0712

【MONOSTICK を水中投下した実験(デバイス間は約 1m)】

50 未満(悪い)
50～100(やや悪い)
100～150(良好)
150 以上(アンテナの近傍)
ソフトウエア情報|LQI 値から電界強度[dBm]の推定 -- MONO-WIRELESS.COM

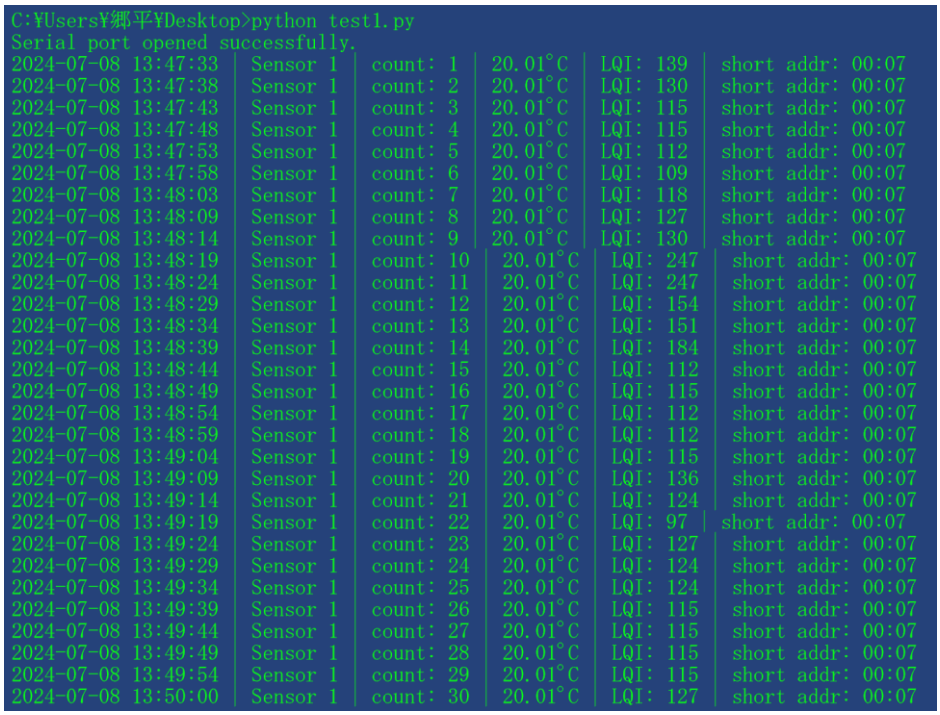
場所は, Coordinator→院生部屋のデスク上， Enddevice→デスクの下
Coordinator と Enddevice は約 1m 離れている.

【デバイス間 1m の場合】
(通常状態)

```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-08 14:03:49 | Sensor 1 | count: 1  | 20.01°C | LQI: 175 | short addr: 00:02
2024-07-08 14:03:54 | Sensor 1 | count: 2  | 20.01°C | LQI: 181 | short addr: 00:02
2024-07-08 14:03:59 | Sensor 1 | count: 3  | 20.01°C | LQI: 169 | short addr: 00:02
2024-07-08 14:04:04 | Sensor 1 | count: 4  | 20.01°C | LQI: 163 | short addr: 00:02
2024-07-08 14:04:10 | Sensor 1 | count: 5  | 20.01°C | LQI: 208 | short addr: 00:02
2024-07-08 14:04:15 | Sensor 1 | count: 6  | 20.01°C | LQI: 160 | short addr: 00:02
2024-07-08 14:04:20 | Sensor 1 | count: 7  | 20.01°C | LQI: 178 | short addr: 00:02
2024-07-08 14:04:25 | Sensor 1 | count: 8  | 20.01°C | LQI: 196 | short addr: 00:02
2024-07-08 14:04:30 | Sensor 1 | count: 9  | 20.01°C | LQI: 196 | short addr: 00:02
2024-07-08 14:04:35 | Sensor 1 | count: 10 | 20.01°C | LQI: 193 | short addr: 00:02
2024-07-08 14:04:40 | Sensor 1 | count: 11 | 20.01°C | LQI: 139 | short addr: 00:02
2024-07-08 14:04:45 | Sensor 1 | count: 12 | 20.01°C | LQI: 151 | short addr: 00:02
2024-07-08 14:04:50 | Sensor 1 | count: 13 | 20.01°C | LQI: 133 | short addr: 00:02
2024-07-08 14:04:55 | Sensor 1 | count: 14 | 20.01°C | LQI: 142 | short addr: 00:02
2024-07-08 14:05:00 | Sensor 1 | count: 15 | 20.01°C | LQI: 151 | short addr: 00:02
2024-07-08 14:05:05 | Sensor 1 | count: 16 | 20.01°C | LQI: 169 | short addr: 00:02
2024-07-08 14:05:10 | Sensor 1 | count: 17 | 20.01°C | LQI: 169 | short addr: 00:02
2024-07-08 14:05:15 | Sensor 1 | count: 18 | 20.01°C | LQI: 133 | short addr: 00:02
2024-07-08 14:05:20 | Sensor 1 | count: 19 | 20.01°C | LQI: 157 | short addr: 00:02
2024-07-08 14:05:25 | Sensor 1 | count: 20 | 20.01°C | LQI: 169 | short addr: 00:02
2024-07-08 14:05:30 | Sensor 1 | count: 21 | 20.01°C | LQI: 163 | short addr: 00:02
2024-07-08 14:05:35 | Sensor 1 | count: 22 | 20.01°C | LQI: 163 | short addr: 00:02
2024-07-08 14:05:40 | Sensor 1 | count: 23 | 20.01°C | LQI: 178 | short addr: 00:02
2024-07-08 14:05:45 | Sensor 1 | count: 24 | 20.01°C | LQI: 154 | short addr: 00:02
2024-07-08 14:05:50 | Sensor 1 | count: 25 | 20.01°C | LQI: 178 | short addr: 00:02
2024-07-08 14:05:55 | Sensor 1 | count: 26 | 20.01°C | LQI: 178 | short addr: 00:02
2024-07-08 14:06:00 | Sensor 1 | count: 27 | 20.01°C | LQI: 169 | short addr: 00:02
2024-07-08 14:06:05 | Sensor 1 | count: 28 | 20.01°C | LQI: 178 | short addr: 00:02
2024-07-08 14:06:10 | Sensor 1 | count: 29 | 20.01°C | LQI: 178 | short addr: 00:02
2024-07-08 14:06:16 | Sensor 1 | count: 30 | 20.01°C | LQI: 172 | short addr: 00:02
```

