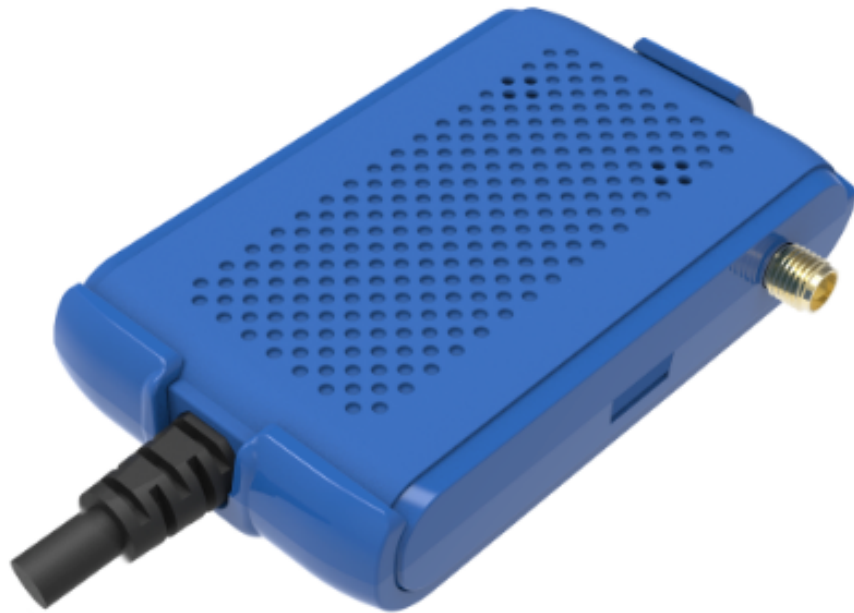

DAViD | LTE-M (Cat.M1) MODEM

사용자 안내서

Version 1.0 - 2022년 5월 10일



(주) 모빌리안



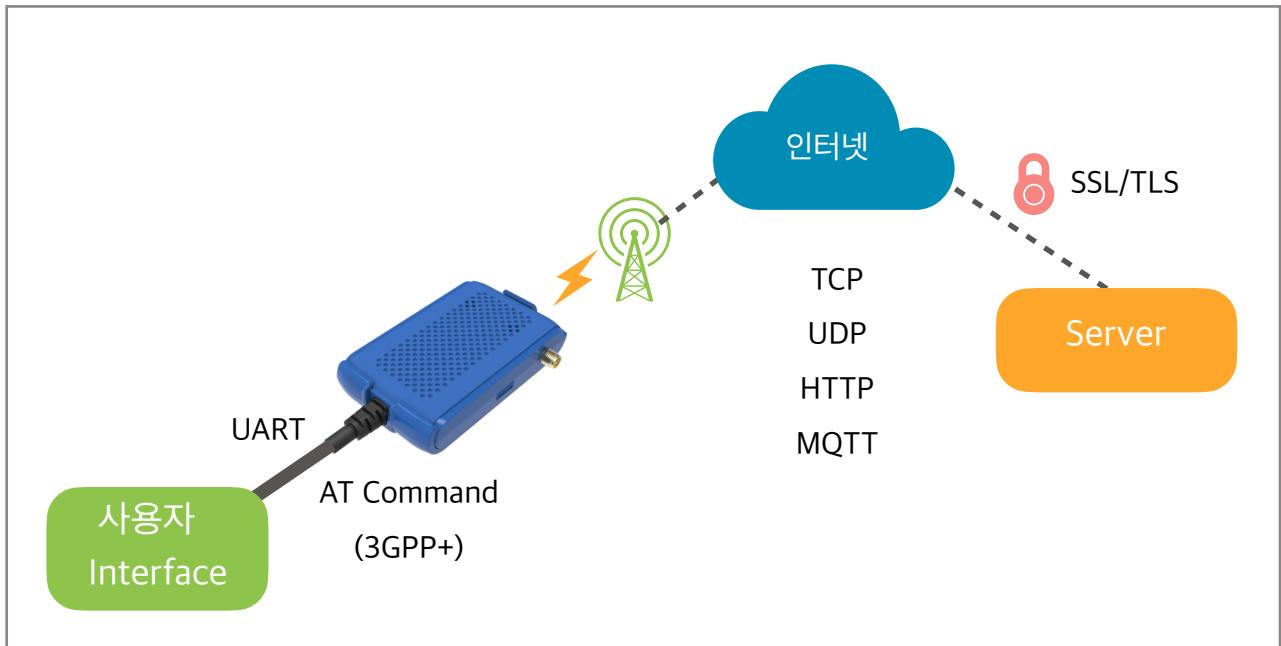
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1. DAViD 소개

DAViD는 최신의 저전력 LTE 기술을 이용한 LTE-M (Cat.M1) 모뎀으로, 사용자 장비가 언제나 인터넷 환경에 접속 할 수 있게 해 주는 전송장치이다.

