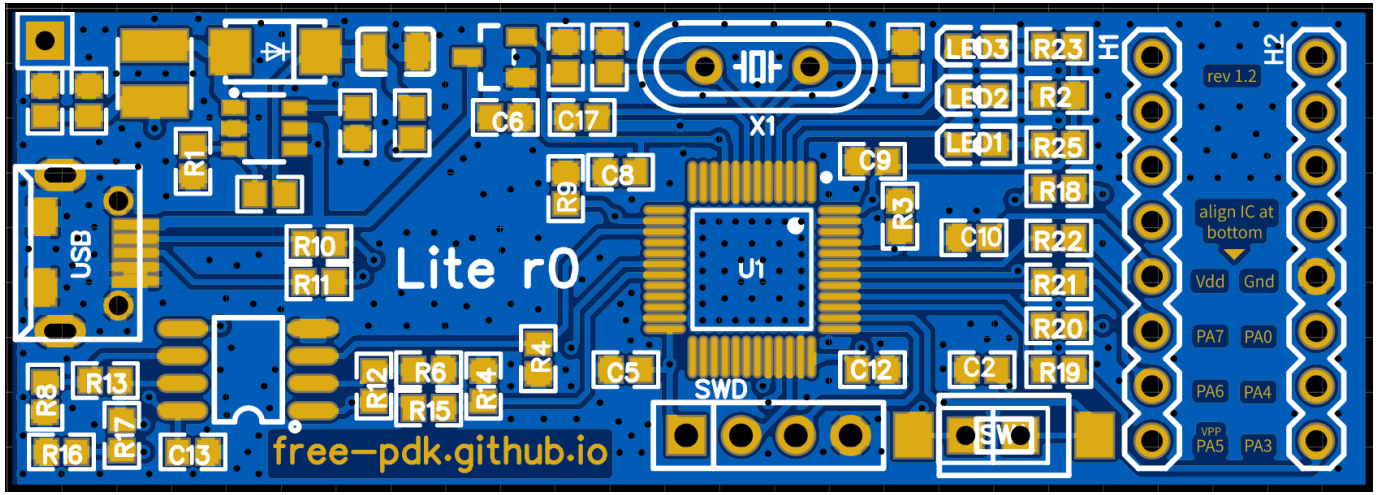
- Removed negative Bias generator and connected Opamp to ground (C3,C14,C21,D2,D3 removed)
- Removed enable circuit for 12 V boost generator (Q1,Q2,R7,R26)
- Increased width of 5V rail to 20mil
- Moved R10,R11 to allow easier soldering of the USB connector
- Moved C5, C9, C12 to allow easier soldering of MCU
- Added „Lite r0“ silk screen
- Moved C10 for better alignment with resistors
- Added optional pins for buttonless activiation of the bootlader
- Replace D1 with SS14 in different package (basic part)
- Replace RT9193 with XC6206P33 (basic part), remove bandgap cap (not needed for XC6206)
- Replace C4 with 22µF cap instead of 47µF. No 47µ cap as basic part available, 22µ is still sufficient according to datasheet. C1 removed, since it is redundant with the additional RC filter.
- Replaced AS358 with LM358 (Basic part)
- Replace MT3680 with FP6291, add 100k current limiting resistor, to limit to 480mA current. Replaced L1 with 3.3µH. (3.3µm is recommended in datasheet, 6.8µH seems too high for FP6291)
- Connected PB8 (Pin 45) of the MCU to ground to be able to detect the lite version from software.

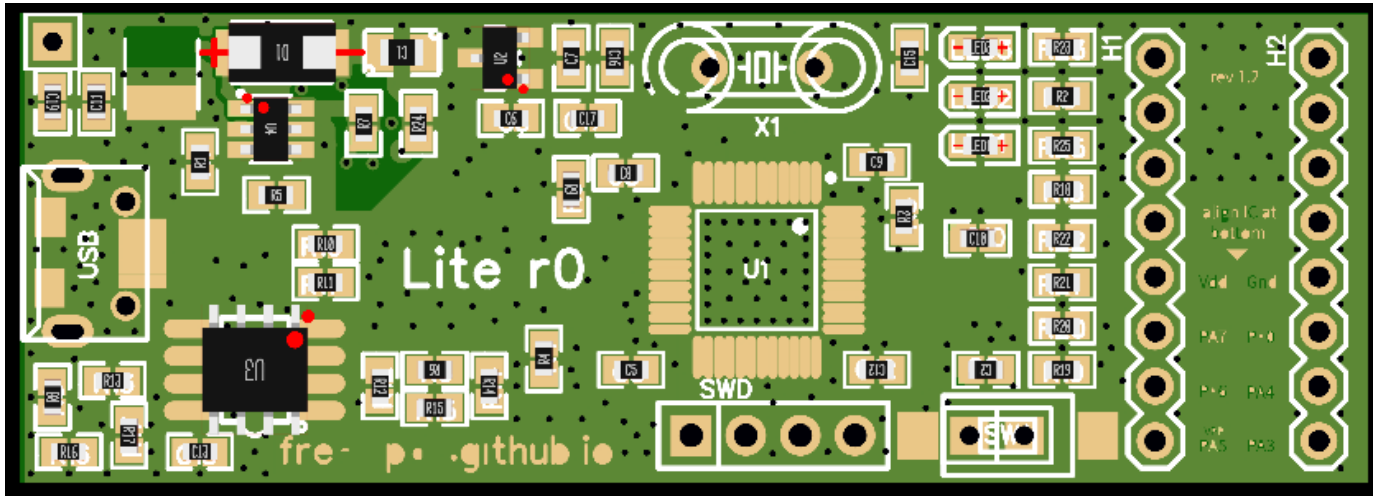
Revision 0 Design, Schematics



Schematic_EasyPDKPROGlite_2020-05-30_15-22-31

Revision 0 design, PCB





easypdkprog_lite_may30.zip

List of parts not populated

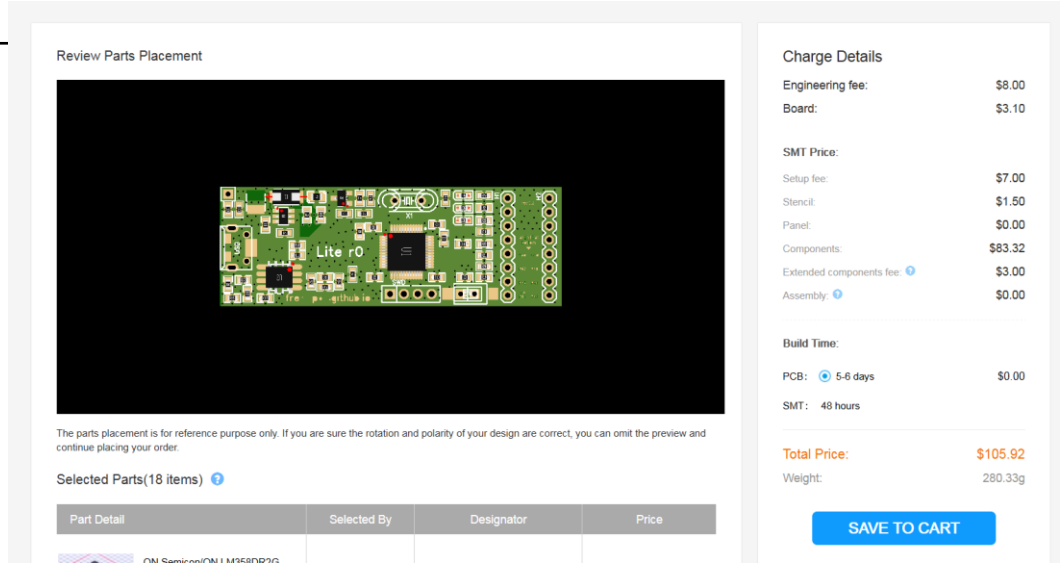
Designator	Name	Footprint	Quantity	Note
SW1	1TS002E-2700-2500	KEY-TACT-SMD-6.1*3.7*2.5	1	Optional, can use wire bridge to invoke bootloader
X1	8MHZ	HC-49S	1	Optional, need to update firmware to use internal oscillator
H1	IC IN OUT	210S-1X8P	1	**Mandatory, programming header**
H2	IC IN OUT	210S-1X8P	1	**Mandatory, programming header**
L2	3.3UH	IND-SMD_L3.0-W3.0	1	**Mandatory**
USB	MICRO USBFEMALE	MICRO-USB-1	1	**Mandatory**
SWD	SWD	DIP-1X4P-2.54MM-M	1	Optional, only needed for development