LQI 値は，ほとんど 150 以上である.

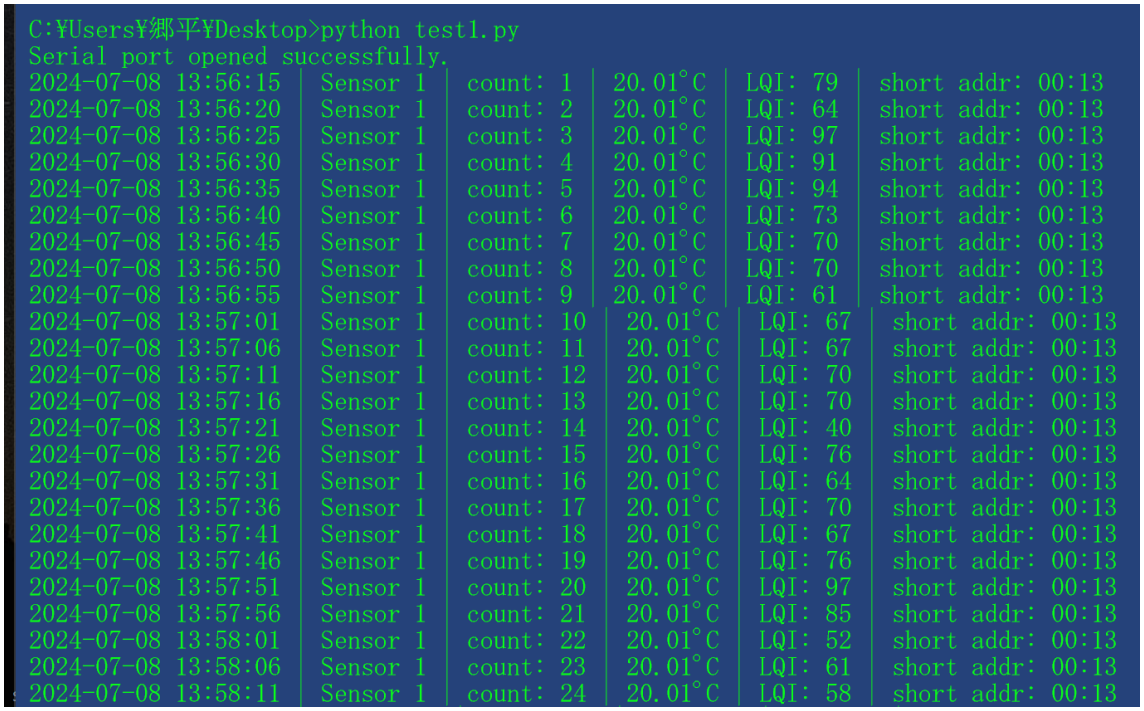
（袋にいれた状態）



```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-08 13:47:33 | Sensor 1 | count: 1  | 20.01°C | LQI: 139 | short addr: 00:07
2024-07-08 13:47:38 | Sensor 1 | count: 2  | 20.01°C | LQI: 130 | short addr: 00:07
2024-07-08 13:47:43 | Sensor 1 | count: 3  | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:47:48 | Sensor 1 | count: 4  | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:47:53 | Sensor 1 | count: 5  | 20.01°C | LQI: 112 | short addr: 00:07
2024-07-08 13:47:58 | Sensor 1 | count: 6  | 20.01°C | LQI: 109 | short addr: 00:07
2024-07-08 13:48:03 | Sensor 1 | count: 7  | 20.01°C | LQI: 118 | short addr: 00:07
2024-07-08 13:48:09 | Sensor 1 | count: 8  | 20.01°C | LQI: 127 | short addr: 00:07
2024-07-08 13:48:14 | Sensor 1 | count: 9  | 20.01°C | LQI: 130 | short addr: 00:07
2024-07-08 13:48:19 | Sensor 1 | count: 10 | 20.01°C | LQI: 247 | short addr: 00:07
2024-07-08 13:48:24 | Sensor 1 | count: 11 | 20.01°C | LQI: 247 | short addr: 00:07
2024-07-08 13:48:29 | Sensor 1 | count: 12 | 20.01°C | LQI: 154 | short addr: 00:07
2024-07-08 13:48:34 | Sensor 1 | count: 13 | 20.01°C | LQI: 151 | short addr: 00:07
2024-07-08 13:48:39 | Sensor 1 | count: 14 | 20.01°C | LQI: 184 | short addr: 00:07
2024-07-08 13:48:44 | Sensor 1 | count: 15 | 20.01°C | LQI: 112 | short addr: 00:07
2024-07-08 13:48:49 | Sensor 1 | count: 16 | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:48:54 | Sensor 1 | count: 17 | 20.01°C | LQI: 112 | short addr: 00:07
2024-07-08 13:48:59 | Sensor 1 | count: 18 | 20.01°C | LQI: 112 | short addr: 00:07
2024-07-08 13:49:04 | Sensor 1 | count: 19 | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:49:09 | Sensor 1 | count: 20 | 20.01°C | LQI: 136 | short addr: 00:07
2024-07-08 13:49:14 | Sensor 1 | count: 21 | 20.01°C | LQI: 124 | short addr: 00:07
2024-07-08 13:49:19 | Sensor 1 | count: 22 | 20.01°C | LQI: 97  | short addr: 00:07
2024-07-08 13:49:24 | Sensor 1 | count: 23 | 20.01°C | LQI: 127 | short addr: 00:07
2024-07-08 13:49:29 | Sensor 1 | count: 24 | 20.01°C | LQI: 124 | short addr: 00:07
2024-07-08 13:49:34 | Sensor 1 | count: 25 | 20.01°C | LQI: 124 | short addr: 00:07
2024-07-08 13:49:39 | Sensor 1 | count: 26 | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:49:44 | Sensor 1 | count: 27 | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:49:49 | Sensor 1 | count: 28 | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:49:54 | Sensor 1 | count: 29 | 20.01°C | LQI: 115 | short addr: 00:07
2024-07-08 13:50:00 | Sensor 1 | count: 30 | 20.01°C | LQI: 127 | short addr: 00:07
```

