Swakeup

PROJECT REPORT

within the lecture of
Microcontroller Programming

at Uppsala University
in the Departement of Information Technology

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1 Introduction

Idea

It is a well-known fact, that it is quite dark in Sweden in the winter. In a strong winter every source of light is a source of happiness. This wakeup light, which is based on a strong light source (10 W RGB LED), is able to give one the optimal start into a dark winter day. The *Swakeup* (from engl. "Swedish Wakeup Light") is communicating to the user through the light. It does not simply wake one up, but also gives one information about Facebook, latest mails, calendar and weather. The user interface consits besides of a big LED of an OLED screen. *Swakeup* is also part of the *IoT* as it has the ability to communicate via *IEEE 802.11*. This of course enables a lot of possibilities e.g. connecting your phone to the wakeup light. A lot of effort has been put into the designing maxim, that everything should be as small as possible. The whole electronics fit on an base area of 5 cm x 4 cm. So the *Swakeup* fits smoothly on the bedside table. And honestly: What is the last thing you are doing before you go to sleep? Right! You look on your phone. That is why *Swakeup* comes with a USB charger for your e.g. phone as well.

Sytem Overview

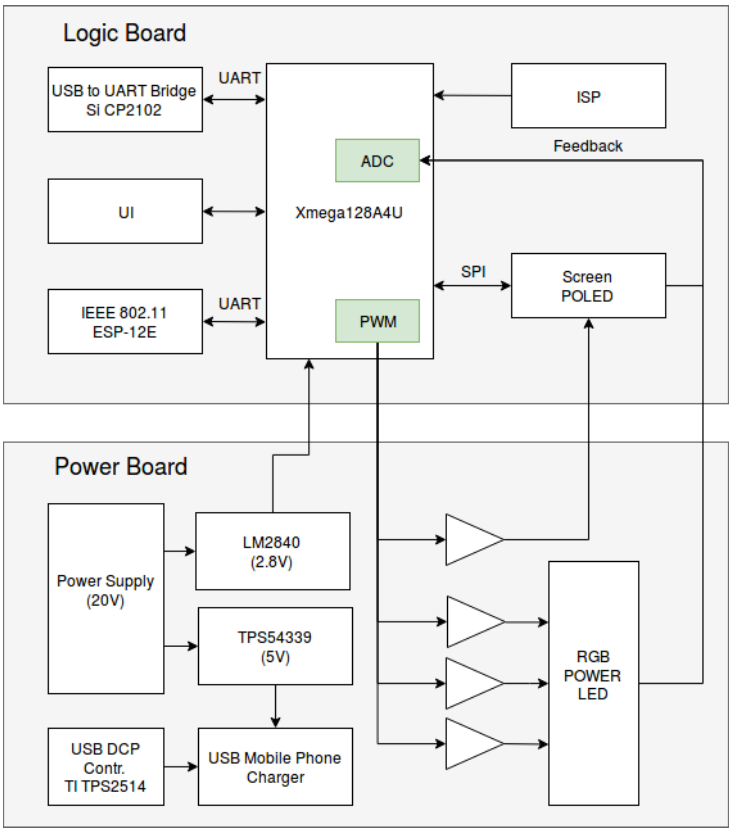


Figure 1.1: Blockdiagram of the Swakeup wakeup light.

In fig. 1.2 the actual system architecture from an abstract point of view is displayed. One can clearly see, that the system is divided into two physical boards. The logic board consists of the μC, a serial connection infrastructure, an OLED screen, an *IEEE 802.11* module, a ISP programming infrastructure and some LEDs/a button (UI).

The power board takes the 20 V input of a low-cost power supply and breaks it down to 2.8 V (Vcc), 5 V for phone charging and the power which is needed for the RGB LED.

The partitioning of the system functionalities on two boards has a bunch of advatages: Two people worked on this project, so each could develop a PCB; It is quite common to seperate signals from power lines out of EMI reasons; There was simply not eanough space on one two-layer board for the whole system keeping a base area of 5 cm x 4 cm.

The two boards are connected together through four headers. By these headers an electrical and mechanical connection is maintained. The headers allow a feedback from the LED driver on the power board to the logic board (ADC). Also the control variable (PWM) comes via the headers from the μC to the LED driver. The 2.8 V Vcc is produced and regulated on the power board and is also availabe at one header. Another voltage available from one header is the OLED driver voltage.