Note

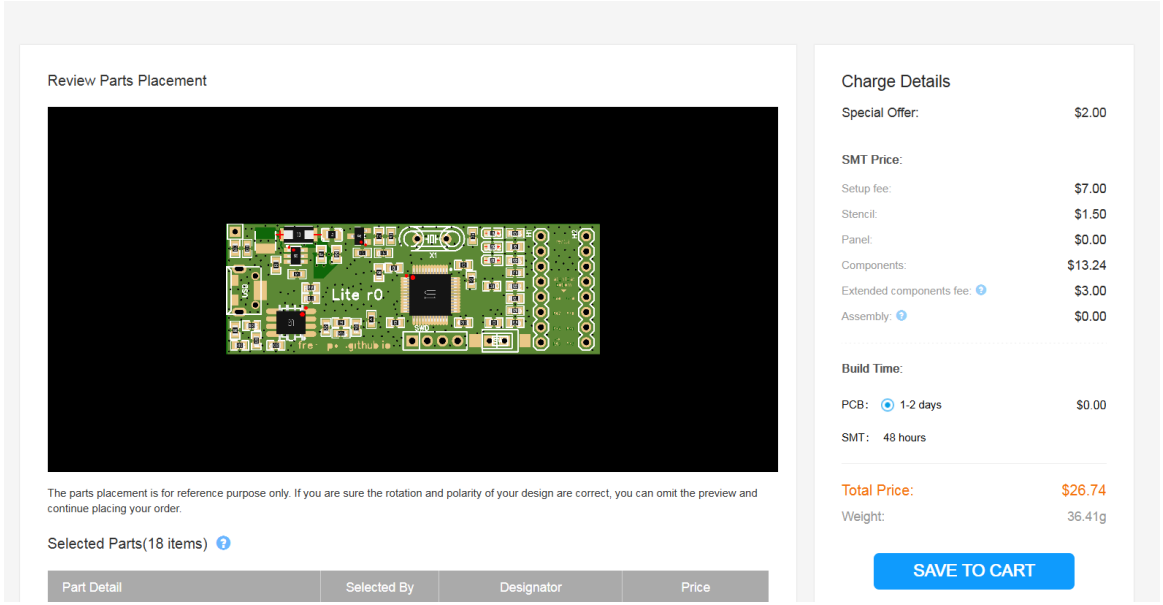
- X1,H1,H2 are through hole parts and cannot be populated by JLCPCB
- L2 is not available at JLCPCB and needs to be mounted manually
- USB cannot be be populated by JLCPCB