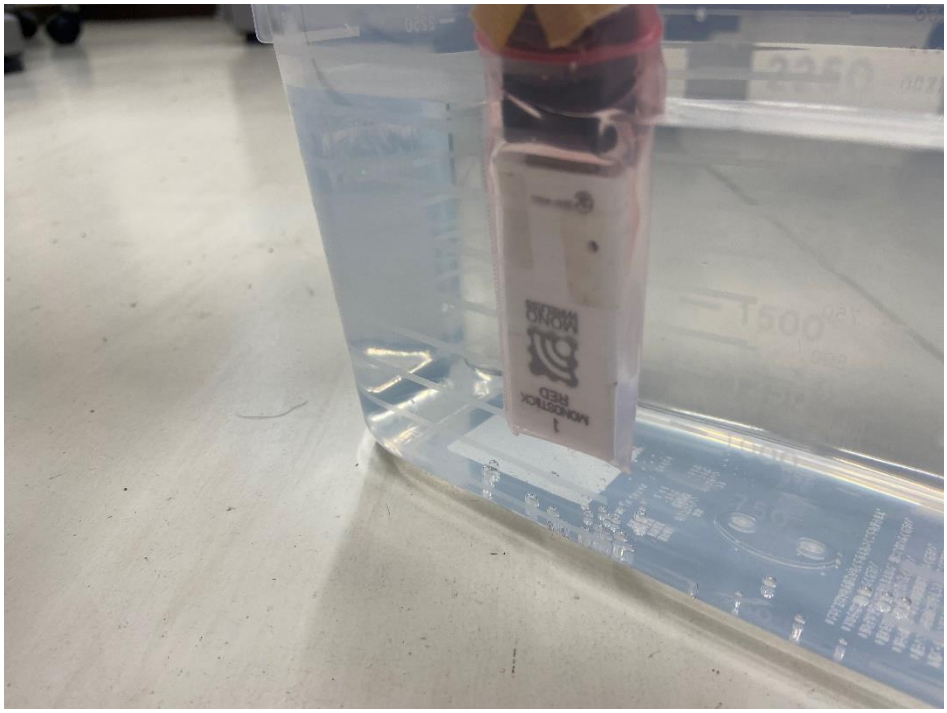
LQI 値は, 100 以上なため，良好.

