

Model Sounds Inc.

DopplerFX® Rev. 03

REFERENCE MANUAL

January 20, 2021

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## CHAPTER 1 - GETTING STARTED – THE BASICS

### PURPOSE OF THE DOPPLERFX FEATURE

The Model Sounds Inc. **DopplerFX** feature is unique in the model RC world.

It is a feature of the **ShockWave 3** sound module and is enabled by the **DopplerFX** accessory board that communicates with the **ShockWave 3** sound module using two signal wires. The **DopplerFX** accessory board takes its +3.3 Volt power from the **ShockWave 3** sound module over the same four wire cable that provides the serial two wire data link.

The concept of the **DopplerFX** feature is that it provides an enhanced Doppler frequency shift experience to a ground observer while the model aircraft or helicopter is in flight. Doppler shift is the change in pitch of a sound as the source gets closer, then gets further away, e.g. like an ambulance, fire engine or police siren. Due to its own motion, every model aircraft produces its own natural Doppler shift as it approaches towards and recedes from a stationary observer on the ground.

But because a scale model aircraft's speed is fairly slow compared to the speed of sound, especially when flown at a realistically slow scale speed, its natural Doppler shift is quite mild in effect. If the model is outfitted with our **ShockWave 3** sound system, this **DopplerFX** accessory board can provide increased Doppler frequency shift to the engine and gunfire sounds played back by the sound module. This can make the model sound as though it is travelling at 350km/hr when its actual speed is only 50km/hr, for example.

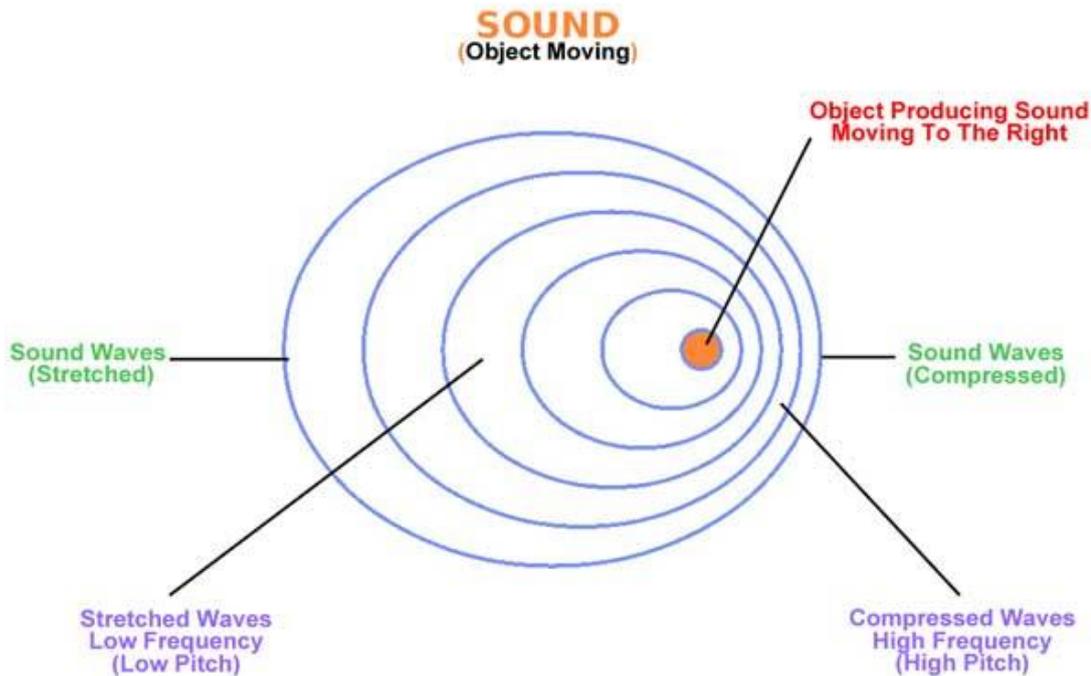
### HOW DOES THE DOPPLERFX FEATURE WORK?