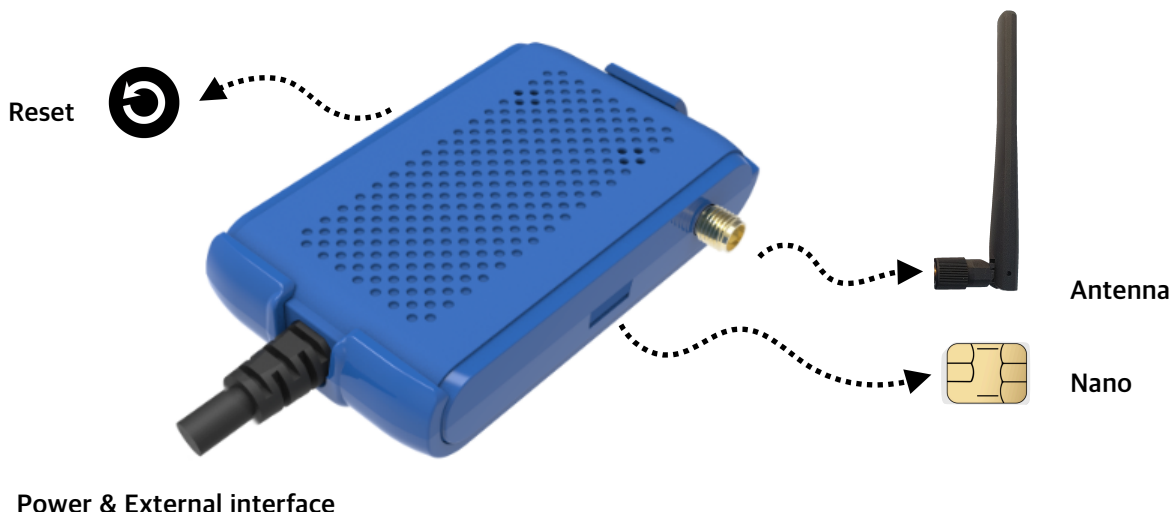
사용자는 TCP / UDP / HTTP / MQTT 프로토콜 및 SSL / TLS를 이용해 데이터를 안전하게 목적지까지 전송 할 수 있다. 이런 모든 기능은 UART 인터페이스를 통해 모뎀으로 3GPP 호환 AT 명령어를 전송하고 응답을 수신 받는 방식으로 구성되어 있다.



<그림1. 시스템 구성>

2. 하드웨어 사양

2.1. 제품 사양



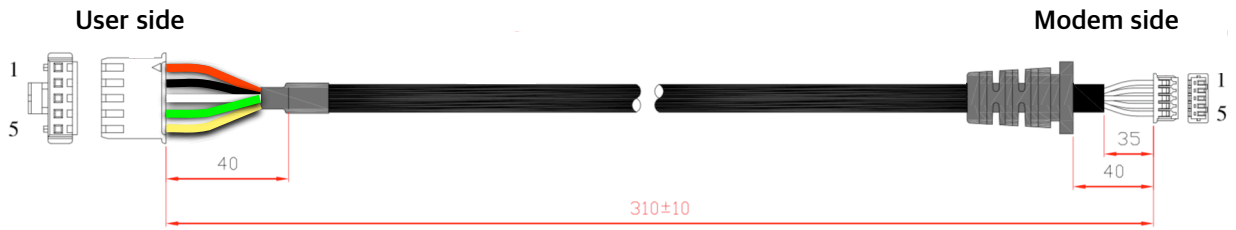
<그림2. 하드웨어 구성>

기능

- ▶ LTE-M / NB-IoT modem | Global Coverage
- ▶ Reset button & LEDs
- ▶ GPS *
- ▶ Bluetooth 5 *
- ▶ Low Power 3-axis Accelerometer *
- ▶ Serial Flash (32 Mbit)* | RTC *
- ▶ Silicon Labs CP210x USB to UART Converter*
- ▶ LiPo battery connector | Charger *
- ▶ AT command (3GPP+)
- ▶ TCP / UDP / HTTP / HTTPS / MQTT
- ▶ eDRX & PSM power saving modes
- ▶ SSL / TLS & Secure FOTA support
- ▶ 700 ~ 2200 MHz LTE band support
- ▶ 23 dBm output power
- ▶ IPv4 / IPv6