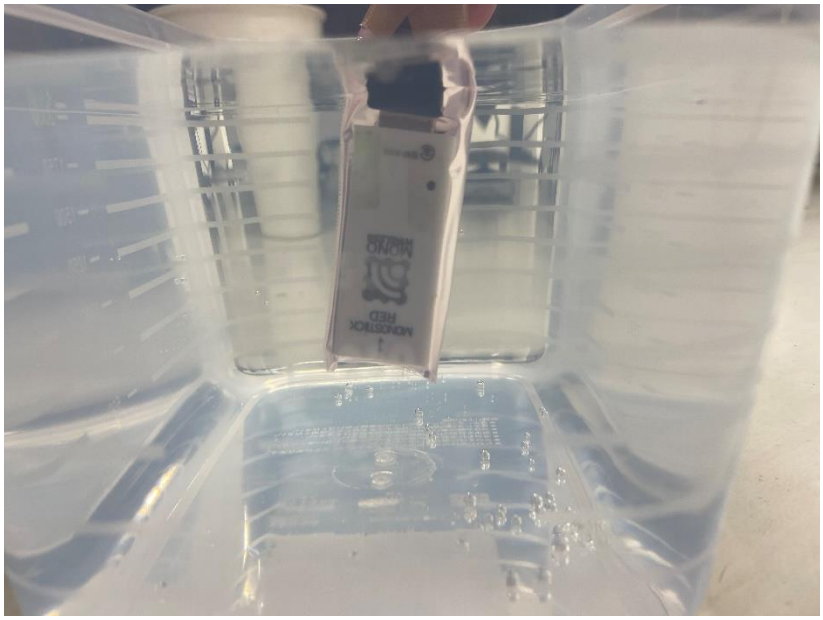
（水中に投下した場合）



```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-08 13:56:15 | Sensor 1 | count: 1  | 20.01°C | LQI: 79 | short addr: 00:13
2024-07-08 13:56:20 | Sensor 1 | count: 2  | 20.01°C | LQI: 64 | short addr: 00:13
2024-07-08 13:56:25 | Sensor 1 | count: 3  | 20.01°C | LQI: 97 | short addr: 00:13
2024-07-08 13:56:30 | Sensor 1 | count: 4  | 20.01°C | LQI: 91 | short addr: 00:13
2024-07-08 13:56:35 | Sensor 1 | count: 5  | 20.01°C | LQI: 94 | short addr: 00:13
2024-07-08 13:56:40 | Sensor 1 | count: 6  | 20.01°C | LQI: 73 | short addr: 00:13
2024-07-08 13:56:45 | Sensor 1 | count: 7  | 20.01°C | LQI: 70 | short addr: 00:13
2024-07-08 13:56:50 | Sensor 1 | count: 8  | 20.01°C | LQI: 70 | short addr: 00:13
2024-07-08 13:56:55 | Sensor 1 | count: 9  | 20.01°C | LQI: 61 | short addr: 00:13
2024-07-08 13:57:01 | Sensor 1 | count: 10 | 20.01°C | LQI: 67 | short addr: 00:13
2024-07-08 13:57:06 | Sensor 1 | count: 11 | 20.01°C | LQI: 67 | short addr: 00:13
2024-07-08 13:57:11 | Sensor 1 | count: 12 | 20.01°C | LQI: 70 | short addr: 00:13
2024-07-08 13:57:16 | Sensor 1 | count: 13 | 20.01°C | LQI: 70 | short addr: 00:13
2024-07-08 13:57:21 | Sensor 1 | count: 14 | 20.01°C | LQI: 40 | short addr: 00:13
2024-07-08 13:57:26 | Sensor 1 | count: 15 | 20.01°C | LQI: 76 | short addr: 00:13
2024-07-08 13:57:31 | Sensor 1 | count: 16 | 20.01°C | LQI: 64 | short addr: 00:13
2024-07-08 13:57:36 | Sensor 1 | count: 17 | 20.01°C | LQI: 70 | short addr: 00:13
2024-07-08 13:57:41 | Sensor 1 | count: 18 | 20.01°C | LQI: 67 | short addr: 00:13
2024-07-08 13:57:46 | Sensor 1 | count: 19 | 20.01°C | LQI: 76 | short addr: 00:13
2024-07-08 13:57:51 | Sensor 1 | count: 20 | 20.01°C | LQI: 97 | short addr: 00:13
2024-07-08 13:57:56 | Sensor 1 | count: 21 | 20.01°C | LQI: 85 | short addr: 00:13
2024-07-08 13:58:01 | Sensor 1 | count: 22 | 20.01°C | LQI: 52 | short addr: 00:13
2024-07-08 13:58:06 | Sensor 1 | count: 23 | 20.01°C | LQI: 61 | short addr: 00:13
2024-07-08 13:58:11 | Sensor 1 | count: 24 | 20.01°C | LQI: 58 | short addr: 00:13
```

