

Meetup TTN Community Enschede
Woensdag 30 Mei 201
Ariensplein 1
Enschede

TTN LoRa stofsensor

t.b.v.

Apeldoornindata

Jaap Bruijn, TTN Community Apeldoorn

Meetup TTN Community Enschede : TTN LoRa stofsensor

Inhoud:

- | | |
|-------------------|--------------------------------------|
| 1. Inleiding | (TTN, Vuurwerk, Apeldoornindata) |
| 2. Hardware | (Arduino, LoRa, Sensor, Voeding) |
| 3. Software | (Arduino IDE, LMIC, dustsensor_01) |
| 4. Meetresultaten | (Stofconcentratie, meetduur/periode) |
| 5. Conclusies | (Nauwkeurigheid, behuizing, plaats) |
| 6. Aanbevelingen | (.....,,,?) |

Apeldoorn , 26 mei 2018

TTN The Things Network

The image shows the homepage of The Things Network. At the top, there is a navigation bar with links to COMMUNITIES, LABS, LEARN, SUPPORT, FORUM, and MARKETPLACE. On the right side of the bar are buttons for SIGN UP and LOGIN. The main visual is a photograph of a city skyline under a cloudy sky. Centered over the image is a large blue cloud icon with the text "THE THINGS NETWORK" below it. Below the main image, the text "BUILDING A GLOBAL INTERNET OF THINGS NETWORK TOGETHER." is displayed in large, bold, blue capital letters. At the bottom center is a blue button with the text "Learn More" and a white arrow pointing to the right.

TTN Community Apeldoorn



How to connect Utrecht E&A exhibition KISS LoRa to TTN?

End Devices (Nodes)



pe1mew Remko

1 Jun '17

@Jaapbr

I looked up your position in the json you provided.
The area you live will not have highest level of coverage. Especially not for SF7.
I propose to lower to SF9. that will increase probability of coverage I expect.

PS: There are currently no plans from the community of Apeldoorn to build aditional gateways in that area.
Unfortunately for you the current focus is on the south.

2 Replies ▾



TTN Community Apeldoorn

The screenshot shows the 'OUR STORY' section of the TTN Community Apeldoorn page. It includes a mission statement about providing Apeldoorn with a free IoT data network, a goal to build an Open Source LoRa Network, and meeting information for "Tot 2021" at Molenstraat-Centrum 1, 7311 XG Apeldoorn. The 'ABOUT THIS COMMUNITY' section displays 41 gateways, 23 contributors, and a green checkmark indicating it's an official community. On the right, the 'CONTRIBUTORS' section lists the Core Team members: Rene van der Weerd, Remko Welling, and Jeroen van Bussel, each with a small profile picture and 'CORE TEAM' below their names. A summary at the bottom right states there are 20 contributors in total, with a 'SHOW ALL' link.

THE THINGS NETWORK

COMMUNITIES LABS LEARN SUPPORT FORUM MARKETPLACE

S

OUR STORY

On a mission to provide Apeldoorn (and Deventer in a later phase) with a free IOT data network!

Our goal is to build a covering Open Source LoRa Network in Apeldoorn.

Let's meet up and join us at "Tot 2021" Molenstraat-Centrum 1, 7311 XG Apeldoorn

ABOUT THIS COMMUNITY

41 Gateways

23 Contributors

Official community

The Core Team of Apeldoorn consists of:

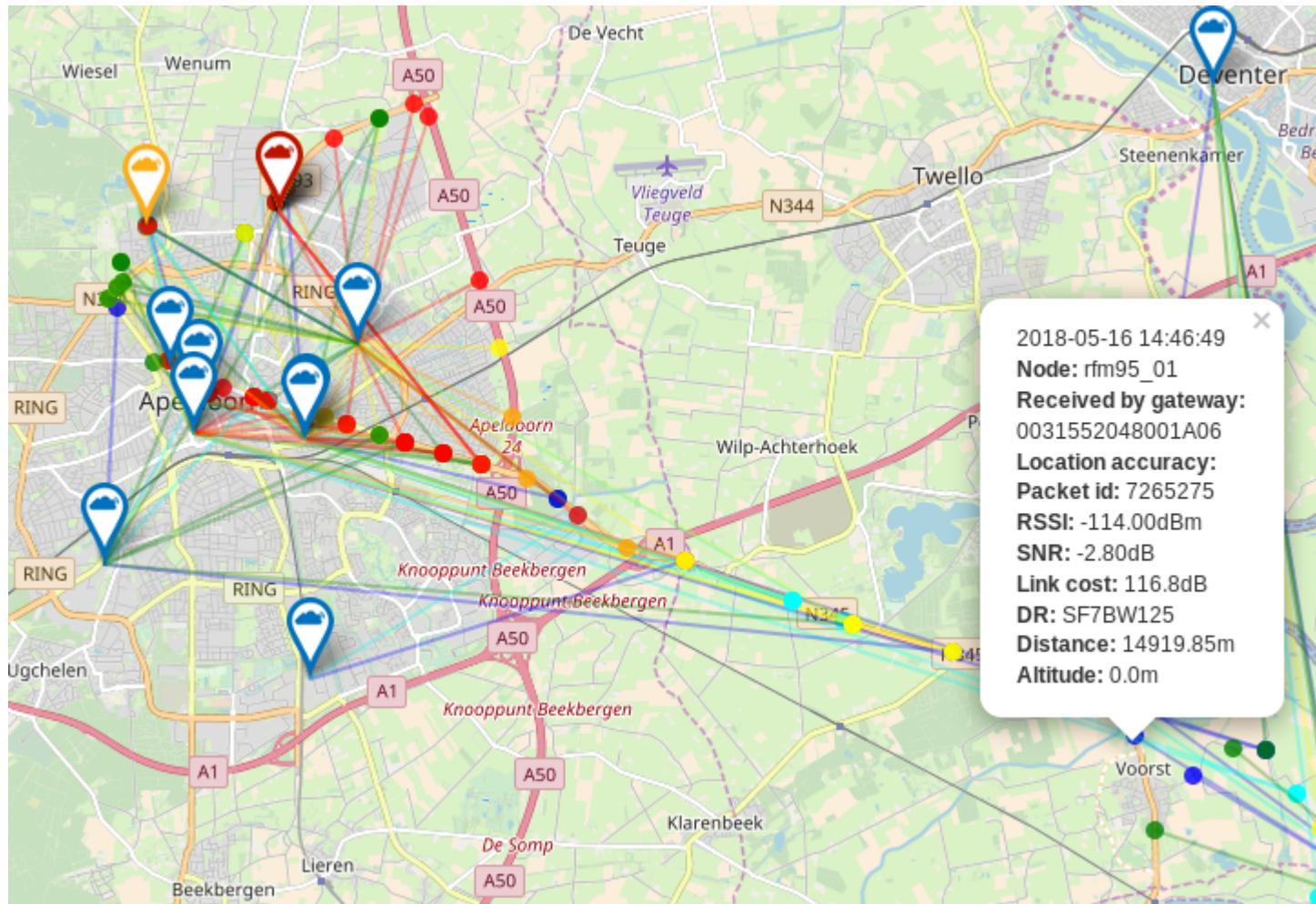
Rene van der Weerd Remko Welling Jeroen van Bussel

CORE TEAM CORE TEAM CORE TEAM

And 20 contributors.

SHOW ALL

TTN Community Apeldoorn



TTN Community Apeldoorn

13
DEC.

woensdag 13 december 2017, 19:30

Bouwavond - vuurwerk + hapje drankje?!



Gehost door [Jeroen van B.](#) en 2 anderen

Nu we volledige dekking in Apeldoorn hebben is het tijd om weer eens apps te bouwen en toepassingen te verzinnen. Dus we gaan vanavond bouwen! Rond oud en nieuw wordt er veel vuurwerk de lucht in geschoten. Onze bedoeling is om een LoRa device te bouwen die fijnstof gaat meten. Alle metingen worden verzameld en op een dashboard



[Tot 2021](#)

Molenstraat-Centrum 1 ·
Apeldoorn



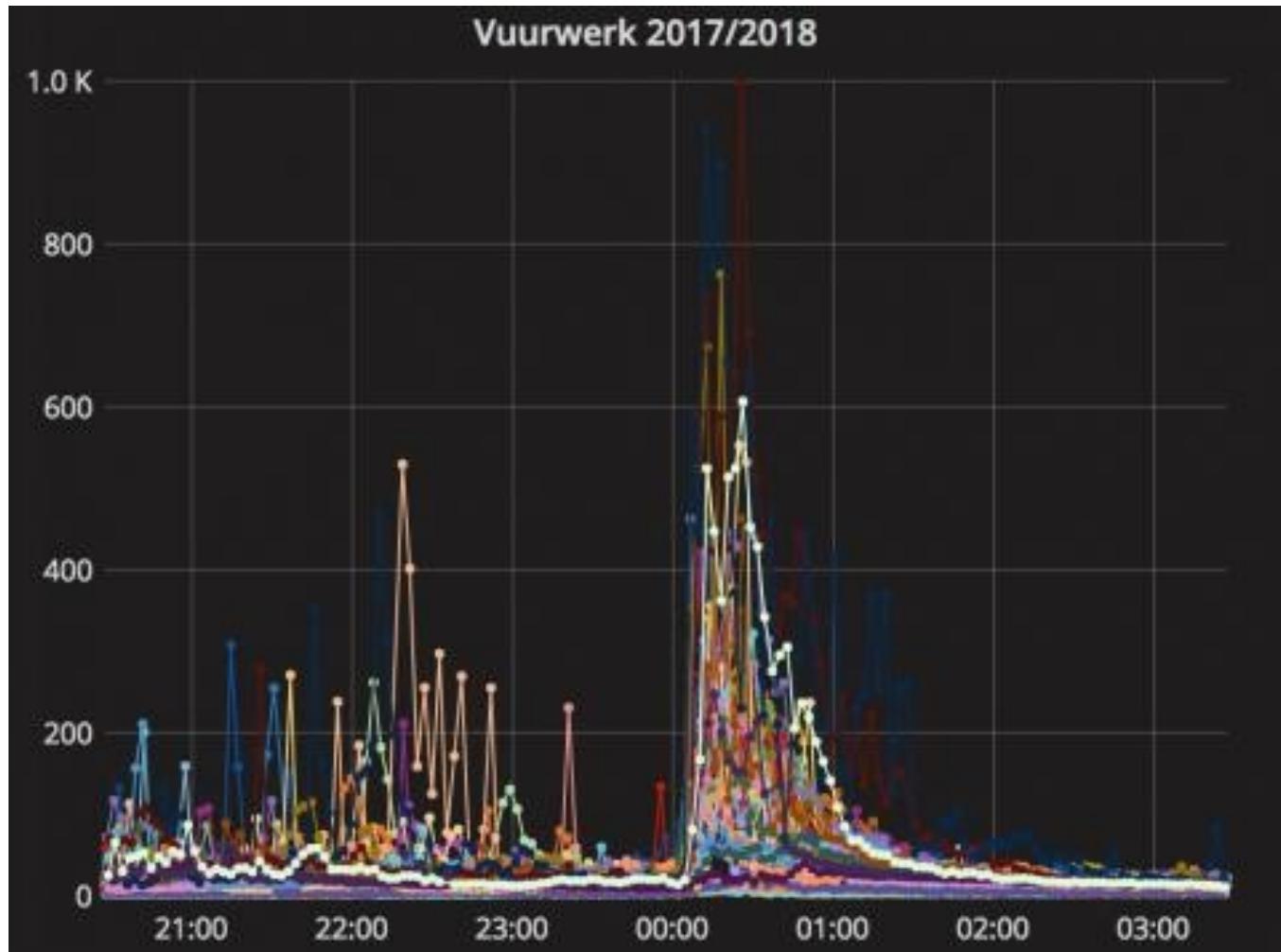
[29 reacties](#)

