Tsunami™
Digital Sound Decoder

Tsunami™ Digital Sound Decoder

Steam Sound
User's Guide

Software Release 1.00

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All Aboard!

Overview

Congratulations on the purchase of your SoundTraxx™ Tsunami™ Digital Sound Decoder™. This **User's Guide** will walk you through the various aspects of programming your Tsunami decoder, as well as some tips on troubleshooting. For the power user, the Tsunami **Technical Reference** will provide a list of all the CVs available for use with Tsunami decoders and their exact function and make-up for those who wish to have a complete reference for advanced programming techniques.

Technical Bulletins and Application Notes covering various topics are also published from time to time, and these may be downloaded free of charge from our website at www.soundtraxx.com.

Operation

Using Your Tsunami Digital Sound Decoder

Your SoundTraxx Tsunami has been shipped with all CVs pre-programmed so you can begin using your locomotive immediately without having to worry about what adjustments to make. Function Assignments are as follows:

Steam Decoders

Function Key	Effect
F0	Headlight/Backup Light/Dynamo
F1	Bell
F2	Whistle
F3	Short Whistle
F4	Steam Release
F5	FX5 Output
F6	FX6 Output
F7	Dimmer
F8	Mute the Sound
F9	Water Stop
F10	Injectors
F11	Brake Squeal/Release
F12	Coupler Clank
Direction Button	Johnson Bar
Throttle	Exhaust Chuff, Snifter Valve

While these are the default settings, you may wish to make changes to the function mapping later. For now, simply set your controller to Locomotive 3, place the locomotive on the mainline and away you go! Now that you have control of your decoder, let's see what happens!

Turn on the Lights

Press F0 on your cab to turn on the Headlight. As you turn on the headlight, the dynamo will 'spool up' in an accelerating whine until it reaches full power, when it will sound more like a soft buzz – can't have lights without turning on the generator now can you? Reverse locomotive direction and the headlight turns off as the backup light turns on.

If you have wired your Tsunami decoder for Functions 5 and/or 6, pressing these keys will activate these effects. While waiting on a siding, you can press F7 to dim the headlight for an oncoming train.

Ring the Bell

Engineers are required to ring the bell during yard movement. To ring the bell, press F1 on your cab. This is an on/off function, i.e. once on, the bell will continue to ring until you turn it off. Press F1 again to turn it off.

Operation

Blow the Whistle

Engineers are required to blow various whistle signals to warn of the approaching train as well as notify both passengers and train crew to the planned movement of the locomotive. Some of these are signals for grade crossings, stopping, moving forward, backing up and more.

Whistle Signals	
Note: ● = Short Blast — = Long Blast	
— — ● —	Approaching Grade Crossing. (Hold final blast until crossing is reached.)
● —	Approaching a bridge or tunnel
●	Stop, set brakes
— —	Release brakes and proceed forward
● ● ●	Backup
● ● ● ●	Request signal from Trainman
— ●	Warning whistle, used when approaching points where view is obstructed.

Learning and using the various whistle signals can add a lot of fun to your operating sessions! Some of the more common signals are indicated here. To activate the Whistle, press F2 on your cab: the longer you press the key, the longer the whistle will blow. While this allows you to make short or long signals, F3 is designated as a 'short' whistle so your shorts will have that nice, crisp, 'toot' regardless of how responsive your cab controls are…try a grade crossing whistle!

Blow Down the Boiler

If your steam engine's been sitting in the station awhile, there's bound to be some particle buildup in the boiler. Press the F4 key to open the blowdown valve and blow out the sediment. Press the F4 key again to close the blowdown valve.

Automatic Steam Sound Functions

Some sound effects happen in response to an action other than pressing a function key. The blowers will automatically simmer in the background to help vent the steam and keep up a good draft.

Airpumps

Brakes on trains operate using air pressure. When the engineer activates the brakes, he is releasing air pressure, forcing the brake shoes against the wheels and causing the train to slow down. When the engine stops the air pressure is build up using a compressor, also called an airpump. The air pumps will pound out a steadily slowing cadence that simulates the build up of air pressure in the main reservoir. Deceleration of the locomotive while applying the brakes will cause the air pump to resume pumping.

Operation

Snifter Valve
Just as you start to move the engine, you'll hear the Pfffffff! of the snifter valve.

Johnson Bar
Changing the locomotive direction will automatically activate the sound of the Johnson Bar being thrown one way or the other.

Fireman Fred
Each time the engine is brought to a stop, Fireman Fred may attend to a randomly selected task (or tasks), including shoveling coal, oiling the side rods, and more.

Exhaust Chuff and Rod Clank
The exhaust chuff and rod clank sounds are automatically generated whenever the locomotive is set into motion. Both effects may be optionally synchronized to a cam (see page 44) and may also be configured to vary in volume in response to load changes using Tsunami's Dynamic Digital Exhaust setting (see page 54).

Activating other Functions and Effects
Depending on the number of function keys provided on your cab, you might have additional functions immediately available for you to activate.

Mute the Sound
Pressing F8 on all Tsunami decoders will gradually mute all sound effects - great for a quick answer of the telephone! Pressing it a second time will allow you to hear the sounds again.