When the sound system is first powered up by the pilot, once a GNSS (e.g. GPS) satellite fix has been acquired, the **DopplerFX** feature will record the accessory board's position. This is called the **Observer Position**. Then as the aircraft moves away from or towards the **Observer Position**, either on the ground, or in the air, the **DopplerFX** accessory board continuously updates its position and altitude at up to 10 times per second and the **ShockWave 3** sound module will calculate its speed and position relative to the **Observer Position**.

Then, depending on its speed and whether it is approaching towards, or receding from, the **Observer Position**, the **ShockWave 3** sound module will compute what the relative Doppler frequency shift should be to simulate the plane's actual speed multiplied by the **Speed Multiplication Factor**. It then changes its playback speed appropriately.

## SOME SIMPLE MATH THAT EXPLAINS DOPPLER FREQUENCY SHIFT

Doppler shift (in the light from stars) was first identified and named after the Austrian physicist Christian Doppler, who described the phenomenon in 1842 and his theory was tested for sound waves by the Dutch chemist Buys Ballot in 1845.



Doppler shift in sound is a time compression of the sound wavefronts (wavelength compression) due to the source's motion.

$V = f \times \lambda$  where  
 $V$  = velocity (speed of sound),  
 $f$  = frequency, and  
 $\lambda$  is the wavelength of the sound.

Therefore  $f = V / \lambda$  and since  $V$ , the speed of sound, is constant, more or less, if the wavelength  $\lambda$  decreases, as when the sound source is approaching you, then frequency  $f$  goes up.

Conversely if the wavelength  $\lambda$  increases, as when the sound source is receding from you, then frequency  $f$  goes down.

And when the source is immediately at your location when it is neither approaching or receding  $f$ , the frequency you hear, is the same as the source's own frequency.

It is important to realize that, under normal circumstances, the source's sound frequency does not actually change at all. It is only due to the wavefront compression and stretching due to its motion that the sound a fixed observer hears appears to change.

The DopplerFX feature implemented in the **ShockWave 3** sound module enhances this natural effect by applying additional frequency shift at the source to emulate a much higher speed.

## WHAT IS GNSS?

GNSS is an acronym for **Global Navigation Satellite System**. This is a generic descriptor for Satellite based navigation systems used worldwide. While the most commonly known of these is the U.S. Department of Defence owned **GPS (Global Positioning System)**, there are several other Satellite Navigation (sometimes abbreviated SATNAV, especially in the U.K.) systems in use developed by other countries.

In particular there is the Russian **GLONASS** system, the European **GALILEO** system, the Chinese **BEIDOU** system and the Japanese **QZSS** system. The Japanese QZSS system uses a small number of satellites in non-geo-synchronous orbits around the Japanese archipelago which work in conjunction with the U.S. GPS satellites to give better coverage in many of the Japanese cities' concrete canyons.

The Model Sounds Inc. **DopplerFX** board has an on-board GNSS receiver that is capable of receiving all of these GNSS satellite signals, although not all simultaneously.

The preferred Data update rate for smoothest operation of the **DopplerFX** features is 10 times per second. However, the more satellite systems it has to listen to, the less frequently it is able to provide updated position data.

The following table shows allowable GNSS Modes supported by the Model Sounds Inc. **DopplerFX** board:

**Table 1: Supported GNSS Receiver Modes**

Supported GNSS Mode	Data Update Rate
GPS ONLY	10 times per second
GPS + GLONASS	5 times per second
GPS + GALILEO	5 times per second
GPS + BEIDOU	5 times per second

QZSS is automatically supported as QZSS satellites augment the GPS System. These various receiver modes are selected in the [DopplerFXSettings.txt file](#) on the microSD card.

## Caution About Using Other GNSS/GPS Receivers

The Model Sounds Inc. **DopplerFX** accessory board has been carefully engineered to give optimum performance in all RC model aircraft applications, including model airplanes and model helicopters. Although there are alternative products which, superficially, seem the same and are less expensive, they almost always use what is known as a ceramic patch antenna.

