

# OKI Semiconductor

## ML7012-04

### 2400 bps Single Chip Full Duplex Data Modem with Protocol

#### GENERAL DESCRIPTION

The ML7012-04 is a single chip modem LSI device that enables data communication conforming to ITU-T recommendations V.22bis, V.22, and V.21. This device is equipped with the error correction protocol function conforming to MNP Class 4. (The MNP Class 4 can be used for V.22bis or V.22.)

The ML7012-04 consists of high speed DSP, analog front end, and digital logic circuit. In addition, this device provides local analog loop testing, synchronous/asynchronous switching, dialing, and auto answering functions.

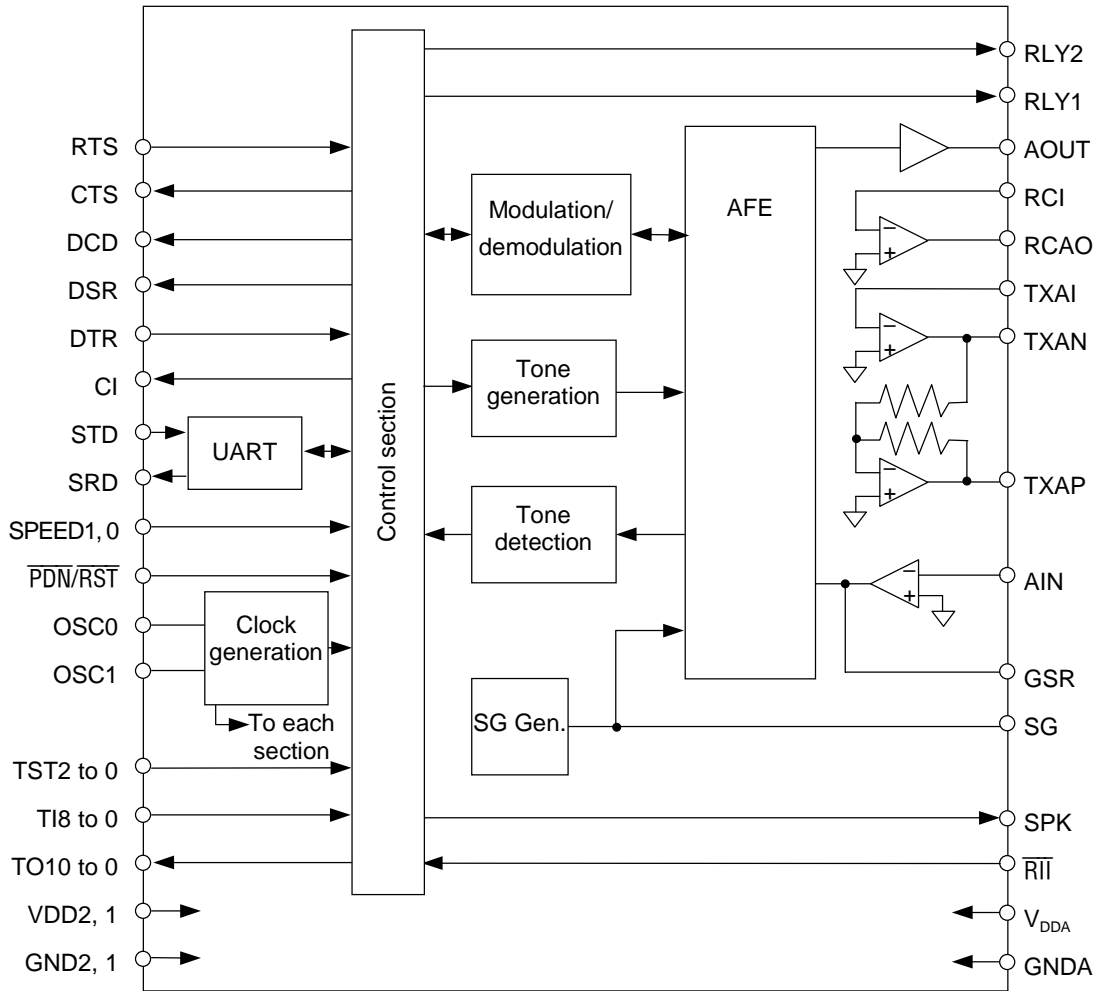
The ML7012-04 has a serial interface as an external interface. When integrated into the system, it is controlled from a control CPU through a serial interface (e.g. UART). By connecting a level converter, the ML7012-04 can easily implement a modem that can be controlled through the RS-232C interface.

#### FEATURES

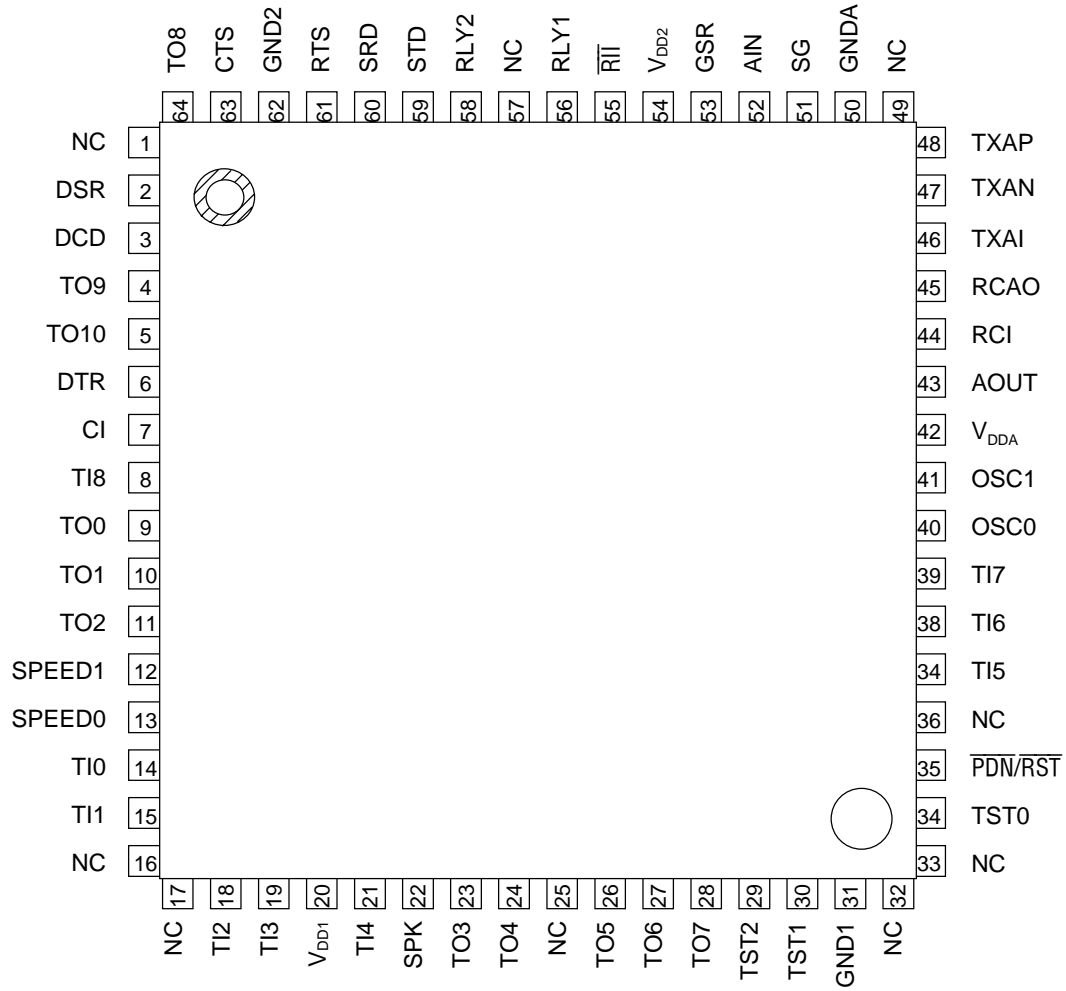
- Conforming to ITU-T Recommendations V.22 bis, V.22, and V.21: Asynchronous
- Error correction function conforming to MNP Class 4
- Serial interface: V.24 interface
- AT commands (excluding automatic command speed detection)
- Terminal data speed between DTE and DCE: 9600 bps, 2400 bps, 1200 bps, 300 bps
- Character format: 10 bit/character
- DTMF sending function
- Pulse-dial control signal output
- Call progress tone
- Auto answering function
- Built-in electronic HYB circuit (a line transformer can be directly coupled)
- Single +3 V power supply
- Power consumption: Typ. = 35 mA ( $V_{DD} = 3.3$  V)
- Package: 64-pin plastic QFP (QFP64-P-1414-0.80-BK) (Product name: ML7012-04GA)