Water Stop
All steam engines require water! The Water Stop initiates a sequence of events beginning with the fireman opening a rather squeaky water hatch, followed by the sound of water filling the tender. This effect is activated when the engine is stopped by pressing F9 and can be stopped by pressing F9 again. If the locomotive is started while the effect is running, the effect will automatically turn off.

Injector
The injector delivers feed water to the boiler. Pressing F10 on all Tsunami decoders will turn on the sound of the injector. Pressing it a second time will turn the injector off.

Brake Squeal/Release
The sound of the brakes squealing is typically heard just before the wheels of the locomotive stop turning. Pressing F11 when the engine is moving will initiate a brake squeal effect. Press F11 again to turn this feature off.

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Coupler Clank

Pressing F12 will activate the coupler clank sound effect, see how well you can time the effect to the actual coupling of the locomotive to the train!

As you see, no programming is necessary to begin enjoying your DSD! However… after you have had a chance to play with your decoder for a little while, you may wish to make some changes such as selecting a new address or altering a sound effect. The following section will introduce you to CVs and how and why you might wish to change them.

Basics of Programming

Programming the CVs

What is a CV?

CV stands for Configuration Variable, which is the industry-adopted term for a decoder's user-programmable memory locations. CVs allow you to customize individual decoder properties such as the address, momentum, throttle response, sound volume and much more. Once a CV has been programmed, the setting will be permanently remembered even after the power has been turned off. A CV can be modified as often as necessary by simply reprogramming it with a new value.

With the large number of CVs available, first inspection of the available options may cause confusion and little panic! Relax. As you have already seen the DSD has been shipped with all CVs pre-programmed so you can begin using your locomotive immediately without having to worry about what adjustments to make.

The following paragraphs break the sound decoder's CVs into various subsystems so it is only necessary to change a few CV's at a time. As you become comfortable with it's operation, move onto a new section and begin exploring the options and capabilities found there. For more technically inclined users, detailed information on any CV can be found in the **Tsunami Technical Reference.**

Bits and Bytes

One of the most confusing aspects of programming a CV is figuring out what all the different bits, bytes and x's found in the various decoder manuals mean. The problem is compounded further by differences in each command station manufacturer's user interface. For users unfamiliar with such terms, a short math lesson (ugh!) is in order before proceeding:

Each decoder CV stores a numeric value that can be represented in one of three forms:

Decimal - This is the form everyone is familiar with and we use in our day-to-day lives. Numbers are represented as a sequence of digits composed of the numerals 0,1,2,3,4,5,6,7,8, and 9.

Hexadecimal - Also referred to as simply "hex", this is a more specialized number representation that, in addition to 0 through 9, also uses the characters A-F. It has the advantage that a given decimal number can be more compactly represented. For example, the decimal number 127 converts to a simple 7F in hex (one less digit). This allows user interfaces with a limited number of digits (i.e., the LCD on your cab) to display a wider range of numbers.

Binary - Binary numbers get their name from the fact they use only two digits 0 and 1 called 'bits' and is the fundamental number system used by all computers including the ones found inside a digital decoder. Because there

are only two bit values, it takes more digits to represent a number using binary. The decimal number 127, for example, is written as 01111111 in binary notation. A 'byte' is a binary number made up of eight bits. And a 'nibble' is half a byte or four bits. Really! We didn't make that up.

Coincidentally, each CV is made up from one byte or eight bits and can store any number between 0 and 255. Most of the CVs contain a single piece of data that can be easily represented in any of the three forms, i.e., CV 3, the acceleration rate, can be loaded with any value from 0 to 255 and it always affects the same thing - the acceleration rate.

On the other hand, some CVs use individual bits to control different features. This allows up to eight individual features to be controlled by a single CV and is done to conserve the number of CVs. As the bit variables can take on only one of two values (0 and 1) they are usually used for simple variables that are either On or Off, enabled or disabled or something similar. Unfortunately, bit variables are difficult to represent in any form other than binary and still preserve any meaning. Because most DCC system user interfaces don't use binary representation, these numbers are the most difficult to work with and require a tedious series of additions to convert to the decimal or hex form used by most systems.

We have tried to use the decimal number system in this manual when describing the proper values to program into a given CV; however, you will occasionally find values listed in the Technical Reference in binary, hex and decimal values. Hex numbers can be distinguished from a decimal number by noting a 0x prefix. Thus 0x10 is the hex version of sixteen and not ten as one might guess. Binary numbers are represented using a 'b' suffix. 100b is really the number four and not one hundred. To further assist the math-impaired, we have provided a handy-dandy conversion table in Appendix A that allows one to quickly convert between decimal, hex and binary.

When working with individual bits such as in CV 29, we suggest the following procedure for determining the correct value to program. Referring to the CV description, write down the value desired for each individual bit. Consider for example, the case of CV 29. We would like to set this CV so that speed tables are enabled and the 28 speed-step mode is in effect. Referring to the Technical Reference, we see that bit 4 and bit 1 should be set to 1 and all other bits are cleared to zero. Remembering that we are dealing with binary, write down the individual bit values and we get:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0	0	0	1	0	0	1	0

We then look up the binary value 00010010b in Appendix A and see that it corresponds to the decimal value 18 (0x12 in hex). This is the value to use when programming the CV.