사양

Operating Voltage / Current	DC 5V / 400mA 이하	Battery Voltage	DC 3.2 ~ 4.2V
Dimensions	48(w) x 80(h) x 20(d)	External Interface	Power, UART, Reset
Throughput (DL/UL)	LTE-M : 300 / 375kbps NB-IoT : 30 / 69 kbps	RX Sensitivity	LTE-M : -108 dBm NB-IoT : -114 dBm
Antenna Gain	2 dBi	Radiation Pattern	Omni - Directional
Core	nRF9160 (Nordic Semiconductor)		



<그림3. 커넥터>

No.	Description	No.	Description	Ext.
1	VCC (5V)	3	Modem TxD	3.3v
2	GND	4	Modem RxD	
		5	nRESET (Active Low)	

User side 커넥터 : SMH250-05 (연호전자)

USIM

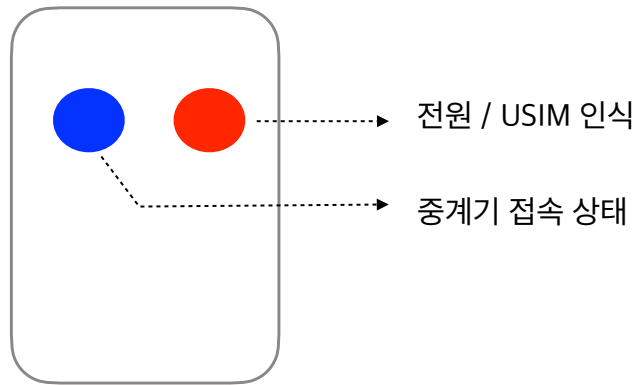
국내 이동통신사 (LG U+) 및 로밍유심 모두 지원

▶ LG U+ USIM

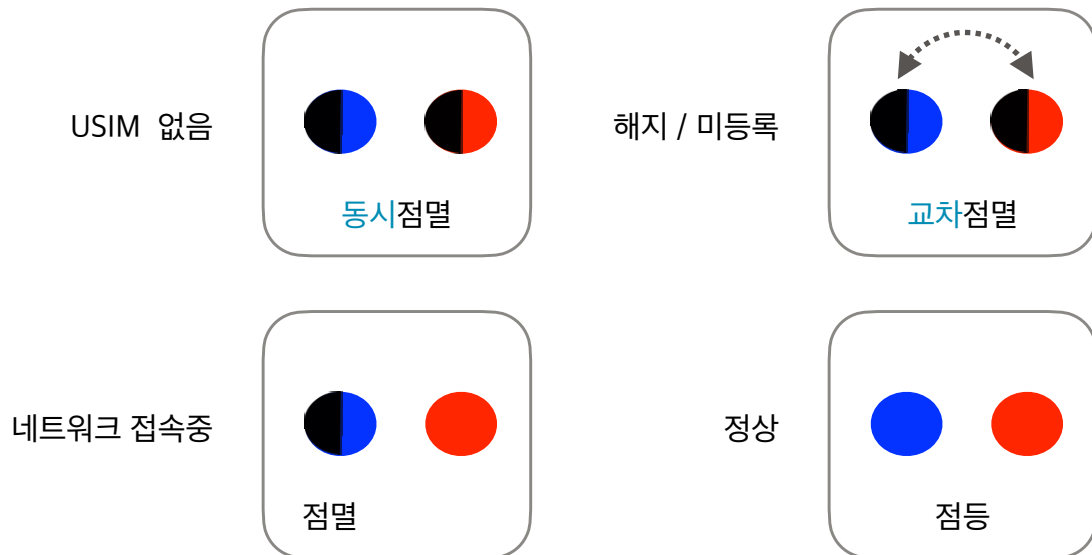
통신사 망 연동 적합성 인증 필요 (디바이스 검증 관리시스템)

2.2. 모뎀 상태 LED

DAViD 에 전원을 인가한 후 동작상태는 전면의 LED를 통해 확인 할 수 있다.



