# Si2400 Design Checklist and Troubleshooting Guide

## Introduction

The following information is intended to aide in the development of an Si2400 application, and it is recommended that the points contained in the design checklist be carefully considered before completion of a design using the Si2400 chipset. While it is impossible to cover all the issues for every design, the important issues involved in most systems that include a modem are discussed. In addition to a design checklist, a troubleshooting guide that highlights the most common issues involving the integration of the Si2400 chipset into a system is included for aid in system debug.

## Design Checklist

Checklists for the schematic, layout, and host modem software are discussed below.

### Schematic

There are not many variations that can be made to the Si2400 data sheet schematic. Accordingly, except for the notes at the bottom of the bill of materials (Table 9), the schematic and bill of materials should be followed exactly as outlined in the Si2400 data sheet.

❑ Compare final schematic, part by part, to the Si2400 data sheet (Figure 3 of data sheet).

❑ Compare final bill of materials, part by part, to the Si2400 data sheet (Table 9 of data sheet).

Before beginning the layout procedure, it is helpful to compare your schematic to the latest data sheet schematic on a part by part basis. Be sure that components of the proper **rating** and **value** have been selected. Also make sure that each component is properly connected. Common mistakes to avoid are diodes and transistors with the wrong pinout.

### Layout

❑ Check layout against the layout guideline diagram in Appendix B of the Si2400URT-EVB data sheet.

❑ Read and understand layout topics in the “Silicon DAA Layout Guidelines” application note (AN19).

The layout guideline diagram in Appendix B of the Si2400URT-EVB data sheet and AN19 cover critical layout issues that can affect performance, operation, reliability, EMI, safety, assembly, and thermal dissipation. AN17 should also be referenced if international safety compliance is an issue.

### Host Modem Software

In most applications the exact conditions and physical environment of the modem in the field are variable. Therefore, it is generally a good idea to include some software on the host that can adapt to the changing conditions the modem might encounter. Some of the in-field variables that the system should consider are as follows:

- Is the phone line extremely noisy or does it exhibit adverse conditions in relation to one of the modem algorithms?
- Is the modem connected to a phone line?
- Does the phone line supply a dial tone?
- Does the phone line support tone dialing or pulse dialing only?

The following software checklist will help handle these situations.

❑ Software provides fallback mechanism for adverse line conditions.

Because the V.22bis algorithm does not include automatic training, the host must supply a fallback mechanism to deal with extremely noisy or adverse line conditions. It is highly recommended that any host software include this simple feature to absolutely ensure modem connections will be established by your product in the field. One thing to note is that the V.22bis algorithm allows for connection at 1200 bps if the connecting modem is a V.22 modem, which is not the same as a retrain. The following steps outline an easy procedure to implement a fallback mechanism:

1. Set the Si2400 to V.22bis mode and attempt a connection (ATS07=06ATDT#). If the Si2400 does not connect (“c” result code echoed if the other modem is V.22bis compatible, and “d” result code of the other modem is V.22 only), then the host should hang up and go to step 2.

  

2. Set the Si2400 to V.22 mode and attempt a connection (ATS07=02ATDT#). If the Si2400 does not connect (“c” result code), then the host should hang up and go to step 3.
3. Set the Si2400 to V.21 mode or Bell 103 mode and attempt a connection (ATS07=03ATDT# or ATS07=01ATDT#).

Because each of the different modem protocols use different algorithms, the likelihood of establishing a connection under any line conditions is extremely high using these steps.

- ❑ Software checks if the Si2400 is connected to a phone line.

Check the value of SDB (ATSDB?) while on-hook. If the reading of this register is anything other than 0x00, then the Si2400 is connected to the phone line.

- ❑ Software checks if a parallel phone is in use before going off hook.

There are a few different methods to implement this, which are detailed in the parallel phone detection heading in the Si2400 data sheet and in the troubleshooting guide.

- ❑ Software checks if the phone line provides a dial tone.

The host software must comprehend that after attempting to dial (ATDT# or ATDP#), the first response echoed by the Si2400 will be a “t” if a dial tone is present and an “n” followed by a hang up if no dial tone is present. Additionally, the following procedure may be used to check for dial tone before any attempt is made to dial out: Issue the command “ATS01=01S02=01” (or any arbitrarily small number). Next issue the command “ATDT5;” (the 5 is arbitrary), if there is no dial tone, the Si2400 will hang up and echo an “n”. If there is a dial tone the Si2400 will echo a “t”.

