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Supporting Information

ODX - A fitness tracker-based device for continuous bacterial growth monitoring

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Table of contents

1. **GitHub links for project files**
2. **Bill of materials**
3. **Instructions to build ODX**
4. **Firmware instructions for ODX**
    a. **Board manager**
    b. **Flashing a soft device**
    c. **Flashing ODX firmware**
    d. **Device setup for black magic probe**
5. **Tools used**
6. **Raw data for Figure 6**

1. GitHub Link (https://github.com/momos123/ODX) contain all the files required for building ODX device in the following order

a. Bill of materials
b. Instructions to build ODX
c. Openscad and STL files for the 3D printed enclosure
d. App
e. Firmware
f. quote for 3D printing of the ODX enclosure

Note: The STl file for the ODX device enclosure can be 3D printed, if one has access to a 3D printer. In the case where 3D printer is not available, there are services which offer 3D printing on demand (sculpteo, 3D Hubs, Shapeways). For reference, we added the quote for the ODX enclosure from 3D HUBS in the in the above GitHub link.

2. Bill of materials:

Part	**Price per unit**	**Quantity**	**Total cost**	**Part No.So**	**Supplier**
Voltage Regulator	€ 1.08	1	$1.20	TPS709B33DBVT	https://ie.farnell.com/
Current Regulator	€ 0.388	1	$0.42	NSI45020AT1G	https://ie.farnell.com/
LED	€ 0.148	1	$0.15	C503B-AAN-CY0B0251	https://ie.farnell.com/
ID107 HR fitness tracker	€ 11	1	$12.30	ID107	http://www.idoosmart.com/c2416.html
Total cost			**$14.07**		

3. Instructions to build ODX

S1. Fitness tracker's top view showing removable screws.



S2. The device is opened with a 0.2mL hex head screwdriver to access the electronics embedded inside



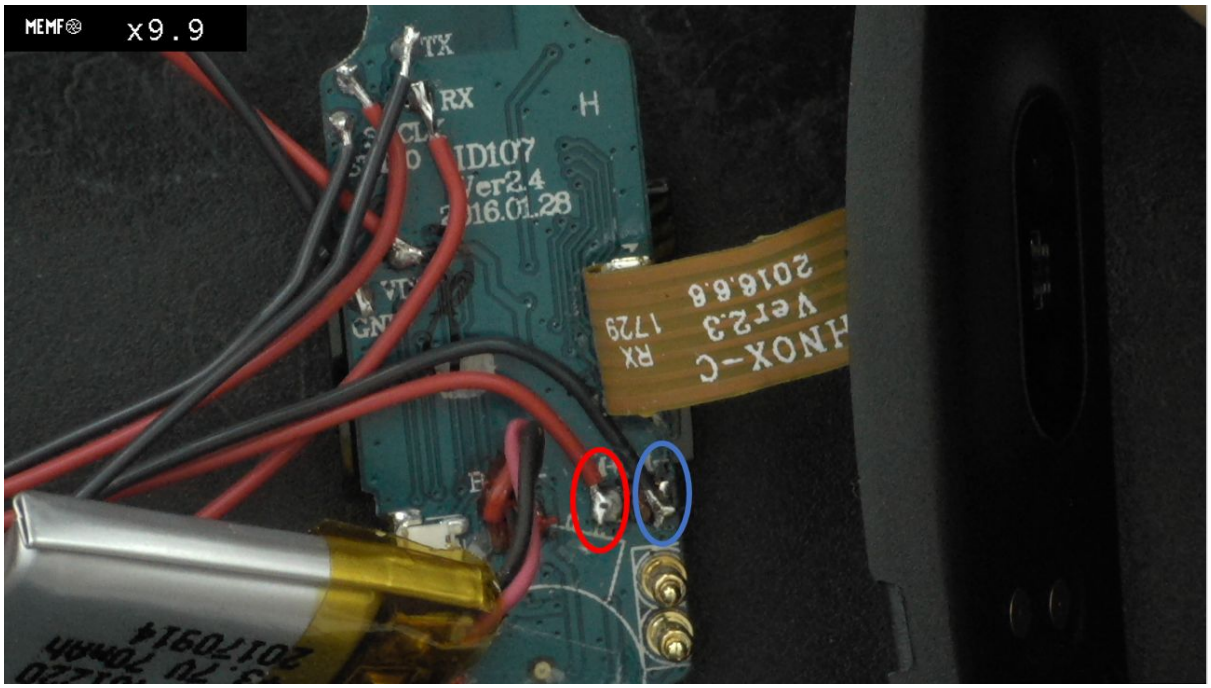
S3. When opened, fitness tracker looks as below.