<그림4>LED 표시 기능>

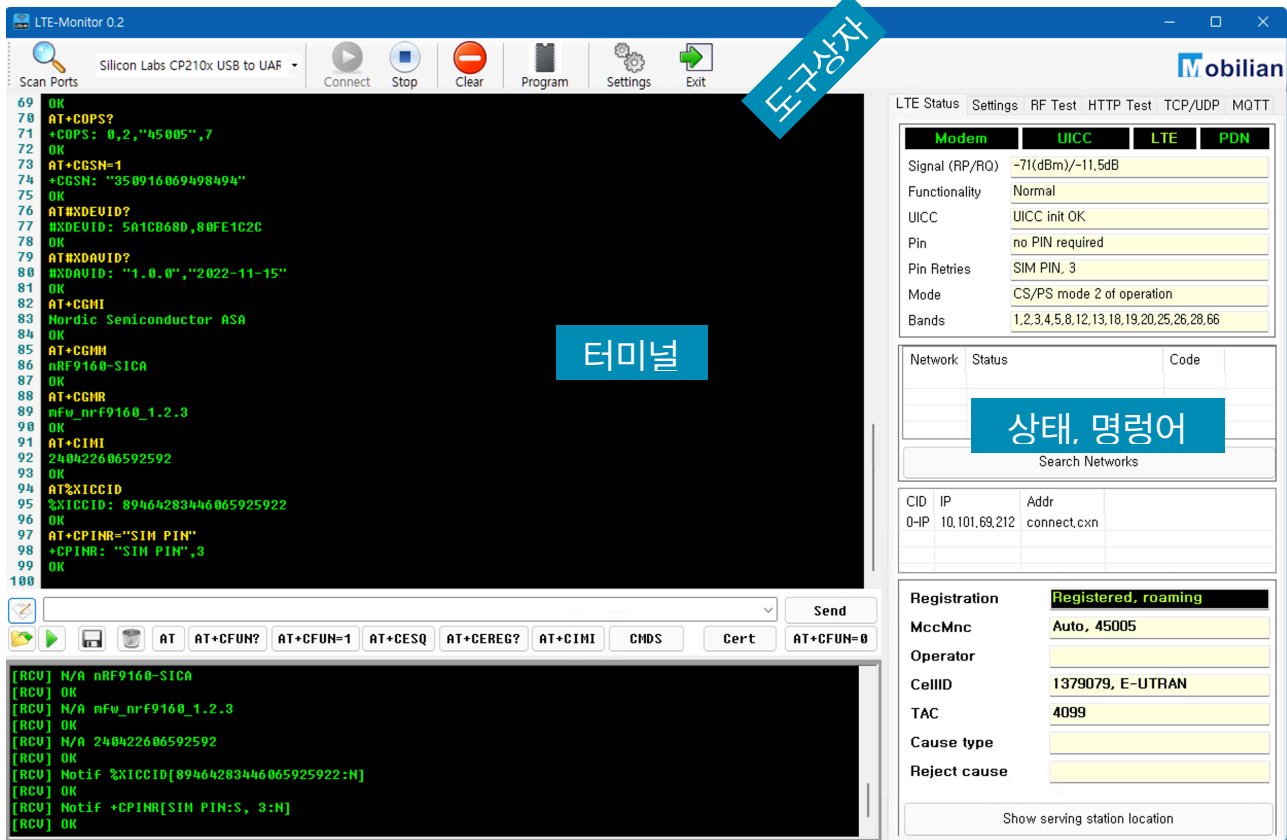


<그림5. 에러 유형별 LED 표시 >

3. LTE-Monitor 사용

DAViD의 기능을 테스트 할 수 있는 가장 간단한 방법으로 LTE-Monitor를 사용 할 수 있으며, 모빌리안 홈페이지에서 다운로드 받고 실행한다.

- ▶ 다운로드 URL : <https://www.mobilian.biz/repo/david/LTE-Monitor.zip>



- 그림3을 참고해서 USB-UART 모듈을 결선하고 PC에 연결한다
- 도구상자의 “Scan Ports”를 선택해서 연결된 장치를 고른 후 “Connect”를 선택하고 연결한다
- 자동으로 AT command가 실행되고 모뎀의 상태가 터미널창 및 우측의 Status 탭에 나타난다

4. AT command Syntax

AT command는 표준화된 문법 규칙으로 표현된다.

<angle bracket> : 문장의 필수 요소를 표현

[square bracket] : 문장의 Optional 요소를 표현

<CR><LF> : 문장의 종료 (명령 실행)

AT<확장 명령어 Symbol> : + (전화, 모뎀제어, SMS), %(Nordic 전용)

자세한 설명은 다음을 참조

- 3GPP 27.007 AT command set for User Equipment (UE) and 3GPP 27.005
- Data Terminal Equipment - Data Circuit terminating Equipment (DTE - DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS).

4.1. Set command <cmd>[=...]

Set commands set values or perform actions.

Example:

```
AT+CMD=1
```

where

- AT is the command line prefix
- + is the prefix for extended commands
- CMD is the body of a basic command
- 1 is a subparameter (multiple subparameters are separated by commas)

4.2. Read command <cmd>?

Read commands check the current values of subparameters.