Cost at JLCPCB

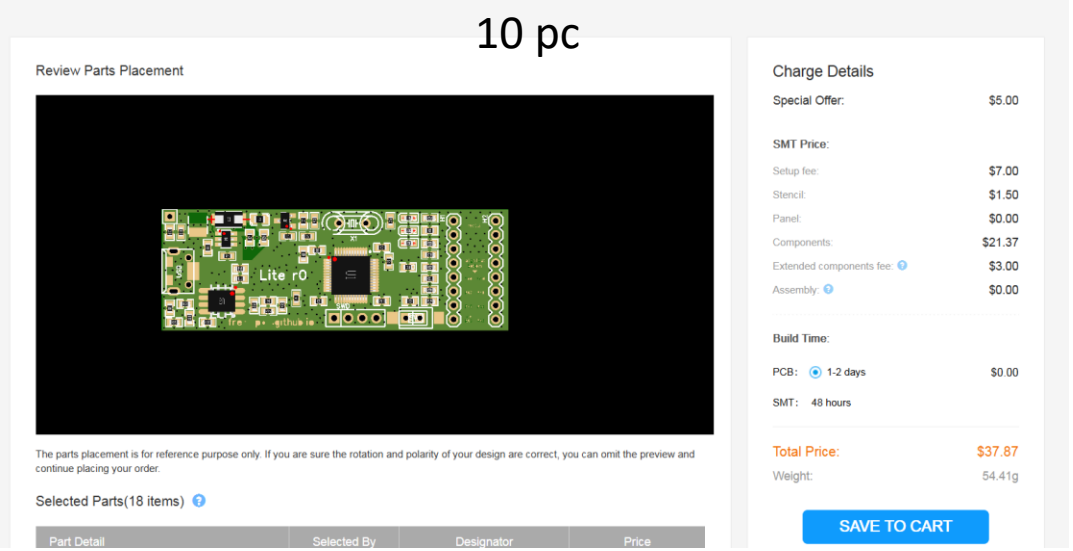
50 pc



5 pc

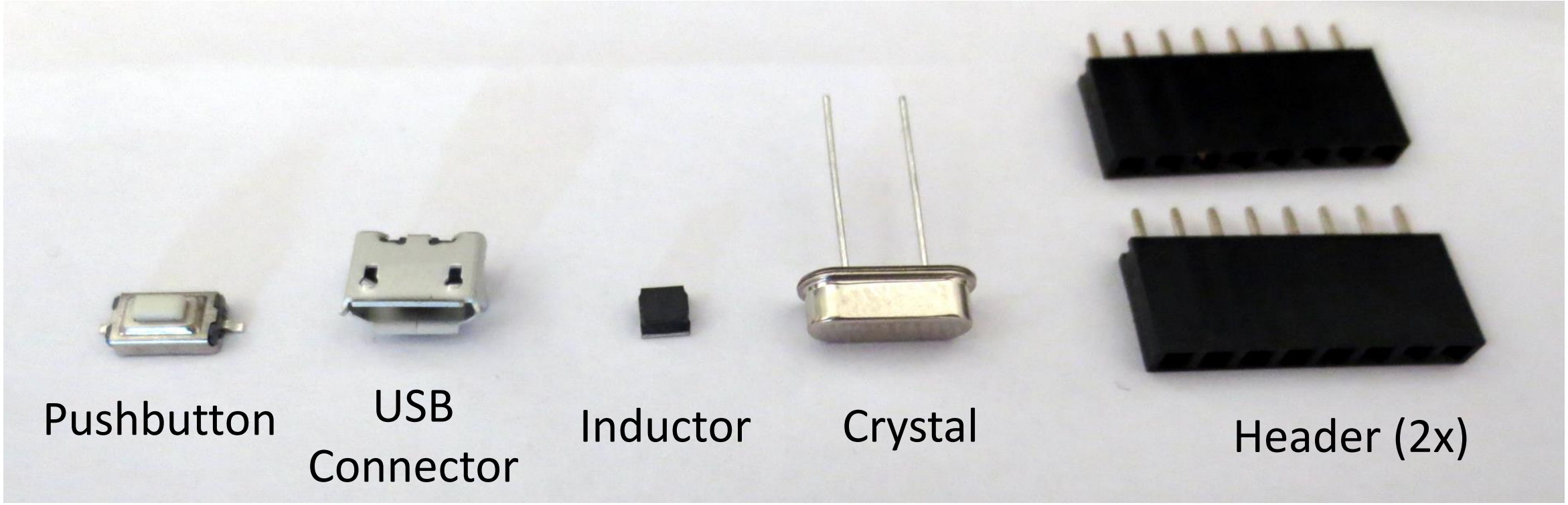


10 pc

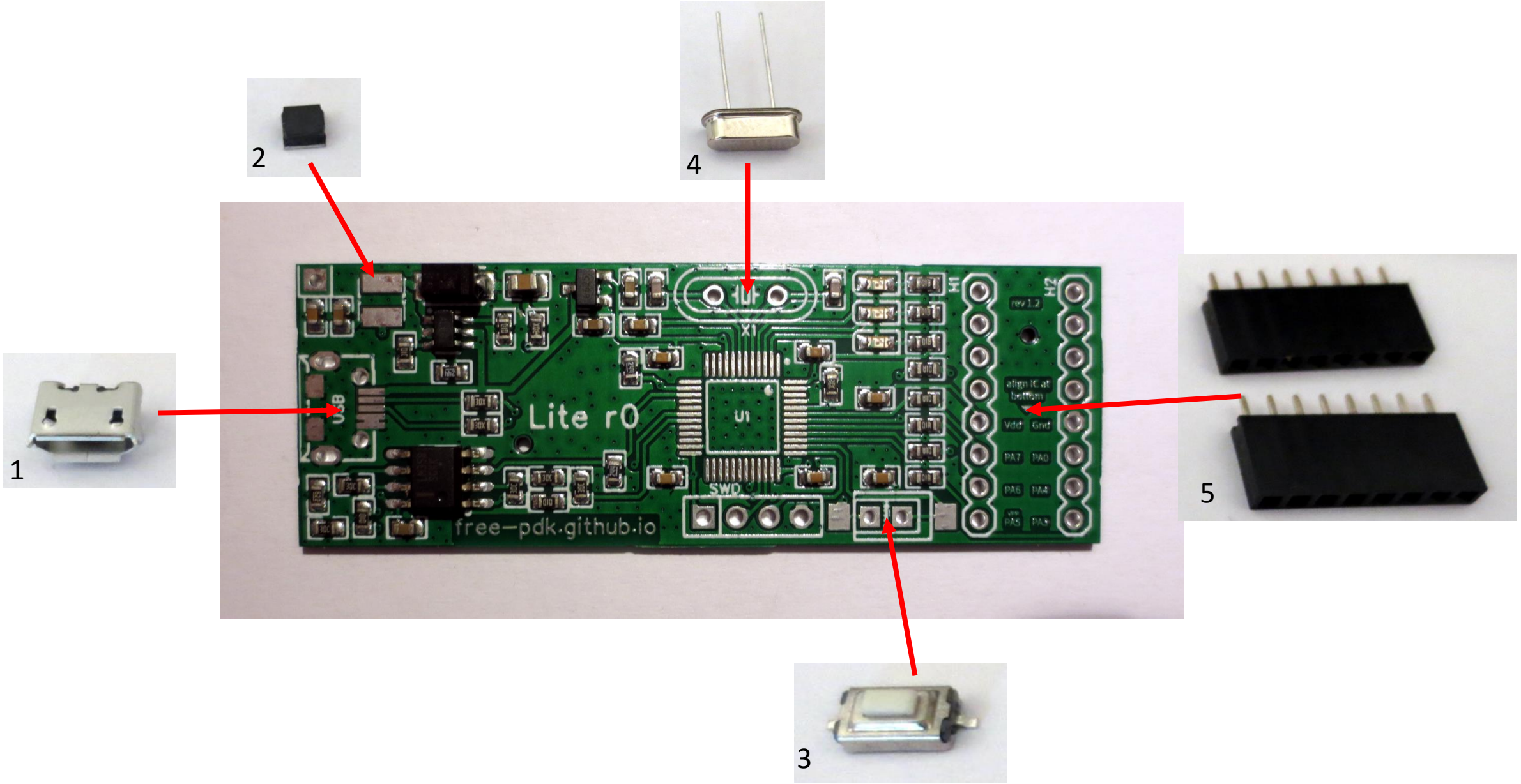


R0 Assembly

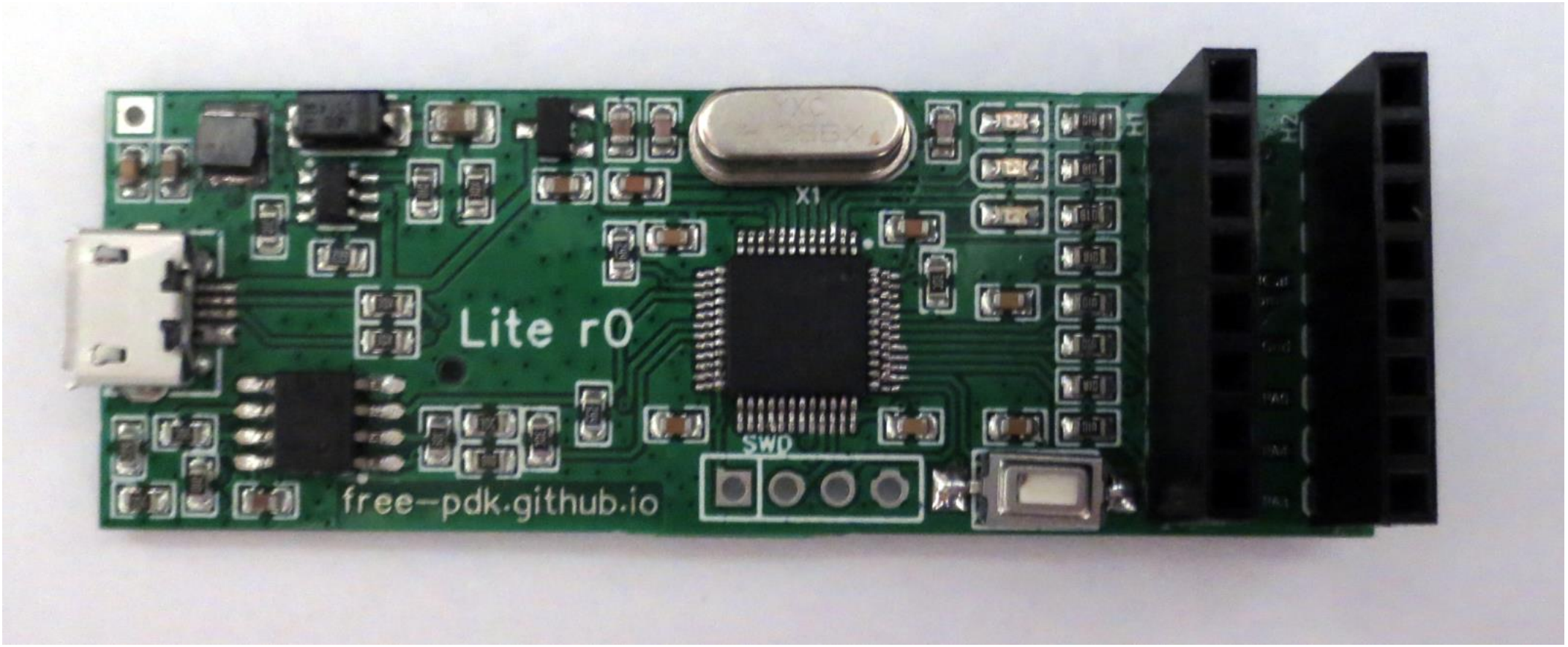
Components that need to be manually assembled