LQI 値は, 50~100 以下のため，やや悪いに分類される．
今回はデバイス間が約 1m しか離れていないため，より間隔を離すと，悪くなる可能性がある．





【デバイス間約４ｍの場合】

（通常）

```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-10 10:25:07 | Sensor 1 | count: 1  | 20.01°C | LQI: 91 | short addr: 00:87
2024-07-10 10:25:12 | Sensor 1 | count: 2  | 20.01°C | LQI: 94 | short addr: 00:87
2024-07-10 10:25:17 | Sensor 1 | count: 3  | 20.01°C | LQI: 94 | short addr: 00:87
2024-07-10 10:25:22 | Sensor 1 | count: 4  | 20.01°C | LQI: 94 | short addr: 00:87
2024-07-10 10:25:28 | Sensor 1 | count: 5  | 20.01°C | LQI: 97 | short addr: 00:87
2024-07-10 10:25:33 | Sensor 1 | count: 6  | 20.01°C | LQI: 97 | short addr: 00:87
2024-07-10 10:25:38 | Sensor 1 | count: 7  | 20.01°C | LQI: 76 | short addr: 00:87
2024-07-10 10:25:43 | Sensor 1 | count: 8  | 20.01°C | LQI: 85 | short addr: 00:87
2024-07-10 10:25:48 | Sensor 1 | count: 9  | 20.01°C | LQI: 94 | short addr: 00:87
2024-07-10 10:25:53 | Sensor 1 | count: 10 | 20.01°C | LQI: 79 | short addr: 00:87
2024-07-10 10:25:58 | Sensor 1 | count: 11 | 20.01°C | LQI: 58 | short addr: 00:87
2024-07-10 10:26:03 | Sensor 1 | count: 12 | 20.01°C | LQI: 55 | short addr: 00:87
2024-07-10 10:26:08 | Sensor 1 | count: 13 | 20.01°C | LQI: 52 | short addr: 00:87
2024-07-10 10:26:13 | Sensor 1 | count: 14 | 20.01°C | LQI: 76 | short addr: 00:87
2024-07-10 10:26:18 | Sensor 1 | count: 15 | 20.01°C | LQI: 76 | short addr: 00:87
2024-07-10 10:26:23 | Sensor 1 | count: 16 | 20.01°C | LQI: 76 | short addr: 00:87
2024-07-10 10:26:28 | Sensor 1 | count: 17 | 20.01°C | LQI: 85 | short addr: 00:87
2024-07-10 10:26:33 | Sensor 1 | count: 18 | 20.01°C | LQI: 82 | short addr: 00:87
2024-07-10 10:26:38 | Sensor 1 | count: 19 | 20.01°C | LQI: 73 | short addr: 00:87
2024-07-10 10:26:43 | Sensor 1 | count: 20 | 20.01°C | LQI: 76 | short addr: 00:87
2024-07-10 10:26:48 | Sensor 1 | count: 21 | 20.01°C | LQI: 67 | short addr: 00:87
2024-07-10 10:26:53 | Sensor 1 | count: 22 | 20.01°C | LQI: 88 | short addr: 00:87
2024-07-10 10:26:58 | Sensor 1 | count: 23 | 20.01°C | LQI: 85 | short addr: 00:87
2024-07-10 10:27:03 | Sensor 1 | count: 24 | 20.01°C | LQI: 85 | short addr: 00:87
2024-07-10 10:27:08 | Sensor 1 | count: 25 | 20.01°C | LQI: 85 | short addr: 00:87
2024-07-10 10:27:13 | Sensor 1 | count: 26 | 20.01°C | LQI: 61 | short addr: 00:87
```

（水中投下）

```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-10 11:24:15 | Sensor 1 | count: 2  | 20.01°C | LQI: 19 | short addr: 00:25
2024-07-10 11:24:21 | Sensor 1 | count: 3  | 20.01°C | LQI: 28 | short addr: 00:25
2024-07-10 11:24:26 | Sensor 1 | count: 4  | 20.01°C | LQI: 61 | short addr: 00:25
2024-07-10 11:24:36 | Sensor 1 | count: 6  | 20.01°C | LQI: 19 | short addr: 00:25
2024-07-10 11:24:41 | Sensor 1 | count: 7  | 20.01°C | LQI: 25 | short addr: 00:25
2024-07-10 11:24:51 | Sensor 1 | count: 9  | 20.01°C | LQI: 31 | short addr: 00:25
2024-07-10 11:25:01 | Sensor 1 | count: 11 | 20.01°C | LQI: 28 | short addr: 00:25
2024-07-10 11:25:06 | Sensor 1 | count: 12 | 20.01°C | LQI: 40 | short addr: 00:25
2024-07-10 11:25:11 | Sensor 1 | count: 13 | 20.01°C | LQI: 31 | short addr: 00:25
2024-07-10 11:25:21 | Sensor 1 | count: 15 | 20.01°C | LQI: 31 | short addr: 00:25
```