2 Hardware

Logic Board

Power Board

The whole board design has been made in *KiCAD*. *Git* was used for version control. In the schematics (Appendix A) one can see that the whole board consists of three main building blocks: Connectors, a LED driver with feedback and two step-down converters. A part of the LED driver is also "abused" to drive the OLED.

Microcontroller Power Supply

There are two step-down converter ICs on the power board. It is the LM2840 which in combination with a simple voltage divider ensures the 2.8 V for Vcc. All step-down converters use the same inductor with a value of 33 uH. It is a low-cost, quite small, shielded inductor which is ment to be used for switching power supplies. Moreover all step-down converters are enhanced with a SMD schottky diode and a of course SMD capacitor for smoothing the output signal. As it is good practice to do so all ICs are making use of decoupling capacitors.

Designated USB Charging Port

For charging ones phone the TS30012, another step-down converter IC, is used. The feedback voltage divider of this IC is already onboard and does not need to be provided externally as the IC provides fixed 5 V. The output is connected to a USB connector type A. This IC can deliver up to 2 A. An interesting feature of the phone charging circuitry on the power board is the "Dedicated Charging Port" (DCP) functionality. The TPS2514 is a small, easy-to-use, 6-pin component, which complies to the USB standard and a majority of the minefield of propriatary standards to signal a DCP. What does that mean? Well this means, that if you connect your IPhone, it will know, that it can draw more than 100 mA, which are the minimum provided by a normal USB port. Otherwise the current drawn by the phone will be limited. The charging functionality can be turned on and off via a GPIO pin. The TS30012 comes in a QFN16 package (pad pitch of 0.5 mm) to save space.

HW Debugging

For testing purposes a lot of test points have been created on the board. Futhermore there are LEDs for different voltages.

RGB LED Driver

The LED driver consists of an actual power electronics part and a feedback part. The idea is, that the voltage driven through the three color channels of the RGB LED can be controlled by software (PID controller). In the power electronics part there are three analog circuits mainly consisting out of a p-channel MOSFET, which is switched by a NPN bipolar transistor. This bipolar transistor gets its intput signal from the μProcessor (PWM). By pulling the 20 V to GND the PMOS "sees" a negative Vgs and opens.