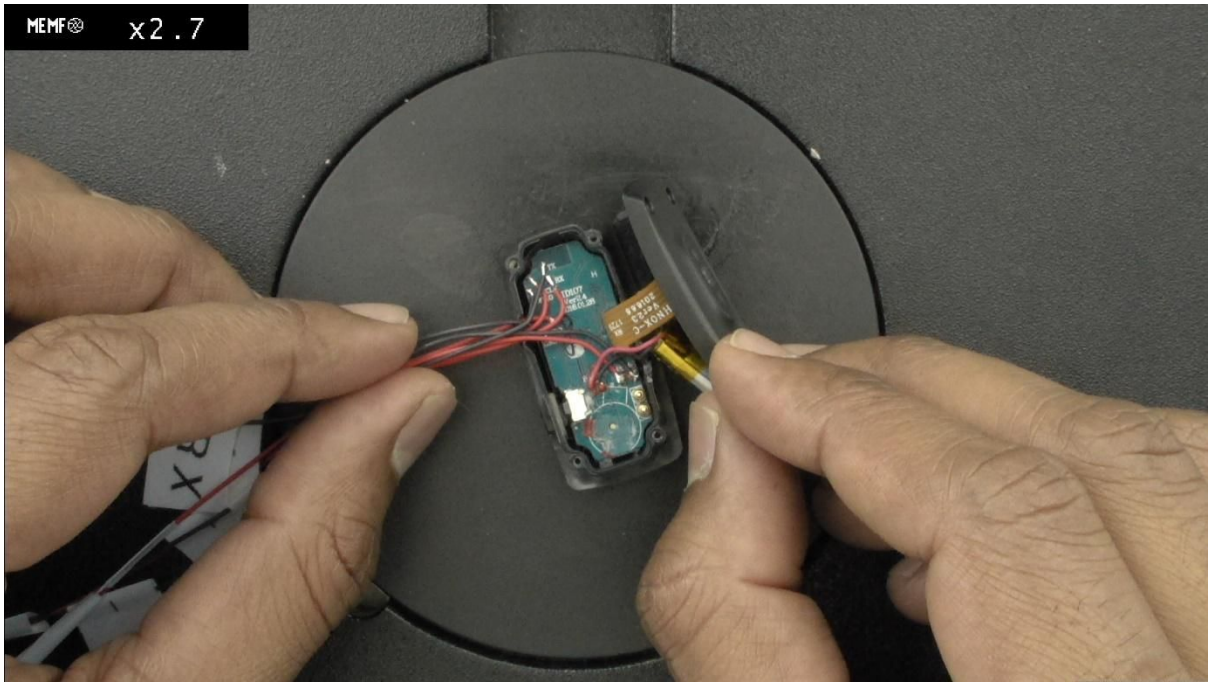
S4. The printed circuit boards is then dislodged from the plastic enclosure to provide access to the contact points. Contact points for TX, RX, SWCLK, CND, VCD and SWDIO can be seen on the PCB.



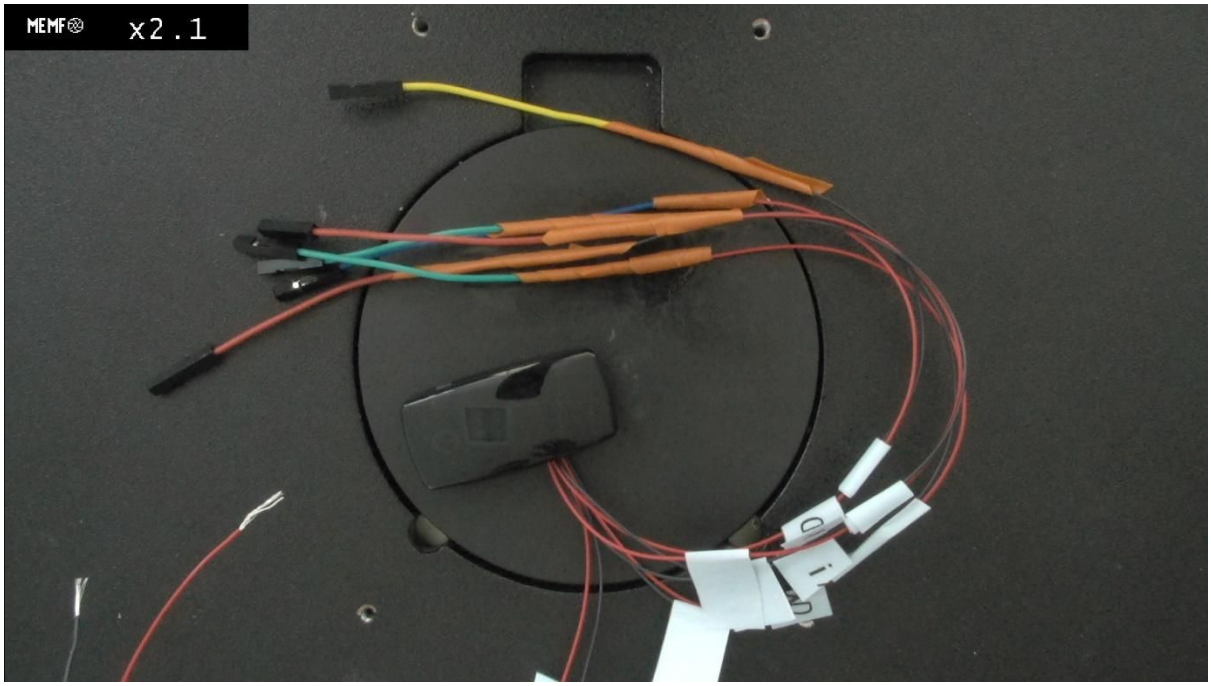
S5. The contact points are soldered to enable flashing of ODX firmware. The vibration motor has been removed and its corresponding contact points (circled) have been used to power the external LED.