TTN LoRa stofsensor: Inleiding 1.2.1

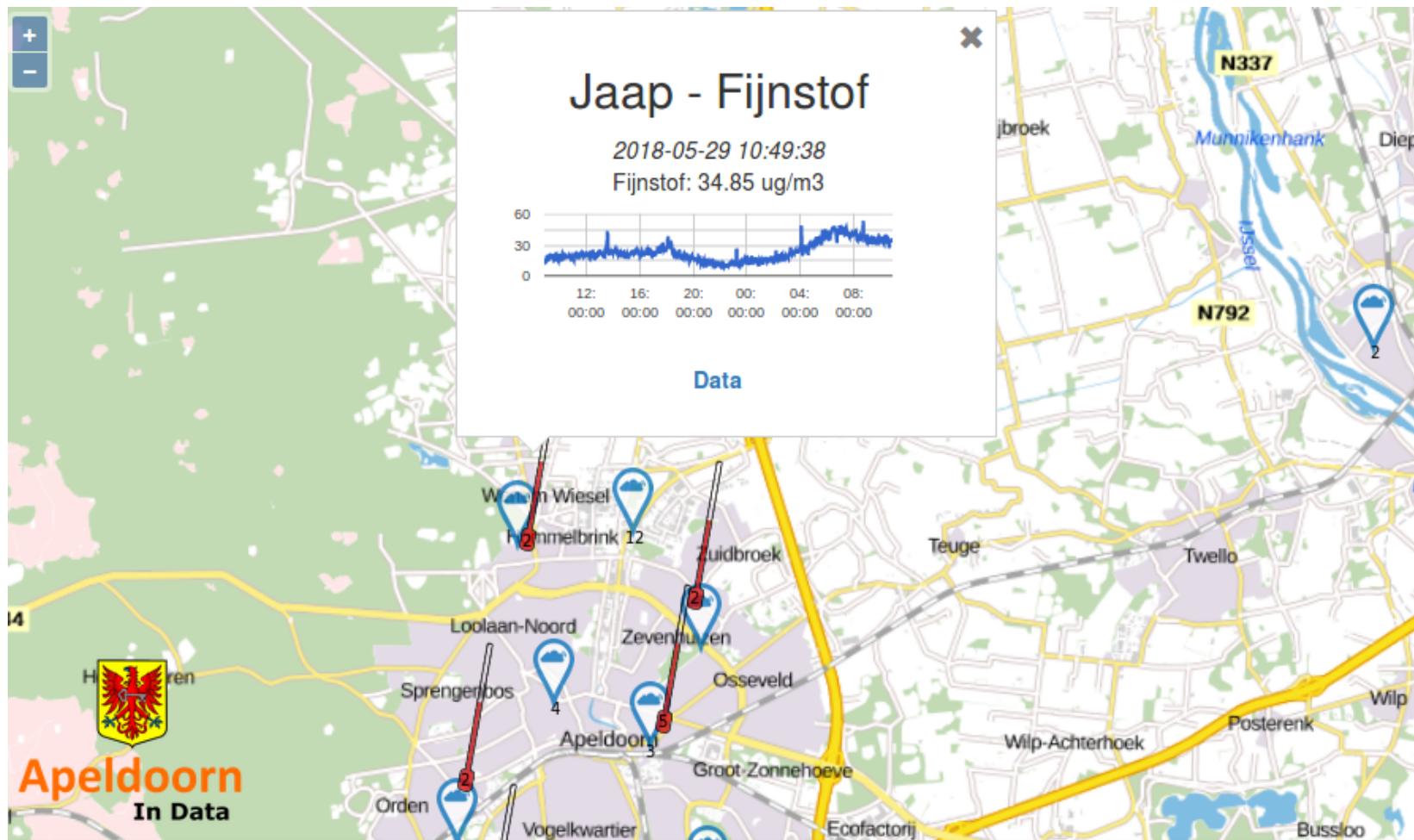
RIVM Vuurwerkexperiment 2016/17



Apeldoornse Vuurwerkdata 2017/18



ApeldoornInData



ApeldoornInData



TTN LoRa stofsensor: Hardware 2.1

Arduino boards

This table shows a quick comparison between the characteristics of all the Arduino and Genuino boards.

Name	Processor	Operating/Input Voltage	CPU Speed	Analog In/Out	Digital IO/PWM	EEPROM [kB]	SRAM [kB]	Flash [kB]	USB	UART
Nano	ATmega168 ATmega328P	5 V / 7-9 V	16 MHz	8/0	14/6	0.512 1	1 2	16 32	Mini	1
Pro Mini	ATmega328P	3.3 V / 3.35-12 V 5 V / 5-12 V	8 MHz 16 MHz	6/0	14/6	1	2	32	-	1
Uno	ATmega328P	5 V / 7-12 V	16 MHz	6/0	14/6	1	2	32	Regular	1

LoRa Circuits/Shields

Hope RFM95:

- Semtech SX 1276 LoRa radio ontvanger/zender
- LoRaWan software op eigen microcontroller

>>>Hope RFM95W circuit (Jaap Fijnstof)

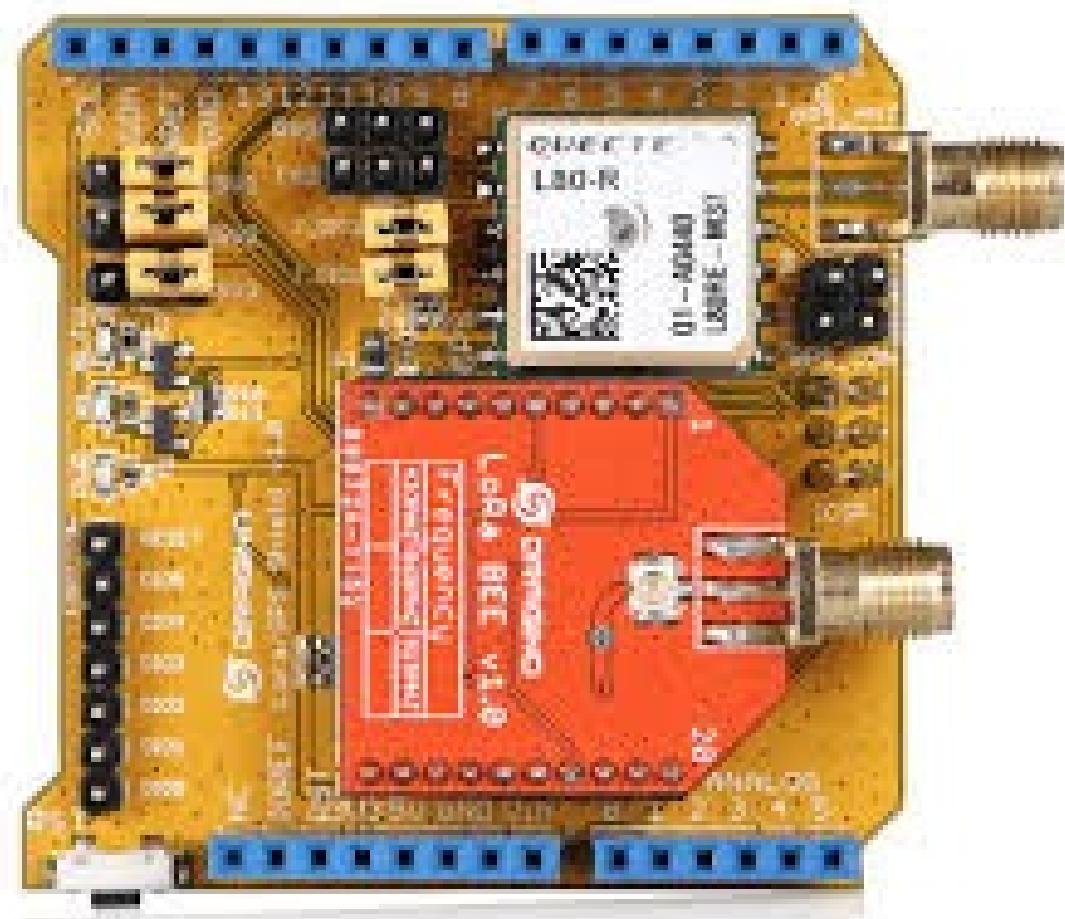
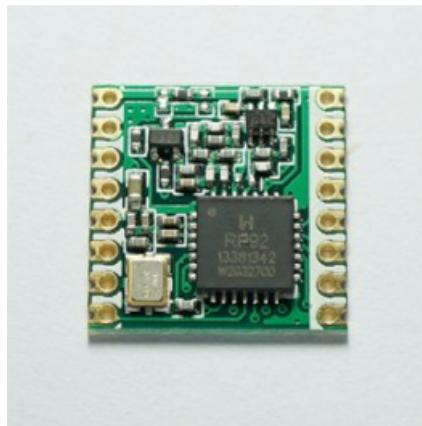
>>>Dragino Arduino Shield (Atranco Fijnstof2)

Microchip RN2483:

- Semtech SX 1276 LoRa radio ontvanger/zender
- Microcontroller met LoRaWan-protocol software

>>>TTN LoRa node

RFM95 Circuits/Shields



Stofsensoren

Shunyei PPD42NJ:

- “pulsjes tellen” ?, onnauwkeurig
- “stookweerstand”, 90 mA, niet geschikt voor batterijvoeding
- goedkoop Euro 5,-

Sharp GP2Y1010AU0F: !!!!!!!

