

# 900MHZ A/V TRANSMITTER INTERFERENCE

White paper presentation by [www.dpcav.com](http://www.dpcav.com)

## INTRODUCTION

The popular 900Mhz A/V transmitters sometimes cause EMI/RFI related interference to nearby electronics. The common symptoms are poor GPS receiver operation and reduced radio control receiver range, especially when these items are close to the A/V transmitter.

Solving the interference problems can often be painful and frustrating. But, with thoughtful changes to the installation, the interference issues from the A/V transmitter can be substantially reduced and in many cases they can be eliminated.

But let's make one thing perfectly clear. Success is the result of several minor changes, where each one provides an incremental advantage. All the changes, when taken together, will often result in improved operation and reduced EMI/RFI problems. So, skipping some of the suggestions presented here may result in failure to solve the problem.

## SCOPE

The 900Mhz / 500mW A/V transmitter is perhaps the most popular, so we will discuss ways to improve its installation to reduce typical EMI/RFI issues. This transmitter is available from several sources, including [www.dpcav.com](http://www.dpcav.com).

The examples discussed here will be directed toward solving GPS receiver interference issues (low satellite counts, fix failures, etc.), but the solutions are just as appropriate for other devices that refuse to work well near the A/V transmitter.

The A/V transmitter interference can be from *radiated* (through the air) or *conducted* (through the wiring) paths. We've found that many users concentrate on just one of these interference mechanisms, and ignore the other, which usually results in a less effective solution. It is important to attack both interference mediums, so we will discuss solutions to do that.

## MY INSTALLATION IS THE SAME AS YOURS, SO IT SHOULD WORK FINE

One of the biggest traps we have seen users get into begins when the installation that has EMI/RFI problems is 'exactly' the same as another one that works well. This causes all sorts of confusion and frustration to those not familiar with RF interference problems.

So, here is the bottom line. When it comes to EMI/RFI, there are no two identical installations. Repeat that again, *there are no two identical installations*. They are all different, regardless of how closely they have been copied. Now that you have memorized this important concept, you can confidently ignore anyone that tells you that "your installation should work without problems because mine is fine." EMI/RFI is a cruel issue and it does not care about such boastful claims.

## DISTANCE IS YOUR FRIEND

Most installers are aware that maximizing the distance between the 900Mhz (500mW) A/V transmitter and the GPS receiver is important. But for some reason they ignore such words of wisdom, perhaps because they have a compact installation that makes this difficult to do. The reality is that unless you provide sufficient distance, your installation will be doomed regardless of any other tricks you try.



For most installations with a nearby GPS receiver, a minimum of sixteen inches distance from the 900MHz A/V transmitter's antenna is recommended. Keep in mind that this is not a hard rule, so the minimum distance may vary. For example, lower power transmitters may need less and it is wise to expect that higher powered transmitters will need more.

Of course there are users that have reported good success with closer-than-recommended spacing. But, we will assume you are not one of those fortunate users since you are desperately reading this white paper. Also, we have seen installations where the user claimed interference-free GPS operation; upon closer review we have been able to show them they were not as fortunate as they believed.

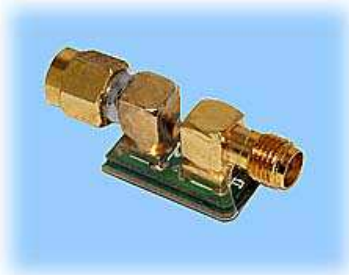
## **RADIATED NOISE**

It's no surprise that EMI/RFI noise can be radiated from the A/V transmitter's antenna. It's the natural place to suspect and of course it's a good place to start. But why would our 900MHz A/V transmitter affect other nearby radio devices that are on completely different frequencies? For example, a GPS is tuned for 1570MHz, which is far from the 900MHz A/V transmitter's operating frequency.

The answer can be summed up in one word: Harmonics. Generating the RF signal results in spurious signals that can cause havoc far outside the expected operating frequency. The most common harmonics occur at multiples of the main RF carrier. So, a 910MHz carrier would have them at 1820MHz, 2730MHz, and so on.

To make matters worse, the unwanted harmonics begin at very low frequencies due to the RF synthesizing hardware inside the transmitter. The intensity of the harmonics can vary due to the component tolerances and adjustments within the transmitter. They also will change behavior when the A/V transmitter's RF channel is changed. Even the content of the video image can cause them to vary. And to really make things interesting, the particular antenna that is installed can affect some harmonics and cause them to become worse.

In a thoughtful RF design the unwanted signals are removed using filtering circuits. But unfortunately the popular A/V transmitters don't include adequate filters.