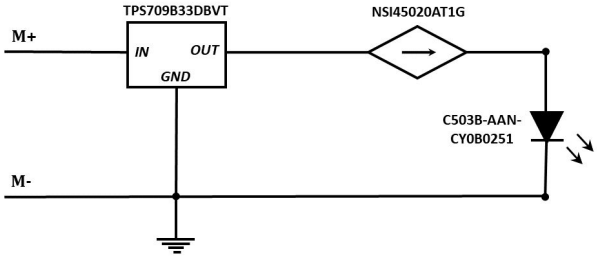
S6. All the wires are bundled to the side to reseal the fitness tracker.

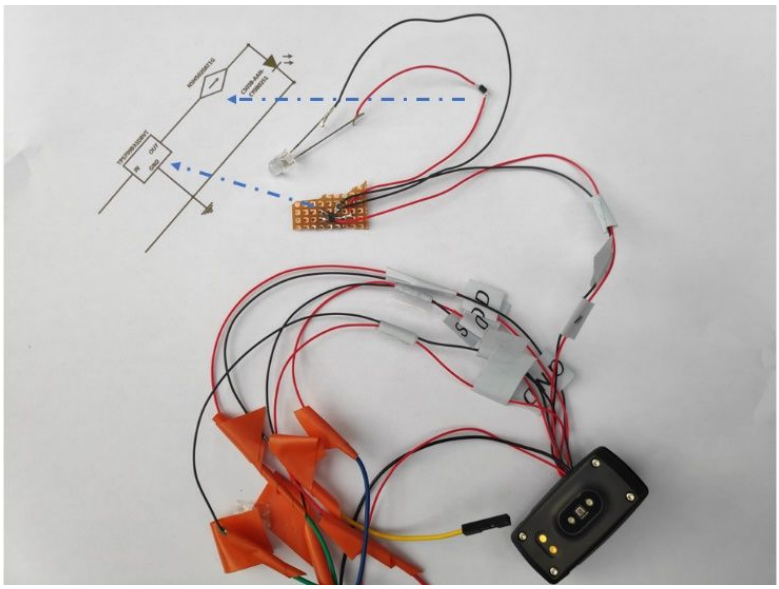


S7. The modified fitness tracker is resealed, after the corresponding wires were labelled.

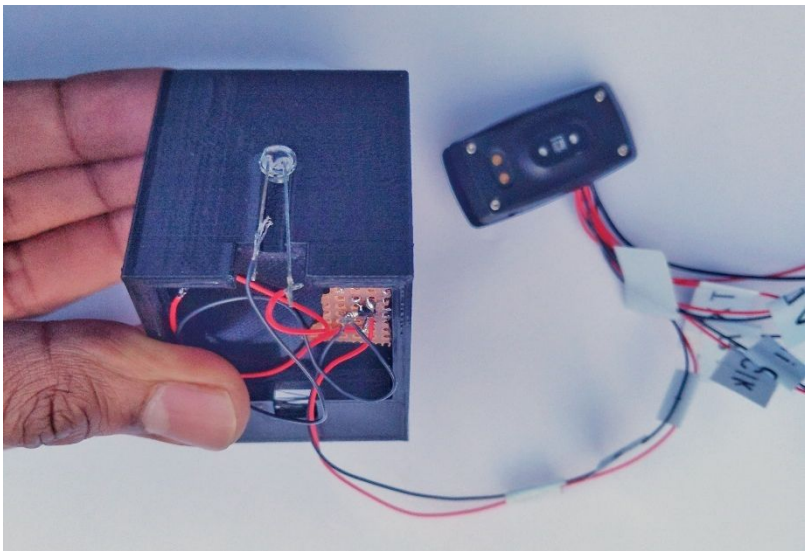


S8. LED and its associated power control circuit is soldered and connected to vibration motor pins.

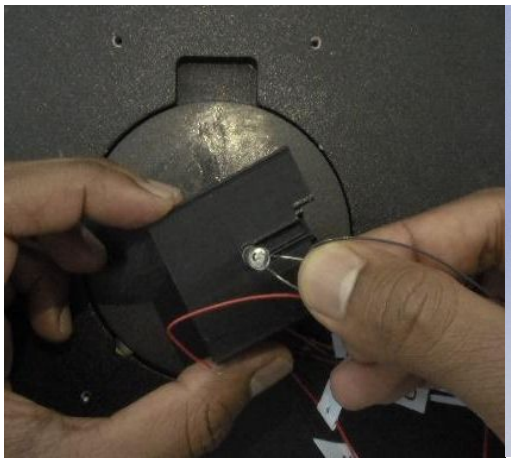


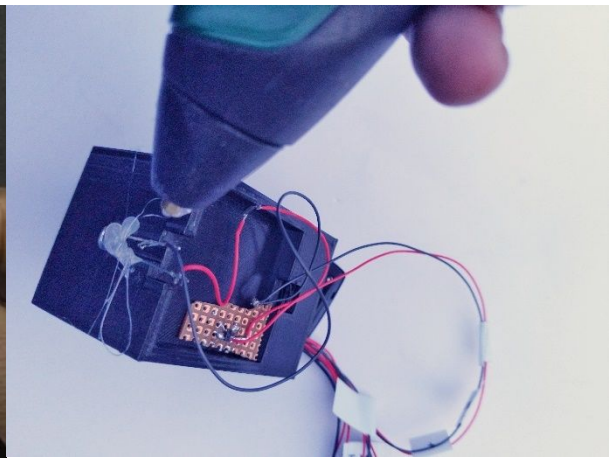


S9. The LED and completed circuit is assembled into 3D printed enclosure.