Example:

where

```
AT+CMD?
```

- AT is the command line prefix
- + is the prefix for extended commands
- CMD is the body of a basic command
- ? represents a read command

4.3. Test command <CMD>=?

Test commands test the existence of the command and provide information about the type of its subparameters. Some test commands have also other functionality, which is described in the command-specific chapters.

Example:

```
AT+CMD=?
```

where

- AT is the command line prefix
- + is the prefix for extended commands
- CMD is the body of a basic command
- =? represents a test command for checking possible subparameter values

4.4 Response

AT responds to all commands with a final response.

The response is one of the following:

```
OK<CR><LF>
ERROR<CR><LF>
+CME ERROR: <cause_value><CR><LF>
+CMS ERROR: <cause_value><CR><LF>
```

"CMS ERROR:" is used as an error response for SMS related commands specified in 3GPP 27.005.

Some commands may also produce a varying number of information response lines before the final response. An information response can be received only when a command-specific response syntax is specified. An information response line usually starts with a prefix, which is the command entered:

```
+CMD: [...]<CR><LF>
```

Some commands may also produce notifications, which do not start with the command prefix:

```
AT+CGSN
490154203237518
OK
```

5. General command

모뎀이 지원하는 상세한 AT command는 다음을 문서를 통해 확인 바랍니다.

- ▶ https://www.mobilian.biz/repo/david/nrf91_at_commands-v2.0.pdf

5.1. Manufacturer identification +CGMI

The +CGMI command requests manufacturer identification.

```
AT+CGMI
```

```
Nordic Semiconductor ASA
```

```
OK
```

SET

5.2. Model identification +CGMM

The +CGMI command requests manufacturer identification.

```
AT+CGMM
```

```
nRF9160-SICA
```

```
OK
```

SET

5.3. Revision identification +CGMR

```
AT+CGMR
```

```
mfw_nrf9160_1.2.3
```

```
OK
```

SET

The +CGMR command requests modem firmware revision identification.

5.4.Product serial number identification +CGSN

The +CGSN command requests product serial number identification.

Syntax : +CGSN[=snt]

<snt>

- 0 - Respond with <sn> (default)
- 1 - Respond with +CGSN: <imei>
- 2 - Respond with +CGSN: <imeisv>
- 3 - Respond with +CGSN: <svn>

<sn>

Information text determined by the manufacturer. Up to 2048 characters.
Electronic Serial Number (ESN) returned if available. International Mobile
(Station) Equipment Identity (IMEI) returned if ESN not available.

<imei>

String in decimal format indicating the IMEI. Composed of Type Allocation Code
(TAC) (8 digits), Serial Number (SNR) (6 digits), and Check Digit (CD) (1 digit).

<imeisv>

String in decimal format indicating the International Mobile (Station) Equipment
Identity, Software Version (IMEISV). The 16 digits of IMEISV are composed of
TAC (8digits), SNR (6 digits), and Software Version Number (SVN) (2 digits).

<svn>

String in decimal format indicating the current SVN which is part of IMEISV.

AT+CGSN 352656100367872 OK	Reads Serial number	SET
AT+CGSN=1 +CGSN: "352656100367872" OK	Reads IMEI	SET

6. Mobile termination control and status commands

Mobile termination control and status commands are used for mobile-terminated power and indicator handling. Commands are listed for accessing Subscriber Identity Module (SIM)/ Universal Integrated Circuit Card (UICC) database records.

6.1.Functional mode +CFUN

The +CFUN command sets and reads the modem functional mode.

6.1.1. Set command

The set command sets the functional mode to Minimum (Power off), Normal, or Offline mode (Flightmode). There is a specific mode for Flight mode with UICC on. It is also possible to activate or deactivate LTE or Global Navigation Satellite System (GNSS) separately.

%XSYSTEMMODE should be used for enabling system modes. It is possible to activate enabled modes.

Syntax : +CFUN=<fun>

<fun>

0 – Sets the device to minimum functionality. Disables both transmit and receive RF circuits and deactivates LTE and GNSS services.

1 – Sets the device to full functionality. Active modes depend on the %XSYSTEMMODE setting.

AT+CFUN=1 OK	Activate the modem	SET
AT+CFUN=0 OK	Deactivate the modem	SET

6.1.2. Read command

The read command reads the current functional mode.

Response syntax : +CFUN=<fun>

AT+CFUN? +CFUN=1 OK	Read current functional mode	READ
---------------------------	------------------------------	------

6.2. Extended signal quality +CESQ

The +CESQ command returns received signal quality parameters. This command issues a valid response only when the modem is activated.