These types of antennas are highly directional and therefore must point to the sky at all times. These are therefore best suited to applications such as vehicle tracking, robots and multi-rotor drones which stay parallel to the earth's surface at all times.

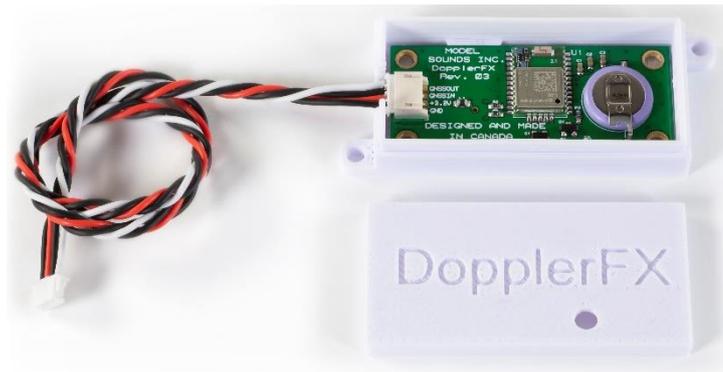
Our **DopplerFX** board uses a ceramic chip antenna which is omni-directional and thus will not lose a GNSS tracking signal when a model aircraft is rolling, climbing or diving.

In addition, the backup battery on-board the DopplerFX board is much larger than these alternative, cheaper, products, and therefore will last a whole flying season without being charged, or between flying seasons if stored in its charged state.

Finally, all of these alternative GNSS/GPS receivers have either no connector or have a different type and/or size and/or different pinouts than those of the **DopplerFX** board which makes it very difficult or impossible for the average modeller to make correct connections to the **ShockWave 3** sound module.



## CHAPTER 2 – MOUNTING THE DOPPLERFX ACCESSORY BOARD



The DopplerFX board is shipped mounted inside its plastic case with the 4-wire cable connected as shown here.

The lid will already be installed. If the cable should become loose, the lid must be removed in order to push the connector fully home.

If you need to adjust the cable connector, remove the lid by gripping the case sides (not the lid sides), pushing them in slightly and lifting off the lid. With the lid off it is much easier to fully insert the cable plug into its connector on the board.

Then, replace the lid on top with the LED hole above the LED. Press the lid firmly home so that its retention indents lock into the corresponding bumps on the case.

Use the supplied hook and loop fastener patch to attach the case, with the lid uppermost to the inside top of your fuselage. Additional glue may be required to attach the hook and loop fastener securely to your fuselage especially when it is left out in the sun and heats up.

In this way the GNSS antenna will be facing upwards and towards the sky when the model is flying level the right way up.

Keep the **DopplerFX** Accessory board as far away as possible from all other electronics and metal or carbon fibre structures as they can interfere with the very weak GNSS satellite signals.



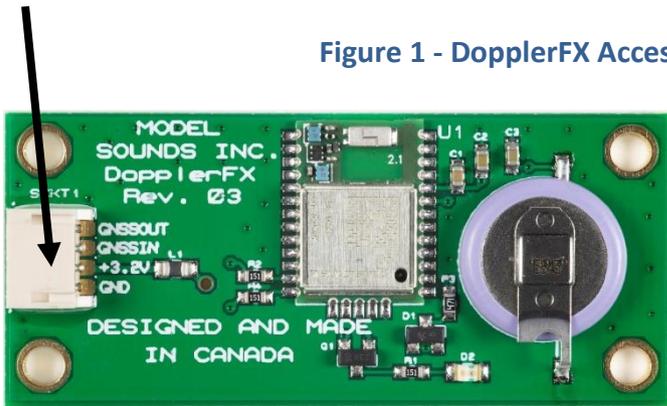
## CHAPTER 3 – HOW TO CONNECT YOUR DOPPLERFX ACCESSORY BOARD

The **DopplerFX** board comes pre-mounted inside a plastic case with its 4-wire cable already connected. The other end of that cable should be firmly inserted into SCKT3 of the **ShockWave 3** sound module.