3 Software

Code Structure

Operating System

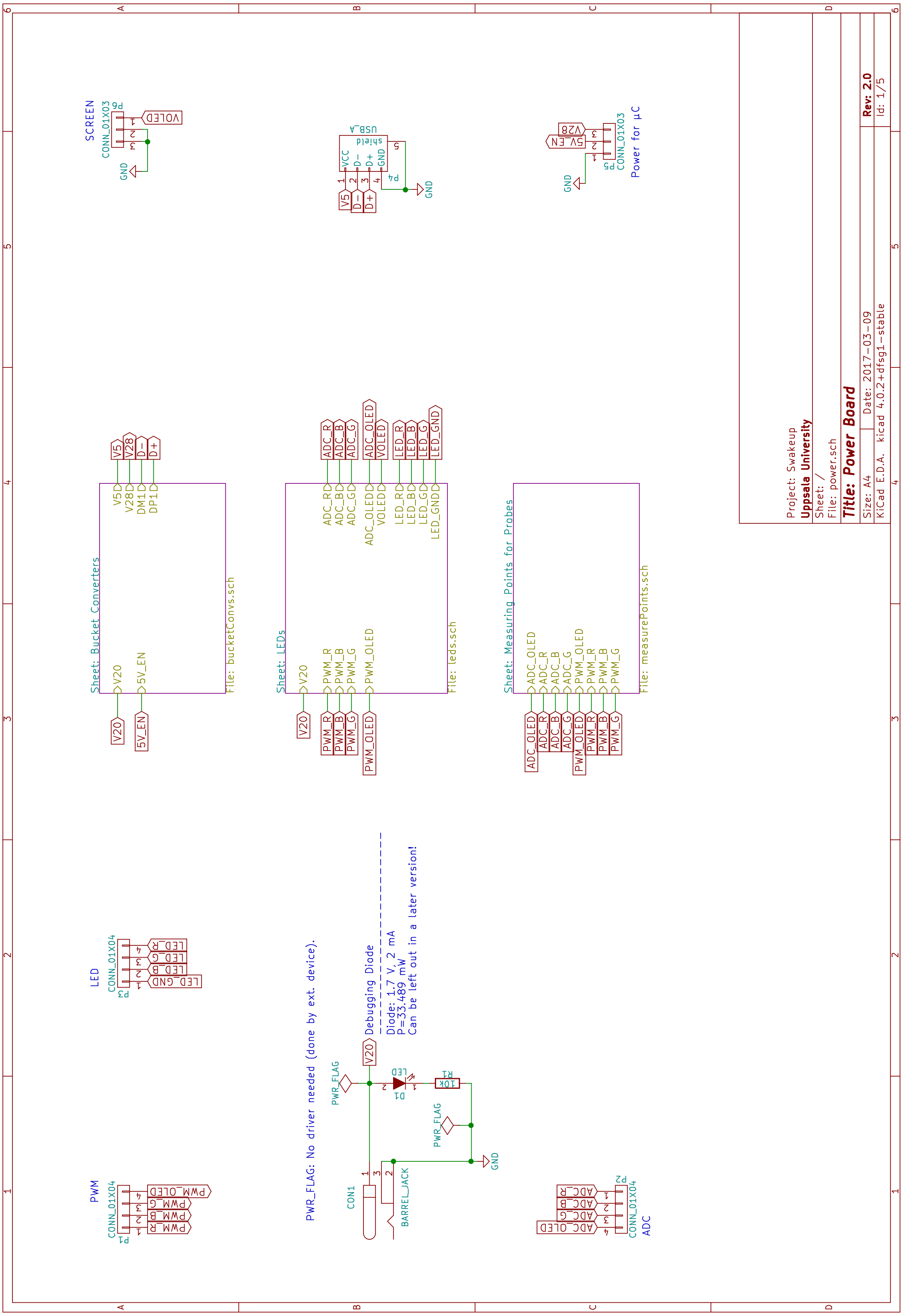
Realization