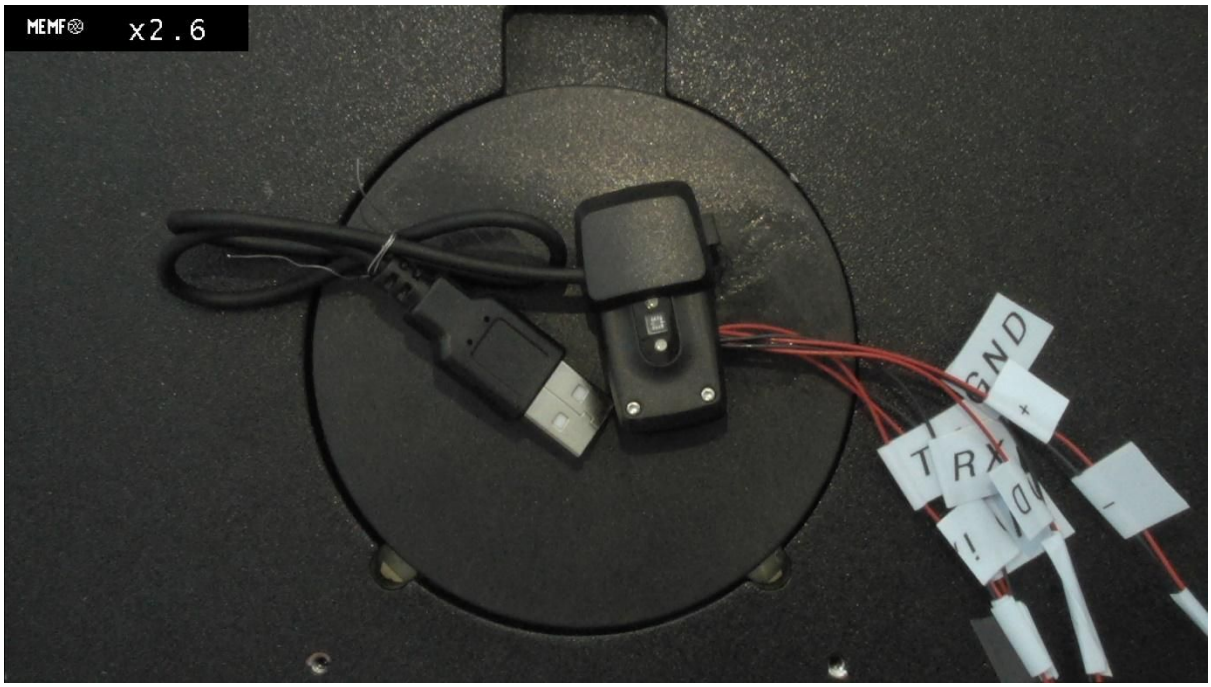


S10. All the circuitry and LED is secured using hot glue.

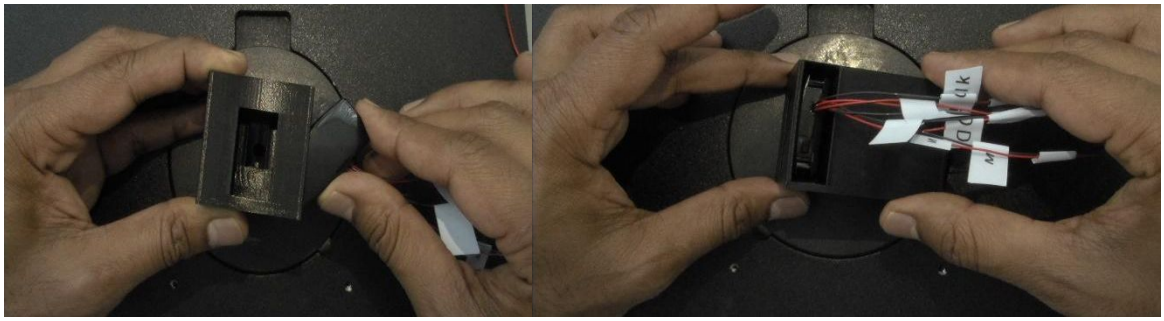




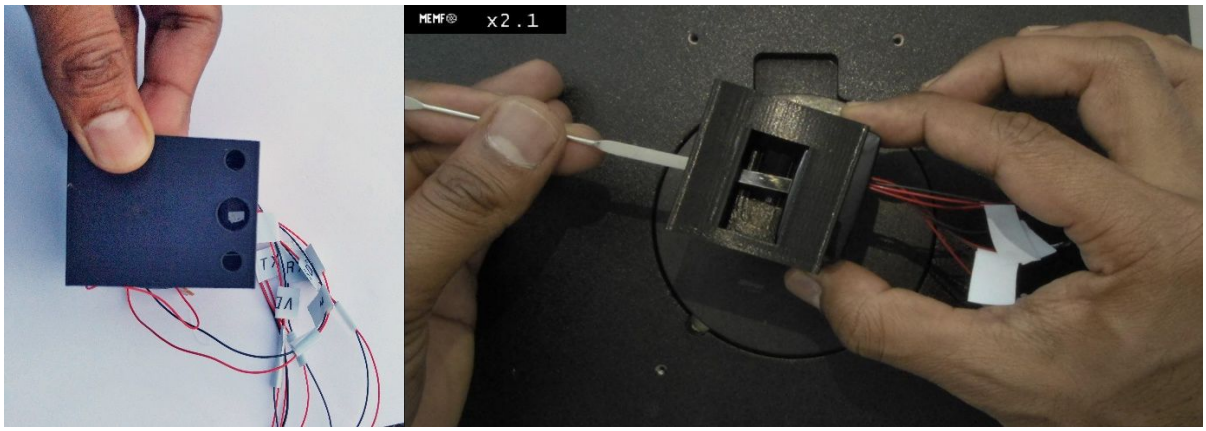
S11. Fitness tracker can be charged by using USB powering devices. The battery in the ODX lasts around 14 hours in our experiments.