Should the cable become disconnected from the **DopplerFX** board, please reconnect it as follows.

1. Remove the lid by gripping the case sides (not the lid sides), pushing them in slightly and lifting off the lid. With the lid off it is much easier to fully insert the cable plug into its connector on the board.
2. Insert the cable connector into the four pin 1.5mm pitch connector **SCKT1**.

Figure 1 - DopplerFX Accessory Board



Use ONLY the 4-wire accessory cable from Model Sounds Inc. provided with the **DopplerFX** board.

**DO NOT** connect the other end of the accessory cable to anywhere other than the accessory port of the **ShockWave 3** sound module.

When connecting the 4-wire accessory cable to the **DopplerFX** board make sure the connector on the cable is inserted into the board connector the right way up. The white wire should always be to the top of the board. The connector is quite stiff, so make sure it is inserted all the way in.

If you need to remove it, do so very carefully by teasing the plug from its socket with a finger or thumbnail or a small screwdriver. **Do not pull on the wires to remove it as they will be pulled out of the plug.**

### ORIENTATION OF THE 4-WIRE ACCESSORY CABLE CONNECTOR ON DOPPLERFX BOARD

Figure 2 - Correct Position of 4-Wire Connector



Figure 3 - Incorrect Position of 4-Wire Connector





## ORIENTATION OF THE 4-WIRE ACCESSORY CABLE CONNECTOR ON SHOCKWAVE 3 BOARD

### Correct Orientation of 4-Wire Connector On ShockWave 3



### Incorrect Orientation of 4-Wire Connector



When connecting the 4-wire accessory cable to the **ShockWave 3** board, make sure the connector on the cable is inserted into the board connector the right way up. The white wire always goes to the top edge of the board connector as shown here. The connector is quite stiff, so make sure it is inserted all the way in.

If you need to remove it, do so very carefully by teasing the plug from its socket with a finger or thumbnail. Do not pull on the wires to remove it as they will be pulled out of the plug.

## POWERING THE DOPPLERFX ACCESSORY BOARD

The **DopplerFX** Accessory board requires +3.3Volts power **AND NO HIGHER**. This power is drawn from the **ShockWave 3** sound module's on-board +3.3V voltage regulator through the provided four-wire cable connecting the **DopplerFX** Accessory board to the **ShockWave 3** module.

This same power provides charging current for the on-board re-chargeable coin-cell backup battery.

**When it is first received, it is advisable to power up the DopplerFX board through the ShockWave 3 board for a period of 24 hours to charge up its rechargeable coin-cell backup battery.**

**It is not necessary to apply power to the ShockWave 3's blue terminal block for this.**

## CHAPTER 4 – HOW TO OPERATE YOUR DOPPLERFX ACCESSORY BOARD

### RC INPUTS ON THE SHOCKWAVE 3 MODULE SUPPORTING THE DOPPLERFX FEATURE

The **ShockWave 3** sound module has a set of **SOUND3** RC input pins on its HEADER1 (at the bottom left hand side of the board).

**Pins 1, 2, 3** on that HEADER1 is configured by default to support an optional input from a spare RC receiver channel to control the **DopplerFX** feature. This input can be used to both reset the Observer Position (more later) and to remotely enable and disable the **DopplerFX** feature.

**Pin 1 is system GND, or battery –ve, pin 2 is receiver power, pin 3 carries the DopplerFX RC receiver signal from the radio receiver into the ShockWave 3 board.**

To use this input effectively, it should be used with a **three-position switch** on your radio with the centre position being the **OFF** position. One direction is used to reset the [Observer Position \(more later\)](#) and the other direction is used to remotely enable and disable the DopplerFX feature.

### SETTING THE OBSERVER POSITION REMOTELY

The Observer Position is always recorded when the system is first powered up and once the GNSS satellite fix has been obtained. While in flight, the Doppler frequency shift is always computed relative to the Observer Position. This may not be what the pilot wants, especially if the pilot station is some distance away from the start-up pits or wherever the plane's electronics were first switched on.