\* MNP is a registered trademark of Microcom Inc.

**BLOCK DIAGRAM**



**PIN CONFIGURATION (TOP VIEW)**



**64-Pin Plastic QFP**

Note: Pins marked (NC) are no-connection pins which are left open.

## PIN DESCRIPTIONS

### System & Clock

| Symbol                      | I/O | Description  |
|-----------------------------|-----|--|
| OSCO                        | I   | Pins to connect crystal, resistors and capacitors for the master clock oscillation. When supplying the master clock from an external source, use OSC0 and leave OSC1 open.   |
| OSC1                        | O   | Master clock frequency = 11.0592 MHz. When $\overline{\text{PDN/RST}} = "0"$ , OSC1 = "1".   |
| $\overline{\text{PDN/RST}}$ | I   | <p>Power-down and reset control input pin. When <math>\overline{\text{PDN/RST}} = "0"</math>, this device is in the power-down state and internal circuits are reset.</p> <p>"0": Power-down state, "1": Normal operation</p> <p>After power-on, use this pin after setting it to "0" for 1 <math>\mu\text{s}</math> or more to reset internal circuits. Waiting for 230 ms or more is required until restarting a normal operation after reset release.</p> <p>If this pin remains at "0" after power-on, the internal circuits become undefined and the power-down current may increase. To avoid this, input "1" to this pin and start oscillation or input the master clock to operate the internal circuits, and then set it to "0"</p> |

### V.24 Serial Interface

| Symbol | I/O | Description  |
|--------|-----|--|
| STD    | I   | Send data input pin<br>0: Space, 1: Mark   |
| SRD    | O   | Receive data output pin<br>When $\overline{\text{PDN/RST}} = "0"$ , SRD outputs "1".<br>0: Space, 1: Mark                  |
| RTS    | I   | RTS (Request to Send) signal input pin<br>0: On, 1: Off  |
| CTS    | O   | CTS (Clear to Send) signal output pin<br>When $\overline{\text{PDN/RST}} = "0"$ , CTS outputs "1".<br>0: On, 1: Off        |
| DCD    | O   | DCD (Data Carrier Detect) signal output pin<br>When $\overline{\text{PDN/RST}} = "0"$ , DCD outputs "1".<br>0: On, 1: Off  |
| DSR    | O   | DSR (Data Set Ready) signal output pin<br>When $\overline{\text{PDN/RST}} = "0"$ , DSR outputs "1".<br>0: On, 1: Off       |
| DTR    | I   | DTR (Data Terminal Ready) signal input pin<br>0: On, 1: Off  |
| CI     | O   | CI (Calling Indicator) signal output pin (*2)<br>When $\overline{\text{PDN/RST}} = "0"$ , CI outputs "1".<br>0: On, 1: Off |

**Analog Interface**

| Symbol | I/O | Description   |
|--------|-----|---|
| AOUT   | O   | Transmit analog output pin<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , AOUT is in a high impedance state.                                       |
| RCI    | I   | Operational amplifier input pin constituting transmit RC active   |
| RCAO   | O   | Operational amplifier output pin constituting transmit RC active<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , RCAO is in a high impedance state. |
| TXAI   | I   | Input pin of the line transformer drive amplifier   |
| TXAN   | O   | Output pin of the line transformer drive amplifier (1)<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , TXAN is in a high impedance state.           |
| TXAP   | O   | Output pin of the line transformer drive amplifier (2)<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , TXAP is in a high impedance state.           |
| AIN    | I   | Input pin of the receive input amplifier  |
| GSR    | O   | Output pin of the receive input amplifier<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , GSR is in a high impedance state.                         |
| SG     | O   | Pin to connect capacitors for the SG circuit<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , SG is in a high impedance state.                       |

**PSTN Line Control Interface**

| Symbol                  | I/O | Description   |
|-------------------------|-----|---|
| RLY1                    | O   | Off-hook and pulse dial control signal output pin (*1)<br>0: On-hook or break state of pulse dial<br>1: Off-hook or make state of pulse dial<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , RLY1 outputs "0".  |
| RLY2                    | O   | The control signal output pin to disconnect interlinked telephones (*1)<br>0: PSTN is connected with interlinked telephones<br>1: PSTN is disconnected with interlinked telephones but connected with modem<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , RLY2 outputs "0". |
| $\overline{\text{RII}}$ | I   | Incoming signal input pin (*2)<br>Input "0" while detecting an incoming signal<br>Input "1" while not detecting an incoming signal<br>Fix this pin to "1" when a ring detector is not used.   |
| SPK                     | O   | Speaker control signal output pin<br>0: speaker On<br>1: speaker Off<br>When $\overline{\text{PDN}}/\overline{\text{RST}} = "0"$ , SPK outputs "1".   |