Assembly locations



Assembled programmer

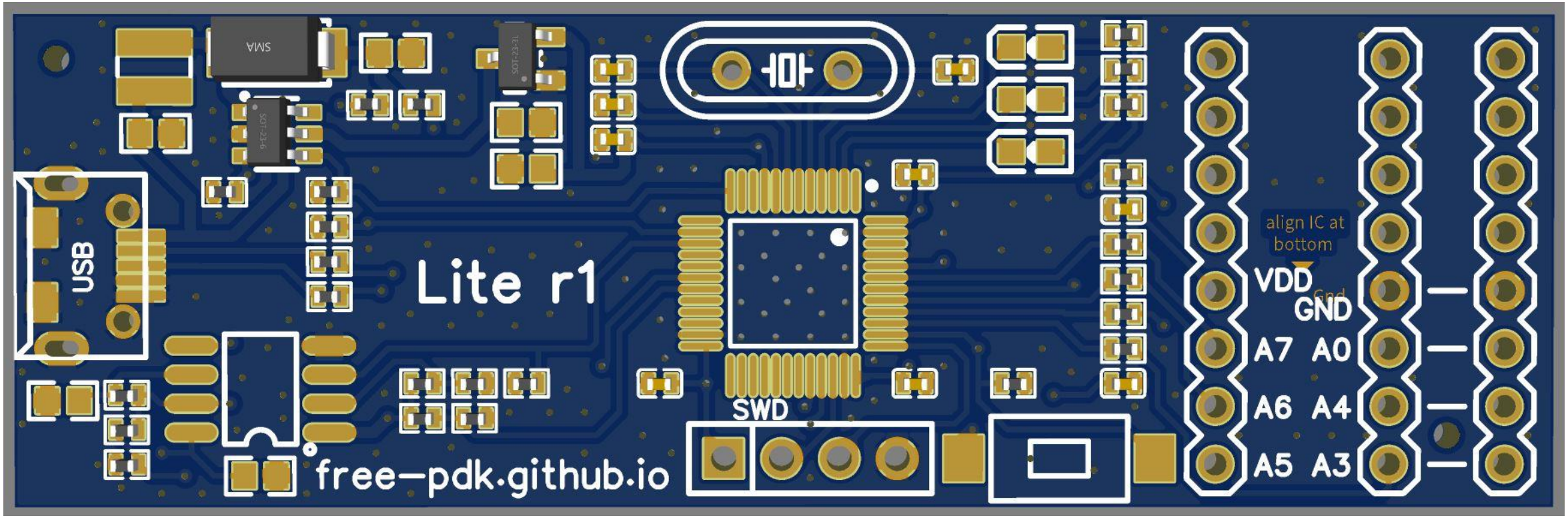


R1 Design

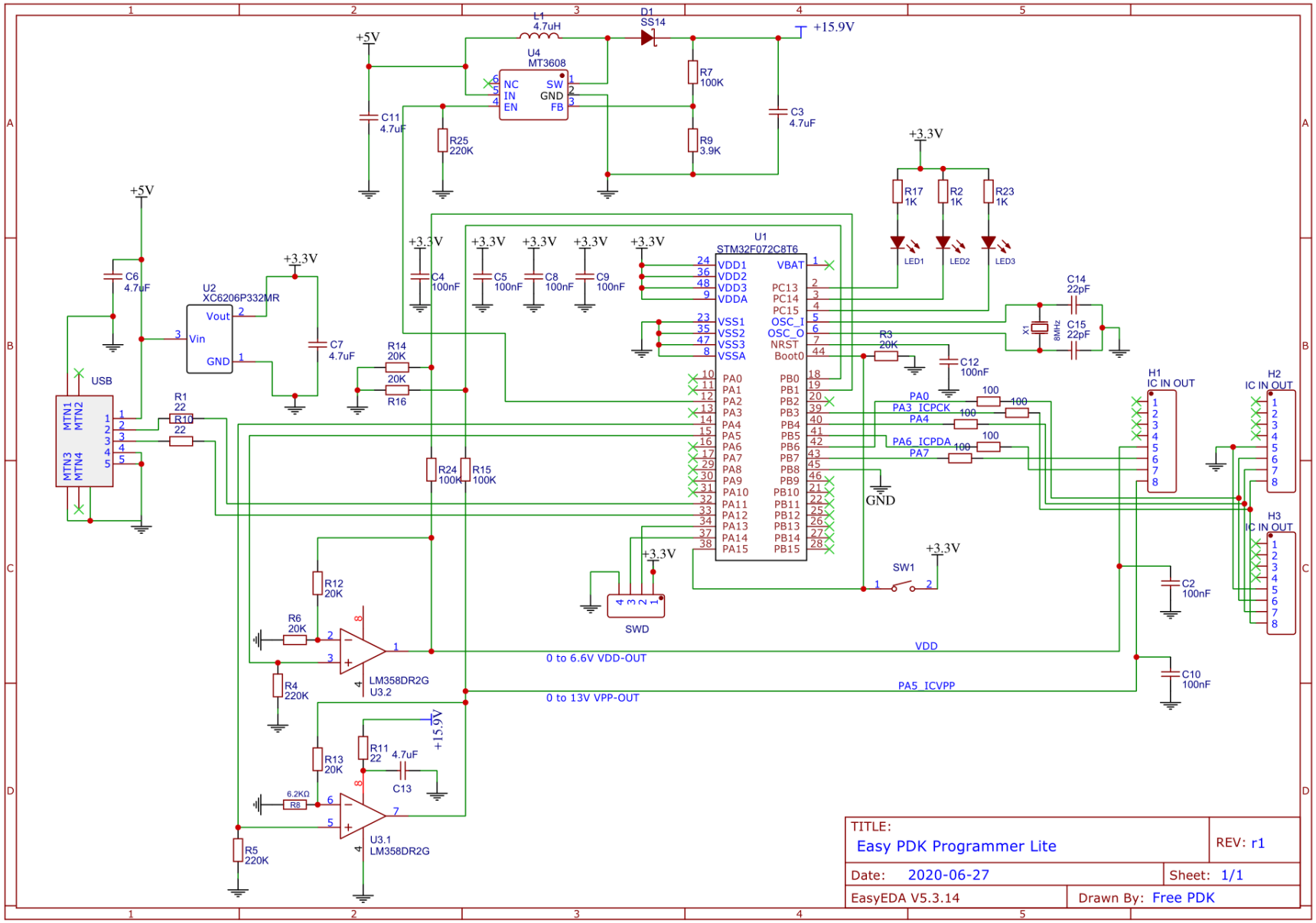
Change log r0 -> r1

- Added keepout area to avoid direct connection between the two GND pins on the USB plug. This prevents formation of solder bridges during manual soldering.
- Removed „rev 1.2“ metallization mark to avoid confusion
- Corrected mistake: Change name of P2 in schematics to „Boot“ instead of GND.
- Create space for tooling holes during JLCPCB assembly:
  - Removed PINs to shortcut button -> Make button mandatory, allow space for mounting hole (It‘s a cheap part and more convenient to have when updating the firmware)
  - Removen GND pin header in top left corner to allow placement of mounting hole -> scope gnd can also be taken from SWD header or many other places.
- Converted „free-pdk.github.io“ inscription to silk screen for better visibility.
- Converted pin descriptions to silk screen for better visibility.
- Replaced almost all 0603 parts with 0402 parts to de-crowd layout and for some cost down.
- Went back to MT3608 boost converter, but with simplified filtering
- Connected enable pin of boost converter to MCU
- Rearranged current loop in boost converter to reference a single GND point.
- Added second row of headers to allow plugging in wide breakout boards
- Added fiducial holes for assembly

R1 lite programmer, PCB



R1 lite programmer, schematics



Requirements for boost converter

LM358-D.PDF

Limitation given by LM358 voltage buffer

- Max output current: 20 mA min, 40 mA typ. -> Max booster current 2x*40 mA
- Out voltage high limit: 1.5 – 2 V below VCC -> VPPmax is 10.5V, so VCCopamp ~13 V
- Ripple not so critical due to PSRR of LKM358. Lets assume <50mV Vpp

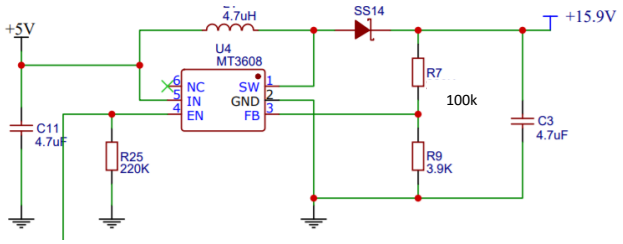
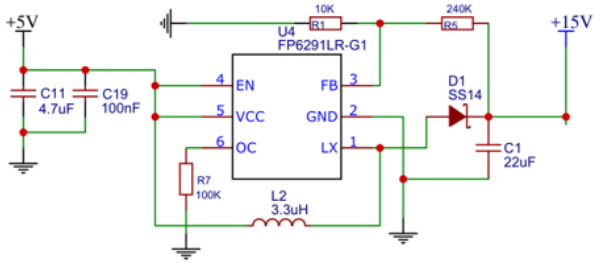
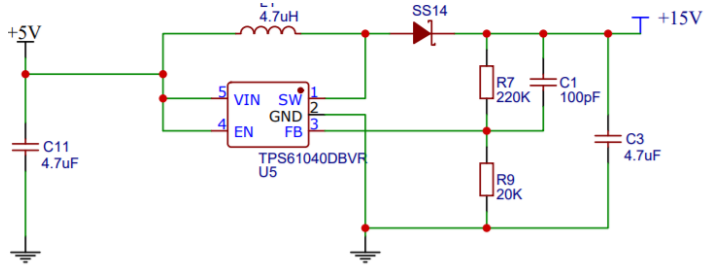
Limitation given by reference voltage divider (R8/R13 in original design)

- 3.3 V *(20 kohm + 6.2 kohm) / (6.2 kohm) = 13.9 V -> VCCopamp ~ 15 V

Requirements for boost converter

- Vout>=15 V, Imax~2*40mA, <50 mVpp ripple

Boost converter options

sdfsdf	Aerosemi MT3608	Feeling Tech FP6291	Texas Instruments TPS61040
Cost	$0.098/pc + $3.00 extended part fee per run	$0.126 (basic part)	$0.42 (basic part)
Circuit			
Notes	22 µF output cap recommended -> replaced with 4.7µF + RC filter	22 µF output cap recommended Addition current limiting resistor needed	Only requires small output capacitor Additional cap C1 needed
Design	Vout = 15.9 V Imax = ??? Dvout <150 mV expected Fmax ~1.2 MHz MOSFET Rdson 0.08 Ohm Pulse frequency modulation feature should prevent ripple	Vout = 15 V (Max is 16V, nominal 12 V) Imax = ??? Dvout ~ 150 mV in current design Fmax ~1 MHz MOSFET Rdson 0.2 Ohm Audible inductor noise!	Vout = 14.8 V Imax = 50 mA Dvout <14.7mV Fmax ~ 1 MHz MOSFET Rdson 0.6 Ohm
	MT3608.pdf	1812101116_Feeling-Tech-FP6291LR-G1_C18701.pdf	1809151118_Texas-Instruments-TPS61040DBVR_C7722.pdf

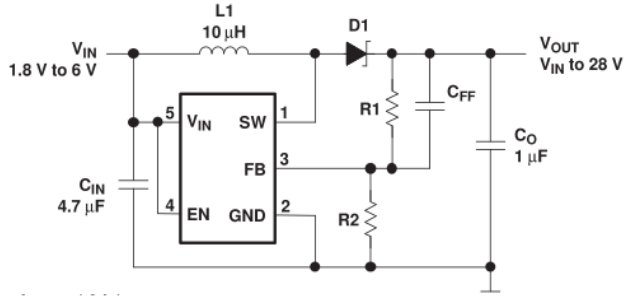
Pick this

Boost converter design with TPS61040

- L=4.7 µH
- Vd of SS14 schottky diode is ~0.3V
- Vout=14.8 V, R1= 220 kOhm, R2= 20 kOhm, Co=4.7 µF
- Ipeak= 400 mA + 5 V/4.7 µH*100 nS = 400 mA + 152 mA = 506 mA
- Fsmax= 1.4 MHz (1 MHz is allowed fsmax, booster should not be loaded above 50 mA)
- Fsload(20 mA)= 0.297 MHz
- Fsload(0.5 mA)=7.43 kHz (this is the quiescent current of the LM358)
- Iloadmax= 68 mA
- CFF ~ 86 pF -> 82 pF (Assuming 10 m
- dVOUT=14.7mV

The output voltage is calculated as:

$$V_{OUT} = 1.233\ V \times \left(1 + \frac{R1}{R2}\right)$$



$$I_{peak(typ)} = 400\ mA + \frac{V_{IN}}{L} \times 100\ ns \text{ for the TPS61040}$$

By selecting the TPS61040 or TPS61041, it is possible to tailor the design to the specific application current limit requirements. A lower current limit supports applications requiring lower output power and allows the use of an inductor with a lower current rating and a smaller form factor. A lower current limit usually has a lower output voltage ripple as well.

For best output voltage filtering, a low ESR output capacitor is recommended. Ceramic capacitors have a low ESR value but tantalum capacitors can be used as well, depending on the application.