Also, if the pilot is trying to impress the judges in a scale model competition, he may want to reset the Observer Position to a point near the judges so that they experience the proper Doppler shift enhancement.

The Observer Position can be reset remotely using the **ShockWave 3** SOUND3 RC input. This is optional and, if connected, it should be controlled by a three-position switch on the Transmitter. This radio channel's OFF position pulse width is measured when the **ShockWave 3** board is powered up.

When the 3-position switch is thrown causing the input pulse width to be different by more than **+100us** from this initial value, the Observer Position will be reset to wherever the plane currently is.

After setting the Observer Position this way, the switch should be returned to its previous OFF position.

## ENABLING/DISABLING THE DOPPLERFX FEATURE

The pilot may not always want the enhanced Doppler Shift feature on all the time. The **ShockWave 3** SOUND3 RC input can be used to enable or disable the feature remotely. When disabled, the motion tracking and all computations relative to the Observer Position will continue but there will be no frequency shift in the played back sounds. This is useful to demonstrate the effectiveness of the **DopplerFX** feature.

With the switch in its initial centre position, the Doppler Enhancement feature is enabled and the Observer Position is setup when the system is powered up. If the 3-position switch is moved to the other extreme where the input pulse width is different by more than **-100us** from its initial value, the Doppler Enhancement feature is disabled until the switch is released back to its centre position.

## THE DOPPLERFX LED INDICATOR

The **DopplerFX** Accessory board has a dual-purpose Green LED. The Green LED will light steadily when power is first applied to the board. Once a satellite fix is obtained it will flash on and off once per second as a satellite fix acquired indicator.

However, since the DopplerFX board is installed inside the model, this LED is of little use to the user, so there needs to be an external mechanism to indicate when a satellite fix has been obtained.

## RANGE OF DOPPLER SHIFT ENHANCEMENT

The **ShockWave 3** sound module can accommodate an increase or decrease in playback speed by up to two times. When applying that number to the standard Doppler shift formula, this represents a maximum simulated speed of 615 km/hr (384 mph) or Mach 0.5.

## CHAPTER 5 – THE DOPPLERFXSETTINGS.TXT FILE

Important settings for the DopplerFX feature are contained in a DopplerFXSettings.txt text file on the microSD card. This file is mandatory. If it is missing, the ShockWave 3 sound module will create one with default values as below:

### DopplerFXSettings.txt File Default Contents

The DopplerFXSettings.txt File looks like this:

```
**** DopplerFXSettings.txt ****

// SatelliteConstellations: can be one of GPS_ONLY, GPS_PLUS_GLONASS, GPS_PLUS GALILEO,
GPS_PLUS BEIDOU
SatelliteConstellations: GPS_ONLY

// DopplerFXSpeedMultiplier: can be one of 1,3,5,7
DopplerFXSpeedMultiplier: 7

// The following can all have values of yes or no.
// If the OnceOnly settings are yes, that means the sound is played only the first time that event occurs.
// If the OnceOnly settings are no, that means the sound is played every time that event occurs.
PlaySatelliteFixAcquiredLostSounds: yes
PlaySatelliteFixAcquiredLostSoundsOnceOnly: no

PlayObserverPositionSetSounds: yes
PlayObserverPositionSetSoundsOnceOnly: no

PlayDopplerFXEnabledDisabledSounds: yes

PlayDopplerFXEnabledDisabledSoundsOnceOnly: no
```

The field names are mostly self-explanatory.

Field names must be EXACTLY as shown here and are case sensitive.

Data values can be yes or no and can be upper or lower case.

Comment lines start with //

## CHAPTER 6 - HOW DO I KNOW WHEN I HAVE A SATELLITE FIX?

When first powered up or when powered up a long distance from when it was previously powered, the “satellites in view” may be different and the time to get the first position fix may be as long as 1 minute or so. This time is called the Time To First Fix (**TTFF**). Under these circumstances it is called a “cold start”.