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If you don't have the conversion chart available, you can also calculate the value in the following manner. Reading from right to left, each bit has a decimal value associated with it, beginning with a 1 and doubling this value as you go from bit 0 to bit 7. This value is only counted when the bit is a '1'. Looking at the figure below, you can see that using this method, bit 1 has a value of 2 and bit 4 has a value of 16. Adding these two numbers together gives the correct decimal value of 18.

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
	0	0	0	1	0	0	1	0
When bit is set to 1, value =	128	64	32	16	8	4	2	1
Therefore:	0 +	0 +	0 +	16 +	0 +	0 +	2 +	0 = 18

Programming Methods

There are two methods for changing the sound decoder's CVs:

Service Mode Programming - This programming mode usually requires the locomotive to be placed on a special programming track or connected to a dedicated programmer. Tsunami is an advanced line of decoders and support four types of service mode instructions:

Address Mode - Can change CV 1 (Primary Address) only.
Register Mode - Can change CVs 1,2,3,4,7,8 and 29 only.
Paged Mode - Uses a page register to indirectly modify any CV.
Direct Mode - Can directly change any CV.

Operations Mode Programming - Sometimes called 'Ops Mode' or 'Programming on the Main', this programming mode allows the CVs to be changed while the locomotive is operating on the layout even when other locomotives are present. The neat thing about this mode is that the CVs can be changed in the middle of operation allowing the engineer for example, to increase the momentum rate of a locomotive after it couples to a train. The main disadvantage of operations mode programming is that the CV data cannot be read back to verify its value.

Reading CVs

Certain command stations also allow you to read a CV during Service Mode Programming, which is useful to verify its current setting. If you have trouble reading or verifying CVs, the problem may be due to the design of your command station and not the DSD itself. Tsunami and all other decoders communicate back to the command station using what's called an acknowledgment pulse, which is defined in NMRA RP-9.2.3 as "an increased load on the programming track of at least 60mA for at least 5ms." Like most decoders, the DSD generates the acknowledgment pulse by momentarily applying power to the motor. You can often visually verify that the Tsunami is properly responding to your programmer by observing a slight twitch in the

motor shaft when a read or write command is given.

If your DSD is otherwise working properly (i.e., responds properly on the mainline to speed and direction commands) but your command station is having troubles reading CV data from the DSD, it may be due to incompatibilities between the electrical requirements of the DSD (which are different from conventional decoders due to the added audio circuitry) and the electrical characteristics of your programming track. In such an event, we suggest you simply go ahead and program the data into the CVs anyway. Usually the DSD will accept the data and function properly when placed back on the main track.

Another option is to use a Programming Track Booster, such as SoundTraxx PTB-100 (P.N. 829002). The PTB-100 amplifies the programming track signals to levels that work best with Tsunami. It is easy to install (see below) and inexpensive. An advantage to using the PTB-100 is that it also provides short circuit detection and some helpful diagnostics. It works well with all other SoundTraxx decoders, too.
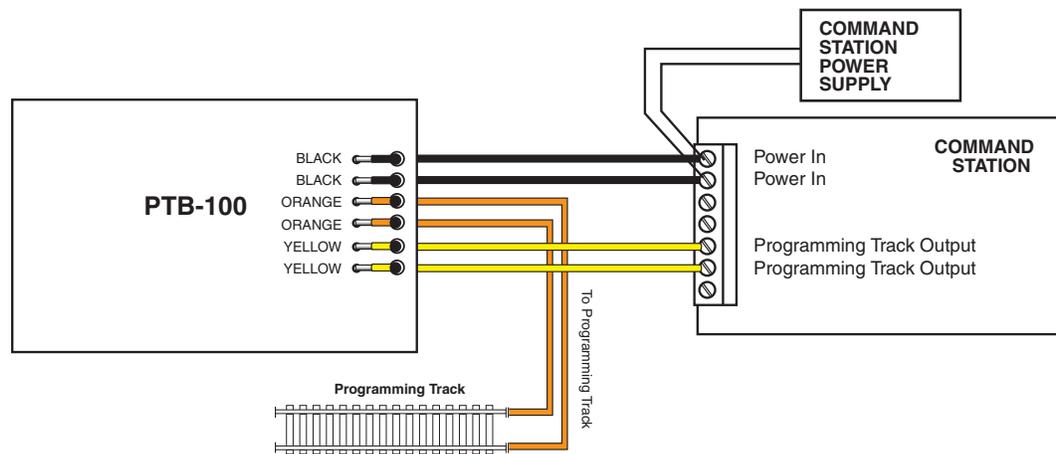
Figure 1 - General Wiring Diagram for the SoundTraxx PTB-100

Finally, if you continue to experience difficulties, try a different programming mode. If your system supports it, the best way to program the CVs is Operations Mode, as it allows you to immediately see or hear the results of your changes. It is important, however, to realize that not all programming modes will program all CVs. Additionally, the specific programming mode you use will depend upon the type of DCC system you are using. Some of the newer DCC systems can automatically select the proper programming mode so all you need to do is specify the CV number and its new value. On the other hand, some systems support only a few of the programming modes and may restrict which CVs you can program. If in doubt, refer to your DCC system's manual or contact the manufacturer to determine which methods they support.