6.2.1. Set command

Syntax +CESQ

Response Syntax +CESQ: <rxlev>,<ber>,<rscp>,<ecno>,<rsrq>,<rsrp>

<rxlev>

99 - Not known or not detectable

<ber>

99 - Not known or not detectable

<rscp>

255 - Not known or not detectable

<ecno>

255 - Not known or not detectable

<rsrq>

0 rsrq < -19.5 dB

1 - When $-19.5 \text{ dB} \leq \text{RSRQ} < -19 \text{ dB}$

2 - When $-19 \text{ dB} \leq \text{RSRQ} < -18.5 \text{ dB}$

...

32 - When $-4 \text{ dB} \leq \text{RSRQ} < -3.5 \text{ dB}$

33 - When $-3.5 \text{ dB} \leq \text{RSRQ} < -3 \text{ dB}$

34 - When $-3 \text{ dB} \leq \text{RSRQ}$

255 - Not known or not detectable

The index value of RSRQ can be converted to decibel with the following formula:

Index $\times \frac{1}{2} - 19.5 = \text{dB}$. For example, $(32 \times \frac{1}{2}) - 19.5 = -3.5 \text{ dB}$.

<rsrp>

0 - RSRP < -140 dBm

1 - When $-140 \text{ dBm} \leq \text{RSRP} < -139 \text{ dBm}$

2 - When $-139 \text{ dBm} \leq \text{RSRP} < -138 \text{ dBm}$

...

95 - When $-46 \text{ dBm} \leq \text{RSRP} < -45 \text{ dBm}$

96 - When $-45 \text{ dBm} \leq \text{RSRP} < -44 \text{ dBm}$

97 - When $-44 \text{ dBm} \leq \text{RSRP}$

255 - Not known or not detectable

The index value of RSRP can be converted to decibel with the following formula:

Index - 140 = dBm. For example, $95 - 140 = -45 \text{ dBm}$.

The following command example reads the current signal quality, mapped Reference Signal ReceivedQuality (RSRQ) 31, and Reference Signal Received Power (RSRP) 62:

```
AT+CESQ
+CESQ: 99,99,255,255,31,62
OK
```

SET

6.3. SNR signal quality notification %XSNRSQ

The Nordic-proprietary %XSNRSQ command subscribes notifications of changes in Signal-to-Noise Ratio(SNR) signal quality.

6.3.1. Set command

The set command subscribes notifications of changes in SNR signal quality.

Syntax %XSNRSQ=<n>

Notification Syntax %XSNRSQ: <snr>,<threshold_index>,<srxlev>,<ce_level>

<n>

0 - Unsubscribe SNR signal quality notifications

1 - Subscribe SNR signal quality notifications

<snr>

0 - SNR < -24 dB

1 - When $-24 \text{ dB} \leq \text{SNR} < -23 \text{ dB}$

2 - When $-23 \text{ dB} \leq \text{SNR} < -22 \text{ dB}$

...

47 - When $22 \text{ dB} \leq \text{SNR} < 23 \text{ dB}$

48 - When $23 \text{ dB} \leq \text{SNR} < 24 \text{ dB}$

49 - When $24 \text{ dB} \leq \text{SNR}$

127 - Not known or not detectable

The index value of SNR can be converted to decibel with the following formula:

Index - 24 = dB. For example, 1 - 24 = -23 dB and 47 - 24 = 23 dB.

<threshold_index>

The index of the SNR threshold which is below the measured SNR value.

0 - SNR is below the first threshold

1 - SNR is between the first and second threshold

2 - SNR is between the second and third threshold

3 - SNR is between the third and fourth threshold

4 - SNR is above the fourth threshold

With default thresholds 16, 24, 32, and 40, the measured value 35 leads to index 3.

<srxlev>

0 - SRXLEV -127 or below -127

1 to 254 - SRXLEV -126 to 127

255 - SRXLEV above 127

32767 - Invalid or not know

<ce_level>

0 - CE Level 0. Normal coverage.

1 - CE Level 1. Enhanced coverage, according to LTE cell access criteria specified in 3GPP TS 36.304.

255 - Invalid or not known

The following command example subscribes E-UTRA signal quality notifications:

```
AT%XSNRSQ=1
OK
```

SET

The following notification example indicates that the measured average SNR has changed to 39 and is mapped to threshold 3:

```
%XSNRSQ: 39,3,130,1
```

Notification

6.3.2. Read command

The read command reads SNR signal quality.

Response syntax %XSNRSQ: <snr>,<srxlev>,<ce_level>

The following command example reads SNR signal quality:

```
AT%XSNRSQ?
%XSNRSQ: 39,168,0
OK
```

READ

6.4. Clock +CCLK

The +CCLK command sets the clock of the device.

6.4.1. Set command

The set command sets the real-time clock of the User Equipment (UE).