Assuming the converter does not show double pulses or pulse bursts on the switch node (SW), the output voltage ripple can be calculated as:

$$\Delta V_{out} = \frac{I_{out}}{C_{out}} \times \left(\frac{1}{fS(Iout)} - \frac{I_P \times L}{Vout + Vd - Vin}\right) + I_P \times ESR$$

where:

I_P = Peak current as described in the *Peak Current Control* section

L = Selected inductor value

I_{out} = Nominal load current

fS (I_{out}) = Switching frequency at the nominal load current as calculated previously

Vd = Rectifier diode forward voltage (typically 0.3 V)

C_{out} = Selected output capacitor

ESR = Output capacitor ESR value (7)

The lower the switching frequency of the converter, the larger the feedforward capacitor value required. A good starting point is to use a 10-pF feedforward capacitor. As a first estimation, the required value for the feedforward capacitor at the operation point can also be calculated using the following formula:

$$C_{FF} = \frac{1}{2 \times \pi \times \frac{fS}{20} \times R1}$$

Where:

R1 = Upper resistor of voltage divider

fS = Switching frequency of the converter at the nominal load current (See the Inductor Selection, Maximum Load Current section for calculating the switching frequency)

C_{FF} = Choose a value that comes closest to the result of the calculation (6)

$$fS_{max} = \frac{V_{IN(min)} \times (V_{OUT} - V_{IN})}{I_P \times L \times V_{OUT}}$$

Where:

I_P = Peak current as described in the *Peak Current Control* section

L = Selected inductor value

$V_{IN(min)}$ = The highest switching frequency occurs at the minimum input voltage

$$fS(I_{load}) = \frac{2 \times I_{load} \times (V_{OUT} - V_{IN} + Vd)}{I_P^2 \times L}$$

Where:

I_P = Peak current as described in the *Peak Current Control* section

L = Selected inductor value

I_{load} = Nominal load current

Vd = Rectifier diode forward voltage (typically 0.3V)

$$I_{load\ max} = \eta \frac{I_P^2 \times L \times fS_{max}}{2 \times (V_{OUT} - V_{IN})}$$

Where:

I_P = Peak current as described in the *Peak Current Control* section

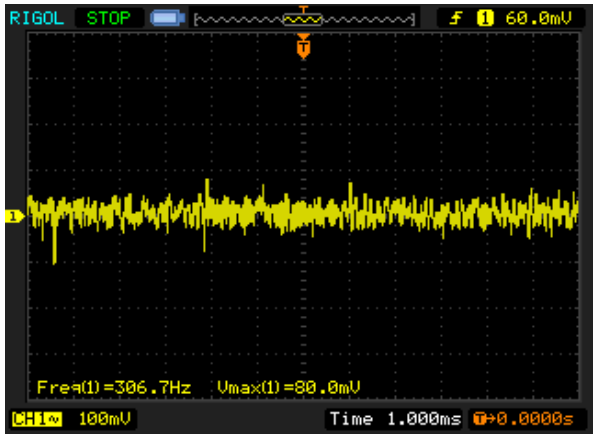
L = Selected inductor value

fS_{max} = Maximum switching frequency as calculated previously

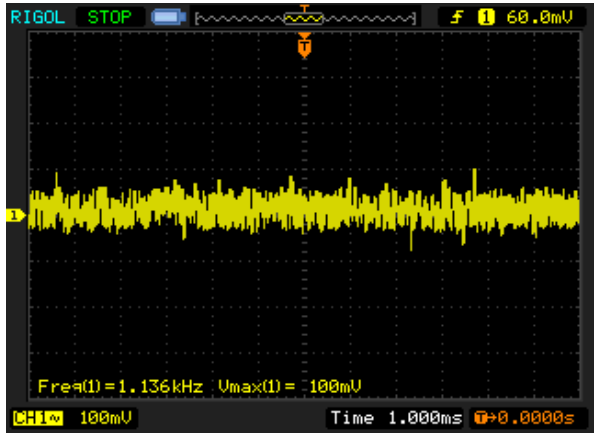
η = Expected converter efficiency. Typically 70% to 85%

Boost converter design with MT3608

- L=4.7 µH
- Vd of SS14 schottky diode is ~0.3V
- Vout=15.9 V, R1= 100 kOhm, R2= 3.9 kOhm, Co=4.7 µF
- Output filtering
  - A 22 µF cap is large and expensive, especially since not used elsewhere
  - Use 4.7 µF instead in addition to existing RC filter, since PSRR of opamp will remove further noise: 22 Ohm/4.7µF -> fc= 1.54 kHz



Original programmer with 47µ cap supply at OPAMP after RC-Filter



Original programmer with removed cap supply at OPAMP after RC-Filter

Cost of MLCC caps:
0603, 4.7 µF, 16 V 0.0206 USD (same for 0805)
0805, 10 µF, 25 V 0.031 USD
0805, 22 µF, 25 V 0.068 USD
1210, 47 µF, 16 V 0.19 USD

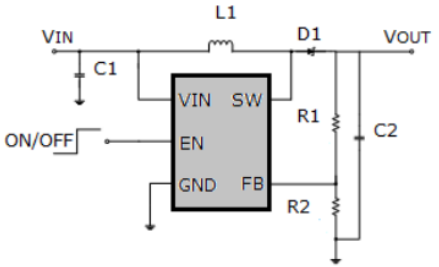


Figure 1. Basic Application Circuit

Setting the Output Voltage

The internal reference VREF is 0.6V (Typical).The output voltage is divided by a resistor divider,R1 and R2 to the FB pin. The output voltage is given by

$$V_{OUT} = V_{REF} \times (1 + \frac{R_1}{R_2})$$

Inductor Selection

The recommended values of inductor are 4.7 to 22µH. Small size and better efficiency are the major concerns for portable device, such as MT3608 used for mobile phone. The inductor should have low core loss at 1.2MHz and low DCR for better efficiency. To avoid inductor saturation current rating should be considered.

Capacitor Selection

Input and output ceramic capacitors of 22µF are recommended for MT3608 applications. For better voltage filtering, ceramic capacitors with low ESR are recommended. X5R and X7R types are suitable because of their wider voltage and temperature ranges.

- Cables & Wires
- Capacitors
- Connectors
- Crystals
- Diodes
- Embedded Processors & Controllers
- Filters
- Functional Modules
- Inductors & Chokes & Transformers
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- Power Management ICs
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Transformers / Power Inductors / TAITEC HPC3015TF-4R7M

See an Error?

TAITEC HPC3015TF-4R7M

Manufacturer	TAITEC
Mfr.Part #	HPC3015TF-4R7M
LCSC Part #	C155140
Package	SMD,3x3x1.5mm
Customer #	Customer Number
Datasheet	TAITEC HPC3015TF-4R7M
EasyEDA Libraries	EasyEDA Model
Description	4.7uH ±20% 1.2A 144mΩ SMD,3x3x1.5mm Power Inductors RoHS

In stock: 5350

Ship Immediately	4100
Ship within 3 days	1250

10 + −

Add to cart

Minimum : 10 Multiples : 10

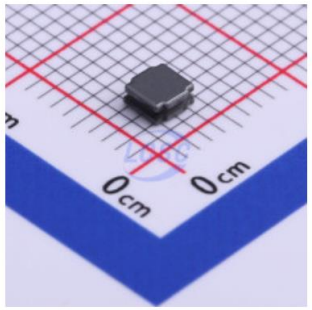
Packaging: Cut Tape

Unit Price	US$ 0.039254
Ext. Price	US$0.39

Pricing(USD)

Sales Unit: Piece Full Reel: 2000

Qty.	Unit Price	Ext. Price



Images are for reference only.

Add to Favourites

Ceaiya CR3015-6R8M

Manufacturer	Ceaiya
Mfr.Part #	CR3015-6R8M
LCSC Part #	C520295
Package	SMD,3.0x3.0x1.5mm
Customer #	Customer Number
Datasheet	Ceaiya CR3015-6R8M
Description	6.8uH ±20% 0.85A 200mΩ SMD,3.0x3.0x1.5mm Power Inductors RoHS

In stock: 1910

10 + −

Add to cart

Minimum : 10 Multiples : 10

Packaging: Cut Tape

Unit Price	US$ 0.031865
Ext. Price	US$0.32

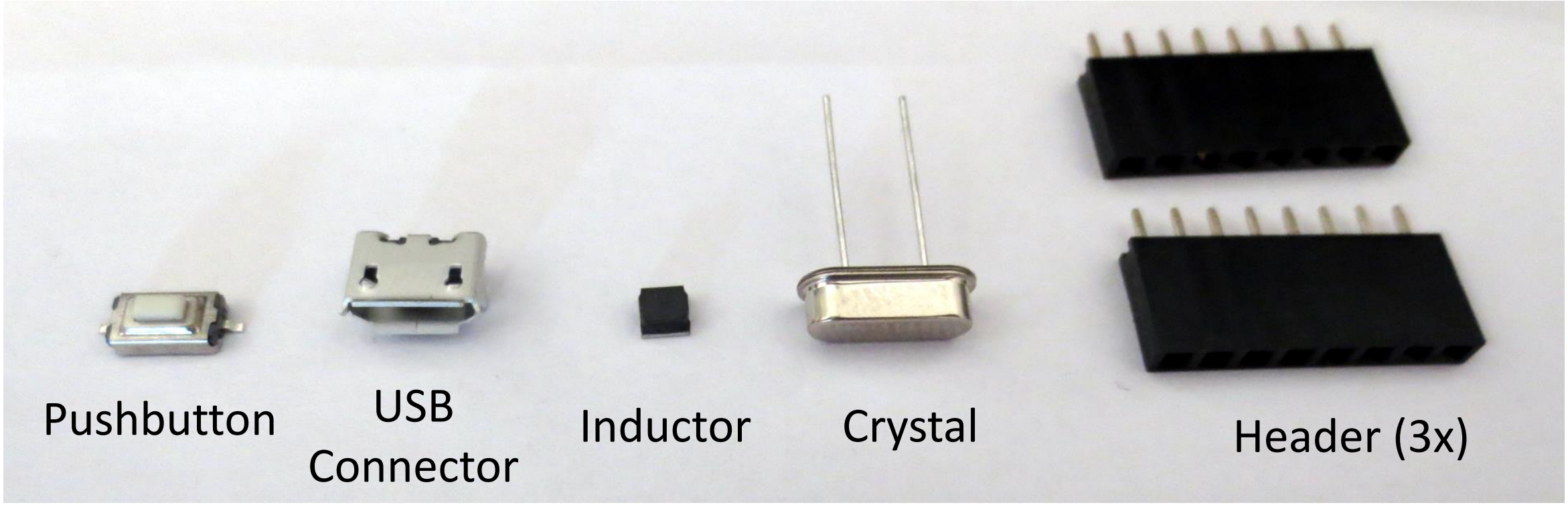
Pricing(USD)