Subsequently, as long as the backup battery is charged, and if you power-up the **ShockWave 3** and **DopplerFX** board in roughly the same location as last time, this time will be less than 10 seconds. This is called a “hot-start”.

### THE EFFECTS OF WEATHER ON THE TIME TO FIRST FIX

GNSS satellites broadcast their signals to earth at microwave frequencies around 1.6GHz. At these frequencies, the radio waves can easily be absorbed by water molecules such as those present in clouds in the atmosphere. This makes it more difficult for the GNSS receiver to acquire the satellite signals and determine its location.

Therefore, the TTFF may be longer on cloudy days compared to sunny, bright and cloudless days.

### USING SYSTEM SOUNDS FOR DOPPLERFX EVENT NOTIFICATIONS

The **ShockWave 3** module can make system sound announcements to notify you of events such as **Satellite Fix Acquired or Lost**, **Observer Position Set** and some others. These system sound announcements can be turned on and off by the user using text entries in the **DopplerFXSettings.txt** file on the microSD card. They can also be changed in the **ShockWave 3 PC software Control Panel->DopplerFX Tab**.

DopplerFX Notification Sounds depend on System Sounds being Enabled on the ShockWave 3.

For those fields whose values are “yes”, the sounds will only play if System Sounds are enabled on the ShockWave 3 module using Button1. It is therefore highly recommended to have System Sounds enabled to start with, when first operating the model with the DopplerFX board. Then, once you have got used to how it behaves, you can turn System Sounds OFF.

## CHAPTER 7 – THE DOPPLERFX BOARD BACKUP BATTERY

When a GNSS receiver is first powered up it does a “Cold Start”. This means that it searches for available satellites and builds a small database of available start-up information and other essential data. If there is a backup battery present, this start-up information is stored in volatile memory (RAM) that would otherwise be lost when its main power is removed, as when the electric power system in the model is switched off.

Since a cold start can take up to 2 minutes or more to perform, by storing the information in backup memory, it can perform a “Warm Start” next time which takes only 10 seconds. The current drain when in backup mode is only about 7uA and the 3V coin-cell will last about 2430 hours (about 101 days) without being recharged. It will likely run down during the winter months when the plane is not in use and will start-up again in Cold Start mode the first time it is powered up in the next flying season.

It is recommended to charge up the battery at least twice during the winter months. The battery gets charged automatically when the main +3.3V power from the **ShockWave 3** sound module is applied.

Care should be taken to **NOT** short circuit the small coin-cell backup battery with stray tools or wires.

## CHAPTER 8 – LIMITATIONS

Since the Doppler frequency shift is calculated relative to the **Observer Position**, the correct frequency shift will be observed only by someone at that position. If the plane is being flown at a large show with a long flight line, most of the people along that flight line will observe the frequency shift from Increasing to Decreasing at the **Observer Position** which is other than where they are standing. This may sound a bit strange.

The amount of available frequency shift is limited to about 2 times faster or slower than the regular playback rate.

### Frequency Shift Limits

Two times faster is achieved when the simulated speed is 615 km/hr (384 mph) or Mach 0.5, so if the speed multiplier is set at the maximum of 7 times, the actual model speed would be 88 km/hr (55 mph). Of course, the model can travel faster than that, but the enhanced Doppler frequency shift will max. out at those speeds. If you have a faster flying model then consider reducing the Model Speed Multiplier to 3 times, instead of the maximum 7 times.

Even if the model's actual speed multiplied by the Speed Multiplication Factor is greater than this speed, the maximum shift will be limited to 2 times so the Doppler Shift will not change while the simulated speed is greater than the above figure.

### Doppler Shift Enhancement Effect is Model Dependent

The perceived Doppler shift, both with and without the DopplerFX feature running, is dependent upon the actual sound playing, depending on its tonal content, i.e. mix of different frequency sounds. Some aircrafts, jets and helicopters sound better than others.

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