**Other Interface**

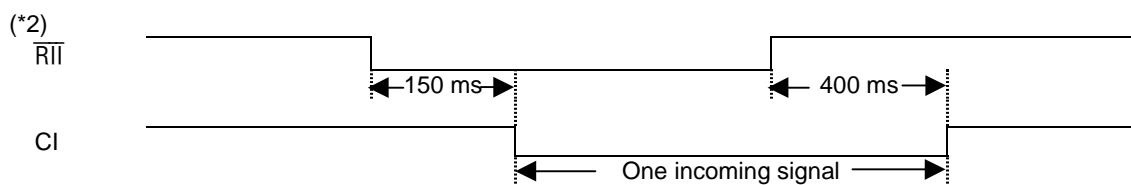
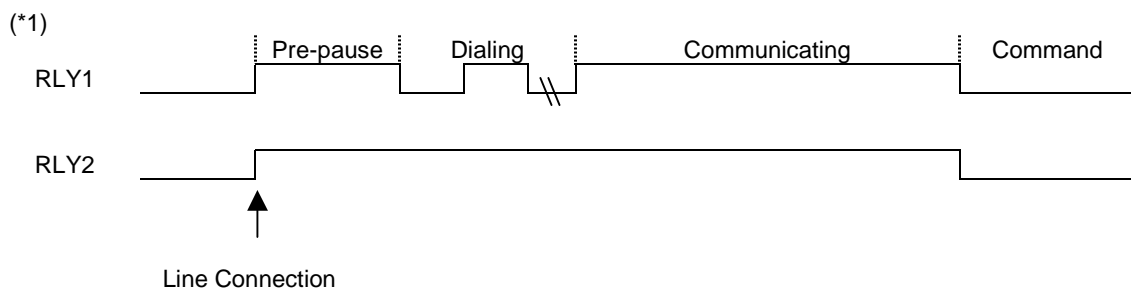
| Symbol  | I/O | Description                                 |         |          |
|---------|-----|---|---------|----------|
| Speed 1 | I   | Data Transmission Speed between DTE and DCE |         |          |
|         |     | Speed 1                                     | Speed 0 | Speed    |
|         |     | 0   | 0       | 300 bps  |
|         |     | 0   | 1       | 1200 bps |
| Speed 0 | I   | 1   | 0       | 2400 bps |
|         |     | 1   | 1       | 9600 bps |

**Test Interface**

| Symbol    | I/O | Description |
|-----------|-----|-------------|
| TST2 to 0 | I   | Input "0".  |
| TI8 to 0  | I   | Input "0".  |
| TO10 to 0 | O   | Leave open. |

**Power Supply**

| Symbol                | I/O | Description                 |
|-----------------------|-----|-----------------------------|
| V <sub>DDA</sub>      | I   | Analog V <sub>DD</sub> pin  |
| GND <sub>A</sub>      | I   | Analog GND pin              |
| V <sub>DD2 to 1</sub> | I   | Digital V <sub>DD</sub> pin |
| GND <sub>2 to 1</sub> | I   | Digital GND pin             |



**Absolute Maximum Ratings**

| Parameter                    | Symbol    | Rating                 | Unit |
|------------------------------|-----------|------------------------|------|
| Power Supply Voltage         | $V_{DD}$  | -0.3 to +5.0           | V    |
| Analog Input Voltage         | $V_{AIN}$ | -0.3 to $V_{DD} + 0.3$ | V    |
| Digital Input Voltage        | $V_{DIN}$ | -0.3 to $V_{DD} + 0.3$ | V    |
| Power dissipation            | $P_D$     | to 500                 | mW   |
| Output short-circuit current | $V_{OUT}$ | to 90                  | mA   |
| Storage Temperature          | $T_{STG}$ | -55 to +150            | °C   |

**Recommended Operating Conditions**

| Parameter                            | Symbol                                | Condition                                | Min.                                     | Typ.    | Max.                 | Unit |     |
|--------------------------------------|---------------------------------------|--|--|---------|----------------------|------|-----|
| Power Supply Voltage                 | $V_{DD}$                              | —  | 2.7                                      | —       | 3.6                  | V    |     |
| Operating Temperature                | $T_{OP}$                              | —  | -20                                      | +25     | +70                  | °C   |     |
| High Level Input Voltage             | $V_{IH}$                              | All digital input pins<br>excluding OSC0 | $0.7 \times V_{DD}$                      | —       | $V_{DD}$             | V    |     |
| Low Level Input Voltage              | $V_{IL}$                              |  | 0  | —       | $0.16 \times V_{DD}$ | V    |     |
| Digital Input Rise time              | $t_{ir}$                              | All digital input pins                   | —  | —       | 20                   | ns   |     |
| Digital Input Fall Time              | $t_{if}$                              |  | —  | —       | 20                   | ns   |     |
| Input Clock Frequency<br>Deviation   | FMCK                                  | 11.0592 MHz                              | -100                                     | —       | +100                 | ppm  |     |
| Master CLK Duty                      | DMCK                                  | Input to OSC0                            | 40                                       | 50      | 60                   | %    |     |
| Digital Output Load                  | $C_{DL}$                              | Digital output pin                       | —  | —       | 50                   | pF   |     |
| R1 to R3 Resistance Ratio<br>(R3/R1) | Rrat1                                 | —  | —  | 1       | 1.05                 | —    |     |
| R4 to R5 Resistance Ratio<br>(R5/R4) | Rrat2                                 | $V_{DD} \geq 3\text{ V}$                 | —  | —       | 2                    | —    |     |
|                                      | Rrat3                                 | $V_{DD} \geq 2.7\text{ V}$               | —  | —       | 1.6                  | —    |     |
| SG Bypass Capacitor                  | $C_{SG}$                              | SG pin                                   | 1  | —       | —                    | μF   |     |
| Oscillator Feedback<br>Resistance    | $R_{OSC}$                             | Between OSC0 and<br>OSC1                 | 800                                      | 1000    | 1200                 | kΩ   |     |
| OSC0 and OSC1 Load<br>Capacitance    | $C_{01}, C_{02}$                      | OSC0 and OSC1 pins                       | —  | 15      | —                    | pF   |     |
| Crystal                              | Oscillation<br>Frequency              | —  | —  | 11.0592 | —                    | MHz  |     |
|                                      | Frequency<br>Deviation                | —  | Including temperature<br>characteristics | -80     | —                    | +80  | ppm |
|                                      | Equivalent<br>Series<br>Resistance *1 | —  | —  | —       | —                    | 90   | Ω   |
|                                      | Load<br>Capacitance *1                | —  | —  | —       | 12                   | —    | pF  |

\*1: If the crystal manufacturer's evaluation is sufficiently verified, the values of equivalent series resistance and load capacitance may be changeable so long as the frequency deviation is within the range specified above.

**ELECTRICAL CHARACTERISTICS****DC Characteristics** $(V_{DD} = 2.7 \text{ to } 3.6 \text{ V}, T_a = -20 \text{ to } +70^\circ\text{C})$ 

| Parameter                         | Symbol    | Condition                  | Min.                | Typ.                 | Max. | Unit          |
|-----------------------------------|-----------|----------------------------|---------------------|----------------------|------|---------------|
| Power Supply Current              | $I_{DO}$  | —                          | —                   | 35                   | 65   | mA            |
|                                   | $I_{DDS}$ | Power-down mode *1         | —                   | 1                    | 1000 | $\mu\text{A}$ |
| Input Leakage Current             | $I_{IH}$  | $V_I = V_{DD}$             | —                   | 0                    | 20   | $\mu\text{A}$ |
|                                   | $I_{IL}$  | $V_I = 0 \text{ V}$        | —                   | 0                    | 20   | $\mu\text{A}$ |
| High Level Digital Output Voltage | $V_{OH}$  | $I_{OH} = -0.4 \text{ mA}$ | $0.8 \times V_{DD}$ | $0.99 \times V_{DD}$ | —    | V             |
| Low Level Digital Output Voltage  | $V_{OL}$  | $I_{OL} = 3.2 \text{ mA}$  | —                   | 0.1                  | 0.4  | V             |
| Input Capacitance                 | $C_{IN}$  | —                          | —                   | 5                    | —    | pF            |

\*1: In the case where the device is powered down after once activated.