- pulsamplitude, nauwkeurigheid? Calibreren?
- eenvoudig A/D interface
- energie zuinig, 5V, 10 mA
- goedkoop Euro 10,-

(NovaFitness?) SDS011:

- digitale PM 2.5 en PM 10, redelijk nauwkeurig
- ventilator, >100 mA, niet geschikt voor batterijvoeding
- redelijke prijs Euro 30,-

Plantower PMS 7003:

- documentatie ziet er goed uit

TTN LoRa stofsensor: Hardware 2.3.2

Sharp GP2Y1010AU0F



TTN LoRa stofsensor: Hardware 2.3.3



GP2Y1010AU0F

■ Absolute Maximum Ratings

(Ta=25°C)			
Parameter	Symbol	Rating	Unit
Supply voltage	V _{CC}	-0.3 to +7	V
* ¹ Input terminal voltage	V _{LED}	-0.3 to V _{CC}	V
Operating temperature	T _{opr}	-10 to +65	°C
Soldering temperature	T _{sol}	-20 to +80	°C

*1 Open drain drive input

■ Electro-optical Characteristics

(Ta=25°C, V _{CC} =5V)						
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Sensitivity	K	* ¹ * ² * ³	0.35	0.5	0.65	V/(0.1mg/m ³)
Output voltage at no dust	V _{OC}	* ² * ³	0	0.9	1.5	V
Output voltage range	V _{OH}	* ² * ³ R _L =4.7kΩ	3.4	—	—	V
LED terminal current	I _{LED}	* ² LED terminal voltage = 0	—	10	20	mA
Consumption current	I _{CC}	* ² R _L =∞	—	11	20	mA

*1 Sensitivity is specified by the amount of output voltage change when dust density changes by 0.1 mg/m³.

And the dust density for detection is a value of the density of cigarette (MILD SEVEN®) smoke measured by the digital dust monitor (P-5L2: manufactured by SHIBATA SCIENTIFIC TECHNOLOGY LTD.).

*2 Input condition is shown in Fig. 1

*3 Output sampling timing is shown in Fig. 2

Sharp GP2Y1010AU0F

■Recommended input condition for LED input terminal

Parameter	Symbol	Value	Unit
Pulse Cycle	T	10 ± 1	ms
Pulse Width	Pw	0.32 ± 0.02	ms
Operating Supply voltage	V _{CC}	5 ± 0.5	V

TTN LoRa stofsensor: Hardware 2.3.5

SHARP

GP2Y1010AU0F

Fig. 1 Input Condition for LED Input Terminal

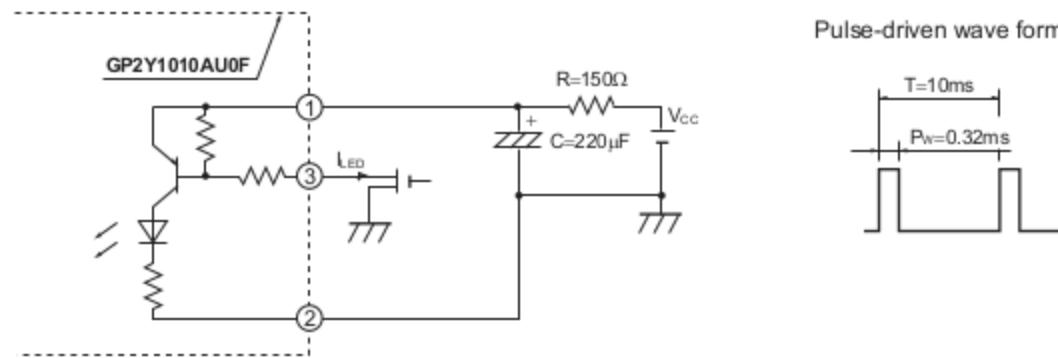
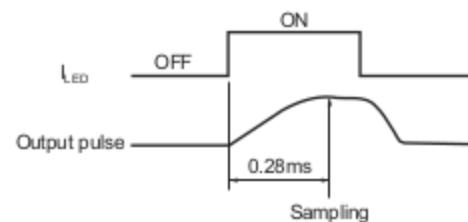
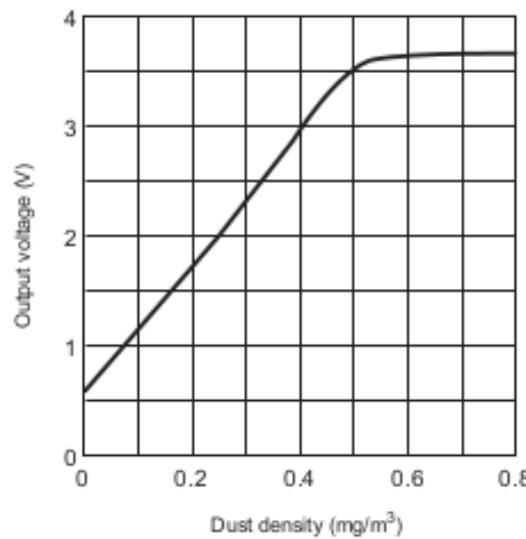