Basics of Programming

Programming Procedure

As each DCC system is different, the procedure for programming a CV will vary depending upon the system. Unfortunately, we cannot provide detailed instructions to cover every command station and have to assume that you have some level of understanding regarding it's capabilities and operating procedures. For specific programming procedures, please consult your DCC system manual.

Locking and Unlocking CVs

The CV Lock/Unlock is a relatively new feature available in some DCC decoders which allows you to program a decoder without the danger of overwriting the programming in another. This especially useful in installations where multiple decoders are used. For example, if you have installed a function decoder in addition to the sound decoder, you may wish to lock the CVs after programming to prevent accidentally programming one or the other.

To use the CV Lock feature implemented in CV 15 and 16, Bit 0 of CV 30 must first be set to 1 (the default value is 0). This is to avoid inadvertently locking the decoder when the CV Lock feature is not needed.

CV 15 and 16 are used for locking and unlocking the decoder. CV 15 is the Unlock Code and may be programmed to any value between 0 and 255 regardless of whether the decoder is locked or unlocked. CV 16 is the Lock Code and may be set to any value between 0 and 7 but only when the decoder is unlocked. Attempts to program CV 16 with a value greater than 7 will be ignored.

The decoder is unlocked when the value in CV 15 matches the value in CV 16. Otherwise the decoder is locked and can not be programmed in either operations mode or service mode. Further, a locked decoder can not be reset to its factory defaults until it is first unlocked. Tsunami decoders are shipped from the factory with all CVs unlocked, that is, CV 15 and 16 are both set to 0.

☞ Note that if the decoder is unlocked, changing the value in CV 16 will instantly lock the decoder. You must then set CV 15 to the same value as was just programmed into CV 16 to unlock the decoder again.

If you decide to use the CV Locking feature for a multi-decoder installation, each decoder installed inside that locomotive must first have its Lock Code in CV 16 set prior to installation of any other decoders. Otherwise, all the decoders will have the same Lock Code and the feature will not work. The easiest way to go about this is to first install one decoder and program its Lock Code. Then install the next decoder and program its Lock Code. Since the first decoder is now locked it will be unaffected by the programming of the second decoder (unless you accidentally set the Lock Code of the two decoders to the same value. If this happens you will need to disconnect one decoder and start over). Continue in this manner until all decoders have been installed and their Lock Codes have been set.

It is a good idea to set up a standardized system so you don't forget the Lock Code settings. You might, for example, set all motor decoders to a CV Lock Value of 1, sound decoders to a value of 2 and function decoders to a value of 3. Keeping CV 15 set to 0 will guarantee the decoder stays locked until you are ready to begin programming.

Example: Let's say you will be installing motor decoder, a sound decoder and a function decoder in one locomotive. Using the previously described system, you would first install the motor decoder and set its Lock Code by programming CV 16 to 1. Since CV 15 is currently set to 0 (the default value), the decoder is immediately locked. Now install the sound decoder and set its Lock Code by programming CV 16 to 2. Since CV 15 is still set to 0, this decoder is also immediately locked. Now install the function decoder and set its Lock Code by programming CV 16 to 3. At this point, all three decoders are installed and locked. Starting with the motor decoder, set CV 15 (the Unlock Code) to 1 to unlock and program the motor decoder. When you are finished set CV 15 to 2 and program the sound decoder. Finally, set CV 15 to 3 and program the function decoder. When you are done, set CV 15 back to 0 to lock all the decoders.

If You Forget the Lock Code
As there are only eight possible combinations, you can easily determine a forgotten Lock Code setting using trial and error with the following procedure:

Place the locomotive on the Programming Track and set CV 15 to 0. Then try to read the value in CV 16. If CV 16 does not read back, the decoder is locked. Set CV 15 to 1 and try reading CV 16 once more. Again, if CV 16 does not read back, the decoder is still locked. Program CV 15 to 2 and try reading CV 16 again. Continuing in the manner, you should eventually find the value stored in CV 16 as it can only be programmed between 0 and 7. If you have tried setting CV 15 to all eight values between 0 and 7 and the decoder still does not respond, there may be a problem with the installation, the program track or the decoder itself and further investigation will be required.

If you do not have access to a programming track with read-back capabilities (or are uncertain as to whether it is working properly) you can also use operations mode to discover the Lock Code by alternately programming CV 15 and setting another CV to a value where there is a known response. For example, changing CV 128, the master volume control, will provide auditory feedback as to whether the decoder is unlocked by virtue of a change in sound level. Thus, you would begin by setting CV 15 to 0 and then setting CV 128 to 0. If the volume does not fall to zero, the decoder is locked. Then set CV 15 to 1 and try programming CV 128 again. Repeat this process until you find a value for CV 15 that results in a change in sound volume as you change CV 128.