（router1 台を水槽付近に設置）

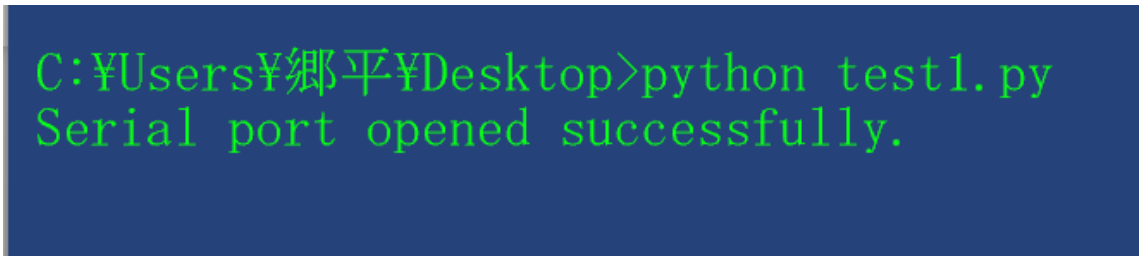
```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-10 11:42:59 | Sensor 1 | count: 2  | 20.01°C | LQI: 106 | short addr: 00:63
2024-07-10 11:43:04 | Sensor 1 | count: 3  | 20.01°C | LQI: 115 | short addr: 00:63
2024-07-10 11:43:09 | Sensor 1 | count: 4  | 20.01°C | LQI: 112 | short addr: 00:63
2024-07-10 11:43:14 | Sensor 1 | count: 5  | 20.01°C | LQI: 115 | short addr: 00:63
2024-07-10 11:43:19 | Sensor 1 | count: 6  | 20.01°C | LQI: 112 | short addr: 00:63
2024-07-10 11:43:24 | Sensor 1 | count: 7  | 20.01°C | LQI: 124 | short addr: 00:63
2024-07-10 11:43:29 | Sensor 1 | count: 8  | 20.01°C | LQI: 124 | short addr: 00:63
2024-07-10 11:43:34 | Sensor 1 | count: 9  | 20.01°C | LQI: 115 | short addr: 00:63
2024-07-10 11:43:39 | Sensor 1 | count: 10 | 20.01°C | LQI: 124 | short addr: 00:63
2024-07-10 11:43:44 | Sensor 1 | count: 11 | 20.01°C | LQI: 115 | short addr: 00:63
2024-07-10 11:43:49 | Sensor 1 | count: 12 | 20.01°C | LQI: 124 | short addr: 00:63
```

【デバイス間 8m の場合】

（通常）

```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-10 10:41:58 | Sensor 1 | count: 1 | 20.01°C | LQI: 64 | short addr: 00:05
2024-07-10 10:42:03 | Sensor 1 | count: 2 | 20.01°C | LQI: 49 | short addr: 00:05
2024-07-10 10:42:08 | Sensor 1 | count: 3 | 20.01°C | LQI: 55 | short addr: 00:05
2024-07-10 10:42:13 | Sensor 1 | count: 4 | 20.01°C | LQI: 58 | short addr: 00:05
2024-07-10 10:42:18 | Sensor 1 | count: 5 | 20.01°C | LQI: 61 | short addr: 00:05
2024-07-10 10:42:23 | Sensor 1 | count: 6 | 20.01°C | LQI: 58 | short addr: 00:05
2024-07-10 10:42:28 | Sensor 1 | count: 7 | 20.01°C | LQI: 61 | short addr: 00:05
2024-07-10 10:42:33 | Sensor 1 | count: 8 | 20.01°C | LQI: 61 | short addr: 00:05
2024-07-10 10:42:38 | Sensor 1 | count: 9 | 20.01°C | LQI: 43 | short addr: 00:05
2024-07-10 10:42:43 | Sensor 1 | count: 10 | 20.01°C | LQI: 52 | short addr: 00:05
2024-07-10 10:42:48 | Sensor 1 | count: 11 | 20.01°C | LQI: 49 | short addr: 00:05
2024-07-10 10:42:53 | Sensor 1 | count: 12 | 20.01°C | LQI: 46 | short addr: 00:05
2024-07-10 10:42:58 | Sensor 1 | count: 13 | 20.01°C | LQI: 58 | short addr: 00:05
2024-07-10 10:43:03 | Sensor 1 | count: 14 | 20.01°C | LQI: 55 | short addr: 00:05
2024-07-10 10:43:08 | Sensor 1 | count: 15 | 20.01°C | LQI: 52 | short addr: 00:05
2024-07-10 10:43:13 | Sensor 1 | count: 16 | 20.01°C | LQI: 52 | short addr: 00:05
2024-07-10 10:43:18 | Sensor 1 | count: 17 | 20.01°C | LQI: 49 | short addr: 00:05
2024-07-10 10:43:24 | Sensor 1 | count: 18 | 20.01°C | LQI: 31 | short addr: 00:05
2024-07-10 10:43:29 | Sensor 1 | count: 19 | 20.01°C | LQI: 40 | short addr: 00:05
```

（水中投下）



受信していない.