Fig. 2 Sampling Timing of Output Pulse



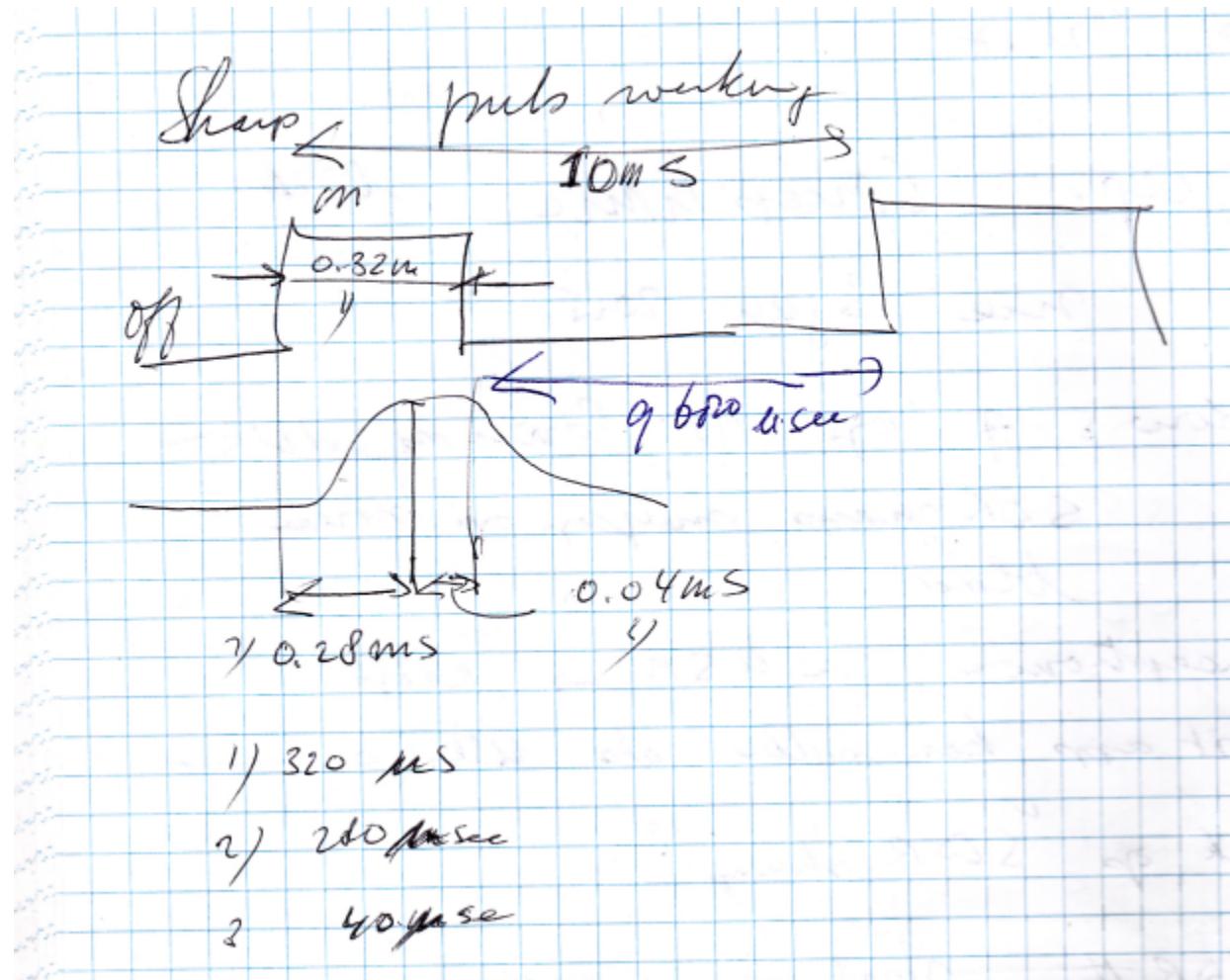
Sharp GP2Y1010AU0F

Fig. 3 Output Voltage vs. Dust Density

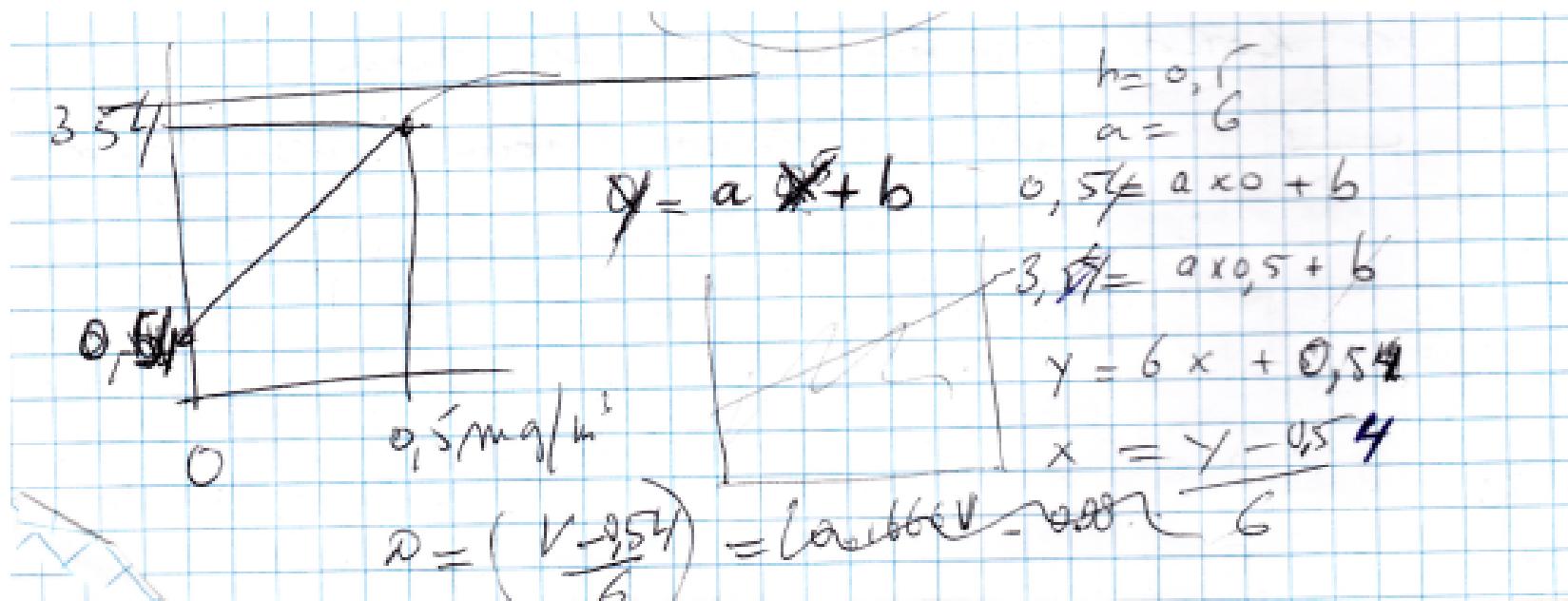


Remarks : Please be aware that all data in the graph are just for reference and are not for guarantee.

Sharp GP2Y1010AU0F



Sharp GP2Y1010AU0F



Stofsensor + Arduino

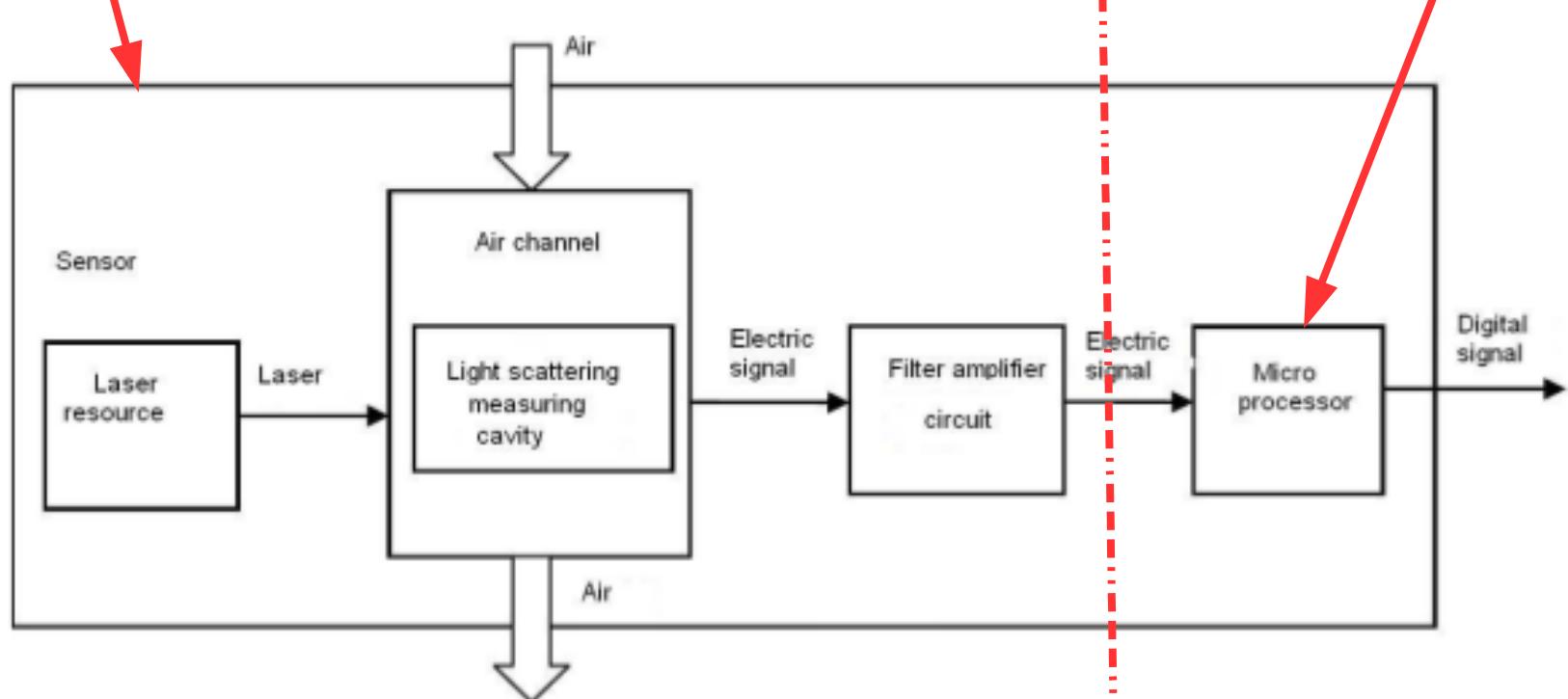


Figure 1 Functional block diagram of sensor

Voeding

USB power 5 V dc :

- direct geschikt voor Arduino Nano en Sharpsensor
- uit PC/laptop tijdens ontwikkeling
- uit Powerbank

Net 220 V ac :

- omzetten naar USB 5 V dc d.m.v. USB lader

Accu 12 V dc :

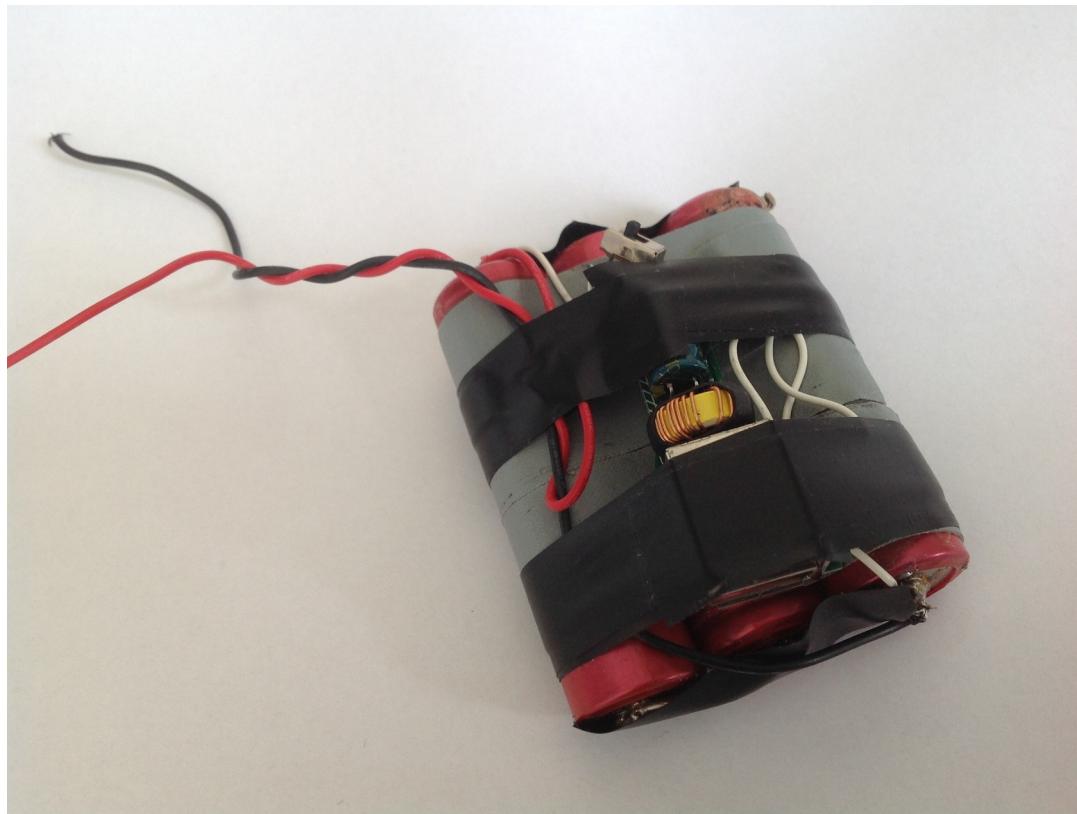
- omzetten naar USB 5 V dc d.m.v. USB Car Charger
- bv. Labr31 Duo: 12-24 V in, 5 V /2.4 A uit

(Oplaadbare) Batterijen x V dc:!!!!!!