Syntax +CCLK=<time>

The set command parameter and its defined value are the following:

<time>

String. Current time in the format "yy/MM/dd,hh:mm:ss±zz", where the characters, from left to right, indicate year, month, day, hour, minutes, seconds, and time zone. Time zone indicates the difference, expressed in quarters of an hour, between the local time and GMT (value range from -48 to +48).

The following command example sets the real-time clock:

```
AT+CCLK="18/12/06,22:10:00+08"
```

```
OK
```

SET

6.4.2. Read command

The read command reads the real-time clock.

Response syntax +CCLK:<time>

<time>

String. Current time in the format "yy/MM/dd,hh:mm:ss±zz", where the characters, from left to right, indicate year, month, day, hour, minutes, seconds, and time zone. Time zone indicates the difference, expressed in quarters of an hour, between the local time and GMT (value range from -48 to +48).

The following command example reads the real-time clock:

```
AT+CCLK?
```

```
+CCLK: "18/12/06,22:10:00+08"
```

```
OK
```

SET

7. Network service related commands

7.1. Network registration status notification +CEREG

The set command subscribes unsolicited network status notifications.

7.1.1. Set command

The set command sets the real-time clock of the User Equipment (UE).

Syntax +CEREG=<n>

<n>

- 0 - Unsubscribe unsolicited result codes
- 1 - Subscribe unsolicited result codes +CEREG:<stat>
- 2 - Subscribe unsolicited result codes
+CEREG:<stat>[,<tac>,<ci>,<AcT>]
- 3 - Subscribe unsolicited result codes
+CEREG:<stat>[,<tac>,<ci>,<AcT>[,<cause_type>,<reject_cause>]]
- 4 - Subscribe unsolicited result codes +CEREG: <stat>[,<tac>],[<ci>],
[<AcT>][,[[<Active-Time>],[<Periodic-TAU>]]]]
- 5 - Subscribe unsolicited result codes +CEREG: <stat>[,<tac>],[<ci>],
[<AcT>][,[[<cause_type>],[<reject_cause>]][,[[<Active-Time>],
[<Periodic-TAU>]]]]]

The following command example subscribes notifications with level 5:

```
AT+CEREG=5
```

SET

```
OK
```

Unsolicited notification level 5, trying to attach:

Unsolicited notification level 5, registered:

```
+CEREG=2,"1003","00150B07",7,0,0,"11100000","11100000"
```

Notification

```
+CEREG=5,"1003","00150B07",7,,,"11100000","11100000"
```

Notification

7.1.2.Read command

The read command reads current network registration status.

Syntax +CEREG: <n>,<stat>[,<tac>],[<ci>],[<AcT>],[<cause_type>],[<reject_cause>]
[,<Active-Time>],[<Periodic-TAU>]]]

<n>

- 0 - Unsubscribe unsolicited result codes
- 1 - Subscribe unsolicited result codes +CEREG:<stat>
- 2 - Subscribe unsolicited result codes
+CEREG:<stat>[,<tac>,<ci>,<AcT>]
- 3 - Subscribe unsolicited result codes
+CEREG:<stat>[,<tac>,<ci>,<AcT>[,<cause_type>,<reject_cause>]]
- 4 - Subscribe unsolicited result codes +CEREG: <stat>[,<tac>],[<ci>],
[<AcT>][,[,<Active-Time>],[<Periodic-TAU>]]]
- 5 - Subscribe unsolicited result codes +CEREG: <stat>[,<tac>],[<ci>],
[<AcT>][,[,<cause_type>],[<reject_cause>][,<Active-Time>],
[<Periodic-TAU>]]]

<stat>

- 0 - Not registered. UE is not currently searching for an operator to register to.
- 1 - Registered, home network
- 2 - Not registered, but UE is currently trying to attach or searching an operator to register to
- 3 - Registration denied
- 4 - Unknown (for example, out of E-UTRAN coverage)
- 5 - Registered, roaming
- 90 - Not registered due to UICC failure

<tac>

String in hexadecimal format. 2-byte Tracking Area Code (TAC).

<ci>

String in hexadecimal format. 4-byte E-UTRAN cell ID.

<AcT>

- 7 - E-UTRAN
- 9 - E-UTRAN NB-S1

<cause_type>

0 - <reject_cause> contains an EPS Mobility Management (EMM) cause value.
See 3GPP TS 24.301 Annex A.

<reject_cause>

EMM cause value. See 3GPP TS 24.301 Annex A

The following command example reads the current registration status:

```
AT+CEREG?
```

READ

```
+CEREG=5,5,"1003","00150B07",7,,,"11100000","11100000"
```

```
OK
```

8. UICC

8.1. Request IMSI +CIMI

The +CIMI command reads the IMSI from the USIM card.