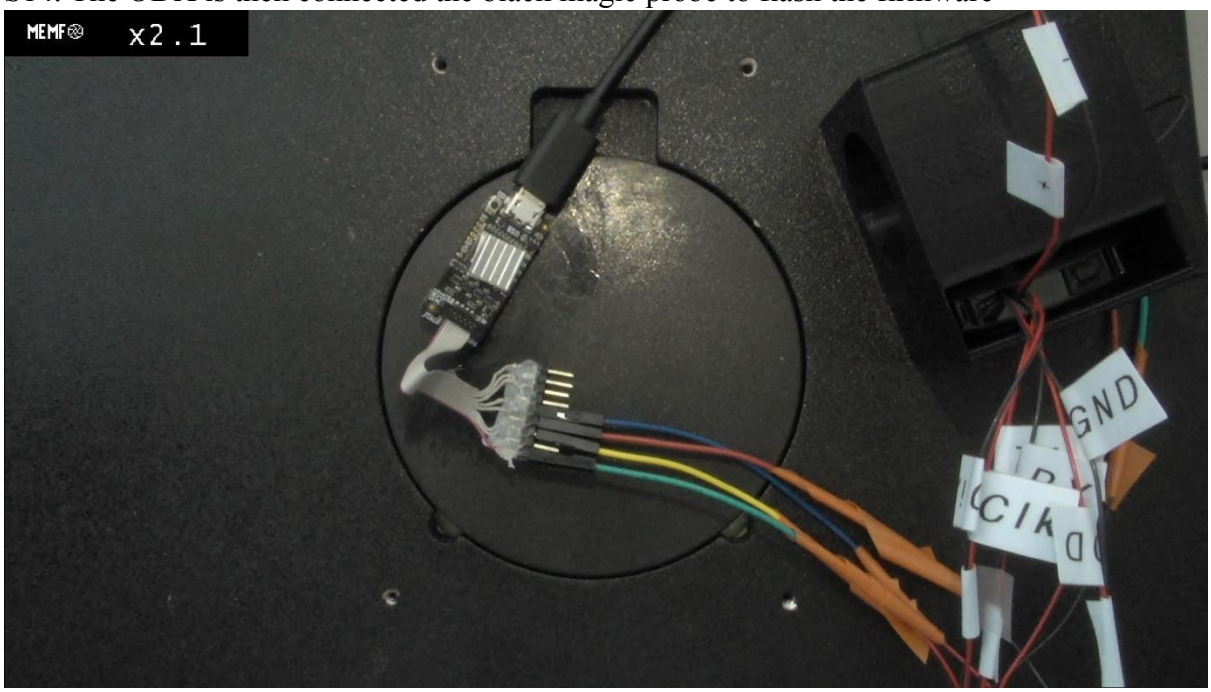
S12. After charging the fitness tracker is inserted into the 3D printed enclosure.



S13. The fitness tracker could be ejected easily for charging whenever required. Since the circuitry is secured with hot glue, the wires are stable.



S14. The ODX is then connected the black magic probe to flash the firmware



4. Firmware instructions for ODX

Note that these instructions are taken from the GitHub repository (https://github.com/sandeepmistry/arduino-nRF5) of sandeepmistry who originally provided the Arduino core for the nRF devices as stated in the ODX manuscript. Here, we provide the instructions of the firmware specifically adopted for the ODX device that contains nrf51 device using Windows PC.

4.1. Board Manager

a) Download and install the Arduino IDE (At least v1.6.12)
b) Start the Arduino IDE
c) Go into Preferences
d) Add https://sandeepmistry.github.io/arduino-nRF5/package_nRF5_boards_index.json as an "Additional Board Manager URL"
e) Add https://micooke.github.io/package_nRF5_smartwatches_index.jsonas an "Additional Board Manager URL"

f) Open the Boards Manager from the Tools -> Board menu and install "Nordic Semiconductor nRF5 Boards"
g) Select ID107 HR from the Tools -> Board menu

4.2. Flashing a Soft Device

a) cd <SKETCHBOOK>, where <SKETCHBOOK> is your Arduino Sketch folder (Windows: ~/Documents/Arduino)
b) Create the following directories: tools/nRF5FlashSoftDevice/tool/
c) Downloadb nRF5FlashSoftDevice.jar to <SKETCHBOOK>/tools/nRF5FlashSoftDevice/tool/
d) Restart the Arduino IDE
e) Select your ID107HR from the Tools -> Board menu
f) Select a SoftDevice S130 from the Tools -> "SoftDevice: " menu
g) Select a Programmer (BMP) from the Tools -> "Programmer: " menu
h) Select Tools -> nRF5 Flash SoftDevice
i) Read license agreement
j) Click "Accept" to accept license and continue, or "Decline" to decline and abort
k) If accepted, SoftDevice binary will be flashed to the board

4.3. Flashing a ODX firmware

a) Download all the files from the from the firmware folder in the github link https://github.com/momos123/ODX/tree/master/firmware
b) Open the ODX.ino with Arduino IDE
c) Select your ID107HR from the Tools -> Board menu
d) Select a SoftDevice S130 from the Tools -> "SoftDevice: " menu
e) Select a Programmer (BMP) from the Tools -> "Programmer: " menu
f) Select the BMP port as the Port on Arduino IDE
g) Upload the ODX.ino

5. Tools used

Windows PC, 3D printer, Hot glue gun, Soldering station, and Black Magic Probe.