- 3 x oude laptop Lipo's = 11.8 V
- omzetten naar USB 5 V dc d.m.v. USB Car Charger

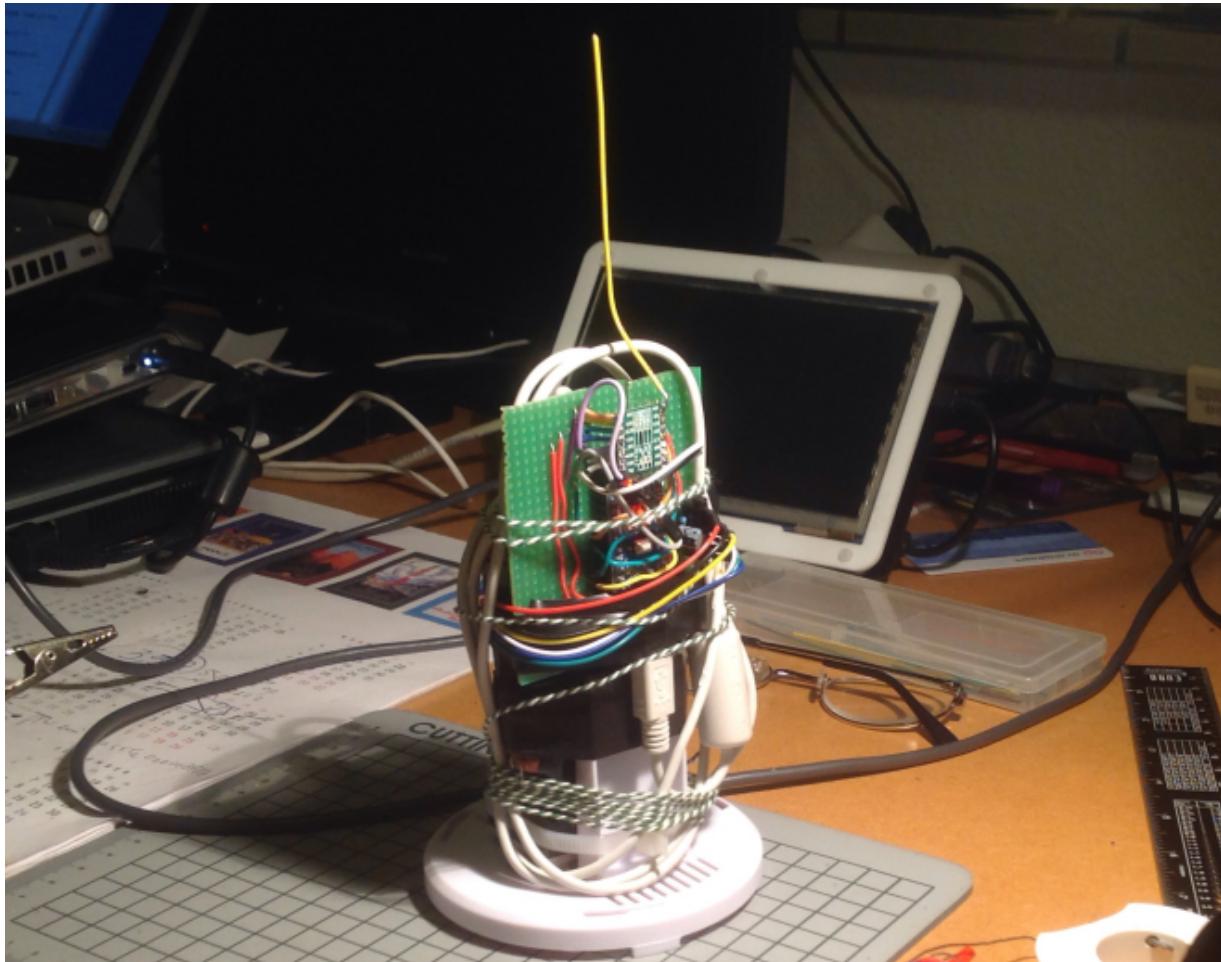
LiPo Batterijen

- 3 x oude laptop Lipo's = 11.8 V
- omzetten naar USB 5 V dc d.m.v. USB Car Charger
- opladen met Lab Power Supply: Vmax:12.4 V, Imax:0.4 A



TTN LoRa stofsensor: Hardware 2.5

Jaap Fijnstof Sensor



IDE = Integrated Development Environment

IDE:

- editor, programmeertalen, compiler/linker
- microcontrollers, boards
- downloader, debugger, monitor
- Windows, MacOS, Linux
- Webbased Online/Offline
- populariteit, Open Source, gratis

Arduino 1.8.1 : !!!!!!!

- Uno, Nano
- Linux Mint 18.1 'Serena' Xfce 64-bit
- Offline

Eclipse:

- !@#%^*%(&%%

Atom + Platform I/O IDE:

- LoPy, Pymakr, Arduino, ESP32, Mbed

Arduino 1.8.1

The screenshot shows the Arduino IDE interface with the following components:

- Top Bar:** Contains menu items: Bestand, Bewerken, Schets, Hulpmiddelen, Help.
- Toolbar:** Includes icons for Open, Save, Print, Upload, and Download.
- Code Editor:** Displays the sketch file "Atrancoapeldoordustsensor_01v3". The code is a LoRaWAN packet example with comments and copyright information.
- Terminal Window:** Titled "/dev/ttyUSB0", showing serial output from the device. The output includes:
 - Starting
 - Voltage: 3.03
 - Dust Density: 446.06 - Dust Density Filter: 148.69
 - Packet queued
 - 480074: EV_TXCOMPLETE (includes waiting for RX windows)
 - Voltage: 3.01
 - Dust Density: 442.15 - Dust Density Filter: 296.07
 - Packet queued
 - 4715354: EV_TXCOMPLETE (includes waiting for RX windows)
 - Voltage: 3.05
 - Dust Density: 449.68 - Dust Density Filter: 320.00
 - Packet queued
 - 8790540: EV_TXCOMPLETE (includes waiting for RX windows)
 - Voltage: 3.01
 - Dust Density: 441.27 - Dust Density Filter: 320.00
 - Packet queued
 - 13004063: EV_TXCOMPLETE (includes waiting for RX windows)
 - Voltage: 2.97
 - Dust Density: 434.72 - Dust Density Filter: 320.00
 - Packet queued
 - 17273197: EV_TXCOMPLETE (includes waiting for RX windows)
- Bottom Status Bar:** Shows "Autoscroll", "Geen regelinde" (unchecked), and "115200 baud" (selected).

Arduino-lmic-v1.5

The screenshot shows a web browser window with the URL https://www.arduinolibraries.info/libraries/lm... in the address bar. The page title is "Arduino Library List". Below the title are navigation links for "Meest bezocht", "Linux Mint", "Blog", "Forums", "Community", "News", "Google", "KPN Webmail", and "The Things Network". On the right side of the header are download, refresh, and search icons. The main content area has tabs for "Arduino Library List", "Search", "Categories", "Types", "Architectures", and "Authors". The "Search" tab is currently selected.

IBM LMIC framework

Arduino port of the LMIC (LoraWAN-in-C, formerly LoraMAC-in-C) framework provided by IBM.

Author	IBM
Maintainer	Matthijs Kooijman
Website	http://www.research.ibm.com/labs/zurich/ics/lrsc/lmic.html
Github	https://github.com/matthijskooijman/arduino-lmic-v1.5
Category	Communication
License	Unknown
Library Type	Contributed
Architectures	Any

Supports SX1272/SX1276 and HopeRF RFM92/RFM95 tranceivers

Downloads

Filename	Release Date	File Size
IBM LMIC framework-1.5.0+arduino-2.zip		824.64 KiB
IBM LMIC framework-1.5.0+arduino-1.zip		813.70 KiB

Arduino Limic config.h

```
// Any runtime assertion failures are printed to this serial port (or
// any other Print object). If this is unset, any failures just silently
// halt execution.
#define LMIC_FAILURE_TO Serial

// Uncomment this to disable all code related to joining
#define DISABLE_JOIN
// Uncomment this to disable all code related to ping
#define DISABLE_PING
// Uncomment this to disable all code related to beacon tracking.
// Requires ping to be disabled too
#define DISABLE_BEACONS

// Uncomment these to disable the corresponding MAC commands.
// Class A
///#define DISABLE_MCMD_DCAP_REQ // duty cycle cap
///#define DISABLE_MCMD_DN2P_SET // 2nd DN window param
///#define DISABLE_MCMD_SNCH_REQ // set new channel
// Class B
#define DISABLE_MCMD_PING_SET // set ping freq, automatically disabled by DISABLE_PING
#define DISABLE_MCMD_BCNI_ANS // next beacon start, automatical disabled by DISABLE_BEACON
```