**Figure 2**, TXF-900 Filter

The solution is to add a low pass filter between the transmitter and antenna. Spurious harmonic noise affects all sorts of radio transmitters and these filters are regularly designed and built by ham radio hobbyists to help their radio stations. But, creating an effective UHF/microwave low pass antenna filter for a compact video transmitter is not a simple task.

Fortunately, low pass antenna filters can be purchased from sources like [www.dpcav.com](http://www.dpcav.com). For example, the TXF-900 filter is specially designed for 900MHz-1040MHz operation (see Figure 2). It attenuates the second harmonic by about -50dB (100,000X reduction) and suppresses noise in the GPS's RF band too. It has low RF insertion loss to help maintain signal strength and it is compact too.

Installation is simple; just remove the transmitter's antenna and then add the filter. Even if you are all thumbs, total installation time will be under a minute.

## **CONDUCTED NOISE**

It would be grand if all the noise was radiated out the antenna and simply solved with a low pass antenna filter. But most installations are not so fortunate. That is because it is quite common to have conducted EMI/RFI noise too. It's a totally different noise path that needs our attention.

Conducted noise travels out through the A/V transmitter's copper wire cable. This cable connects to the video camera, battery power, and microphone. These connections then go elsewhere, such as to an OSD board, common power, and so on. Eventually the noise makes its way to the GPS receiver through these copper paths. The noise is coupled into the GPS receiver, either directly by its host cable, or indirectly by offensively radiating noise from it or the other cables.

The typical cure for the conducted noise is to use common mode filters on the cables. The most popular EMI/RFI filters are Toroid Ferrite cores (see Figure 3). These donut shaped components are designed to attenuate the high frequency noise that travels along the cables. All you need to do is wrap your cable through them a few times.



As easy as they are to use, it's very common to see improperly configured Toroids **Figure 3**, Ferrite that have too few cable windings on them or other installation mistakes. So, it is important to follow some basic recommendations that we present to you.

The Toroids come in a wide variety of formulations that are designed to be most efficient at their rated frequency range. None of the common types will have specifications that include the frequencies we are concerned with. In fact, most are rated for the VHF and low UHF range, which is far below the RF regions that we need to suppress. But fortunately, they can still be effective with sufficient wraps on them.

We have had good luck with a wide variety of Toroid formulations, including the common Fair-rite type 43 and 77, as well as others. Sometimes it may be necessary to try a couple different types to find the best choice. For many noisy 900MHz installations the #TOR-001 from [www.dpcav.com](http://www.dpcav.com) has worked well. Because it is small, the wire size needs to be small gauge in order to get sufficient wraps.

We recommend that you avoid the split (snap together) Toroids. We agree that they are easy to use because then just snap over the wires. But they are much less effective at reducing the EMI/RFI that needs to be attenuated. So, only use the one-piece type!

Generally speaking, the most effective location for this Toroid is close to the transmitter module, perhaps one to two inches from it. **All of the transmitter cable wires must be wrapped through the Toroid.** If you are not using the audio (microphone) input then feel free to cut the wire to a short length.



**Figure 4**, 10 Wraps!

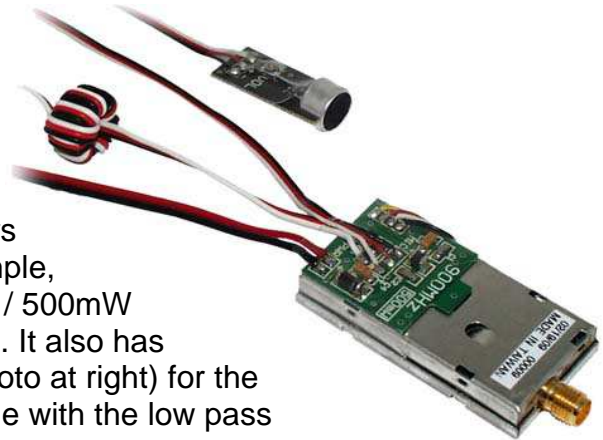
Now here is the most important rule in using Toroids: More wraps results in better success. We have seen an endless number of installations where only three or four wraps were used. This is not enough. Seriously not enough.

Honestly, we have become stubborn Toroid users that advise ten or more (10+) wraps are needed to achieve best noise reduction. The usual reaction to our mantra is that it's hard to do because the wire is too thick, not long enough, or requires modifying the A/V cable.

The work-around is to roll up your sleeves and install smaller gauge wire. For video connections and other low current applications (including GPS cables), 28 to 32 AWG wire is fine. Unfortunately the A/V cable that comes with the popular 900MHz transmitters is very large diameter. But, you can remove the outside rubber jacket to expose the smaller gauge wires that are inside. If they are not long enough, or still too big to allow enough wraps on your Toroid, then the next step is to splice smaller gauge wires onto the A/V cable.

Splicing the wires will require some basic soldering. If you are unable to solder then there are plenty of online guides and videos that will show you how. But you can also use a friend that has the necessary tools and skills.