Sales Unit: Piece Full Reel: 2000

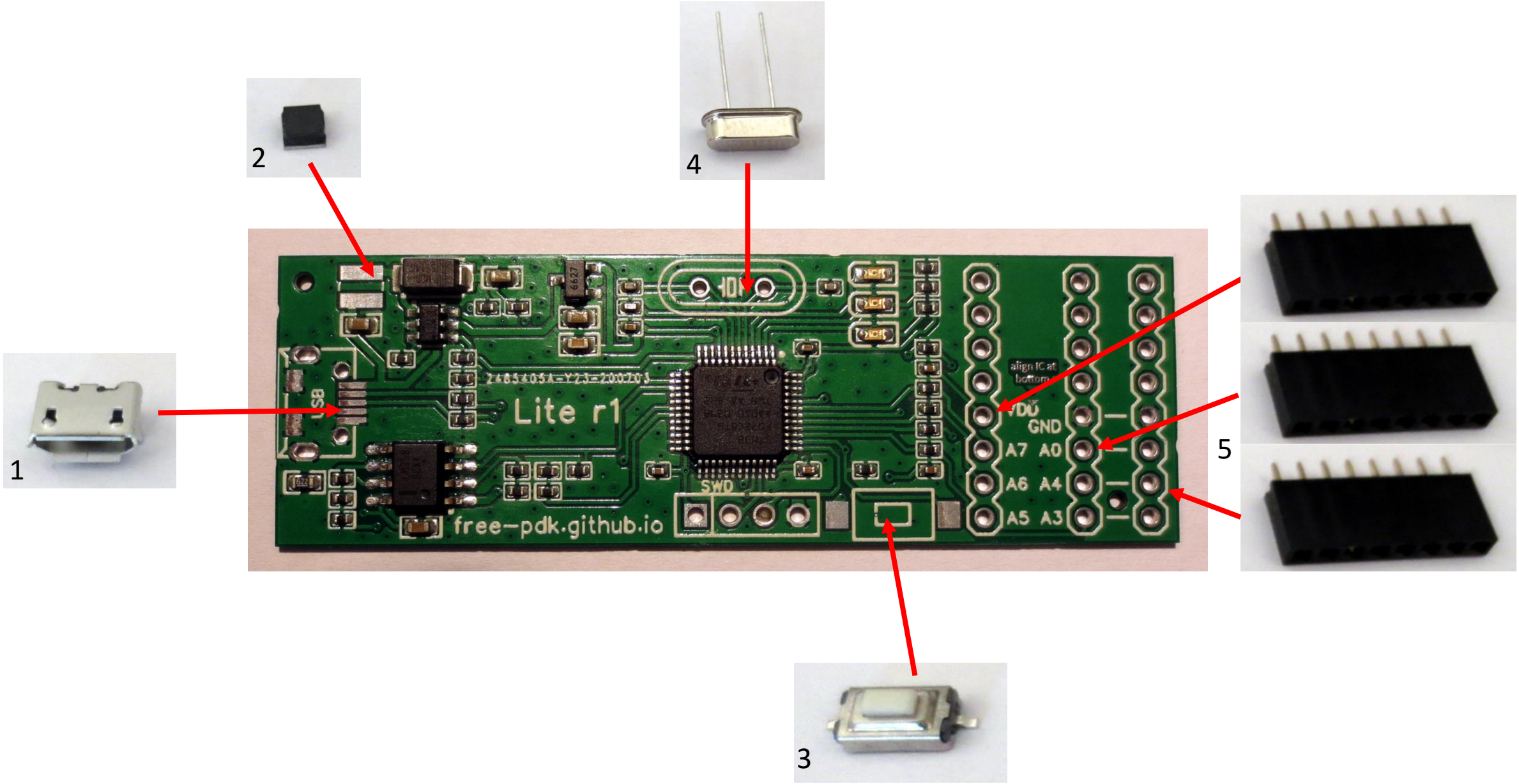
Qty.	Unit Price	Ext. Price
10+	US$0.031865	US$0.32

R1 Assembly

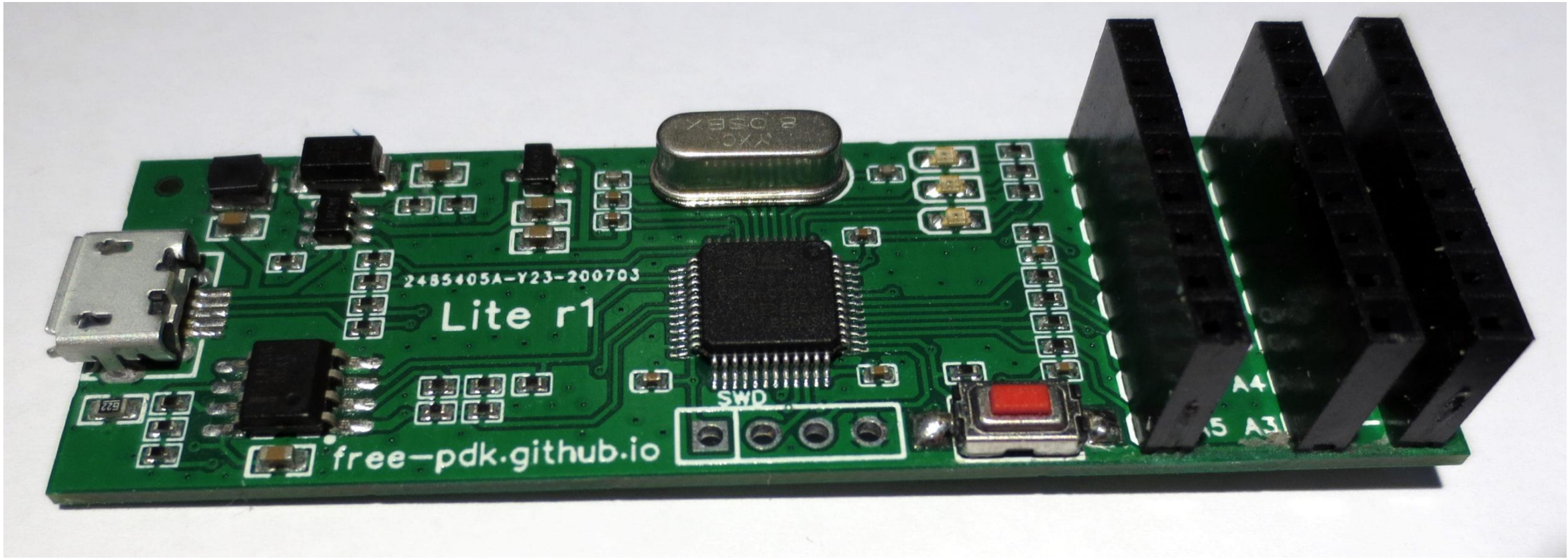
Components that need to be manually assembled



Assembly locations



Assembled programmer



R1 Design Validation

EasyPDKProg lite R1 – Design Validation

Power supply

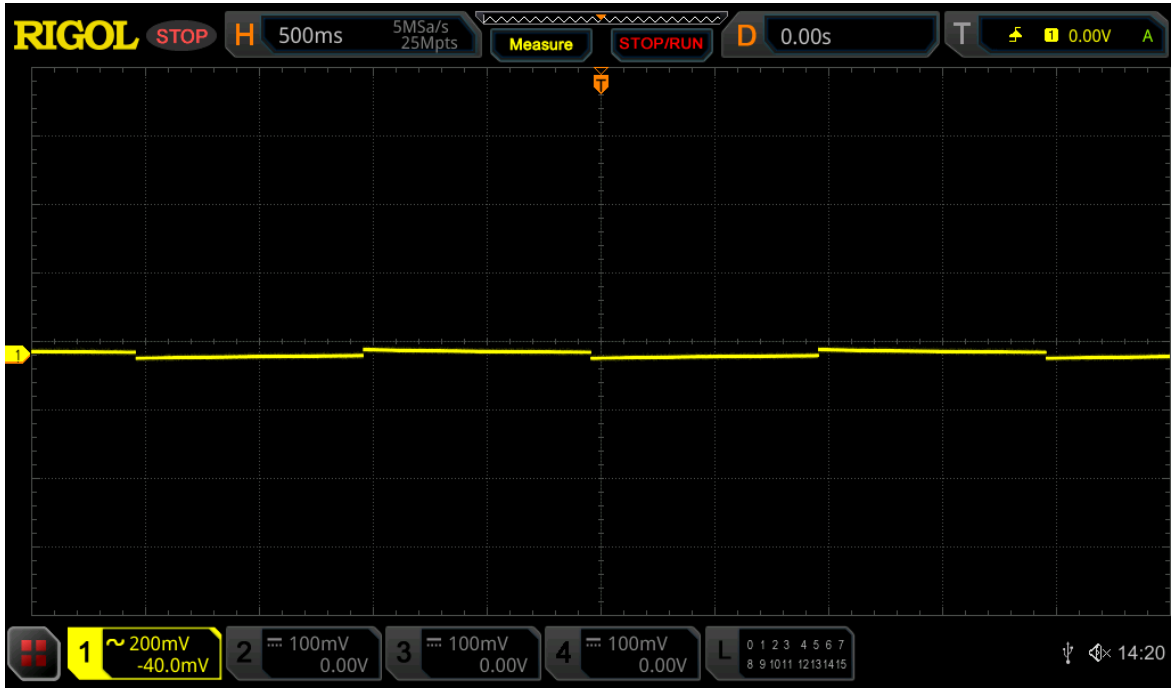
Test point	Measured	Expected	Result	Comment
5V Supply (@ USB port)	4.98 V	5.0 V	**Pass**	Ok, lower voltage since this is a different computer
15 V Boosted (@U3_18)	32.0 V	15.9 V	**Fail**	R7 was incorrectly set to 220k, switched to 100k
15 V Boosted (@U3_18)	15.8 V	15.9 V	**Pass**	With R7=100k
3.3 V LDO (@U2_2)	3.3 V	3.3 V	**Pass**	Ok
VDD idle (@ header)	5 mV	0 V	**Pass**	Offset voltage of Opamp due to non-negative supply. Still within acceptable limits.
VPP idle (@ header)	5 mV	0 V	**Pass**	Offset voltage of Opamp due to non-negative supply. Still within acceptable limits.
VDD test mode (@ header)	4.98 V	5.0 V	**Pass**	Using EASYPDKPROGTEST.EXE
VPP test mode (@ header)	4.97 V	5.0 V	**Pass**	Using EASYPDKPROGTEST.EXE