>>>> Code configuren: kleiner maken

dustsensor_01

Applications > atrancoapeldoorn > Devices > dustsensor_01

Application ID atrancoapeldoorn

Device ID dustsensor_01

Description dustsensor apeldoornindata

Activation Method ABP

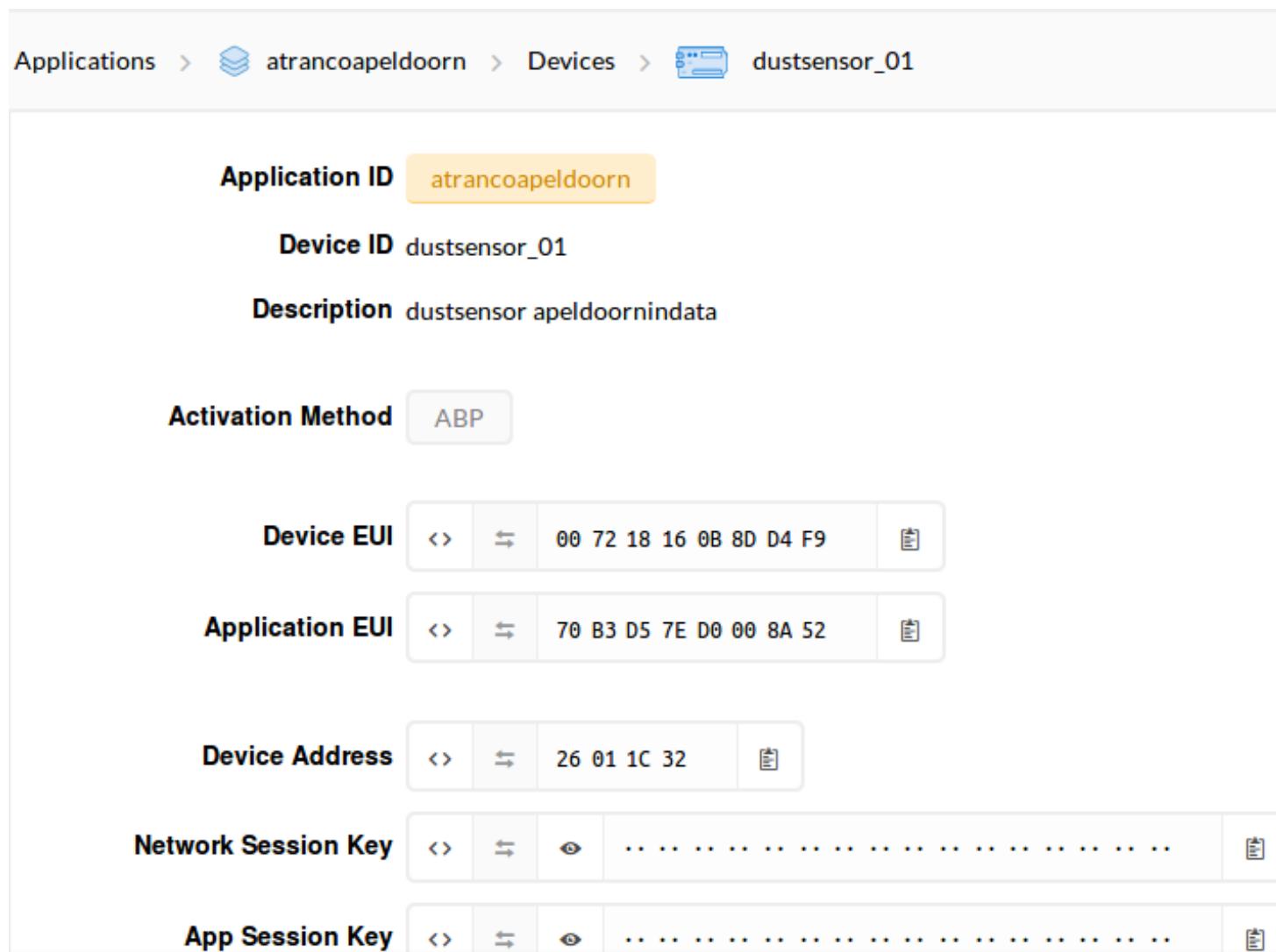
Device EUI 00 72 18 16 0B 8D D4 F9

Application EUI 70 B3 D5 7E D0 00 8A 52

Device Address 26 01 1C 32

Network Session Key (key visible as dots)

App Session Key (key visible as dots)



dustsensor_01

PAYLOAD FORMATS

Payload Format

The payload format sent by your devices

Cayenne LPP

dustsensor_01>>> apeldoornindata

The screenshot shows the TTN LoRaWAN console interface. The top navigation bar includes 'Applications' (with a stack icon), 'atrancoapeldoorn', 'Integrations', and 'atrancoapeldoorn'. The main section is titled 'SETTINGS'. It contains three configuration sections: 'Access Key', 'URL', and 'Method'. The 'Access Key' section describes the access key used for downlink and includes tabs for 'default key', 'devices', and 'messages', with 'devices' being the active tab. The 'URL' section describes the URL of the endpoint and contains a text input field with the value 'https://apeldoornindata.nl/data/loraendpoint.php'. The 'Method' section describes the HTTP method to use and contains a text input field with the value 'POST'.

Applications > atrancoapeldoorn > Integrations > atrancoapeldoorn

SETTINGS

Access Key
The access key used for downlink

default key devices messages

URL
The URL of the endpoint

`https://apeldoornindata.nl/data/loraendpoint.php`

Method
The HTTP method to use

POST

dustsensor_01v3 TTN keys

Atrancoapeldoordustsensor_01v3

```
31 | ****
32 |
33 |#include <lmic.h>
34 |#include <hal/hal.h>
35 |#include <SPI.h>
36 |#include <CayenneLPP.h>           // include for Cayenne library
37 |
38 // LoRaWAN NwkSKey, network session key
39 // This is the default Semtech key, which is used by the prototype TTN
40 // network initially.
41 // NB.Nieuwe key te verkrijgen via de TTN Console.
42 | static const PROGMEM u1_t NWKSKEY[16] = { 0xE0, 0xCF, 0xCE, 0xB4, 0xDB, 0x9C, 0xC1, 0x35, 0x48
43 //static const PROGMEM u1_t NWKSKEY[16] = { 0xB2, 0x83, 0x95, 0x2D, 0x69, 0xE5, 0x09, 0x28, 0xEF
44 |
45 // LoRaWAN AppSKey, application session key
46 // This is the default Semtech key, which is used by the prototype TTN
47 // network initially.
48 // NB.Nieuwe key te verkrijgen via de TTN Console.
49 | static const u1_t PROGMEM APPSKEY[16] = { 0xC1, 0xD7, 0x3B, 0xE2, 0x3C, 0xAE, 0x95, 0x88, 0x4E
50 //static const u1_t PROGMEM APPSKEY[16] = { 0xBF, 0xCB, 0xAC, 0xA5, 0xF0, 0x83, 0xFC, 0xC1, 0xBC
51 |
52 // LoRaWAN end-device address (DevAddr)
53 // See http://thethingsnetwork.org/wiki/AddressSpace
54 // Copied from TTN console
55 static const u4_t DEVADDR = 0x26011C32; // <-- Change this address for every node!
56 //static const u4_t DEVADDR = 0x26011390;
57 // These callbacks are only used in over-the-air activation, so they are
58 // left empty here (we cannot leave them out completely unless
59 // DISABLE_JOIN is set in config.h, otherwise the linker will complain).
60 // NB. Alleen ABP activation blijkt goed te werken!
61 void onActivation( ... *buf) { }
```

dustsensor_01v3 sensor set+pins

```
82 //***** Setup Sharp Dust Sensor *****/
83 * NB LMIC uses pins: 10, 9, 2, 6, 7
84 * Sharp pin 1 (V-LED)      => 5V (connected through 150ohm resister)
85 * Sharp pin 2 (LED-GND)   => Arduino GND pin
86 * Sharp pin 3 (LED)       => Arduino pin 3
87 * Sharp pin 4 (S-GND)     => Arduino GND pin
88 * Sharp pin 5 (Vo)        => Arduino A0 pin
89 * Sharp pin 6 (Vcc)       => 5V
90 *****/
91 //Pin mapping etc.
92 int measurePin = 0;
93 int ledPower = 3;
94 //Timing dustsensor
95 int samplingTime = 280;
96 int deltaTime = 40;
97 int sleepTime = 9680;
98 //Meetwaarden
99 float voMsom = 0;
100 float voMeasured = 0;
101 float calcVoltage = 0;
102 float dustDensity = 0;
```

dustsensor_01v3 MA-filter

```
104 // MA-filter, maximaal middelen over 10 meetwaarden = 10 minuten
105 float f1 = 0;
106 float f2 = 0;
107 float f3 = 0;
108 float f4 = 0;
109 float f5 = 0;
110 float f6 = 0;
111 float f7 = 0;
112 float f8 = 0;
113 float f9 = 0;
114 float f10 = 0;
115 float dustDensityFilter = 0;
```

dustsensor_01v3 10 samples=1 meetwaarde

```
194 void do_send(osjob_t* j){  
195     // Check if there is not a current TX/RX job running  
196     if (LMIC.opmode & OP_TXRXPEND)  
197     {  
198         Serial.println(F("OP_TXRXPEND, not sending"));  
199     }  
200     else  
201     {  
202         //*****Hier de code voor het opvragen van de dustsensor data *****  
203         *  
204         ****  
205         for (int i = 1; i <= 10; i++)  
206         {  
207             digitalWrite(ledPower,LOW); // power on the LED  
208             delayMicroseconds(samplingTime);  
209  
210             voMeasured = analogRead(measurePin); // read the dust value  
211  
212             delayMicroseconds(deltaTime);  
213             digitalWrite(ledPower,HIGH); // turn the LED off  
214             delayMicroseconds(sleepTime);  
215  
216             voMsom= voMsom + voMeasured;  
217             |  
218             delay( 90); // looptime=samplingtime: 280+40+9680=10mS + 90mS=0.1 Sec  
219         }  
220  
221         voMeasured = voMsom/10; // gemiddelde over 10 samples (= 10 x 0.1 = 1 Sec)  
222  
223         voMsom =0 ;
```

dustsensor_01v3 convers + lineair

```
226 // 0 - 5 V mapped to 0 - 1023 integer values
227 // recover voltage
228 calcVoltage = voMeasured * (5.0/ 1023);
229
230 // linear equation by
231 // Chris Nafis (c) 2012
232 // dustDensity = 0.17 * calcVoltage - 0.1;
233 // Jaap Bruijn 2017
234 dustDensity = (calcVoltage - 0.8)/5 ; // experimenteel bepalen
235 dustDensity = dustDensity * 1000; // ug/m3
236
237 //Serial.print("Raw Signal Value (0-1023): ");
238 //Serial.print(voMeasured);
239 Serial.print("Voltage: ");
240 Serial.println(calcVoltage);
241
242 Serial.print(" - Dust Density: ");
243 Serial.print(dustDensity);
244
```