Some vendors have introduced 900MHz A/V transmitters that already have the proper Toroids installed. For example, [www.dpcav.com](http://www.dpcav.com) offers a special version of the 900MHz / 500mW transmitter that includes a Toroid filter on its video cable. It also has additional filtering on an integrated circuit board (see photo at right) for the power and audio cables. This transmitter is also available with the low pass antenna filter.



### **MORE PROTECTION FROM CONDUCTED NOISE**

While you are busy adding a Toroid to the transmitter's cable, you should add one to the video camera's cable too. That is because cameras can be another source of EMI/RFI. Like the noise from the 900MHz transmitter, they can cause problems to other nearby electronic items. As mentioned before, use ten or more tight wraps around the Toroid and placed it one or two inches from the camera.



**Figure 6, Camera Toroid**

Additional Toroids may be needed on other cables that are in the system. For example, when a GPS receiver is installed it is wise to add a Toroid to its cable. An example of a GPS host cable filter is published here: [www.dpcav.com/data\\_sheets/whitepaper\\_GPS.pdf](http://www.dpcav.com/data_sheets/whitepaper_GPS.pdf)

Overall, it may be necessary to experiment with additional Toroid placements if you are fighting a very noisy installation. So we advise that you to keep extra Toroid filters in your tool box.

### **EPILOG**

EMI/RFI from your 900MHz A/V transmitter is a cruel problem that can affect GPS systems, nearby radio receivers, and other electronic items. Fortunately, it can be solved.

The recommendations presented here are useful in combating 900MHz A/V transmitter induced EMI/RFI. However, we cannot promise they will completely solve every installation's interference problems. But we do believe you stand a much better chance of success if you implement them.

[For those with a bit more time on their hands, please continue to next page!](#)

## **DIRTY POWER: YET ANOTHER NOISE PROBLEM**

Many installations that use a 900MHz video transmitter are portable and therefore battery powered. For convenience, it is desirable to share a common battery. For example, robot builders and radio control modelers are tempted to connect the video system to the 12V battery that also operates electric motors and other high current devices.

But sometimes the shared battery causes the video image to have interference. It is usually in the form of fixed or moving lines in the image that appear when the motor or high current device is operated. When this occurs a typical reaction is to assume it is EMI/RFI. So out come the Toroids, wire twisting, and other tricks that are best suited for RF interference issues. But, this is not an EMI/RFI problem at all. So those techniques won't fully solve the problem.

Don't get us wrong, sharing the battery does indeed increase the EMI/RFI issues. It's one of the reasons that we don't recommend doing it. But, in the case where operating a high current motor causes the image to have artifacts, and a common battery is in use, then our experience has been that it isn't an EMI/RFI issue.

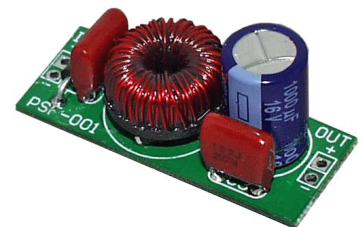
The problem is usually caused by "dirty" power, but in rare cases it may be from other issues. But how can this happen when stable power is being provided by a high capacity battery? Well, when a motor (or other high-current device) is operating, it causes large current spikes (fluctuations) on the battery circuit. In the case of an electric motor, this is a byproduct of motor commutation. The spikes, which can take the form of transient or ripple voltages, are the reason why the video noise changes in concert with changes in motor speed.

To be more blunt, the voltage spikes compromise the power that is supplied to the video gear. Because of their short duty time, your voltmeter will never see them. Observing them requires much more sophisticated test equipment. So, take our word for it that they are indeed there and making a mess of things.

Of course there are installations that are perfectly happy when sharing the video's power with high current motors and other such devices. Success or failure depends on an endless number of things, many of which are out of our control. And like problems experienced with EMI/RFI, we have observed installations that were exact copies, yet one worked fine and the other didn't. That's because nuances in battery performance (while under load), motor speed circuitry characteristics, wiring techniques, and so on, will all result in installation variations.

So what do we do? The simplest solution is to use a dedicated battery to operate the video equipment. If that is not an option, then begin by trying out the shared battery arrangement. If the video has noisy lines when the motor is operated, then you'll just have to filter the power supply.

But, since it isn't an EMI/RFI problem, the solutions are different than those already presented in this paper. Instead, this is a task for large value inductors and capacitors (L-C). The photo on the right shows dpcav.com's #PSF-001 L-C power filter, which is one example of what is used to fight this problem.



**Figure 7, L-C Filter**

So, maybe an Internet search for "L-C power supply filters" is in your future. Fortunately for most of us, a dedicated battery is not a problem and eliminates the nasty surprises.