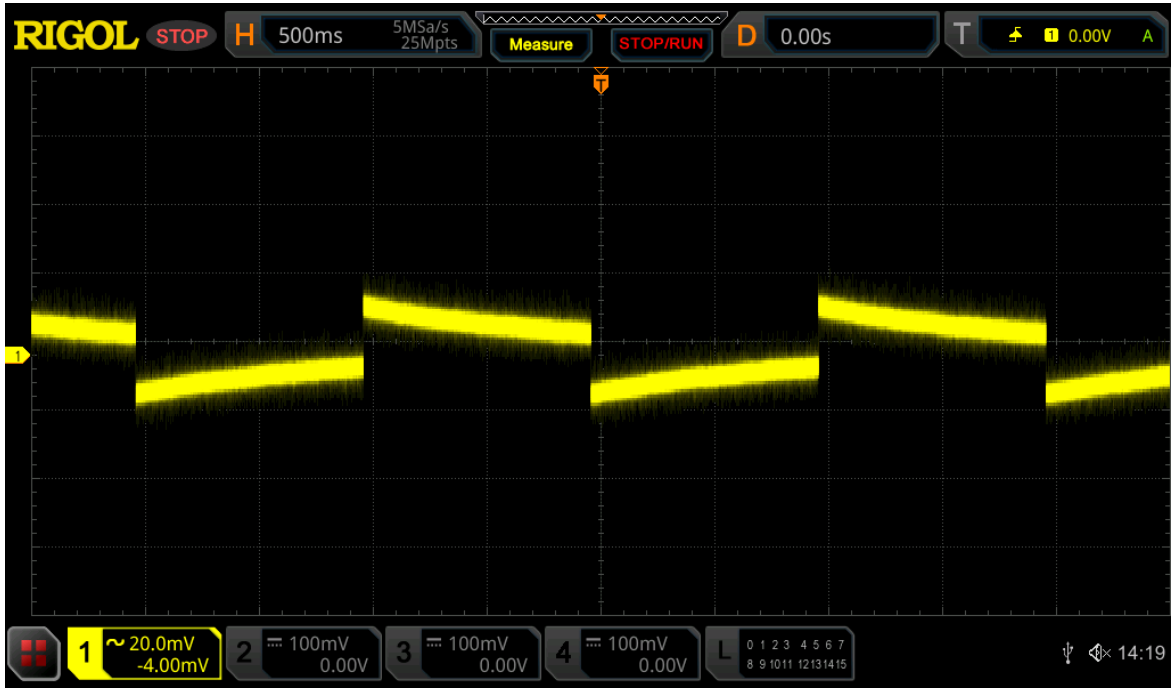
Programming

Device	Test case (command)	Result	Comment
PFS173-S08	probe	**Pass**	
PFS173-S08	-n pfs173 erase	**Pass**	
PFS173-S08	-n pfs173 read out.txt	**Pass**	
PFS173-S08	-n pfs175 write main.ihx	**Pass**	uartsend – including IHRC calibration
PFS173-S08	-n pfs173 start	**Pass**	uartsend

Boost converter loading

15 V power supply ripple (U3_18)
Loaded with blinky (lite r1 version)





- Very low visible ripple, even at 20 mV setting.
- => Boost converter filtering perfoms fine

Padauk Flash MCU Breakout Boards

CPLDCPU – June 27th, 2020

Summary of Flash Variants and Datasheets

PFS (RapiDragon)

Product Name	FPPA	ADC (max)	IO (max)	ROM (word)	RAM (byte)	LCD (VDD/2)	PWM	Special Functions	Remarks
PFS154	1	--	14	2KW	128	4	8bit x 2 / 11bit x 3	CMP x 1	--

Product Name	FPPA	ADC (max)	IO (max)	ROM (word)	RAM (byte)	LCD (VDD/2)	PWM	Special Functions	Remarks
PFS172	1	8bit x 12ch	14	2KW	128	--	8bit x 2	CMP x 1	--
PFS173	1	8bit x 13ch	18	3KW	256	5	8bit x 2 / 11bit x 3	CMP x 1	--

PFS154 datasheet_v105_EN_20200609.pdf

PFS172 datasheet_v001_EN_20200506.pdf

PFS173 datasheet_v105_EN_20200619.pdf

PFC (LeapDragon)

Product Name	FPPA	ADC (max)	IO (max)	ROM (word)	RAM (byte)	LCD (VDD/2)	PWM	Special Functions	Remarks
PFC151	1	--	8	2KW	128	--	8bit x 2	CMP x 1	--
PFC154	1	--	14	2KW	128	4	8bit x 2 / 11bit x 3	CMP x 1	--

PFC151 datasheet_EN_V000_20190823.pdf

PFC154 datasheet_EN_V001_20191008.pdf

Product Name	FPPA	ADC (max)	IO (max)	ROM (word)	RAM (byte)	LCD (VDD/2)	PWM	Special Functions	Remarks
PFC232	2	12bit x 12ch	14	2KW	128	5	8bit x 2 / 11bit x 3	--	--

PFC232 datasheet_V000_EN_20190823.pdf

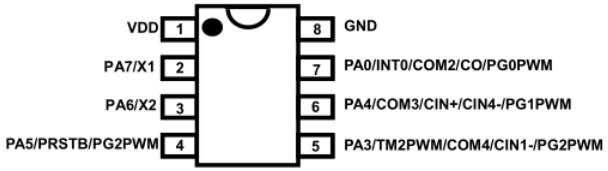
Product Name	FPPA	ADC (max)	IO (max)	ROM (word)	RAM (byte)	LCD (VDD/2)	PWM	Special Functions	Remarks
PFC161	1	--	8	2KW	128	--	8bit x 2	CMP x 1	Touch CH: 7

PFC161 datasheet_EN_V000_20190823.pdf

Pinouts SO8 Flash variants

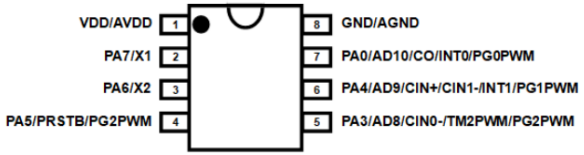
Type I

PFS154



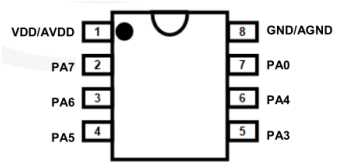
PFS154-S08:SOP8 (150mil)

PFS173



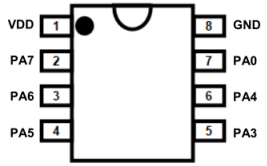
PFS173-S08 (SOP8-150mil)

PFC151



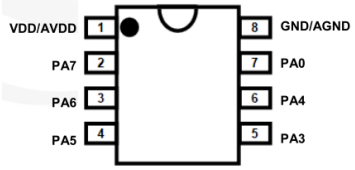
PFC151-S08A(SOP8A-150mil)

PFC154



PFC154-S08: SOP8 (150mil)
PFC154-D08: DIP8 (300mil)

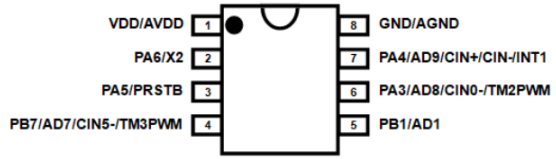
PFC161



PFC161-S08A(SOP8A-150mil)

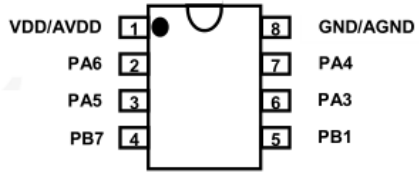
Type II

PFS172



PFS172-S08 (SOP8-150mil)