## Analog Interface

 $(V_{DD} = 2.7 \text{ to } 3.6 \text{ V}, T_a = -20 \text{ to } +70^\circ\text{C})$ 

| Parameter  | Symbol    | Condition                   | Min.                                | Typ.  | Max.  | Unit      |     |
|--|-----------|-----------------------------|-------------------------------------|-------|-------|-----------|-----|
| Input Resistance                                 | $R_{IN}$  | RCI, TXAI, AIN              | —                                   | 10    | —     | $M\Omega$ |     |
| Output Load Resistance                           | $R_{L1}$  | AOUT, RAO, GSR              | 20                                  | —     | —     | $k\Omega$ |     |
|  | $R_{L2}$  | Between TXAN and TXAP       | 1080                                | —     | —     | $\Omega$  |     |
| Output Load Capacitance                          | $C_L$     | Analog output               | —                                   | —     | 100   | pF        |     |
| SG Output Voltage                                | $V_{SG}$  | SG                          | 1.3                                 | 1.4   | 1.65  | V         |     |
| SG Output Impedance                              | $R_{SG}$  | SG                          | —                                   | 30    | —     | $k\Omega$ |     |
| Carrier Output Level                             | VAOM      | AOUT, S34 = 0 dm            | -19.5                               | -18.0 | -16.0 | dBm       |     |
| DTMF Low Group Output Level                      | VDTL      | AOUT, S35 = 0 dm            | -17.0                               | -15.5 | -13.5 | dBm       |     |
| DTMF High Group Output Level                     | VDTH      | AOUT, S35 = 0 dm            | -16.0                               | -14.5 | -12.5 | dBm       |     |
| DTMF Output Frequency Precision                  | TSDF      | Against a nominal frequency | -1.5                                | —     | +1.5  | %         |     |
| Answer Tone Output Level                         | VAOAT     | AOUT, S34 = 0 dB            | -20                                 | -18.0 | -15.5 | dBm       |     |
| Answer Tone Output Frequency Precision           | TSAF      | Against 2100 Hz             | -10                                 | —     | +10   | Hz        |     |
| Undesired Sending Level                          | VS1       | TXAN,<br>TXAP               | 4 to 8 kHz                          | —     | —     | -20       | dBm |
|  | VS2       |                             | 8 to 12 kHz                         | —     | —     | -40       | dBm |
|  | VS3       |                             | 12 kHz or more<br>(each 4 kHz band) | —     | —     | -60       | dBm |
| Carrier Receive Input Level                      | VGSR      | GSR level                   | -46                                 | —     | -15   | dBm       |     |
| Carrier Detection Level                          | VON       | GSR level *2                | OFF → ON                            | -46   | —     | —         | dBm |
|  | VOFF      |                             | ON → OFF                            | —     | —     | -54       | dBm |
| Carrier Detection Delay Time                     | $t_{CDD}$ | —                           | OFF → ON                            | —     | 25    | ms        |     |
| Carrier Detection Hold Time                      | $t_{CDH}$ | —                           | ON → OFF                            | —     | 15    | ms        |     |
| Answer Tone Detection/Non-detection Level        | ATDL      | GSR level                   | —                                   | -50   | —     | dBm       |     |
|  |           |                             | —                                   | —     | —     | dBm       |     |
| Call Progress Tone Detection/Non-detection Level | CPDL      | GSR level                   | —                                   | -50   | —     | dBm       |     |
|  |           |                             | —                                   | —     | —     | dBm       |     |

\*1: The unit of the signal level (dBm) is  $0 \text{ dBm} = 0.775 \text{ Vrms}$ .

\*2: The values of the carrier detection level are those for QAM, PSK and FSK modulation signals.

## COMMAND DESCRIPTIONS

### AT Commands

#### (1) Command format

AT commands begin with <AT> or <at>. Character strings to a carriage return code are interpreted as commands to be executed successively. A result code is returned to DTE after the completion of interpretations.

|    |            |    |    |
|----|------------|----|----|
| AT | Characters | CR | LF |
|----|------------|----|----|

However, the commands of A, D, Dc, On, Zn, Ax, &Tn and &Zn must be set at the end of the sequence of commands.

Any commands set after those commands are ignored.

The maximum command character string is 40 characters (space <20h> is ignored).

Input characters can be deleted by a backspace function (a cord is changeable).

<CR> is a Carriage Return code (changeable).

<LF> is a Line Feed code (not mandatory and changeable).

Both capital and small letters can be recognized with the exception of At and aT. The communication with the terminal when inputting commands is handled as an asynchronous mode, and the character format is checked automatically as soon as <AT> or <at> is input.

This device cannot be guaranteed for normal operation when character strings or parameters not listed below are input.

#### (2) Terminal data speed and character format

The communication mode to DTE with the V.24 interface is as follows:

Terminal data speed: 9600/2400/1200/300 bps

Character format: Listed below

| Start Bit | Data Bit | Parity      | Stop Bit | Character Length |
|-----------|----------|-------------|----------|------------------|
| 1         | 7        | None        | 2        | 10               |
| 1         | 7        | Odd number  | 1        | 10               |
| 1         | 7        | Even number | 1        | 10               |
| 1         | 8        | None        | 1        | 10               |

## (3) AT command list

It is regarded that n = 0 when the parameter is not specified to the command with parameter (n).