Note: These are tools used and are considered as one-off costs only.

Alternatives to black magic probe:

Black magic probe (BMP) was used to upload the firmware into ODX as it was available at our disposal. However, any debugger/programmer device such as Segger J-Link, ST-Link can be used for this purpose. Therefore, BMP is also not the only method to upload the code. Moreover, one can also convert a low-cost **$2** STM32F103 (commonly known as a blue pill) as BMP by flashing with the open source software. The following links that explain the process have also been included in the supplementary file.

(1.https://medium.com/@paramaggarwal/converting-an-stm32f103-board-to-a-black-magic-probe-c013cf2cc38c

2. https://www.stm32duino.com/viewtopic.php?t=3546

Driver Setup for Black Magic Probe

1. Download .inf file drivers from blacksphere github
2. Plugin Black Magic Probe
3. Point the installer to the folder containing blackmagic.inf

6. Raw data for Figure 6

	Ecoli				Staph				Strep		
Time	N=1	N=2	N=3		N=1	N=2	N=3		N=1	N=2	N=3
2.858333333	0.094843	0.103964	0.069945		0.083465	0.075877	0.054446		0.037928	0.05105	0.020803
8.691666667	0.103884	0.11707	0.083469		0.101996	0.092724	0.076274		0.050546	0.06385	0.028613
14.525	0.112111	0.127023	0.096022		0.110627	0.10057	0.080637		0.058088	0.081264	0.035773
20.35833333	0.118113	0.134811	0.092039		0.125928	0.11448	0.089564		0.065216	0.077024	0.044686
26.19166667	0.123087	0.140964	0.094059		0.131141	0.119219	0.097995		0.068252	0.08556	0.047051
32.025	0.129845	0.143896	0.096421		0.13996	0.127236	0.101736		0.079234	0.083187	0.051949
37.85833333	0.134196	0.155697	0.099961		0.144671	0.131519	0.102836		0.084012	0.087669	0.056871
43.69166667	0.141238	0.153262	0.104391		0.149882	0.136256	0.112188		0.086891	0.09586	0.059909
49.525	0.144107	0.156465	0.115416		0.151229	0.137481	0.115544		0.087345	0.096012	0.065778
55.35833333	0.145001	0.159365	0.125751		0.159849	0.145317	0.118843		0.089677	0.09306	0.063011
61.19166667	0.148076	0.161624	0.141411		0.163186	0.148351	0.118068		0.094904	0.098666	0.06808
67.025	0.151353	0.162866	0.153534		0.16518	0.150164	0.120982		0.095042	0.101712	0.069095
72.85833333	0.153145	0.16466	0.161203		0.161928	0.147207	0.12612		0.092807	0.111376	0.06981
78.69166667	0.154741	0.165704	0.151608		0.17162	0.156018	0.123871		0.091382	0.104957	0.07218
84.525	0.15647	0.166705	0.167239		0.168524	0.153203	0.128817		0.091559	0.10451	0.076618
90.35833333	0.158228	0.167768	0.157269		0.172751	0.157046	0.131674		0.094265	0.106664	0.074689
96.19166667	0.159415	0.168697	0.167241		0.175329	0.15939	0.130245		0.097625	0.106447	0.077459
102.025	0.161849	0.16989	0.167326		0.174676	0.158797	0.136853		0.097521	0.110175	0.076985
107.8583333	0.162301	0.172891	0.165911		0.180421	0.164019	0.138088		0.092592	0.103471	0.080381
113.6916667	0.162701	0.171505	0.172436		0.171538	0.155943	0.139319		0.092429	0.112078	0.080541
119.525	0.163672	0.171284	0.170983		0.175893	0.159903	0.137859		0.093573	0.111825	0.082847
125.3583333	0.164979	0.171243	0.169299		0.179455	0.163141	0.136852		0.094557	0.112659	0.081248
131.1916667	0.165494	0.171922	0.171614		0.177893	0.161721	0.135941		0.095521	0.112769	0.086015
137.025	0.166753	0.172497	0.176088		0.183206	0.166551	0.136978		0.095787	0.115977	0.085243
142.8583333	0.167419	0.172929	0.167962		0.184431	0.167665	0.140324		0.099042	0.11345	0.085921