Troubleshooting Tip
Be aware that even if you are not planning to use the CV Lock feature, it can still be accidentally activated by inadvertently programming CV 15 or 16 with a non-default value. If you have a decoder that is otherwise working

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(i.e., making sound and responding to throttle function commands) but has suddenly stopped accepting CV changes, then first run through the procedure under *"If you Forget the Lock Code"* to determine if the decoder has been locked.

Resetting the CVs or Starting Over

Occasionally, something goes wrong and Tsunami will not respond as expected. Usually, this is caused by one or more CVs being programmed to the wrong value. The CVs can be quickly reset to their factory default values using the following procedure.

1. Program CV 30 to 2 (or CV 8 to 8) using either Service Mode or Operations Mode
2. Place locomotive on a powered section of track. If locomotive is already on the mainline, cycle power to the decoder by turning power to the track off and then back on.
3. After power is restored to the track there should be no indication of activity other than the power LED turning on for a period of six seconds. If sound comes on imediately upon restoring power, the decoder did not reset. Repeat steps 1 and 2.
4. Once the six-second period has elapsed, the sound should come on and the headlight, backup light and onboard diagnostic light will blink 16 times indicating that the CVs were successfully reset.
5. Tsunami should now respond to short address 3 just as it did when it was first unpacked.
6. If you cannot get the decoder to reset, check to see that it has not been inadvertently locked (see "If You Forget the Lock Code" in the previous section).

Basic Programming

Step 1: Configuring the Address

The first group of CVs you will want to change are those that set Tsunami's address:

> CV 1, Primary Address
> CV 17:18, Extended Address

Tsunami may be set up to recognize either the primary address (also called the short address), which provides a range of 1 to 127 or the extended (long) address, which has a range of 1 to 9999! Whether you use the primary or extended address will first depend on whether or not your DCC system uses extended addressing (not all of them do - if in doubt, see your command station owner's manual.) Second, it will depend on your preferences and the numbering scheme you use for setting your decoder addresses. The extended address has the advantage that you can use all four digits of a locomotive's road number for the decoder address making it easy to remember. Be aware that some DCC systems do not support the full range of available addresses.

Primary Address

To use the primary address, simply set CV 1 to the desired address between 1 and 127.

Programming Notes: Both the primary and extended address may be changed at any time using service mode.

Some DCC systems will also allow the decoder address to be modified using operations mode programming (consult your system manual for details). Please note that when programming in operations mode, the following restrictions apply:

> If the decoder's primary address is enabled (i.e., CV 29, bit 5 is 0), only the extended address may be changed using operations mode programming.

> If the decoder's extended address is enabled (i.e., CV 29, bit 5 is 1), only the primary address may be changed using operations mode programming.

Extended Address

The extended address is actually made up of two CVs, 17 and 18. Unless you are an experienced user, you should not try to program these CVs individually as a specific protocol is required in order for the DSD to accept the new data (See the Technical Reference for details). Since most command stations that support extended addressing will automatically generate the correct protocol, simply follow their instructions for setting the extended address.

Basic Programming

Once the extended address is stored in CV 17 and 18, bit 5 of CV 29 must be set to 1 so the decoder will recognize the extended address format. Otherwise, the decoder will continue to respond only to its primary address. See the next section, Configuring the Decoder.

Basic Programming

Step 2: Configuring the Decoder

The next CV you will want to change is **CV 29, Decoder Configuration Byte.** CV 29 is one of those complicated bit variables mentioned earlier and is used in conjunction with other CVs to set a multitude of decoder characteristics including Locomotive Direction, Speed Step Mode Selection, Speed Table Enable and Alternate Power Mode Enable.

Bit 7   **Bit 0**

0	0	EAM	STE	ACK	APS	F0	DIR

Locomotive Direction - Causes the decoder to invert direction commands so that the locomotive runs in reverse when it receives a command to move forward and vice-versa. This operating mode is most useful for setting up diesel engines that ran with the long hood section forward. However, it is also useful for electronically correcting installations where the motor wires were accidentally reversed and avoids tearing apart the locomotive a second time.

Speed Step Mode Selection - As it is a digital system, Tsunami splits the throttle voltage over its minimum and maximum range into discrete speed steps. Tsunami can be configured so there are 14, 28 or 128 individual speed steps. The largest number of steps will give the smoothest throttle response. Since not all DCC systems have the ability to control 28 or 128 speed steps, your choice will depend upon the technical capabilities of your command station.

Speed Table - Sets the decoder to use the speed table specified by CV 25 (see "Configuring the Throttle", page 17).

Primary or Extended Address - Sets the decoder to recognize its primary address in CV 1 or extended address in CV 17:18 (see "Configuring the Address", page 13).

Alternate (Analog) Power Mode - Enables the decoder to work with an alternate power mode (such as DC operation) as set by CV 12 when a DCC signal is not present.

To assist the novice user, we have created Table A on the next page that lists the correct value for CV 29 to get the desired operating modes.

To use the table, simply find the row that has the modes you want and program CV 29 with the listed value.