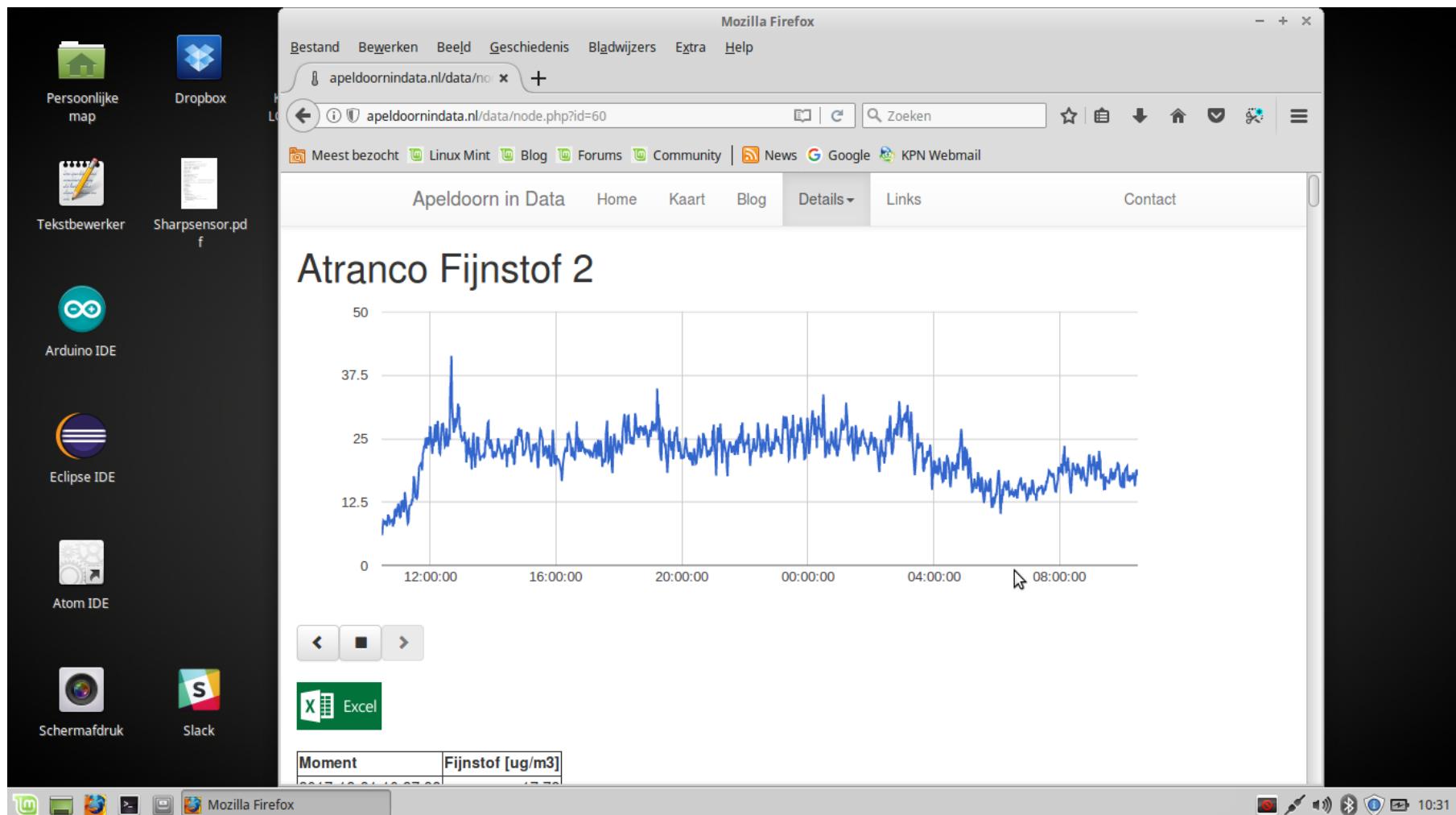
sensor_01v3 dustDensityFilter

```
247 //***** moving average filter
248 //f10 = f9;
249 //f9 = f8;
250 //f8 = f7;
251 //f7 = f6;
252 //f6 = f5;
253 //f5 = f4;
254 //f4 = f3;
255 f3 = f2;
256 f2 = f1;
257 f1 = dustDensity;
258 //dustDensityFilter = (f1+f2+f3+f4+f5+f6+f7+f8+f9+f10)/10; // 10 min gemiddelde
259 //dustDensityFilter = (f1+f2+f3+f4+f5)/5; // 5 min gemidelde
260 dustDensityFilter = (f1+f2+f3)/3; // 3 min gemidelde
261
262 // dustdensity > 0, Cayenne format(16 bit):
263 // -320.00<dust<320.00 (2^15 = 2^5 x 2^10 = 32 k)
264 if (dustDensityFilter > 320) {dustDensityFilter = 320;}
265 if (dustDensityFilter < 0) {dustDensityFilter = 0;}
266
267 Serial.print(" - Dust Density Filter: ");
268 Serial.println(dustDensityFilter);
269 //*****
```

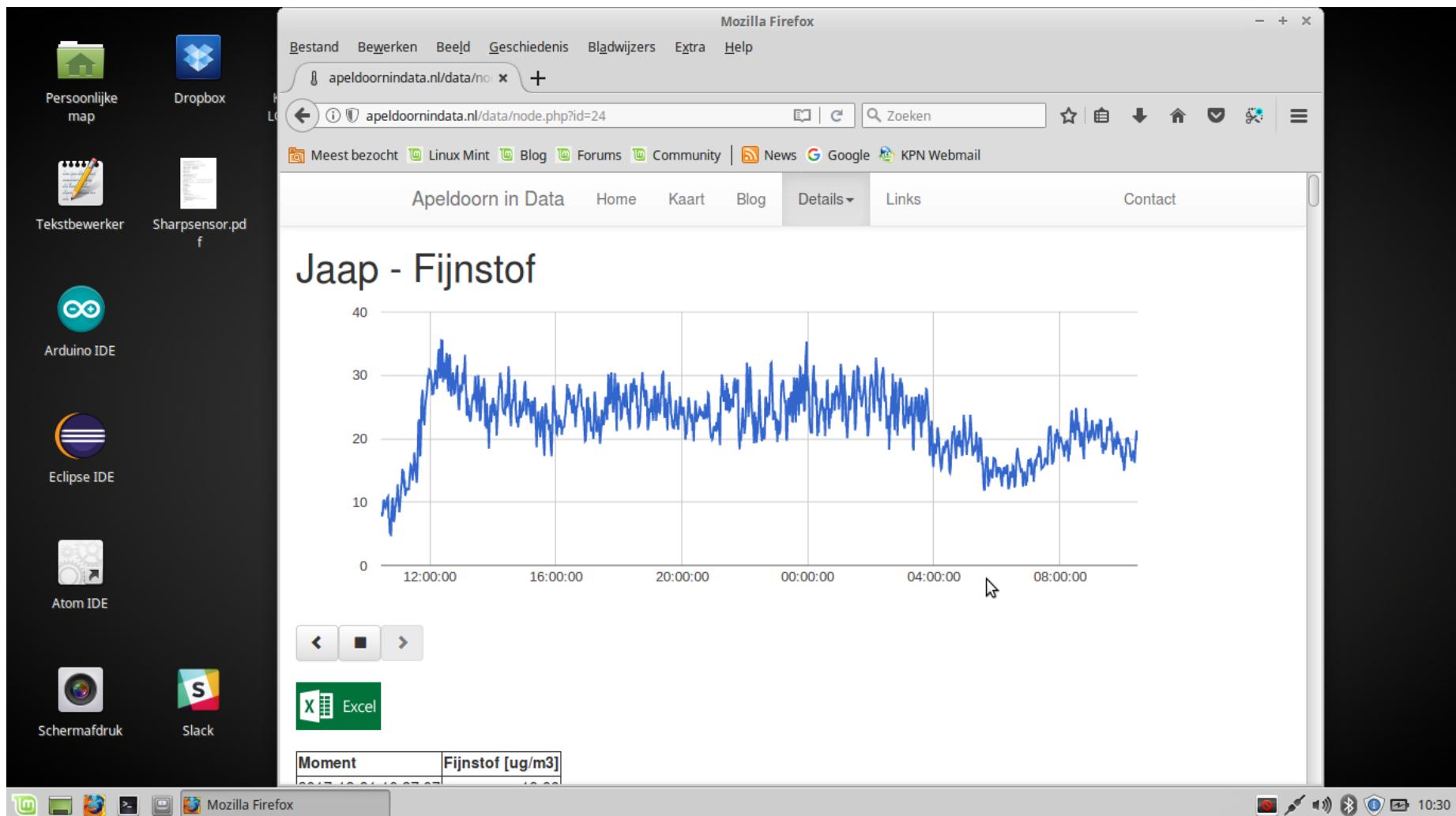
dustsensor_01v3 Cayenne format

```
272 // Compose Cayenne message
273 lpp.reset(); // reset cayenne object
274 lppChannel = 0; // reset channel counter
275
276 // Add sensor values to cayenne data package
277 lpp.addAnalogInput(lppChannel++, dustDensityFilter);
278
279 // The node's GPS location here not required,
280 // but perhaps easier for AiD to place the node at W.P. 17 on the map?
281 // lpp.addGPS(lppChannel++,52.23579400,5.95374400, 3);
282
283 // Prepare upstream data transmission at the next possible time.
284 LMIC_setTxData2(APPLICATION_PORT_CAYENNE, lpp.getBuffer(), lpp.getSize(), 0);
285
286 // Float naar character?
287 // dtostrf(calcVoltage, 6, 2, mydata); // mydata for test
288 // Prepare upstream data transmission at the next possible time.
289 // LMIC_setTxData2(1, mydata, sizeof(mydata)-1, 0);
290
291     Serial.println(F("Packet queued"));
292 }
293 // Next TX is scheduled after TX_COMPLETE event.
294 }
295
296 void setup() {
```