（router 1 台を設置した場合）

```
C:¥Users¥郷平¥Desktop>python test1.py
Serial port opened successfully.
2024-07-10 12:26:48 | Sensor 65 | count: 80 | 405.16°C | LQI: 58 | short addr: 00:50
2024-07-10 12:26:53 | Sensor 67 | count: 104 | 1340.95°C | LQI: 99 | short addr: 00:65
2024-07-10 12:26:58 | Sensor 116 | count: 97 | 867.66°C | LQI: 107 | short addr: 00:63
2024-07-10 12:27:03 | Sensor 101 | count: 110 | 405.11°C | LQI: 58 | short addr: 00:74
2024-07-10 12:27:08 | Sensor 110 | count: 104 | 1254.67°C | LQI: 110 | short addr: 00:61
2024-07-10 12:27:13 | Sensor 101 | count: 100 | 1479.33°C | LQI: 101 | short addr: 00:20
2024-07-10 12:27:18 | Sensor 110 | count: 116 | 712.53°C | LQI: 50 | short addr: 00:20
2024-07-10 12:27:23 | Sensor 10 | count: 1 | 1361.95°C | LQI: 132 | short addr: 00:01
2024-07-10 12:27:28 | Sensor 166 | count: 1 | 1174.45°C | LQI: 132 | short addr: 00:02
2024-07-10 12:27:33 | Sensor 166 | count: 1 | 1286.95°C | LQI: 132 | short addr: 00:03
```

データは受信しているが， 数値が正しくない.

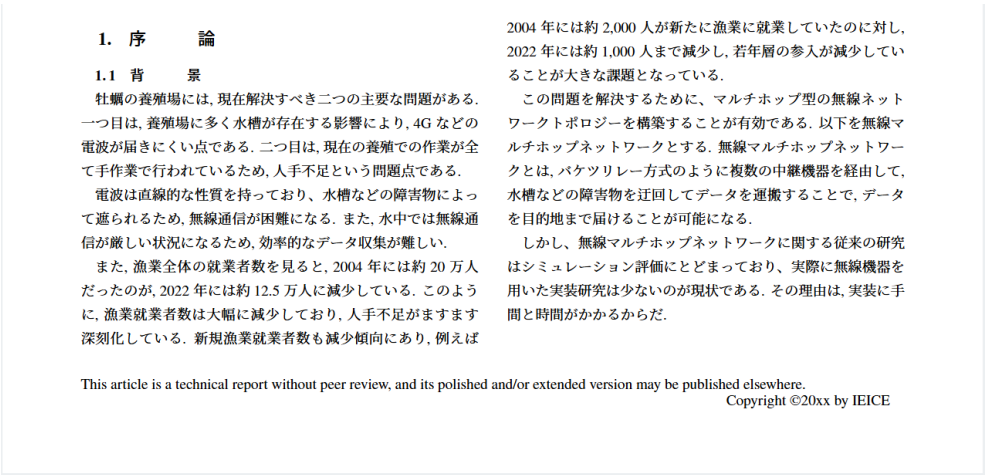
【リアルタイムでのグラフ描画】

Python の streamlit で，Enddevice ごとにグラフを描画すれば複数台を同時にモニタできる．

センサーデータをリアルタイムに可視化する Streamlit アプリを作る！（with ESP32）#Python - Qiita

【学会の原稿】

（序論）



1. 序　　論

1.1 背　　景

牡蠣の養殖場には，現在解決すべき二つの主要な問題がある．一つ目は，養殖場に多く水槽が存在する影響により，4G などの電波が届きにくい点である．二つ目は，現在の養殖での作業が全て手作業で行われているため，人手不足という問題点である．

電波は直線的な性質を持っており、水槽などの障害物によって遮られるため，無線通信が困難になる．また，水中では無線通信が厳しい状況になるため，効率的なデータ収集が難しい．

また，漁業全体の就業者数を見ると，2004 年には約 20 万人だったのが，2022 年には約 12.5 万人に減少している．このように，漁業就業者数は大幅に減少しており，人手不足がますます深刻化している．新規漁業就業者数も減少傾向にあり，例えば 2004 年には約 2,000 人が新たに漁業に就業していたのに対し，2022 年には約 1,000 人まで減少し，若年層の参入が減少していることが大きな課題となっている．

この問題を解決するために、マルチホップ型の無線ネットワークトポロジーを構築することが有効である．以下を無線マルチホップネットワークとする．無線マルチホップネットワークとは，バケツリレー方式のように複数の中継機器を経由して，水槽などの障害物を迂回してデータを運搬することで，データを目的地まで届けることが可能になる．

しかし、無線マルチホップネットワークに関する従来の研究はシミュレーション評価にとどまっており、実際に無線機器を用いた実装研究は少ないのが現状である．その理由は，実装に手間と時間がかかるからだ．