The advanced user should refer to the Technical Reference for more details. Remember, table values are in decimal. If your command station uses Hex (Hexadecimal), you will need to convert the value shown using Appendix A.

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Table A. Quick-Reference Table for CV 29 Values					
Address Type	**Use Speed Tables?**	**Analog Mode?**	**Speed Steps**	**Locomotive Direction**	**CV 29 Value**
Primary (CV1)	No	No	14	Normal	0
Primary (CV1)	No	No	14	Reversed	1
Primary (CV1)	No	No	28/128	Normal	2
Primary (CV1)	No	No	28/128	Reversed	3
Primary (CV1)	No	Yes	14	Normal	4
Primary (CV1)	No	Yes	14	Reversed	5
Primary (CV1)	No	Yes	28/128	Normal	6
Primary (CV1)	No	Yes	28/128	Reversed	7
Primary (CV1)	Yes	No	14	Normal	16
Primary (CV1)	Yes	No	14	Reversed	17
Primary (CV1)	Yes	No	28/128	Normal	18
Primary (CV1)	Yes	No	28/128	Reversed	19
Primary (CV1)	Yes	Yes	14	Normal	20
Primary (CV1)	Yes	Yes	14	Reversed	21
Primary (CV1)	Yes	Yes	28/128	Normal	22
Primary (CV1)	Yes	Yes	28/128	Reversed	23
Extended (CV17:18)	No	No	14	Normal	32
Extended (CV17:18)	No	No	14	Reversed	33
Extended (CV17:18)	No	No	28/128	Normal	34
Extended (CV17:18)	No	No	28/128	Reversed	35
Extended (CV17:18)	No	Yes	14	Normal	36
Extended (CV17:18)	No	Yes	14	Reversed	37
Extended (CV17:18)	No	Yes	28/128	Normal	38
Extended (CV17:18)	No	Yes	28/128	Reversed	39
Extended (CV17:18)	Yes	No	14	Normal	48
Extended (CV17:18)	Yes	No	14	Reversed	49
Extended (CV17:18)	Yes	No	28/128	Normal	50
Extended (CV17:18)	Yes	No	28/128	Reversed	51
Extended (CV17:18)	Yes	Yes	14	Normal	52
Extended (CV17:18)	Yes	Yes	14	Reversed	53
Extended (CV17:18)	Yes	Yes	28/128	Normal	54
Extended (CV17:18)	Yes	Yes	28/128	Reversed	55

Step 3: Configuring the Throttle

There are seven CVs that characterize the Tsunami's throttle response and 28 more used to create a custom speed table:

> CV 2, VStart
> CV 3, Acceleration Rate
> CV 4, Braking Rate
> CV 25, Speed Table Select
> CV 29, Configuration Data
> CV 66, Forward Trim
> CV 95, Reverse Trim
> CV 67-94, Loadable Speed Table

This may sound like a lot of CVs but don't worry; it's not necessary to change all of them if you don't want to. We've already talked about speed step selection in CV 29 (Step 2).

Set the Start Voltage

Tsunami provides CV 2, Vstart, to set the starting voltage that is applied to the motor at Speed Step 1 and is used to compensate for inefficiencies in the locomotive's motor and driveline. CV 2 may be programmed with any value between 0 and 255 with each step in value being about 0.5% of the maximum available motor voltage. To calculate the value of CV 2, you can use the formula:

$$\text{CV 2} = 255 \times \frac{\textbf{Desired Starting Voltage}}{\textbf{Maximum Motor Voltage}}$$

If your DCC system supports Operations Mode Programming, an alternative method for setting Vstart is to turn your throttle to the first speed step and then use the operations mode programming feature to increase the value in CV 2 until the locomotive just begins to move.

Set the Acceleration and Braking Rates

Tsunami provides two CVs to simulate the momentum due to train weight. CV 3, Acceleration Rate, controls how fast the locomotive responds to increases in throttle settings and CV 4, Braking Rate, controls how fast the locomotive will respond to decreases in the throttle setting.

Both CVs can be programmed with any value between 0 and 255 with 255 corresponding to the slowest acceleration or braking rate. Lower settings yield a more responsive locomotive, which is useful for switching. When both CVs are set to 0, the locomotive will respond nearly instantly to any throttle changes. A setting of 255, on the other hand, will require several minutes for a locomotive to reach full speed from a standing stop!

Tsunami's Dynamic Digital Exhaust feature will be more dramatic if you use

larger values for these CVs; we therefore suggest setting CV 3 and CV 4 to a minimum value of 16 or higher.

If you are using 14 or 28 Speed Step modes, setting CV 3 and CV 4 to any value greater than 0 will also improve the Tsunami's throttle response. While it is accelerating or braking, Tsunami interpolates between speed steps so in effect, your locomotive will respond as if it were being controlled with 128 speed steps. No more sudden lurching from one speed step to another!