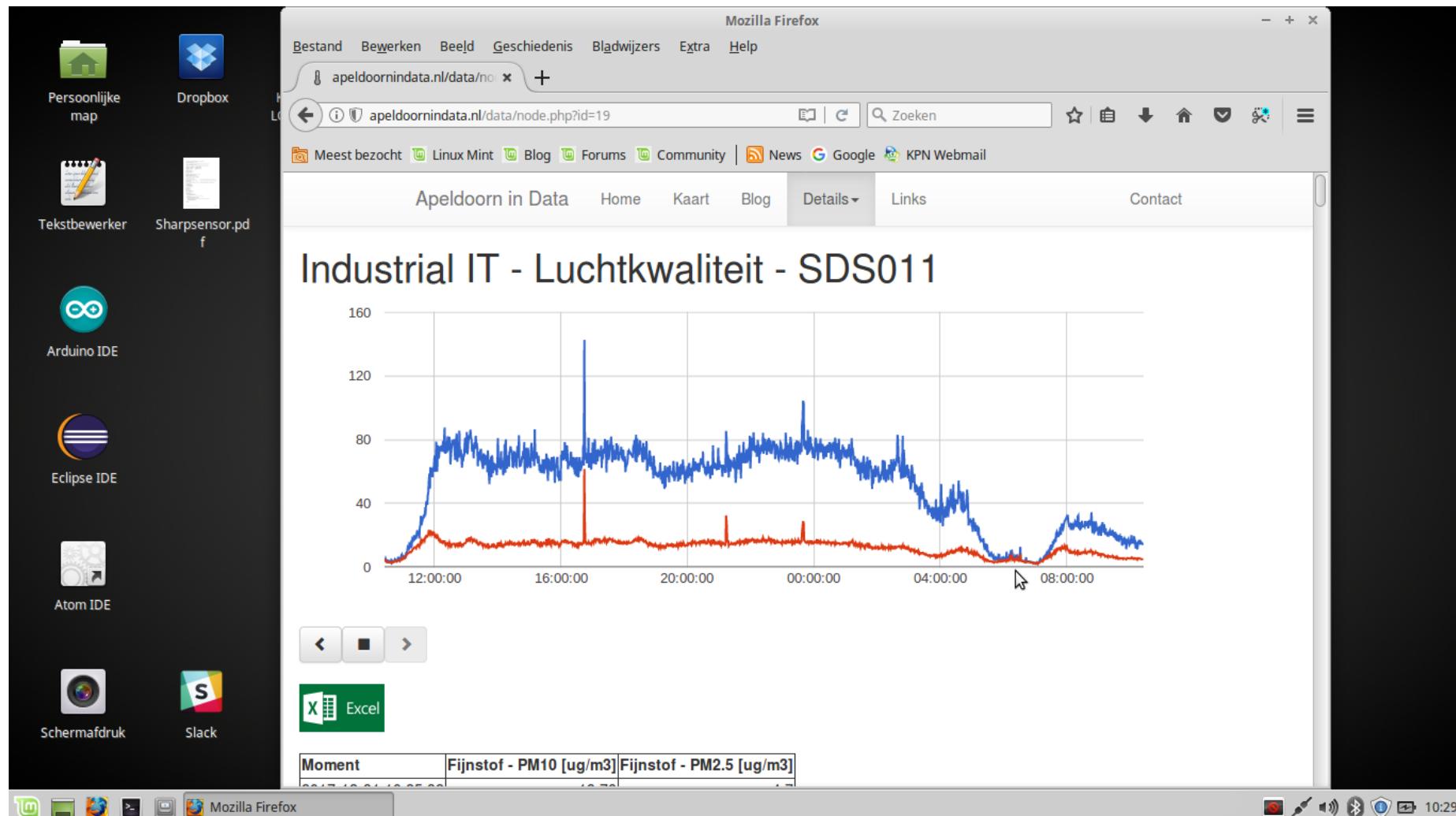
Testmeting december 2017



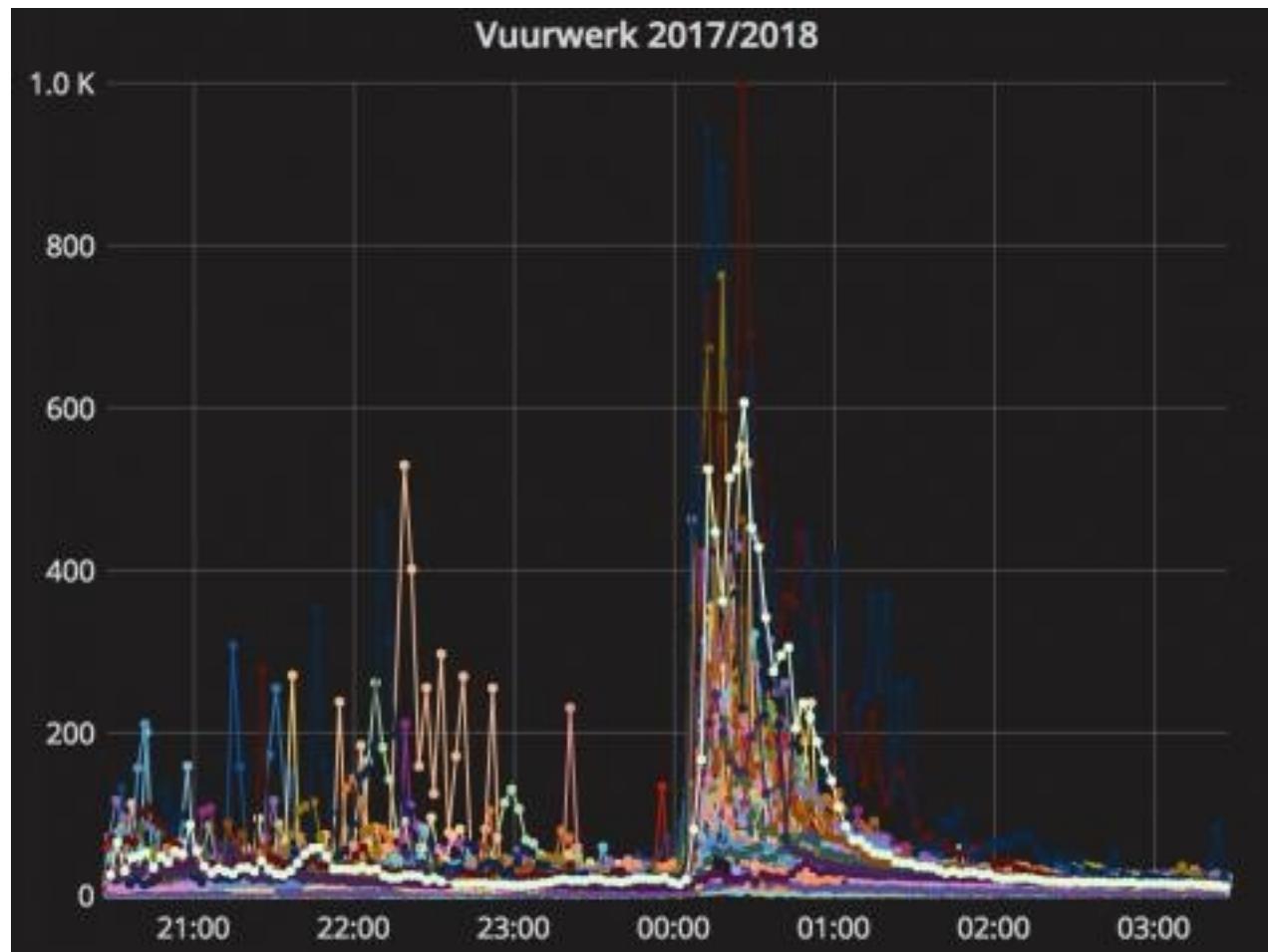
Testmeting december 2017



Testmeting december 2017



Vuurwerpiek Apeldoorn 2017/18



Meetduur

Jaap Stofsensor (3x LiPo's)

– 2.5 dagen

Meetperiode

Jaap Stofsensor (Netvoeding)

– jan. 2017 tot heden

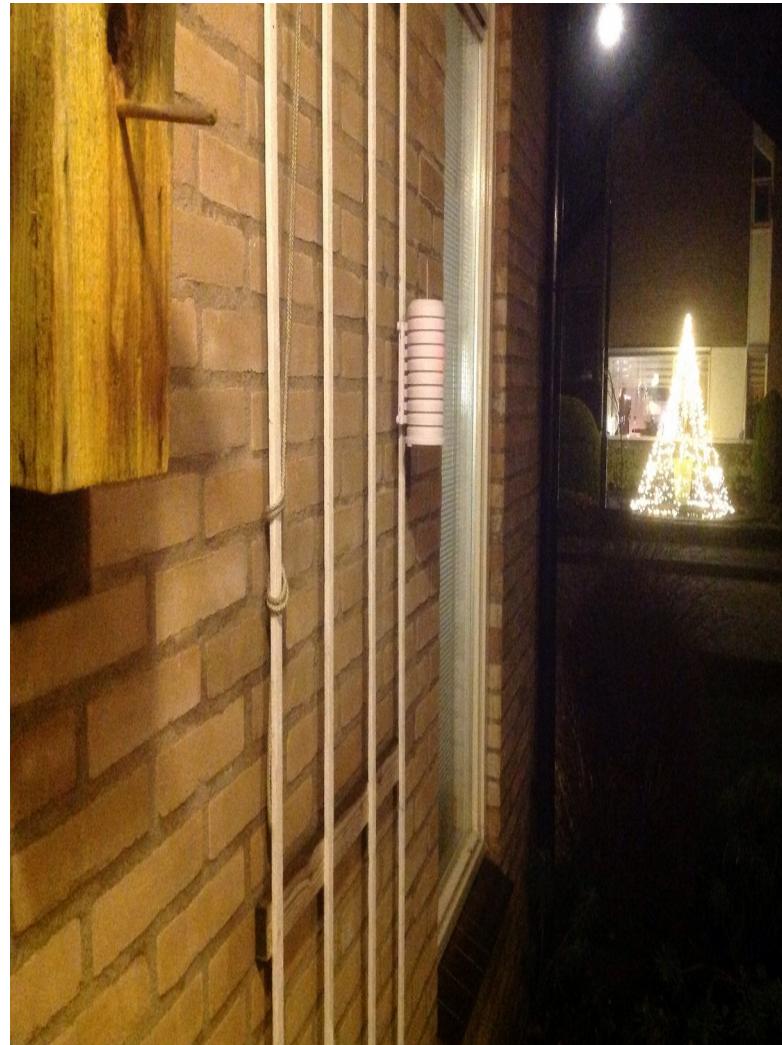
Nauwkeurigheid

Sharp sensor:

- nauwkeurigheid ???
- meet stofcentraties
- laat duidelijk stofpieken zien
- globale kwalitatieve metingen
- correlatie met SDS011
- afhankelijk omgevingstemp en -licht

niet geschikt voor kwantitatieve stofconcentratie-metingen

Behuizing & Plaatsing 1



Behuizing & Plaatsing 2



Behuizing & Plaatsing 3



Behuizing & Plaatsing 4



Behuizing & Plaatsing 5



Aanbevelingen

- geen batterij voeding
- dalende prijzen
- kies betere sensor: SDS 011, Plantower, Honeywell
- andere microcontrollers/boards: ARM Mbed, ESP32, LoPy

Vragen

