

# Auto Signal Source Locator using Sage UCTT

Renshou Dai  
Sage Instruments

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## Abstract

This paper describes an easy and comfortable way of locating a signal source using Sage's 8901 UCTT. A user simply drives around with a UCTT connected to both a GPS antenna and an omni-directional RF antenna mounted on the car. With the Auto Signal Source Locator (ASSL) feature running, measurements of the signal strength will automatically take place internally as the user drives around. Once the algorithm accumulates enough measurement points (at different locations), the possible signal source location will be shown as the center of a red-colored circle over-laid on the map. The radius of the circle is inversely proportional to the estimation confidence level. With the press a button, the detailed GPS location of the signal source will also be shown on a pop-up dialog.

## 1 Introduction

Locating the signal source (where the transmitting antenna is) using a wireless test instrument has always been an interesting challenge. Using directional antenna seems the easiest-to-understand approach. But for this approach to work, you'll have to be already close enough to the source, otherwise, the job can potentially be dangerous. Asking someone to walk around with heavy test equipment and pointing the directional antenna around may not be a fun job in an area with lots of traffic. Such work may even arouse unwanted attention or suspicion.

In this paper, we describe an easier Auto Signal Source Locator (ASSL) by Driving feature. This feature is offered on Sage's UCTT product [1]. This feature can be used as a preliminary reconnaissance measurement, giving you the first-degree approximation to the signal source. With this information, a user may then further pin-point the source location with directional antenna and on-foot measurements.

Using this ASSL feature, all you need is a map for the area of interest, a car and a Sage UCTT connected to an RF measurement antenna (omni-directional) and a GPS antenna. Both antennas should be mounted on top of the car. After driving a while (more than 10 KM), the auto signal source locating algorithm should start and the approximate source location will be marked as a red-colored circle over-laid on the map. As you keep driving and as more data points are added, the source location will get more accurate (the radius of the red circle should get smaller). At any time, you can see the detailed numerical report of the estimated source location (latitude and longitude) by pressing a button.

## 2 Principle

### 2.1 Forward problem

Given the antenna location and radiation pattern, calculating the spatial distribution of the relative signal strength is mathematically a forward problem. It's a simple, well-defined and straight forward

problem. For most antennas, the far-field signal strength is always inversely proportional to the distance between the measuring point and the antenna location.

## 2.2 Inverse problem

Given the measured spatial distribution of the signal strength, locating the signal source (antenna location) is mathematically an inverse problem. An inverse problem is more complex, and may not have a unique and stable solution.

## 2.3 Solving inverse problem by forward modelling

This ASSL feature on UCTT solves the inverse problem by forward modelling. Basically, for the data points that have been accumulated so far (location and field strength data), the ASSL algorithm will use forward modelling to build an ideal field strength distribution model for each possible antenna location within the map. The antenna location(s) with the field strength distribution model(s) that best match the actual measurement data will be recorded and marked on the map as potential signal source location. Such computation keeps going on as more data are acquired and the ultimate solution should be unique and confined to a small region on the map.

## 3 Application Example

Figure 1 shows an application example using this ASSL feature. The signal we were locating is a CDMA signal with center frequency at 862.9 MHz. The cell site of this signal is near the airport of Watsonville, California.

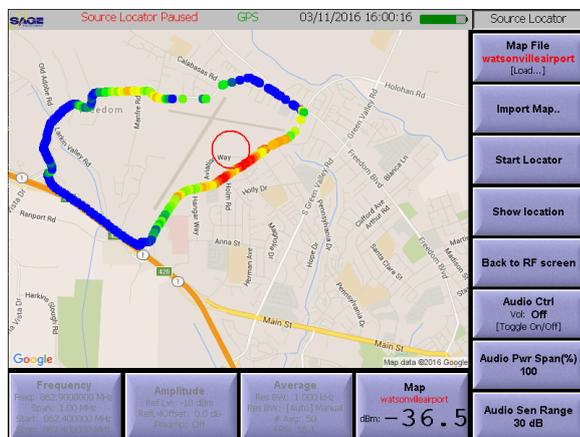


Figure 1: Example of using ASSL to locate a CDMA cell site in Watsonville, California.

As shown in Figure 1, we drove around the perimeter of the airport for a distance about 5 miles (8km) in about 15 minutes (some traffic stops during a Friday rush hour in midst of a gusty rain storm). The signal strength measured at each location around the driving path are shown as color-coded solid dots. The red color shows high signal power (higher than -45 dBm), and the deep blue color indicates weaker signal power (below -75 dBm).

The example here successfully shows (within the red circle) the signal source location. This is exactly where the actual cell site is.

## 4 How to use ASSL on UCTT

To use the ASSL feature on Sage UCTT, please follow these steps:

1. Connect UCTT to a GPS antenna and turn UCTT on so that the internal GPS receiver can get into the GPS-locked state with accurate GPS location. This requires acquiring at least 4 satellites. If UCTT has been transported to a new location (more than 200km away), or has not been connected to any GPS signal for over 2 weeks, this GPS lock stage may take a while (up to 5 minutes).
2. Use Sage's PC application SW "UCTTMapper.exe" to create a map for your area of interest (where the signal source is located). This map should be as small as possible to just include your areas of interest. Export the map to a USB thumb-drive. See Figure 2 for an example.