| CMD           | Style | Function  | Initial Value | Note |
|---------------|-------|---|---------------|------|
| +++AT<br><CR> | —     | Goes to on-line command mode from data mode.<br>Inputs +++AT <CR> in data mode.<br>Does not move to on-line command mode until <CR> is input.   | —             |      |
| A             | ATA   | Starts line connection in answer mode   | —             |      |
|               | ATD   | Starts line connection in originate mode  | —             |      |
| D             | ATDc  | Connects lines in originate mode after dialing.<br>c: Dial control character<br>Pulse: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9<br>Tone: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, *, #<br><br>@ Silence Detection<br>Next dialing is executed when continuous silence of 5 sec is detected after ring back tone within the period specified in S7 register.<br>Sends back 'BUSY' when busy tone is detected and sends back 'NO ANSWER' when no silence is detected after ring back tone.<br><br>! Flash<br>Dialing is put on hold for the period specified in the S8 register for pause settings.<br><br>,Comma<br>The line is put on-hook for 0.5 sec.<br>Dialing is put on hold for the period specified in the S8 register for pause settings.<br><br>; Moves to command mode without disconnecting lines after dialing is completed.<br><br>P: Dials the number in pulse mode thereafter.<br>T: Dials the number in tone mode thereafter.<br>W: Detects a dial tone.<br>Detects the next dial string process when dial tone is detected during the period specified in S7 register regardless of ATXn command settings.<br>When it is not detected, 'NO DIALTONE' is returned. | —             |      |
| E             | ATEn  | Selects the answer-back function for the commands.<br>N = 0: No answer back for command input characters.<br>N = 1: Answer back for command input characters.   | 1             |      |
| H             | ATH   | Controls the line connection.<br>N = 0: On-hook<br>N = 1: Off-hook  | —             |      |
| I             | ATI   | Displays the modem manufacturer's code<br>'24A' as a result code is returned to DTE after ATIO<CR> is executed.   | —             |      |
| M             | ATMn  | Selects the monitor speaker operation.<br>N = 0: Always OFF<br>N = 1: ON from dialing to line connection<br>N = 2: Always ON<br>N = 3: ON when connected with a remote modem  | 1             |      |
| O             | ATO   | Goes to data mode from on-line command mode.  | —             |      |

| CMD | Style    | Function  | Initial Value | Note |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
|-----|----------|---|---------------|------|-----------------------------|--------------|--|----------|-------------|---|---|---|---|---|--|--|---|---|---|---|---|----------------------------|---------|---|---|---|---|---|-----------------------------|--------------|---|---|---|---|---|-----------------------------|--------------|---|---|---|---|---|---------------------|--------------|---|---|---|---|---|------------------------|------|---|--|
| P   | ATP      | Sets dialing mode to pulse.   | —             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| Q   | ATQn     | Selects the result code transmission.<br>n = 0: Result code is transmitted.<br>n = 1: Result code is not transmitted.   | 0             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| S   | ATSr     | Sets the pointer value for S resistor to "r".   | —             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
|     | ATSr?    | Echoes back the content of S resistor specified by "r".   | —             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
|     | ATSr = d | Sets the content of S resistor specified by "r" to "d".   | —             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| T   | ATT      | Sets dialing mode to DTMF.  | —             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| V   | ATVn     | Selects the type of result code.<br>n = 0: Number<br>n = 1: Characters  | 1             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| X   | ATXn     | Selects the extended result code and call progress tone detection.<br><br><table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="5">n</th> <th>Function</th> <th>Result Code</th> </tr> <tr> <th>0</th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td>o</td> <td>o</td> <td>o</td> <td>o</td> <td>o</td> <td>Line connection<br/>300 bps</td> <td>CONNECT</td> </tr> <tr> <td>—</td> <td>o</td> <td>o</td> <td>o</td> <td>o</td> <td>Line connection<br/>1200 bps</td> <td>CONNECT 1200</td> </tr> <tr> <td>—</td> <td>o</td> <td>o</td> <td>o</td> <td>o</td> <td>Line connection<br/>2400 bps</td> <td>CONNECT 2400</td> </tr> <tr> <td>—</td> <td>—</td> <td>o</td> <td>—</td> <td>o</td> <td>Dial tone detection</td> <td>NO DIAL TONE</td> </tr> <tr> <td>—</td> <td>—</td> <td>—</td> <td>o</td> <td>o</td> <td>Busy tone<br/>detection</td> <td>BUSY</td> </tr> </tbody> </table> | n             |      |                             |              |  | Function | Result Code | 0 | 1 | 2 | 3 | 4 |  |  | o | o | o | o | o | Line connection<br>300 bps | CONNECT | — | o | o | o | o | Line connection<br>1200 bps | CONNECT 1200 | — | o | o | o | o | Line connection<br>2400 bps | CONNECT 2400 | — | — | o | — | o | Dial tone detection | NO DIAL TONE | — | — | — | o | o | Busy tone<br>detection | BUSY | 4 |  |
| n   |          |   |               |      | Function                    | Result Code  |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| 0   | 1        | 2   | 3             | 4    |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| o   | o        | o   | o             | o    | Line connection<br>300 bps  | CONNECT      |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| —   | o        | o   | o             | o    | Line connection<br>1200 bps | CONNECT 1200 |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| —   | o        | o   | o             | o    | Line connection<br>2400 bps | CONNECT 2400 |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| —   | —        | o   | —             | o    | Dial tone detection         | NO DIAL TONE |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| —   | —        | —   | o             | o    | Busy tone<br>detection      | BUSY         |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| Z   | ATZ      | Reset in the same way the PDN/RST pin is set to "0".  | —             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| &C  | AT&Cn    | Controls data carrier detection signals (DCD).<br>n = 0: Always sets DCD to ON.<br>n = 1: Controls DCD by detecting reception carriers.   | 0             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| &D  | AT&Dn    | Controls the modem in DTR signal state.<br>n = 0: Ignores DTR signals.<br>n = 1: Ignores DTR signals. In data mode, however, moves to on-line command mode when DTR signals change from ON to OFF<br>n = 2, 3: Goes to command mode after disconnecting lines when the change of DTR from ON to OFF is detected during communication.   | 2             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| &G  | AT&Gn    | Sets the guard tone transmission.<br>n = 0: No guard tone<br>n = 1: With guard tone of 550 Hz<br>n = 2: With guard tone of 1800 Hz  | 0             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |
| &P  | AT&Pn    | Selects the make rates of pulse dialing.<br>n = 0: 39% (10 pps)<br>n = 1: 33% (10 pps)<br>n = 2: 33% (20 pps)   | 1             |      |                             |              |  |          |             |   |   |   |   |   |  |  |   |   |   |   |   |                            |         |   |   |   |   |   |                             |              |   |   |   |   |   |                             |              |   |   |   |   |   |                     |              |   |   |   |   |   |                        |      |   |  |

| CMD | Style | Function   | Initial Value | Note |
|-----|-------|--|---------------|------|
| &T  | AT&Tn | Controls the loop back test mode.<br>n = 0: None<br>n = 1: Starts local analog loop back test (ALB)<br>n = 2, 3: None<br>n = 4: Responds to the RDL test requirement<br>n = 5: Does not respond to the RDL test requirement<br>n = 6: Starts remote digital loop back test (RDL)<br>n = 7: Starts RDL self-diagnostic test.<br>n = 8: Starts ALB self-diagnostic test. | —             |      |
| %E  | AT%En | Selects automatic re-training function due to poor incoming conditions of the receive section.<br>n = 0: Automatic re-training is invalid.<br>n = 1: Automatic re-training is valid.   | 1             |      |
| \L  | AT\Ln | Checks the line type and displays the result.<br>n = 0: Checks PBX or direct line.<br>n = 1: Checks pulse or tone line.  | —             |      |
| \N  | AT\Nn | Selects data control mode.<br>n = 0,1: Selects normal mode (without error correction).<br>n = 2-5: None<br>n = 6: Selects reliable mode. Disconnects the line when MNP connection is not available.<br>n = 7: Selects auto-reliable mode. Connects in normal mode when MNP connection is not available.  | 7             |      |
| \Q  | AT\Qn | Selects the flow control between DTE and modem.<br>n = 0: No flow control<br>n = 1: None<br>n = 2: None<br>n = 3: Bi-directional control by CTS/RTS  | 3             |      |
| \V  | AT\Vn | Selects extended result code.<br>n = 0: Displays the normal result code.<br>n = 1: Displays the result code with the mode of the MNP connection.<br>n = 2, 3: None   | 0             |      |

**Result Code**

The result code is returned to DTE after AT command is executed.

