

# Telephony Extension

# Application Note

By: Ericson Palermo

Preliminary

05-28-03

---

## Introduction

The telephony extension feature is based on Smart DAA's ability to measure the tip and ring voltage (TRV). The modem essentially polls the line periodically and analyzes the stream of TRV samples to detect any sudden change in line voltage. Therefore, the telephony extension feature applies to silicon-based DAA modem designs only. These modems include, but not exclusive to SCXV22bis, Smart V.XX, Smart ACF and Smart SCM.

The Parallel Phone Detection (PPD) has two main features, which are extension pick-up and line-in-use. This application note provides basic understanding on how PPD works. It does not cover all the detailed implementation in the code.

Both extension pick-up and line-in-use are disabled by default and are enabled via the `-STE1` command. The extension pick-up feature drops the modem connection and alerts the host when a parallel phone is picked-up while the modem is off-hook. On the other hand, the line-in-use feature prevents the modem from dialing out if the line is already in use by a parallel extension. The table below summarizes the two responses returned by the modem when extension is picked-up.

Feature	Modem State	Response
Line-in-use	ONHOOK	LINE IN USE
Extension Pick-up	OFFHOOK	OFF-HOOK INTRUSION

## OFF-HOOK INTRUSION (Modem is Off-Hook)

The Tip and Ring Voltage drops when a parallel phone is picked up due to the additional impedance introduced to the circuit. The extension pick-up feature monitors this drop or sudden change in TRV and compares it to the given threshold defined in the second parameter of the `-TTE` command. If the voltage difference exceeds the threshold then the modem drops the connection and notifies the host by returning an 'OFF-HOOK INTRUSION' message.

For example, let us suppose that the TRV is 8V when the modem is off-hook or connected in data mode. If the TRV drops to 5V when a parallel phone is picked-up then a difference of 3V exceeds the 1V default threshold and thus forcing the modem to go back on-hook and return an extension pick-up message.

## LINE IN USE (Modem is On-Hook)

Line-in-use utilizes the same mechanism as extension pick-up except the modem is on-hook. Let us say that an on-hook voltage of a central office is 50V. Again, the TRV drops to 5V when a parallel phone is picked-up for voice connection. When the modem detects a sudden voltage drop of 45V (50 – 5), which exceeds the 10V default threshold then the line-in-use flag is set. Consequently, any subsequent attempt to make a connection will prevent the modem from dialing while returning the 'LINE IN USE' message.

---

<sup>1</sup> See AT command Reference Manual for parameters



The line-in-use threshold can be modified through the first parameter of the –TTE command. For example, changing the threshold to 45V will effectively disable the feature assuming the same condition holds. In this example, the maximum difference between the on-hook voltage (50V) and 5V line voltage when the extension is picked-up equals 45V, which cannot exceed the threshold and therefore disables the line-in-use detection.

## **Polling the Tip and Ring Voltage**

Having a basic understanding of the telephony extension's functionality leads us to explore its mechanism with further details.

We know that it is a sudden TRV change that allows the modem to determine when a parallel phone is in use or has just been picked-up. But how does the modem detect any voltage rise or drop? The modem polls the line every 100 ms and keeps track of the difference between two TRV levels, which are reference voltage (REFV) and instantaneous voltage (INSTV) to detect any sudden voltage change. However, the INSTV does not get compared to REFV on every sample. It is only compared when its level has settled for at least 200 ms or two samples. This means that as long as INSTV is changing on every sample no voltage comparison will be made and thus no chance of parallel phone detection.

## **Dynamic Reference Voltage**

The REFV is not a static or fixed variable but rather a dynamic one that adapts to various and changing line conditions. Basically, REFV is nothing more than a record of the most recent stabled voltage. In other words, every time the modem samples two consecutive and equal INSTV, REFV gets updated to this newly settled voltage. Of course, REFV and INSTV are compared first to record the difference before overwriting the former with the value of the latter.