8.1.1. Set command

The set command reads the IMSI from the SIM card.

Syntax +CIMI

Response syntax <IMSI>

<IMSI>

String without double quotes. IMSI.

Note: ERROR is returned if IMSI is not available.

The following command example reads the IMSI string:

```
AT+CIMI
```

```
284011234567890
```

```
OK
```

READ

8.2. Request ICCID %XICCID

The Nordic-proprietary %XICCID command reads the Integrated Circuit Card Identifier (ICCID) from the USIM card.

8.2.1. Set command

The set command reads the ICCID from the USIM card.

Syntax %XICCID

Response syntax %XICCID: <ICCID>

The response parameter and its defined value are the following:

<ICCID>

String without double quotes. ICCID from the USIM card.

The following command example requests the ICCID of the USIM card:

```
AT%XICCID
```

```
%XICCID: 8901234567012345678F
```

```
OK
```

READ

8.3.Subscriber number +CNUM

The +CNUM command returns the subscriber Mobile Station International Subscriber Directory Number (MSISDN).

8.3.1. Set command

The set command reads the ICCID from the USIM card.

Syntax +CNUM

Response syntax +CNUM: ,<number1>,<type1>

An ERROR response is returned if MSISDN is not available on SIM card or if SIM card is not initialized.

The set command parameters and their defined values are the following:

<numberx>

String. Phone number of format specified by <typex>.

<typex>

Integer. Type of address octet (see 3GPP TS 24.008, subclause 10.5.4.7).

The following command example reads the subscriber number stored in the SIM:

```
AT+CNUM
```

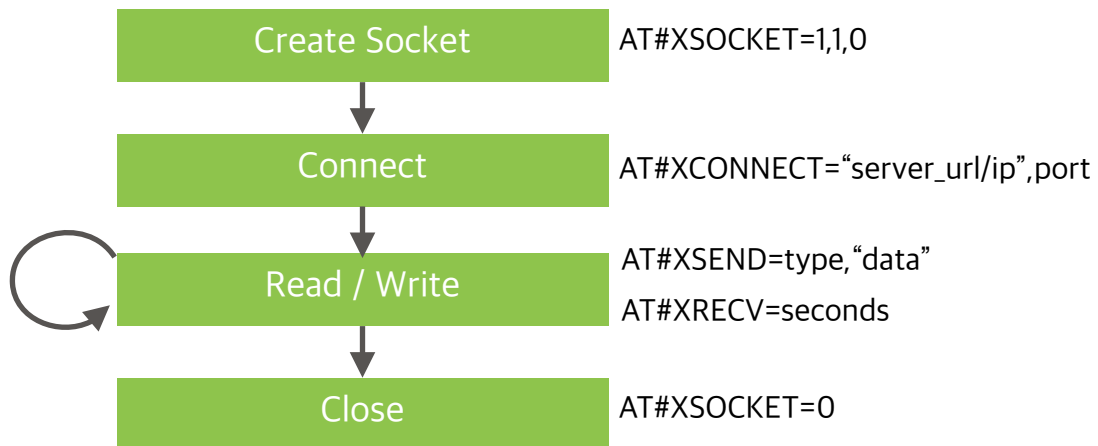
```
+CNUM: ,"+1234567891234",145
```

```
OK
```

READ

9. TCP / UDP

TCP/UDP를 이용해 서버에 데이터를 송.수신 하기 위한 절차는 다음의 순서를 참고한다.



상세한 설명은 TCP/IP AT commands 에서 확인하시고 LTE-Monitor를 통해 테스트 하십시오.

https://developer.nordicsemi.com/nRF_Connect_SDK/doc/1.5.1/nrf/applications/serial_lte_modem/doc/TCPIP_AT_commands.html

10. HTTP

상세한 설명은 HTTP Client commands에서 확인하시고 LTE-Monitor를 통해 테스트 하십시오.

https://developer.nordicsemi.com/nRF_Connect_SDK/doc/1.5.1/nrf/applications/serial_lte_modem/doc/HTTPC_AT_commands.html

11. MQTT

상세한 설명은 MQTT commands에서 확인하시고 LTE-Monitor를 통해 테스트 하십시오.

https://developer.nordicsemi.com/nRF_Connect_SDK/doc/1.5.1/nrf/applications/serial_lte_modem/doc/MQTT_AT_commands.html

12. Arduino examples

TCP / HTTP / MQTT에 대한 예제를 다운로드 하고 테스트 할 수 있습니다.

다운로드 URL : https://www.mobilian.biz/repo/david/arduino_examples.zip