Two types of result codes are available and can be selected by the Vn command. It is possible to select whether the result code is returned or not by using the Qn command.

The format of 2 types of result codes is as follows:

In the case of number     | number | CR | \_\_\_\_\_

In the case of characters     | CR | LF | Characters | CR | LF | \_\_\_\_\_

**Result Code List**

| Number | Character String | Meaning                              |
|--------|------------------|--------------------------------------|
| 0      | OK               | Command is correctly executed.       |
| 1      | CONNECT          | Connected                            |
| 2      | RING             | Incoming signal is detected.         |
| 3      | NO CARRIER       | Aborted the connection or on-hook    |
| 4      | ERROR            | Found the error in the command       |
| 5      | CONNECT 1200     | Connected at 1200 bps                |
| 6      | NO DIAL TONE     | Dial tone cannot be detected.        |
| 7      | BUSY             | Busy tone is detected.               |
| 8      | NO ANSWER        | Silence state cannot be detected.    |
| 10     | CONNECT 2400     | Connected at 2400 bps                |
| 12     | CONNECT 9600     | Connected at 9600 bps in normal mode |
| 22     | CONNECT 1200/REL | Connected at 1200 bps in MNP mode    |
| 23     | CONNECT 2400/REL | Connected at 2400 bps in MNP mode    |
| 90     | EXT              | Judged as PBX line                   |
| 91     | DIRECT           | Judged as a direct line              |
| 92     | DTMF             | Judged as a tone line                |
| 93     | PULSE            | Judged as a pulse line               |

## REGISTERS

### S Register Setting

In this modem, memory used as S Registers is provided in RAM to set variables used for modem environment settings or to read modem status.

Normal operation is not guaranteed when register numbers not specified in this data sheet or parameters outside the specification are input.

#### (1) S register setting

The format to set S registers is as follows:

AT<Sn> = <d>

<n> specifies the register No. from decimal 0 to 27, 34, and 35. <d> specifies the number to be set from decimal 0 to 255. If no number is specified at <n> and <d>, it is regarded as "0".

#### (2) S register reading

The format to read S registers is as follows:

ATS<n>?

<n> specifies the register No. from decimal 0 to 27, 34, and 35. If no number is specified at <n>, it is regarded as "0".

**S Register List**

Refer to the “Bit map S register list” if the function is specified as “Bit map register”.

| Register No. | Set Range | Unit       | Initial Value | Function   |
|--------------|-----------|------------|---------------|--|
| 0            | 0-255     | time       | 0             | Setting of the number to receive the ring signal at automatic receive mode. When set to “0”, automatic receive function is disabled.   |
| 1            | 0-255     | time       | 0             | The number of receiving rings  |
| 2            | —         | —          | —             | Not used   |
| 3            | 0-127     | ASCII code | 13            | Carriage return code   |
| 4            | 0-127     | ASCII code | 10            | Line feed code   |
| 5            | 0-127     | ASCII code | 8             | Back space code  |
| 6            | 4-255     | sec        | 4             | Pause time from off-hook to start dialing (Only when setting ATX0, X1, and X3)   |
| 7            | 1-115     | sec        | 60            | Waiting time for carrier from the far end modem. It is set to on-hook when no carrier is detected after the time specified.  |
| 8            | 0-255     | sec        | 2             | Pause time for dialing. It is referred when dial character < , > is used.  |
| 9            | —         | —          | —             | Not used   |
| 10           | 1-255     | 1/10 sec   | 14            | Carrier lost detection time<br>It is set to on-hook automatically when the lost of carrier signal is longer than the specified time.<br>Carrier lost detection is invalid when 255 is set. |
| 11           | 1-255     | 1/100 sec  | 9             | DTMF tone transmit time<br>Sets DTMF transmit time. DTMF tone is continuously transmitted when set at 255.   |
| 12           | —         | —          | —             | Not used   |
| 13           | —         | —          | —             | Not used   |
| 14           | —         | —          | 170           | Bit map register   |
| 15           | —         | —          | —             | Not used   |
| 16           | —         | —          | 0             | Bit map register   |
| 17           | —         | —          | —             | Not used   |
| 18           | 0-255     | sec        | 0             | Timer for loop back test   |
| 19           | —         | —          | —             | Not used   |
| 20           | —         | —          | —             | Not used   |
| 21           | —         | —          | 18            | Bit map register   |
| 22           | —         | —          | 244           | Bit map register   |
| 23           | —         | —          | 23            | Bit map register   |
| 24 to 27     | —         | —          | —             | Not used   |
| 34*          | 0-255     | dB         | 2             | Sets the level attenuator of transmit carrier.<br>When 15 to 255 is input, value is fixed to 15.   |
| 35*          | 0-255     | dB         | 0             | Sets the sending level attenuator of DTMF signal.<br>When 15 to 255 is input, value is fixed to 15.  |

\*Refer to the “Analog Interface Characteristics” for the analog transmit level for S34 and S35.



## Bit Map Register List

| S14 |               |                                   |   |         |
|-----|---------------|-----------------------------------|---|---------|
| Bit | Initial value | Function in 0 setting             | Function in 1 setting                       | Command |
| 7   | 1             | Answer mode                       | Originate mode                              | A, D    |
| 6   | 0             | Not used                          | Not used                                    |         |
| 5   | 1             | Tone dial                         | Pulse dial                                  | T, P    |
| 4   | 0             | Pulse speed 10 pps                | Pulse speed 20 pps                          | &P      |
| 3   | 1             | Makes the result code the number. | Makes the result code the character string. | V       |
| 2   | 0             | With the result code              | No result code                              | Q       |
| 1   | 1             | No echo back                      | With echo back                              | E       |
| 0   | 0             | Not used                          | Not used                                    |         |

| S16 |               |   |   |         |
|-----|---------------|---|---|---------|
| Bit | Initial value | Function in 0 setting                           | Function in 1 setting                         | Command |
| 7   | 0             | Not used  | Not used                                      |         |
| 6   | 0             | Stops analog loop back self-diagnostic.         | Analog loop back self-diagnostic test         | &T8     |
| 5   | 0             | Stops remote digital loop back self-diagnostic. | Remote digital loop back self-diagnostic test | &T7     |
| 4   | 0             | Stops remote digital loop back test.            | Remote digital loop back test                 | &T6     |
| 3   | 0             | Not used  | Not used                                      |         |
| 2   | 0             | Not used  | Not used                                      |         |
| 1   | 0             | Not used  | Not used                                      |         |
| 0   | 0             | Stops analog loop back test.                    | Analog loop back test                         | &T1     |