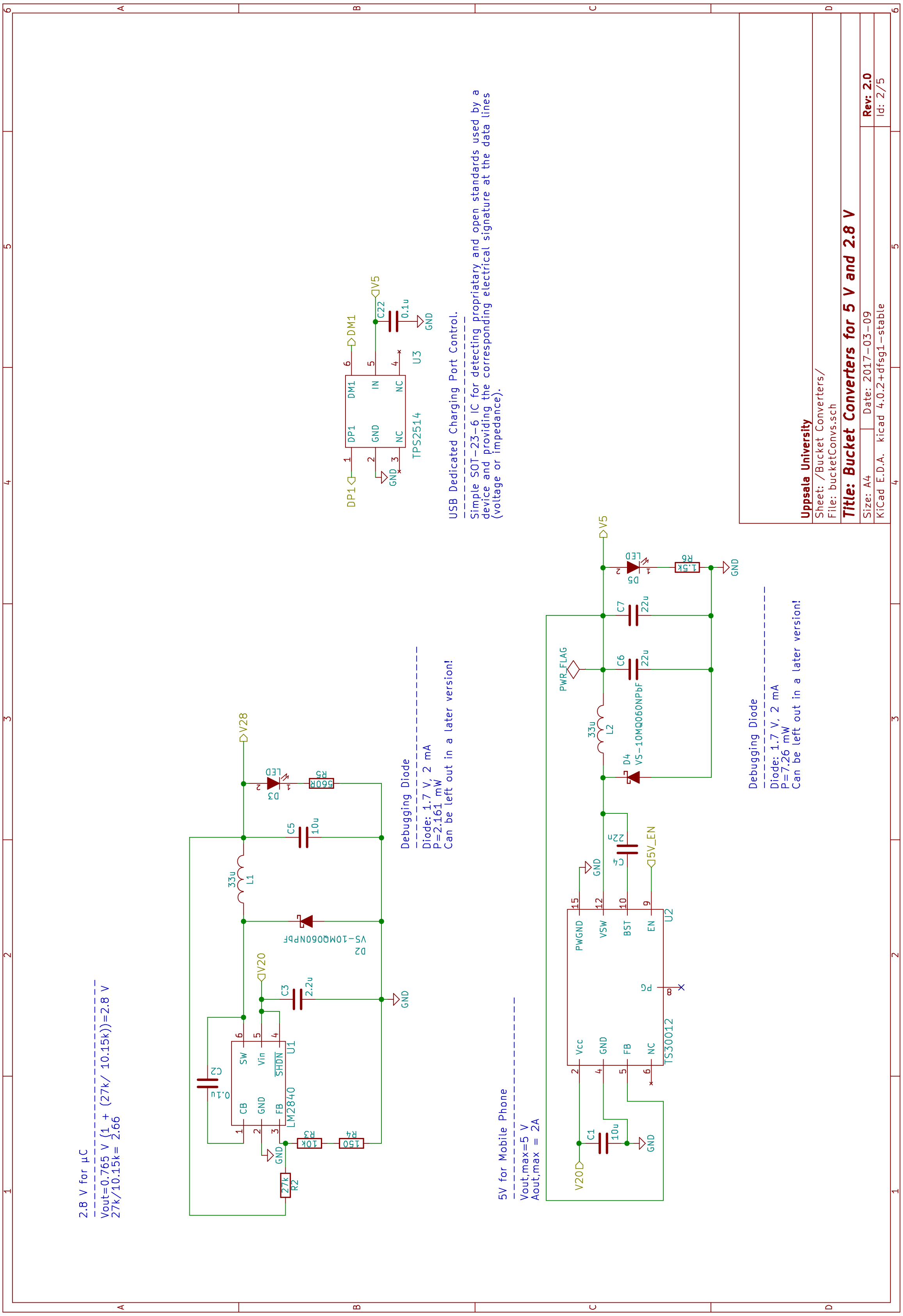
4 Status Quo and Outlook

What works? What does not work?