148.6916667	0.168181	0.173193	0.174543		0.18087	0.164428	0.134647		0.097697	0.114747	0.084605
154.525	0.168639	0.173586	0.179648		0.179026	0.162751	0.135523		0.098967	0.115087	0.085267
160.3583333	0.169369	0.173738	0.175433		0.188025	0.170932	0.141368		0.100542	0.115428	0.087749
166.1916667	0.17008	0.174421	0.172445		0.20039	0.182172	0.141364		0.10425	0.121137	0.089918
172.025	0.170692	0.174431	0.18009		0.185318	0.168471	0.142064		0.108415	0.126846	0.093816
177.8583333	0.171643	0.174685	0.1825		0.187853	0.170776	0.145875		0.108089	0.124404	0.089589
183.6916667	0.17317	0.175397	0.17468		0.200625	0.182387	0.143496		0.107622	0.135098	0.093152
189.525	0.17312	0.175415	0.179539		0.189124	0.171931	0.148615		0.110702	0.126003	0.098291
195.3583333	0.173975	0.175884	0.18662		0.188873	0.171702	0.147993		0.112009	0.1301	0.095586
201.1916667	0.173969	0.176387	0.177751		0.247172	0.224702	0.149705		0.114285	0.1309	0.101919
207.025	0.175263	0.17674	0.178407		0.212153	0.192867	0.151248		0.118743	0.131699	0.10498
212.8583333	0.176048	0.176731	0.185411		0.225713	0.205194	0.153072		0.118743	0.132499	0.107299
218.6916667	0.176618	0.17683	0.183734		0.190709	0.173372	0.154849		0.118743	0.133298	0.111886
224.525	0.178156	0.177237	0.178396		0.193745	0.176131	0.160106		0.118743	0.133553	0.115251
230.3583333	0.179269	0.177522	0.185235		0.233416	0.212196	0.174803		0.1331	0.142721	0.118957
236.1916667	0.179649	0.17809	0.190568		0.200585	0.18235	0.167966		0.149506	0.145914	0.122436
242.025	0.180972	0.178778	0.179801		0.235419	0.214017	0.171266		0.155028	0.146116	0.131378
247.8583333	0.182426	0.179217	0.185039		0.207951	0.189046	0.224908		0.162168	0.149072	0.136525
253.6916667	0.185254	0.180589	0.193131		0.267671	0.243337	0.185015		0.177185	0.149027	0.142666
259.525	0.185909	0.182957	0.185208		0.234609	0.213281	0.20627		0.176786	0.158964	0.148144
265.3583333	0.187236	0.181856	0.188886		0.268634	0.244213	0.236862		0.176786	0.160479	0.153788
271.1916667	0.189055	0.182779	0.195717		0.26104	0.237309	0.21377		0.176786	0.168126	0.162917
277.025	0.19179	0.183866	0.189235		0.228451	0.207683	0.283875		0.191281	0.183252	0.169963
282.8583333	0.195266	0.18559	0.190966		0.241287	0.219352	0.237274		0.200581	0.185446	0.179658
288.6916667	0.198695	0.187528	0.203136		0.304651	0.276956	0.26743		0.208284	0.196	0.195758
294.525	0.20451	0.189861	0.202237		0.34186	0.310782	0.266732		0.211554	0.196539	0.202168
300.3583333	0.209749	0.193124	0.20061		0.31382	0.285291	0.277458		0.215316	0.204907	0.20657
306.1916667	0.219001	0.195545	0.209062		0.30509	0.277355	0.286436		0.216002	0.211468	0.208076
312.025	0.222912	0.200005	0.215804		0.317399	0.288545	0.296929		0.220489	0.216589	0.215033
317.8583333	0.229225	0.205525	0.216264		0.294945	0.268132	0.312382		0.222733	0.225217	0.218764
323.6916667	0.240655	0.210751	0.227409		0.313126	0.28466	0.323444		0.226904	0.235199	0.22669
329.525	0.254751	0.21915	0.254415		0.336156	0.305596	0.340869		0.231725	0.238418	0.232815
335.3583333	0.270546	0.232384	0.276487		0.354341	0.322128	0.356569		0.236101	0.241106	0.241331
341.1916667	0.290512	0.24853	0.270403		0.381155	0.346505	0.369004		0.241849	0.244979	0.249815
347.025	0.314598	0.251561	0.304854		0.408791	0.371628	0.388874		0.249025	0.252079	0.260281
352.8583333	0.343426	0.26777	0.339305		0.442019	0.401835	0.401009		0.25732	0.257816	0.271925
358.6916667	0.376299	0.29002	0.373756		0.482261	0.438419	0.418465		0.264368	0.269616	0.286077
364.525	0.412878	0.315155	0.408207		0.515456	0.468596	0.442226		0.271131	0.275814	0.299278
370.3583333	0.448339	0.343228	0.442658		0.553113	0.50283	0.45788		0.28002	0.285313	0.317623
376.1916667	0.482197	0.377251	0.477109		0.596653	0.542412	0.479216		0.29271	0.296281	0.328968
382.025	0.522306	0.408806	0.51156		0.640193	0.581994	0.499674		0.302102	0.306284	0.348783
387.8583333	0.586604	0.443516	0.546011		0.682633	0.620576	0.518077		0.316148	0.318436	0.367967
393.6916667	0.595903	0.481223	0.580462		0.696704	0.633367	0.540873		0.32914	0.333452	0.395103
399.525	0.636741	0.520721	0.614913		0.724842	0.658948	0.561676		0.342421	0.343163	0.406176
405.3583333	0.671033	0.564934	0.636352		0.760016	0.690923	0.583808		0.357647	0.35427	0.410574
411.1916667	0.699019	0.586997	0.6443		0.795982	0.72362	0.605608		0.372873	0.372012	0.419779