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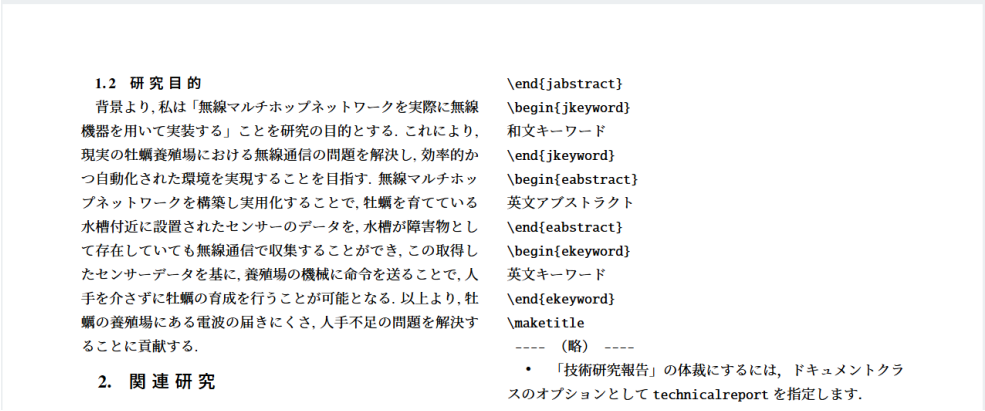

1.2 研 究 目 的

背景より，私は「無線マルチホップネットワークを実際に無線機器を用いて実装する」ことを研究の目的とする．これにより，現実の牡蠣養殖場における無線通信の問題を解決し，効率的かつ自動化された環境を実現することを目指す．無線マルチホップネットワークを構築し実用化することで，牡蠣を育てている水槽付近に設置されたセンサーのデータを，水槽が障害物として存在していても無線通信で収集することができ，この取得したセンサーデータを基に，養殖場の機械に命令を送ることで，人手を介さずに牡蠣の育成を行うことが可能となる．以上より，牡蠣の養殖場にある電波の届きにくさ，人手不足の問題を解決することに貢献する．

2. 関 連 研 究

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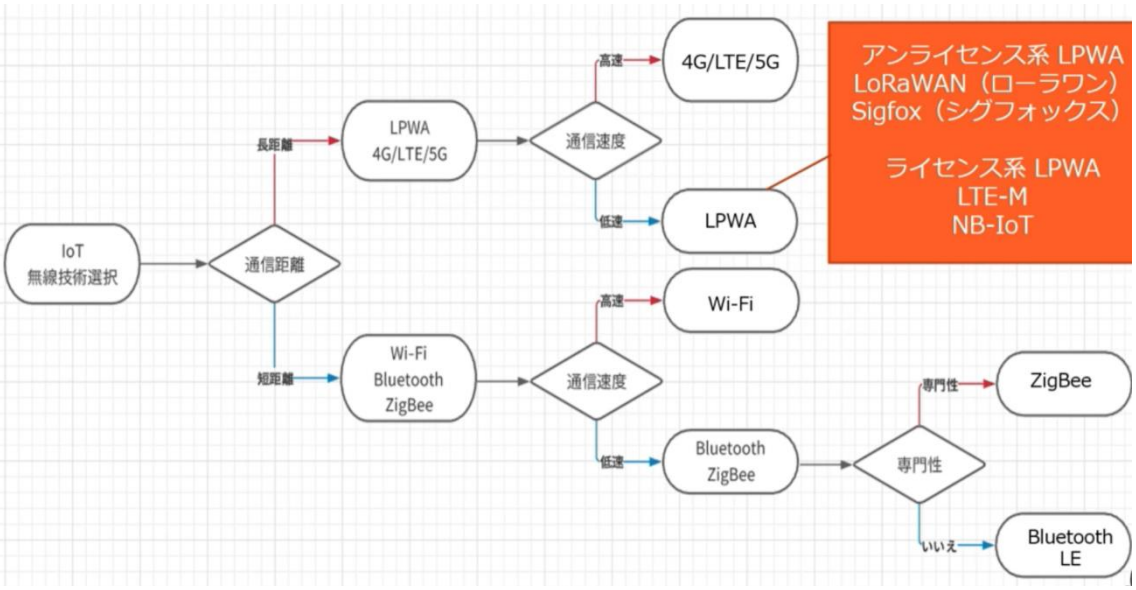
- 「技術研究報告」の体裁にするには，ドキュメントクラスのオプションとして technicalreport を指定します．

（関連論文）

1. ローカル５G →　高コスト
2. Wi-Fi　→壁などの障害物に弱いため，屋内との通信ができない（クラウドに接続する？）
3. LTE（４G）→　月額料金がかかる．(Nb-IoT は月数十円で利用可能)
4. LoRaWAN（Nb-IoT）
5. ZigBee


IoT
無線技術選択
通信距離
長距離
LPWA
4G/LTE/5G
通信速度
高速
4G/LTE/5G
低速
LPWA
アンライセンス系 LPWA
LoRaWAN（ローラワン）
Sigfox（シグフォックス）
ライセンス系 LPWA
LTE-M
NB-IoT
短距離
Wi-Fi
Bluetooth
ZigBee
通信速度
高速
Wi-Fi
低速
Bluetooth
ZigBee
専門性
専門性
ZigBee
いいえ
Bluetooth
LE