PFC232

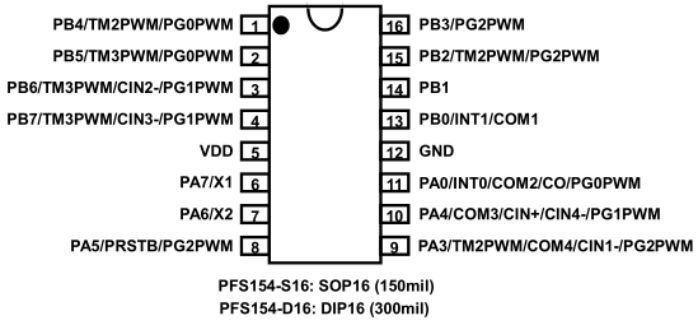


PFC232-S08 (SOP8-150mil)
PFC232-D08 (DIP8-300mil)

Pinouts SO16 Flash variants

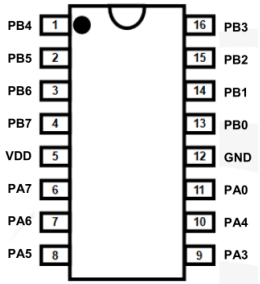
Type I

PFS154



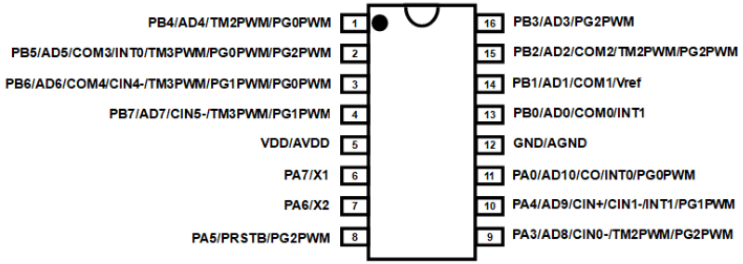
PFS154-S16: SOP16 (150mil)
PFS154-D16: DIP16 (300mil)

PFC154



PFC154-S16: SOP16 (150mil)
PFC154-D16: DIP16 (300mil)

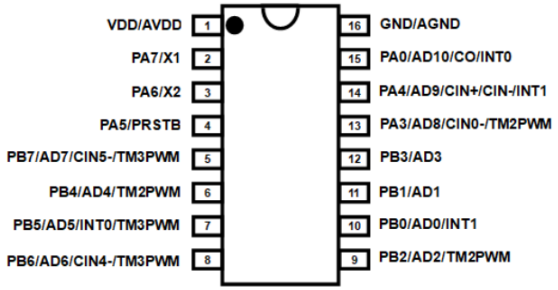
PFS173



PFS173-S16 (SOP16-150mil)
PFS173-D16 (DIP16-300mil)

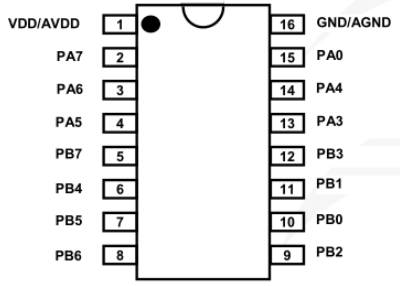
Type II

PFS172



PFS172-S16A (SOP16-150mil)

PFC232



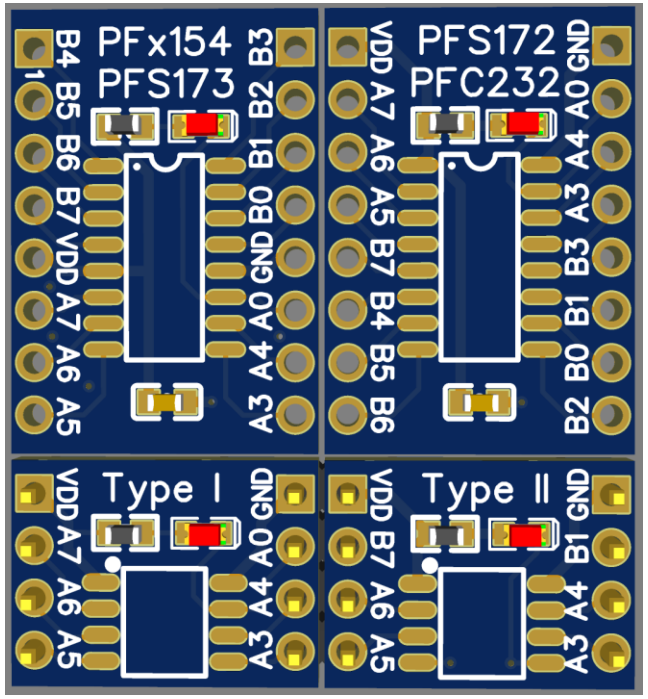
PFC232-S16 (SOP16-150mil)
PFC232-D16 (DIP16-300mil)

No SO16 package:

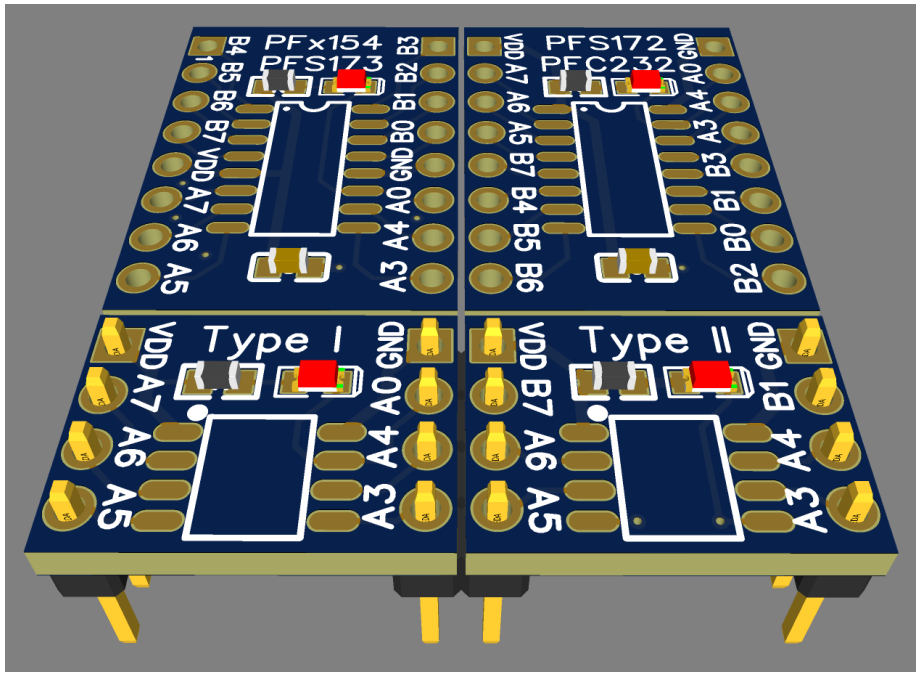
PFC151 PFC161

Plug-in Breakout boards

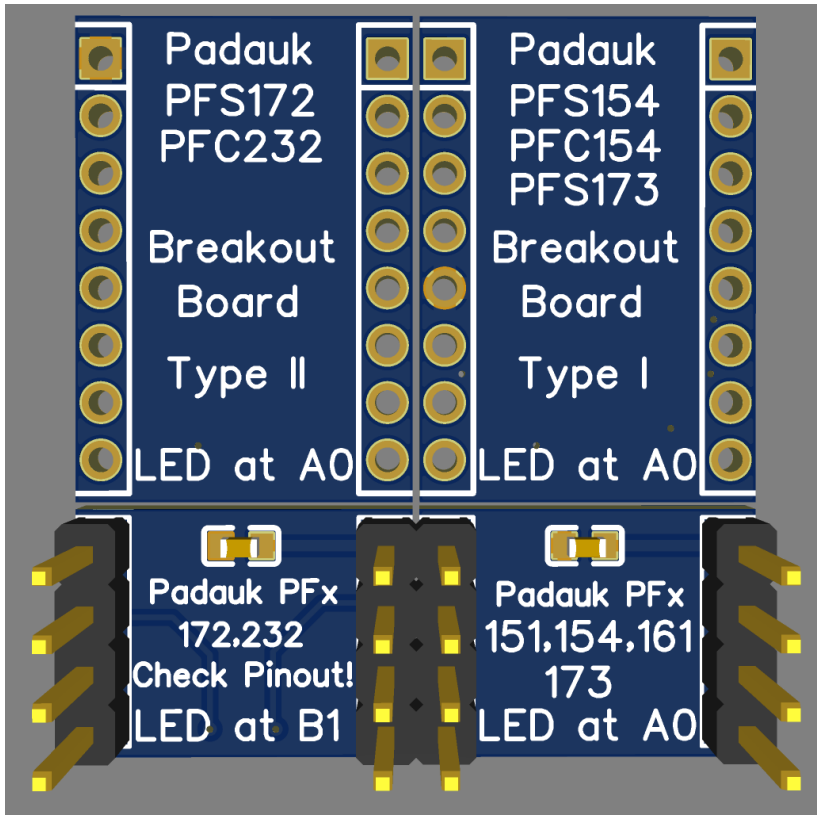
Top



Oblique



Bottom



Photos of boards (Type I only)