Outlook

A Schematics Power Board




Uppsala University
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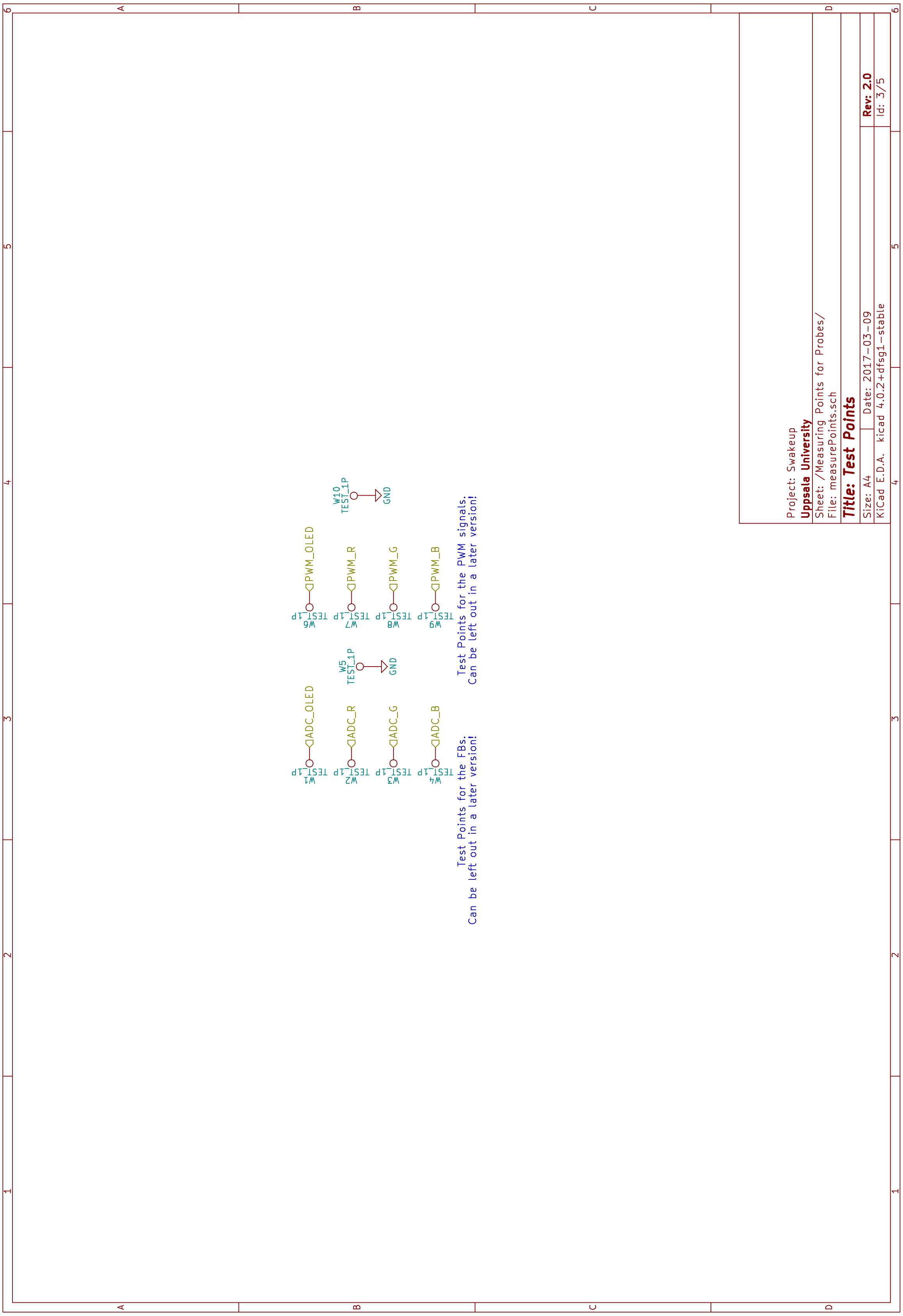
File: bucketConvs.sch
Title: Bucket Converters for 5 V and 2.8 V
Size: A4
Date: 2017-03-09
Rev: 2.0
KiCad E.D.A. kicad 4.0.2+dfsg1-stable
Id: 2/5
USB Dedicated Charging Port Control.
Simple SOT-23-6 IC for detecting propriatary and open standards used by a device and providing the corresponding electrical signature at the data lines (voltage or impedance).
TPS2514
U3
DP1
DM1
V5
C22
0.1u
GND
IN
NC
2.8 V for µC
Vout=0.765 V (1 + (27k/ 10.15k))=2.8 V
27k/10.15k= 2.66
LM2840
U1
SW
Vin
SHDN
CB
FB
C2
0.1u
R2
27k
R3
10k
R4
150
V20
C3
2.2u
D2
VS-10MQ060NPbF
L1
33u
C5
10u
D3
LED
R5
560k
V28
Debugging Diode
Diode: 1.7 V, 2 mA
P=2.161 mW
Can be left out in a later version!