- ❑ Software checks if phone line supports tone dialing or pulse dialing.

One method to check for tone dialing is to simply try to connect with “ATDT#”, and if unsuccessful try to connect with “ATDP#”. Additionally, the following procedure may be used to check for dial tone before any attempt is made to dial out. First, issue the command “ATDT5;” (the 5 is arbitrary), assuming a dial tone, the Si2400 will echo a “t”. Next, issue the command “ATDT;”. If the phone line supports tone dialing, there will not be any dial tone after this and the Si2400 will hang and up and echo an “n”. If the Si2400 instead echoes a “t”, then the phone line only supports pulse dialing. This command should be followed by “ATH” to return to the on-hook state.

- ❑ Software checks for parallel phone intrusion while the Si2400 is off hook.

In order to check for a parallel phone intrusion while off-hook, the host must configure GPIO4 (or ninth bit) as the ALERT pin and read register IND when ALERT is set as described in the Si2400 data sheet.

## Troubleshooting Guide

The following sections describe some of the features of the Si2400 and the related areas where a correction may be found. Additionally, these sections discuss design tips and deliver a more detailed description of each feature than is provided in the Si2400 and Si2400URT-EVB data sheets.

### Parallel phone detection

The Si2400 includes an automatic parallel phone intrusion detection algorithm while on-hook and off-hook. The Si2400 on-hook algorithm searches for rapid changes in the TIP-RING DC voltage and can be tripped by ring events. Thus, any host software that takes advantage of the Si2400 automatic on-hook algorithm should disregard the “i” and “I” result codes that occur near a ring event. (With automatic on-hook intrusion turned on, a ring will typically cause the “iRI” result code instead of “R”). In order to avoid filtering the “i”s and “I”s during ringing, the following alternate method can be implemented: First, disable the result codes by setting DOF (SF33.5) = 1. Next, determine the Si2400 on-hook TIP-RING voltage for no off hook parallel phone. This may be accomplished by checking the value of the LVCS register upon system powerup. Further, the LVCS register may be checked periodically, with the maximum value stored (call this MVL) and updated. (This avoids the possibility that a parallel phone was in use during system powerup.) Then, before dialing, the host can check LVCS. If LVCS is significantly lower than MVL, then the modem should not dial out until LVCS returns to a value close to MVL. Most phone lines have an on-hook DC voltage much greater than 30 V and off-hook voltages less than 30 V, so MVL may alternatively be permanently set to 30 V.

While the Si2400 is off-hook it continues to monitor for parallel phone intrusions. The ALERT pin (or ninth bit ALERT) must be enabled (ATSE2=C0). The two most significant bits enable ALERT, the others can be any value. When an intrusion is detected, it pulls the ALERT pin high and it is up to the host processor to then act on the intrusion or to ignore it. The ALERT function is a sticky bit and must be cleared using register SE3.

### UART

Care should be taken to ensure that the host UART and Si2400 UART are set to the same rate. In particular, a V.22bis connection has the ability to fallback to 1200 baud if the other modem only supports V.22. In this case, the Si2400 will echo a “d” instead of “c”. If CTS flow control is *not* implemented, it is necessary upon receipt of the “d” to escape into command mode, change the Si2400 UART to 1200 baud, change the host UART to 1200 baud, and put the Si2400 back on line with “ATO”. If CTS is implemented, then this procedure is not necessary, and therefore the use of CTS is recommend in order to simplify the host software.

The Si2400 UART is also capable of different baud rates separate from the line rate. It is configurable via register SE0 to be 300, 1200, 2400, 9600, 19200, 228613, 245760, and 307200 bps. When programming a new baud rate, the following procedure should be followed (example shows a change to 9600 baud).

1. Issue the command “ATSE0=23<CR>”.
2. Wait for the host UART to empty, indicating that the entire command has been sent.
3. Change the host UART to 9600 baud.
4. Issue a carriage return to ensure that the Si2400 is ready to accept a new command.