Select the Speed Table

Tsunami provides 14 preset and one loadable speed table that can be used for several purposes:

1. Matching the Auto Exhaust chuffing rate to locomotive speed.
2. Speed matching one locomotive to another.
3. Changing the feel of the throttle. For example, you could configure a switching locomotive so there are more speed steps available at lower speeds for switching and fewer steps at high speeds where the locomotive is seldom operated.
4. Compensating for an improperly designed driveline so the locomotive will operate within its prototypical speed range.

Preset Speed Tables

CV 25, Speed Table Select, is used to select which speed curve will be used by the DSD. CV 25 may be programmed with any value between 2 and 15 to select one of the preset speed curves shown in Table B, below.

Table B. Speed Table Selection	
CV 25	**Speed Curve Type**
2	Straight LIne
3	Logarithmic Curve 1
4	Logarithmic Curve 2
5	Logarithmic Curve 3
6	Logarithmic Curve 4
7	Logarithmic Curve 5
8	Logarithmic Curve 6
9	Logarithmic Curve 7
10	Exponential Curve 1
11	Exponential Curve 2
12	Exponential Curve 3
13	Exponential Curve 4
14	Exponential Curve 5
15	Exponential Curve 6
16	User Loadable Speed Table
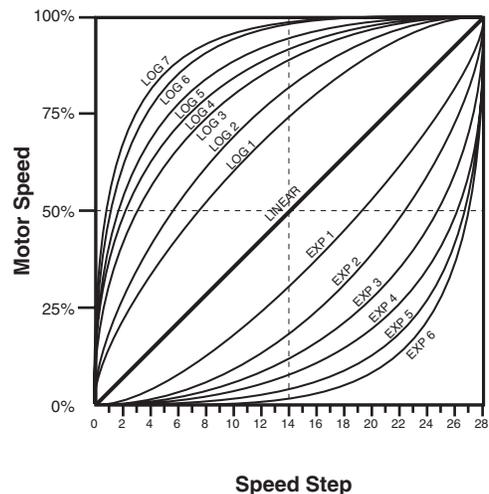
Basic Programming

The exact throttle response for each curve is shown graphically. The logarithmic curve provides a rapid throttle response at low speeds, while the exponential curve provides a rapid throttle response at higher speeds.

In order for the speed table selection in CV 25 to take effect, bit 4 of CV 29 must be set to 1. Refer to the previous section "Configuring the Decoder" or the Technical Reference to determine the correct value for CV 29.

Set the User Loadable Speed Curve

The User Loadable Speed Table allows you to create virtually any throttle response curve you can imagine. You will first need to design and program the Loadable Speed Table. The Loadable Speed Table consists of 28 data points contained in CVs 67 through 94, each defining the percentage of motor voltage applied at a given speed step. Each data point can contain a value of 0 to 255 corresponding to 0 to 100% of available motor voltage.

In 28 speed-step mode, each data point directly corresponds to a speed step. In 128 speed-step mode, each data point corresponds to every four and a half speed steps. The motor voltage for intermediate steps is interpolated by Tsunami to produce a smooth curve. In 14 speed-step mode, alternate (odd numbered) data points correspond to speed steps 1-14. Important: all 28 data points must be programmed even for 14 speed-step mode or an unpredictable throttle response may occur while accelerating or braking.

To create a speed curve, begin by assuming that Tsunami will be operated in 28-speed step mode. Don't worry if you are using another mode - Tsunami will automatically take care of the translation between modes.

1. Start by making a table containing 28 entries - one entry for each speed step.
2. For each entry, record the desired throttle response as a percentage of full speed, i.e., 0 to 100%.

Table C. Calculating the User Loadable Speed Table			
CV#	Speed Step	% Full Speed	CV Value
67	1	4	9
68	2	7	18
69	3	11	27
70	4	14	36
71	5	18	45
72	6	22	55
73	7	25	64
74	8	39	73
75	9	32	82
76	10	36	91
77	11	39	100
78	12	43	109
79	13	46	118
80	14	50	127
81	15	54	137
82	16	57	146
83	17	61	155
84	18	64	164
85	19	67	173
86	20	71	182
87	21	75	191
88	22	78	200
89	23	82	209
90	24	86	219
91	25	89	228
92	26	93	237
93	27	96	246
94	28	100	255

3. Compute and record the CV value for each step using the following formula:

$$\text{CV Value} = 255 \times \frac{\text{Percentage of Full Speed (from Step 2)}}{100}$$

4. Program CV 67 with the value computed in step 3 for the first data entry (Speed Step 1).
5. Program CV 68 with the value computed in step 3 for the second data entry (Speed Step 2).
6. Repeat step 5 for each of the remaining 26 CVs from CV 69 to CV 94 until they have been programmed with their respective values.
7. Set CV 25 to 16 to select the user loadable speed table.
8. Set bit 4 of CV 29 to 1 to enable speed table use. Refer back to the previous section "Configuring the Decoder" to determine the correct value for CV 29.

Table C may be followed as an example and lists the CV values for a straight-line response.

Adjust the Forward and Reverse Trim

Tsunami provides two CVs for adjusting or 'trimming' the forward and reverse speeds.