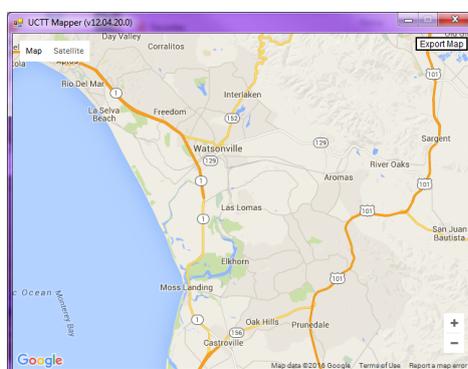


Figure 2: Example of using the "UCTTMapper.exe" PC SW to create a map for Watsonville area.

3. On the UCTT, press the MODE button and switch to the "Sig Loc" soft button (see Figure 3). Tune the center frequency so that the signal of interest is right at the center. Narrow the SPAN to as narrow as possible to only cover the signal of interest.



Figure 3: UCTT feature selection after pressing the MODE button.

4. Press the “MAP” soft button on the upper right corner and you’ll see the input dialog as shown in Figure 4.

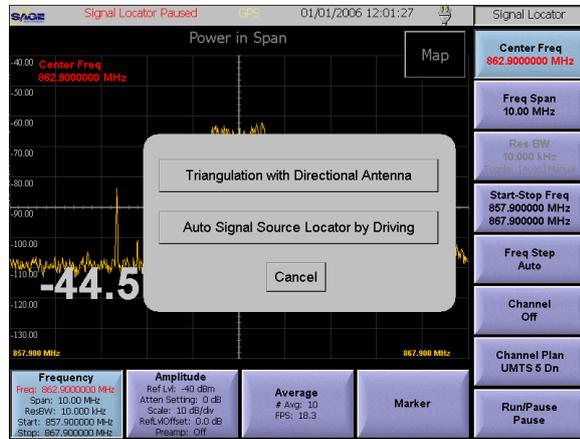


Figure 4: Signal Locator mode selection dialog.

5. Press and select the “Auto Signal Source Locator by Driving”. If the GPS is already locked, you’ll see a screen similar to that shown in Figure 5.

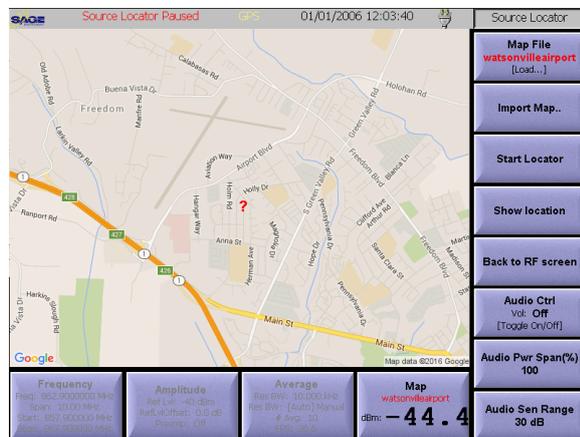


Figure 5: Auto Signal Source Locator by Driving Screen.

6. If this is the first time you’re working with UCTT or you’re working in a new area, it’s likely that UCTT does not have the map for your area. Assume you have already accomplished step 1 in creating a map and exporting the map to a USB thumb-drive, you now need to plug in the USB thumb drive to UCTT, and then press the “Import Map” soft button. Find the correct map file name and select “OK”. Then press the “Map File” soft button to select the map file name you just imported. The correct map should now show up on UCTT display.
7. Press the “Start Locator” soft button, and start driving and the ASSL feature has started.

8. ASSL feature will not provide any source location estimation (no red circle) until you have driven over 1 km. Once the source location is displayed (the red circle shows up), you can then press the “Show Location” soft button. A pop up dialog will show the location’s exact latitude and longitude numbers.
9. To stop ASSL feature, just press “Stop Locator” button. You can perform screen-print of your test result by pressing on the keypad ”Shift-PrtScr” and then follow the instructions.

## 5 ASSL application scope and limitations

For this ASSL feature to work well, the following conditions must be met:

1. The signal source must have a stable and steady output power.
2. The signal source can be modelled as a simple point source. Basically, the measured signal strength must be inversely proportional to the distance from the source.
3. The measurement points are not too close so that the far-field propagation model applies; yet also close enough to preserve decent signal-to-noise ratio.
4. Absence of complex propagation environments, such as tall buildings, dense woods or steep elevation changes. Basically, for this feature to work well, the measured signal power must be inversely proportional to the distance from the source.

## References

- [1] Renshou Dai, ”Quick Introduction to UCTT”, Sage Instruments Technical Paper.