417.025	0.723337	0.61216	0.660962		0.829615	0.754196	0.652572		0.379247	0.385205	0.431447
422.8583333	0.751532	0.636527	0.681883		0.8698	0.790727	0.686775		0.385621	0.406921	0.439328
428.6916667	0.777876	0.656845	0.703345		0.897014	0.815468	0.721299		0.402827	0.412152	0.447389
434.525	0.812308	0.678041	0.727482		0.92777	0.843427	0.759805		0.413681	0.427266	0.449329
440.3583333	0.850099	0.700987	0.746373		0.962481	0.874982	0.793682		0.422015	0.44066	0.448516
446.1916667	0.879548	0.745796	0.768717		0.997191	0.905517	0.82528		0.429068	0.451199	0.453753
452.025	0.919398	0.760977	0.80259		1.031902	0.939317	0.8564		0.437093	0.459291	0.457928
457.8583333	0.928213	0.776616	0.827221		1.065436	0.968578	0.886306		0.442989	0.465893	0.461228
463.6916667	0.944802	0.799912	0.852663		1.100952	0.998667	0.920246		0.446205	0.472741	0.46415
469.525	0.955369	0.822817	0.872826		1.136468	1.032877	0.950982		0.451008	0.478167	0.46696
475.3583333	0.970684	0.844496	0.893214		1.171984	1.058633	0.988699		0.451404	0.477416	0.468011
481.1916667	0.990905	0.864212	0.917497		1.1845	1.094045	1.019117		0.453339	0.481009	0.468966
487.025	1.006559	0.88477	0.937426		1.190883	1.135127	1.053681		0.454781	0.484841	0.470137
492.8583333	1.020207	0.90538	0.952948		1.210874	1.153213	1.082931		0.456506	0.485762	0.472081
498.6916667	1.029603	0.921288	0.970162		1.232657	1.173959	1.116685		0.459004	0.491511	0.471303
504.525	1.044206	0.935442	0.990535		1.25733	1.197457	1.148471		0.45942	0.492129	0.4725
510.3583333	1.058923	0.94823	1.009317		1.287321	1.22602	1.17297		0.46075	0.489792	0.473602
516.1916667	1.067983	0.958051	1.019605		1.312712	1.250202	1.199043		0.46368	0.492378	0.480004
522.025	1.066786	0.965725	1.025189		1.332149	1.268713	1.227655		0.462406	0.495485	0.480842
527.8583333	1.075533	0.973185	1.033967		1.345778	1.281693	1.250242		0.463665	0.491362	0.481874
533.6916667	1.082468	0.979173	1.044525		1.362649	1.297761	1.265697		0.466219	0.497743	0.482947
539.525	1.093402	0.989317	1.059001		1.383113	1.31725	1.282009		0.46655	0.497032	0.485042
545.3583333	1.093623	0.990075	1.063089		1.399397	1.332759	1.300552		0.469692	0.498195	0.487268
551.1916667	1.103303	0.993343	1.074657		1.414055	1.346719	1.318476		0.46957	0.504352	0.488488
557.025	1.112779	1.011493	1.090037		1.429168	1.361112	1.338668		0.470816	0.50614	0.486896
562.8583333	1.105578	1.029642	1.079411		1.441988	1.373322	1.353007		0.470976	0.51014	0.486852
568.6916667	1.106403	1.027078	1.083892		1.44433	1.382845	1.366804		0.47145	0.506743	0.490106
574.525	1.10341	1.044404	1.083029		1.442631	1.400612	1.380438		0.47408	0.505988	0.492001
580.3583333	1.112256	1.051729	1.088125		1.440558	1.393722	1.3986		0.474027	0.504298	0.50018
586.1916667	1.114281	1.038733	1.088267		1.431485	1.389822	1.389792		0.477946	0.502607	0.501529
592.025	1.116183	1.053769	1.093746		1.425774	1.384368	1.384247		0.477667	0.510168	0.499605
597.8583333	1.119594	1.052587	1.096654		1.427804	1.385371	1.386218		0.480883	0.509012	0.502002
603.6916667	1.119595	1.058489	1.098493		1.423123	1.380926	1.381673		0.476697	0.509012	0.49816
609.525	1.121442	1.054647	1.102035		1.420563	1.382714	1.379187		0.484485	0.511974	0.50504
615.3583333	1.12481	1.042718	1.104508		1.417564	1.379407	1.376276		0.481958	0.511889	0.512107
621.1916667	1.12742	1.053001	1.109385		1.416026	1.378965	1.374782		0.483934	0.511217	0.511418
627.025	1.130378	1.042471	1.108602		1.414116	1.37719	1.372928		0.483871	0.511766	0.506949
632.8583333	1.128351	1.041507	1.111574		1.410091	1.374163	1.36902		0.4855	0.513258	0.511388
638.6916667	1.129462	1.049566	1.111892		1.406511	1.374074	1.365544		0.486179	0.514121	0.518121
644.525	1.129284	1.04029	1.115434		1.402694	1.369232	1.361839		0.487818	0.515141	0.515814
650.3583333	1.133523	1.044697	1.118454		1.400493	1.368789	1.359702		0.491398	0.516161	0.518637
656.1916667	1.130969	1.046676	1.116393		1.397676	1.368883	1.356967		0.516546	0.519084	0.514008
662.025	1.131992	1.047276	1.116999		1.393099	1.365883	1.352523		0.521391	0.525244	0.517538
667.8583333	1.134151	1.048767	1.119302		1.393827	1.363934	1.353231		0.522827	0.523829	0.521825