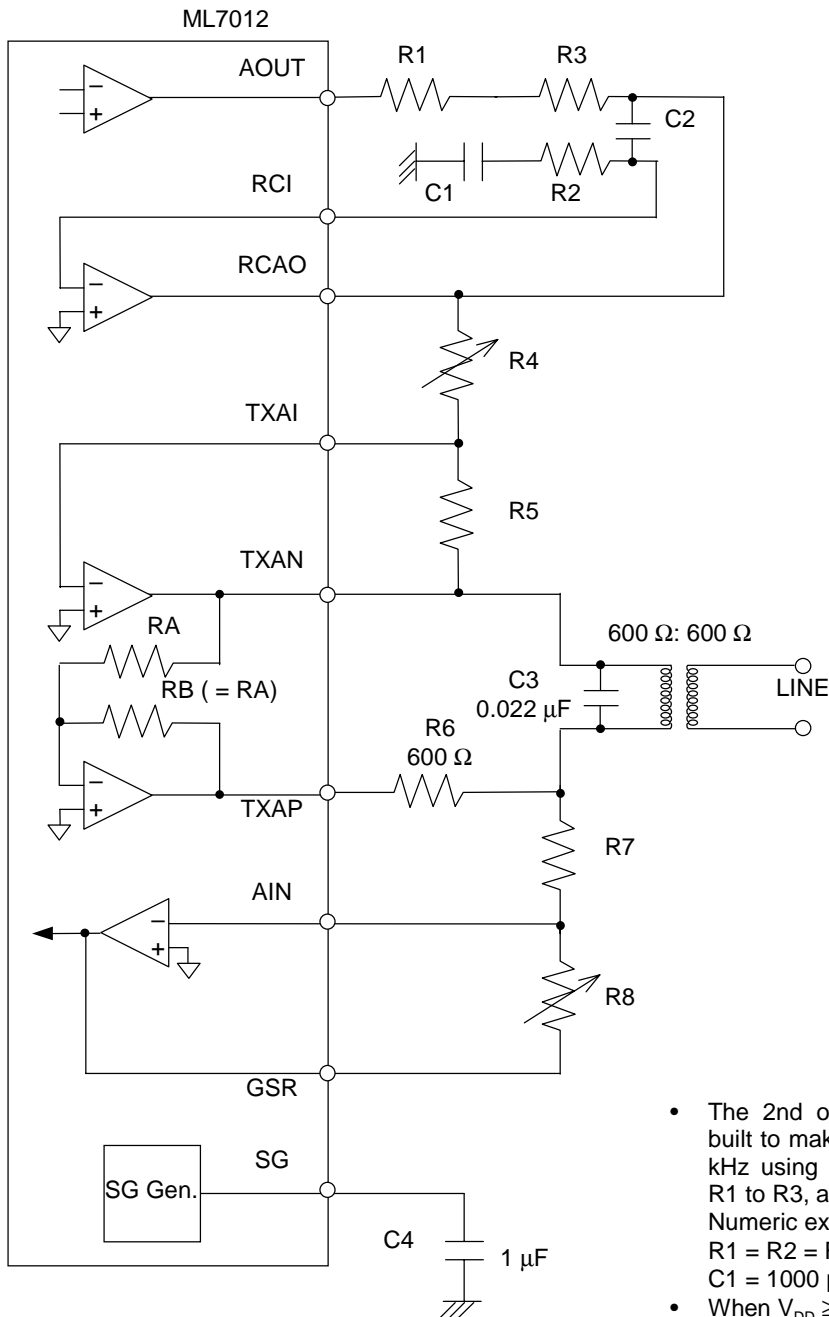
| S21 |             |                                |                                       |                   |
|-----|-------------|--------------------------------|---------------------------------------|-------------------|
| Bit | First value | Function in 0 setting          | Function in 1 setting                 | command           |
| 7   | 0           | Does not break                 | Breaks                                | Y                 |
| 6   | 0           | DSR signal is always ON.       | DSR signal operates by ITU-T.         | &S                |
| 5   | 0           | CD signal is always ON.        | CD signal is ON by carrier detection. | &C                |
| 4   | 1           | 0 <input type="checkbox"/> &D0 | 1 <input type="checkbox"/> &D2        | &D<br>DTR Control |
| 3   | 0           | 0 <input type="checkbox"/> &D0 | 1 <input type="checkbox"/> &D3        |                   |
| 2   | 0           | Not used                       | Not used                              |                   |
| 1   | 1           | Auto re-train disabled         | Auto re-train enabled                 | %E                |
| 0   | 0           | Not used                       | Not used                              |                   |

| S22 |               |                            |                            |                            |                            |                          |
|-----|---------------|----------------------------|----------------------------|----------------------------|----------------------------|--------------------------|
| Bit | Initial value | Function in 0 setting      |                            | Function in 1 setting      |                            | Command                  |
| 7   | 1             | Pulse dial make rate 39%   |                            | Pulse dial make rate 33%   |                            | &P                       |
| 6   | 1             | 0 <input type="checkbox"/> | 1 <input type="checkbox"/> | 1 <input type="checkbox"/> | 1 <input type="checkbox"/> | X<br>Extended<br>command |
| 5   | 1             | 0 <input type="checkbox"/> | 0 <input type="checkbox"/> | 1 <input type="checkbox"/> | 1 <input type="checkbox"/> |                          |
| 4   | 1             | 0 <input type="checkbox"/> | 0 <input type="checkbox"/> | 1 <input type="checkbox"/> | 1 <input type="checkbox"/> |                          |
| 3   | 0             | 0 <input type="checkbox"/> | 0 <input type="checkbox"/> | 1 <input type="checkbox"/> | 1 <input type="checkbox"/> | M                        |
| 2   | 1             | 0 <input type="checkbox"/> | 1 <input type="checkbox"/> | 0 <input type="checkbox"/> | 1 <input type="checkbox"/> |                          |
| 1   | 0             | Not used                   |                            | Not used                   |                            |                          |
| 0   | 0             | Not used                   |                            | Not used                   |                            |                          |

| S23 |               |   |                            |   |                            |          |
|-----|---------------|---|----------------------------|---|----------------------------|----------|
| Bit | Initial value | Function in 0 setting                         |                            | Function in 1 setting                             |                            | Command  |
| 7   | 0             | 0 <input type="checkbox"/>                    | 0 <input type="checkbox"/> | 1 <input type="checkbox"/>                        | 1 <input type="checkbox"/> | &G       |
| 6   | 0             | 0 <input type="checkbox"/>                    | 1 <input type="checkbox"/> | 0 <input type="checkbox"/>                        | 1 <input type="checkbox"/> |          |
| 5   | 0             | 0 <input type="checkbox"/>                    | 0 <input type="checkbox"/> | 1 <input type="checkbox"/>                        | 1 <input type="checkbox"/> |          |
| 4   | 1             | 0 <input type="checkbox"/>                    | 1 <input type="checkbox"/> | 0 <input type="checkbox"/>                        | 1 <input type="checkbox"/> |          |
| 3   | 0             | Not used                                      |                            | Not used  |                            |          |
| 2   | 1             | Not used                                      |                            | Not used  |                            |          |
| 1   | 1             | Not used                                      |                            | Not used  |                            |          |
| 0   | 1             | Ignores the remote digital loop back request. |                            | Responds to the remote digital loop back request. |                            | &T4, &T5 |