5V for Mobile Phone
Vout,max=5 V
Aout,max = 2A
TS30012
U2
Vcc
PWGND
VSW
BST
EN
PG
5V_EN
C1
10u
C4
22n
L2
33u
D4
VS-10MQ060NPbF
PWR_FLAG
C6
22u
C7
22u
D5
LED
R6
1.5k
Debugging Diode
Diode: 1.7 V, 2 mA
P=7.26 mW
Can be left out in a later version!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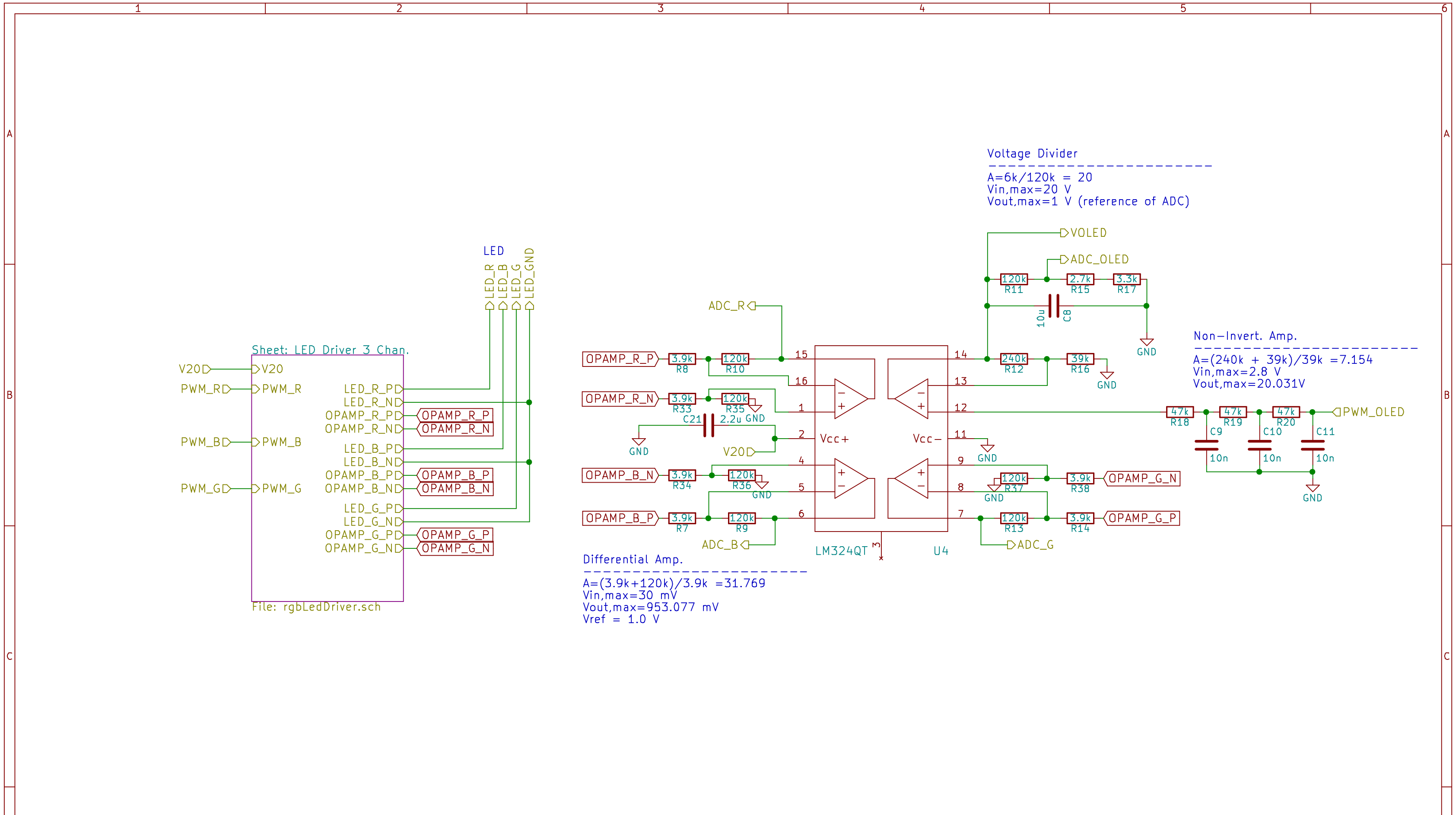
Uppsala University
Sheet: /Measuring Points for Probes/
File: measurePoints.sch
Title: Test Points
Size: A4
Date: 2017-03-09
Rev: 2.0
KiCad E.D.A. kicad 4.0.2+dfsg1-stable
Id: 3/5
Test Points for the FBs.
Can be left out in a later version!
Test Points for the PWM signals.
Can be left out in a later version!
ADC_OLED
ADC_R
ADC_G
ADC_B
PWM_OLED
PWM_R
PWM_G
PWM_B
W1 TEST_1P
W2 TEST_1P
W3 TEST_1P
W4 TEST_1P
W5 TEST_1P
W6 TEST_1P
W7 TEST_1P
W8 TEST_1P
W9 TEST_1P
W10 TEST_1P
GND
GND