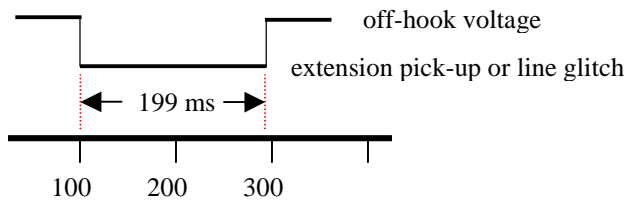
Let's go back to our off-hook intrusion example in which the off-hook voltage is 8V and extension pick-up causes the line to drop to 5V. The REFV must be equal to 8V since it is the assumed stabled level during data connection or when off-hook. What's actually happening at this point is that the REFV gets updated with the same value every 200 ms since presumably INSTV will consistently sample 8V. Now, if all of a sudden the parallel phone is picked-up the next TRV sample might be 6.5V followed by two consecutive 5V as the line voltage settles in which case is compared to the 8V REFV, yielding 3V difference. REFV now gets updated to 5V while the 3V line drop is compared to the 1V threshold, which evidently leads to a dropped connection and the modem notifying the host of extension pick-up activity.

Another perspective into the effect of dynamic REFV is that if the voltage drifts slowly enough meaning the TRV gets at least two identical samples within less than 1V (threshold) change then the off-hook voltage can slowly change at any level without falsely detecting an extension pick-up.

We talked enough about the criteria for what is considered a settled voltage level. So what if we have a specific application in which the modem normally sees a line glitch with duration greater than 100 ms? This scenario can potentially fool the modem into thinking that the extension has been picked-up assuming the glitch blows our threshold level. Fortunately, the next section addresses this issue by incorporating the Line Interruption Immunity feature. The second generation SCXV22bis (CX84100-31/-22), third generation SmartV.XX (CX81801-74) and later silicon DAA-based modem design includes this feature.

## Line Interruption Immunity

The Line Interruption Immunity (LII) feature allows for a command-based specification of a settled voltage. In other words, the predefined two sample criteria for a stabled voltage can be lengthened through the fifth parameter<sup>2</sup> of the `-TTE` command. This feature was designed to allow a specific application to tune the sensitivity and responsiveness of extension pick-up detection. For example, increasing the number of required samples to 3 or 300 ms to qualify a settled voltage means the modem will definitely ignore a line glitch with 199 ms duration as depicted in Figure 1 below. Since the modem samples at 100 ms interval, there is no way of detecting three equal samples with a 199 ms glitch. Generally, more samples equate to desensitized parallel phone detection and thus less responsive.



**Figure 1.** A 199 ms line glitch cannot possibly induce a false extension pick-up detection if LII = 3.

Older models such as first generation SCXV22bis (Patton1) and second generation Smart V.XX (Banshee2) have a patch-based code that hard codes LII or the number of samples required for a settled voltage.

Note that LII's default value is 0, which corresponds to two samples or 200 ms minimum time period. Settings equal to 1 and 2 also equate to two samples. A value of 3 and greater is a one to one correspondence, i.e. 5 = 5 samples.

## Exercise

The `-TRV` command, as the command implies, returns the instantaneous TRV sample. We can use this command to test what we just covered. Send the `-TRV` command a couple of times when the modem is on-hook to get the line voltage. Pick-up the parallel phone and continue to issue `-TRV` to see the voltage drop. Try to dial and see that the modem won't allow it. Don't forget to enable line-in-use by issuing `AT-STE=1`. Now, try changing the threshold to 45 or 50 via `-TTE` command and observe the difference. Similar procedure applies to extension pick-up.

## Summary

The telephony extension feature relies on the Smart DAA to deliver continuous stream of TRV samples every 100 ms, which is analyzed by the modem using simple arithmetic to determine any sudden change in line voltage. The modem is flexible enough to tolerate various and changing off-hook voltage through its dynamic reference voltage. In addition, certain modems even allow individual application to tune the sensitivity and responsiveness of the detection mechanism through the Line Interruption Immunity parameter.

<sup>2</sup> The default is 0 equal to 2 samples (minimum). Range is 0 – 255 with 100 ms/unit for values 3 and greater.