APPLICATION CIRCUITS

Analog Interface



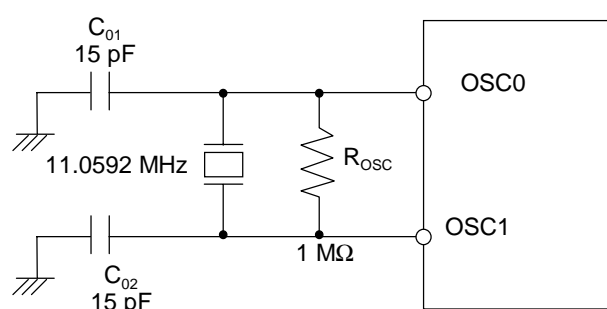
- The 2nd order LPF should be built to make  $f_c$  approximately 5 kHz using the built-in amplifier, R1 to R3, and C1 and C2.  
 Numeric examples:  
 $R1 = R2 = R3 = 68 \text{ k}\Omega$   
 $C1 = 1000 \text{ pF}$ ,  $C2 = 220 \text{ pF}$
- When  $V_{DD} \geq 3 \text{ V}$ ,  $R5/R4 \leq 2$ .
- When  $V_{DD} < 3 \text{ V}$ ,  $R5/R4 \leq 1.6$ .

### Examples of Level Diagram

- (1) Modem transmit:  $V_{DD} \geq 3$  V  
 AOUT = -20 dBm, RCAO = -20 dBm, TXAN = -14 dBm, TXAP = -14 dBm, LINE = -16 dBm  
 (S34 = 2 dB (initial value), R5/R4 = 2, transformer loss = 2 dB)
- (2) DTMF transmit:  $V_{DD} \geq 3$  V: high group level  
 The low group levels are approximately 1 dB smaller than the values below.  
 AOUT = -14.5 dBm, RCAO = -14.5 dBm, TXAN = -8.5 dBm, TXAP = -8.5 dBm, LINE = -10.5 dBm  
 (S35 = 0 dB (initial value), R5/R4 = 2, transformer loss = 2 dB)
- (3) Modem transmit:  $V_{DD} \geq 2.7$  V  
 AOUT = -20 dBm, RCAO = -20 dBm, TXAN = -15.9 dBm, TXAP = -15.9 dBm, LINE = -17.9 dBm  
 (S34 = 2 dB (initial value), R5/R4 = 1.6, transformer loss = 2 dB)
- (4) DTMF transmit:  $V_{DD} \geq 2.7$  V: high group level  
 The low group levels are approximately 1 dB smaller than the values below.  
 AOUT = -14.5 dBm, RCAO = -14.5 dBm, TXAN = -10.4 dBm, TXAP = -10.4 dBm, LINE = -12.4 dBm  
 (S35 = 0 dB (initial value), R5/R4 = -1.6, transformer loss 2 dB)
- (5) Maximum modem receive:  
 LINE = -9 dBm, connecting point of R6, and R7 = -11 dBm, GSR = -15 dBm  
 (R8/R7 = 0.63 = -4 dB, transformer loss = 2 dB)
- (6) Minimum modem receive  
 LINE = -40 dBm, connecting point of R6 and R7 = -42 dBm, GSR = -46 dBm  
 (R8/R7 = 0.63 = -4 dB, transformer loss = 2 dB)

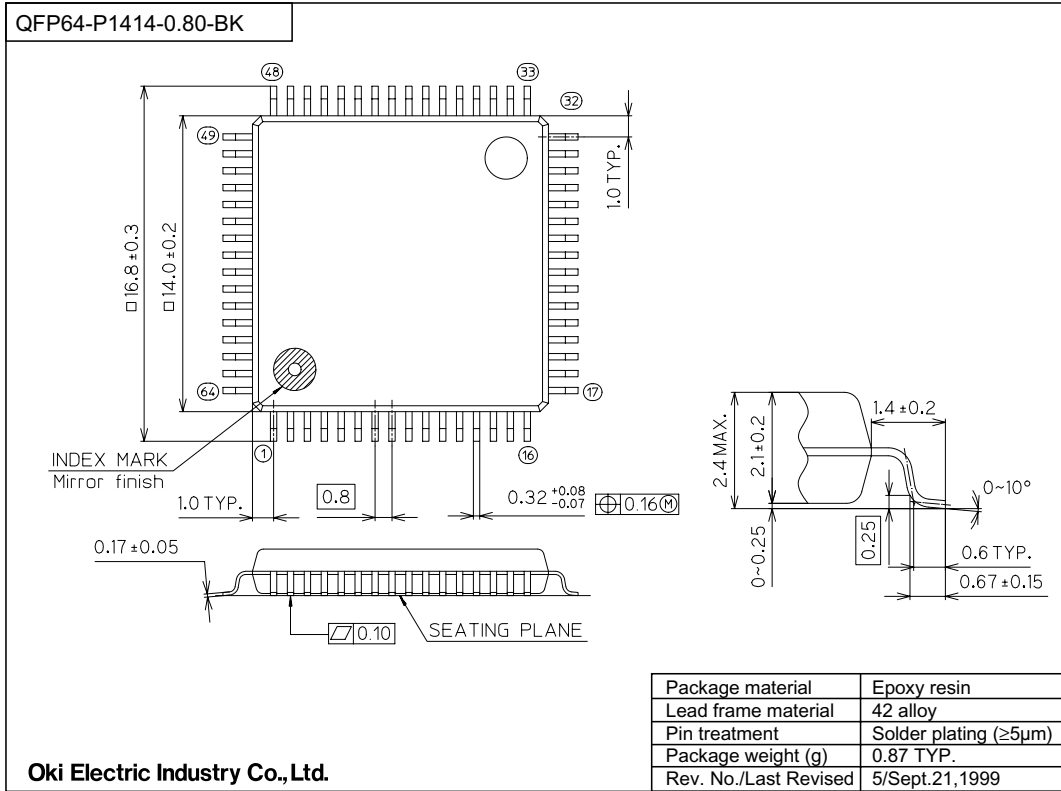
### Connection of Crystal Oscillator

Connect a 11.0592 MHz crystal unit and a 1 M $\Omega$  feedback resistor between OSC0 and OSC1.  
 The values of capacitors  $C_{01}$  and  $C_{02}$  connected between OSC0 and GND, and OSC1 and GND vary with the load capacitance of the crystal unit and the wiring capacitance of the board. Set the values by the crystal manufacture's matching evaluation.  
 If an external clock is used, input it to OSC0.



**PACKAGE DIMENSIONS**

(Unit: mm)



**Notes for Mounting the Surface Mount Type Package**

The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact Oki's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

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