### Reset

RESET is the only method to return all of the Si2400 registers to their power-up state. (“ATZ” does not affect E0, E2, E4, E5, E6, E7, EA, F8, F9 or internal registers.) Reset is also the only way to take the Si2400 out of total powerdown mode. For these reasons, it is recommended that reset be connected to a software controllable pin. It is also important that reset meets the specifications in the data sheet (held low for at least 5 ms and a rise time of 100 ns or faster). During RESET, CTS should be held high. This can be implemented with a pull-up resistor to VCC. Upon negation of RESET, the host must wait 3 msec prior to transmitting any characters to the Si2400.

### DTMF detection

The Si2400 is capable of detecting DTMF tones while it is on-hook or off-hook. On hook detection may be implemented with following command strings:

ATSF0=02SE8=02SE6=01S83=66<CR>

ATO<CR>

If on-hook DTMF detection is left on continually, call progress events such as ringing, intrusion, polarity reversal, etc. will not be reported. Also, any DTMF digits pressed on a parallel phone will be echoed back by the Si2400. To exit this mode, issue the following command:

ATSF0=00<CR>

or

ATH<CR>

This causes the Si3015 SF0 bit to return to the proper state. If SF0 is not set to the proper state before attempting to go off-hook, the Si3015 can lose communication with the Si2400 until a hardware reset is performed.

Off-hook DTMF detection is a built-in mode and can be activated when dialing or answering a call using "ATDT!0" or "ATA0". After the "ATA0" or "ATDT!0" command is sent, the Si2400 will switch over to the voice mode routing (see Figure 10 in the Si2400 data sheet) after dialing. The voice mode of operation requires that one of the GPIO pins be properly configured as an analog input. Otherwise, a DC offset results and DTMF detection is compromised. Also, if DTMF must be transmitted after going off hook, it is necessary to use the following procedure.

Instead of issuing the "ATDT!0" command, use the following sequence:

1. Issue "ATDT!0<CR>" and wait for the comma "," result code, indicating that the DTMF digits have been sent.
2. Issue "ATSE4=02<CR>" to place the modem back into the data routing mode of operation.
3. Issue "ATO<CR>" to get back on line (i.e., detecting DTMF).

Instead of issuing the "ATA0" command, use the following sequence:

1. Issue "ATA0<CR>"
2. Issue "ATSE4=02<CR> to place the modem back into data routing mode of operation.
3. Issue "ATO<CR>" to get back on line.

Another item to note when detecting DTMF digits is that register S1D controls how long of a pulse width the Si2400 will consider a valid digit. When sending digits, the spacing and duration can be controlled using S04.

**Si2400 Communication**

Verify that the Si2400 can receive AT commands. (AT should cause the Si2400 to respond with "O".) If not, check the following:

- Use a multimeter to measure VCC. It should be between 3 to 5 V relative to the Si2400's GND pin.
- Verify that the Si2400 is being clocked properly. Use an oscilloscope to measure XTALI (relative to GND) and XTALO (relative to GND). This should be a sine wave of approx 3 V peak-to-peak.
- Verify that the Si2400 PLL is operational. Use an oscilloscope to measure CLKOUT. This should be a 9.8 MHz square wave.
- Measure the $\overline{\text{RESET}}$ rise time using an oscilloscope. This should be faster than 100 ns.
- Measure the voltage level on the Si2400's RXD pin. It should be 5 V.
- Connect a digitizing oscilloscope to the Si2400's RXD pin. Do not forget to ground the probe. Send an ASCII character "3". Capture on falling edge. Measure the first low going pulse. This measurement should be 416.6 μsec.
- Move oscilloscope probe to Si2400's TXD pin. Send an ASCII character "3". Capture on falling edge. This should be identical to the RXD pin because the Si2400 echoes back any characters by default. The first low pulse should be 416.6 μsec wide.

If any of the above points do not occur, the most likely cause is bad wiring or improper component values on the board.

**Si3015 Communication**

Verify that the ISOcap™ link is operating between the Si2400 and the Si3015. Send the "ATSF2?<CR>" and the Si2400 should echo "08", assuming that the modem is not connected to the phone line. If the Si2400 echoes "00", perform the following steps.

1. Check Si3015 pin 9 relative to pin 3. This should be in the 3.6 V range. During the on-hook case, this is the power supply to the Si3015. The power is transferred from the Si2400 to the Si3015 through C1 and back through C2(or C4/C9)/C24/C25 to GND.
2. Check Si2400 pin 13. This should yield approximately 4.6 V.
3. Use multimeter to verify connectivity of the ground terminals (C2/C24/C25 or C4/C24/C25 GND terminal) to the Si2400's GND pin.