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Uppsala University
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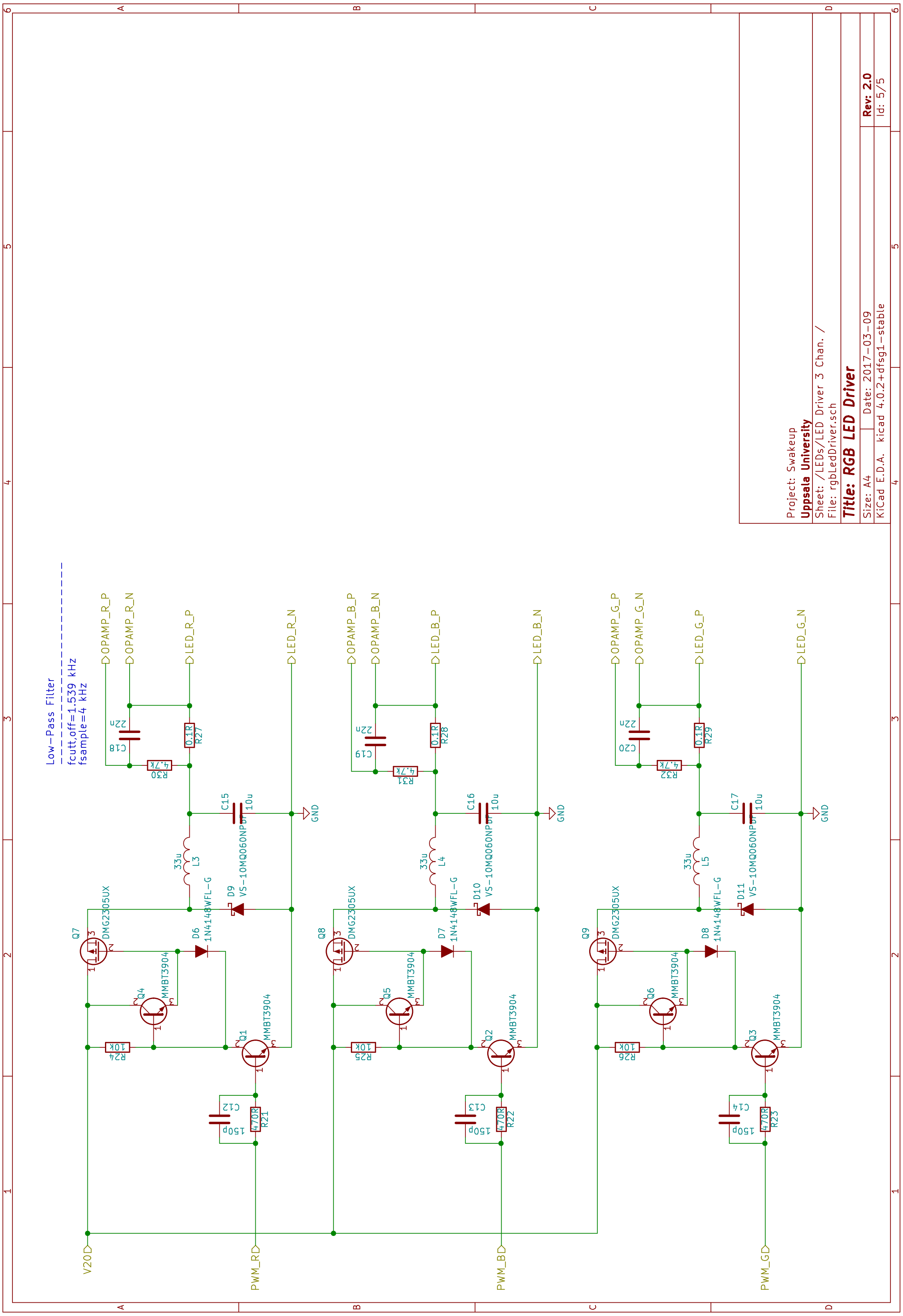
File: leds.sch
Title: LEDs
Size: A4 Date: 2017-03-09 **Rev: 2.0**
KiCad E.D.A. kicad 4.0.2+dfsg1-stable Id: 4/5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Uppsala University
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File: rgbLedDriver.sch
Title: RGB LED Driver
Size: A4
Date: 2017-03-09
Rev: 2.0
KiCad E.D.A. kicad 4.0.2+dfsg1-stable
Id: 5/5
Low-Pass Filter
fcutt,off=1.539 kHz
fsample=4 kHz
OPAMP_R_P
OPAMP_R_N
LED_R_P
LED_R_N
OPAMP_B_P
OPAMP_B_N
LED_B_P
LED_B_N
OPAMP_G_P
OPAMP_G_N
LED_G_P
LED_G_N
GND
V20
PWM_R
PWM_B
PWM_G
Q7 DMG2305UX
Q8 DMG2305UX
Q9 DMG2305UX
Q4 MMBT3904
Q5 MMBT3904
Q6 MMBT3904
Q1 MMBT3904
Q2 MMBT3904
Q3 MMBT3904
D6 1N4148WFL-G
D7 1N4148WFL-G
D8 1N4148WFL-G
D9 VS-10MQ060NPbF
D10 VS-10MQ060NPbF
D11 VS-10MQ060NPbF
L3 33u
L4 33u
L5 33u
C15 10u
C16 10u
C17 10u
C18 22n
C19 22n
C20 22n
C12 150p
C13 150p
C14 150p
R27 0.1R
R28 0.1R
R29 0.1R
R30 4.7k
R31 4.7k
R32 4.7k
R24 10k
R25 10k
R26 10k
R21 470R
R22 470R
R23 470R