If any of the above points do not occur, the most likely cause is bad wiring or improper component values on the board.

**On-hook verification**

Without the modem connected in the system, measure the TIP-RING voltage at the phone line. Measure TIP/RING again once the modem is connected to the phone line. There should be no noticeable difference in voltage. If there is a noticeable voltage drop, perform the following steps until the problem is identified.

1. Measure the Q3 base/emitter voltage. It should be 0 V. If there is a voltage, remove the Si3015. If the voltage persists, then there is a problem with the PCB. If the problem follows the Si3015, then replace the Si3015.
2. Reinstall the Si3015. Remove R25/R26/R9/R10. Check TIP-RING voltage. If the problem goes away, then R25/R26 or the ringer network (R9/R10/C8/C7/C19/C18) has an incorrect component. If the problem persists, reinstall these components and continue.
3. Remove Q1, Q2, Q3. Check TIP-RING voltage. If problem persists, then D1/D2 is the problem. If the problem goes away, then D1/D2 is ruled out, continue.
4. Reinstall Q3 and Q2. Measure the TIP-RING voltage to ensure that there is no voltage drop. If the problem appears again, then the problem is either Q2 or Q3. If Q2/Q3 is ruled out, continue.
5. Reinstall Q1. Measure TIP/RING voltage. If the problem appears again, the culprit is Q1.

### Off-hook verification

The following procedure can be used to debug problems with taking the Si2400 chipset off-hook.

1. Issue the command ATS07=40<CR>" followed by "ATDT**;**". This places the modem off hook indefinitely.
2. Measure TIP-RING voltage. This should be approximately 7–8 V for most loop currents. If the TIP/RING voltage is about 12 V, the culprit is Q4. The collector and emitter are reversed.
3. Measure the following pins relative to IGND (pin 3):

| Pin | Name | Approx. Voltage |
|---|---|---|
| 1 | QE2 | 2.7 |
| 2 | DCT | 4.0 |
| 7 | QB | 3.3 |
| 8 | QE | 2.7 |
| 9 | VREG | 3.7 |
| 10 | VREG2 | 2.2 |

4. Check Transistor voltages while the modem is off hook.
   - Q1 and Q2 are in saturation. ($V_{CE}$ is small; $V_{BE}$ is a diode drop.)
   - Q3 is acting as a current source. ($V_{BE}$ is a diode drop.)
   - Q4 is in the active region. ($V_{BE}$ is a diode drop.)
5. If the voltages are not correct, try removing Z1 to ensure that this is not the culprit. If removing Z1 does not help:
   - Turn off power and verify connectivity of R24, R5, R16/R17/R19, R7/R8/R15.
   - Turn off power and verify resistance of R24=150, R5=100K, R6=120 K, R16/R17/R19=1.62 K, R7/R8/R15=1.62 K.
   - Check connectivity of Q1,Q2,Q3,Q4.

### Transmit Path

Verify Transmit Path.

1. Reset board, then issue the command "ATS07=40<CR>" to enable blind dialing. This will make the Si2400 ignore the presence of dial tone prior to dialing out.
2. Use a phone splitter and place a handset in parallel with the modem. Issue the command "ATDT555555;" then pick up a parallel phone to check to determine if DTMF digits are transmitted.
3. You should see a comma "," after the Si2400 assumes that it has sent out the "ATDT" command. If you do not hear the DTMF digits before the "," is sent, then verify R11, R2, C13, C12 and Q4.

### Receive Path

Verify Receive Path.

1. Reset the Si2400. Connect the phone to a phone line or something that emits a dial tone when the modem goes off hook. Verify that you have a dial tone by listening to it first using a handset.
2. Issue the command "ATDT#####<CR>".
3. The result code "t" followed by a comma "," should appear. The "t" means that a dial tone was detected, hence verifying the receive path.
4. If no dial tone is detected, check C5 and R18.

### Ring Network

Verify Ring Network

1. Place modem on phone network, and call the modem. The result code "R" should appear as a result of the ring event.
2. If the Si2400 does not respond with the "R" result code, check R9, R10, C7, C8, C18, and C19.

## NOTES:

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