CV 66, Forward Trim
CV 95, Reverse Trim

These CVs multiply all data points in the speed tables by a factor of n/128 (n is the CV value) allowing the overall speed curve to be adjusted up or down without reloading all 28 data points again. These CVs will not have any effect when the speed tables are disabled (i.e., CV 29, bit 4 = 0)

These CVs may contain any value between 0 and 255. Trim values between 129 and 255 will increase speed curve values between 100% and 200% in approximately 1% steps. Trim values between 1 and 127 will decrease speed curve values between 1% and 99%. A value of 128 yields a scaling factor of 1.0 and has no effect on the speed curve.

Using different values for the forward and reverse trim will yield different forward and reverse speeds.

Step 4: Configuring for Consist Operation

The DSD supports advanced consist operations, which use five related CVs:

> CV 19, Consist Address
> CV 21, Consist Function Control 1
> CV 22, Consist Function Control 2
> CV 23, Consist Acceleration Rate
> CV 24, Consist Braking Rate

Consists Explained

A consist is a group of locomotives that are set up to respond to throttle commands as a single unit. Consists make it easy for one operator to run a double headed steam train or a multi-unit diesel lash-up for example. The consist CVs allow the DSD to recognize a new address assigned to the consist without changing its primary or extended addresses. Additionally, they allow each locomotive in the consist to be run as a single unit but with different function properties allowing for example, only the horn to blow on the lead engine.

Consist Address

Each locomotive in the consist is assigned the same consist address by programming CV 19 with the consist address between 1 and 127. If a locomotive is facing backwards in the consist (common in diesel operations), it should be programmed with the same consist address plus 128. If the forward facing locomotives are set to consist address 60 for example, the backwards engine must be set to 60+128 = 188. Failure to do this will turn the consist into an angry pushme-pullyou as all locomotives will try to move forward from the perspective of their own cab and a few pulled couplers might result!

To deactivate the consist address and restore normal operation, CV 19 must be reprogrammed to 0.

Note that when the consist address is set, the DSD will continue to respond to instructions sent to its primary or extended address except for speed and direction data.

The DSD will not respond to operations mode programming commands sent to its consist address. These commands must always be used with the primary or extended address.

Consist Function Enable

CV 21 and 22 allow you to define how each engine individually responds to function commands sent to the consist address. When the consist is enabled, CV 21 controls which of functions 1-8 are active and CV 22 controls the F0 function for forward (F0(f)) and reverse (F0(r)), as well as functions 9-12.

Basic Programming

CV 21 and 22 take effect only when the consist address is set. When function commands are used with the DSD's primary or extended address, all functions will continue to work regardless of the settings of CV 21 and 22.

Use Table D to calculate the correct value for CV 21, and Table E to calculate the correct value for CV 22. Begin by looking at Table D and determining which functions you want active in the consist and circle the number below it. When you are done, add up all the circled numbers in the row and program the total into CV 21.

Table D. Consist Function Control 1							
CV#	F1	F2	F3	F4	F5	F6	F7	F8
21	1	2	4	8	16	32	64	128

Now look at Table E and do the same: add up all the circled numbers in the row and program CV 22 with the sum.

Table E. Consist Function Control 2					
CV#	F0(f)	F0(r)	F9	F10	F11	F12
22	1	2	4	8	16	32

Note that each DSD in the consist will require a different set of values for CV 21 and 22 depending upon your requirements.

Consist Example:

Consider a double-header consisting of two engines, #4088 and #5239. Let's suppose we wish to operate these two engines as a single unit with consist address 40.

Lead Unit   Trailing Unit

Forward
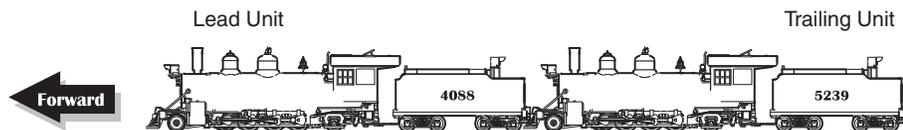
Engine Address	4088	5239
Direction	Normal	Normal
CV 19 (Consist Address)	40	40
CV 21	135	128
CV 22	17	18

You might want the brake squeal (F11) and audio mute (F8) functions to work on both engines. However, you will likely want the headlight (F0(f)), whistle (F2) short whistle (F3) and bell (F1) to only work on the lead engine, #4088, and the backup light (F0 (r)) to work only on #5239.

Engine 4088.
This is the lead engine. Program CV 19 to 40, the new consist address. Using Table D, program CV 21 with the sum of the value corresponding to F1, F2, F3 and F8:

> CV 21 = 1 + 2 + 4 + 128 = 135

Then using Table E, determine the value for CV 22 by summing the values for F0(f) and F11:

> CV 22 = 1 + 16 = 17

Engine 5239.
Program CV 19 with the new consist address, 40. As this engine will only have the reverse light, mute, and brake squeal functions active, different values are required for CV 21 and 22. Using Table D, program CV 21 with the value corresponding to F8:

> CV 21 = 128

Then using Table E, determine the value for CV 22 by summing the values for F0(r) and F11:

> CV 22 = 2 + 16 = 18

Consist Inertia Control

CVs 23 and 24 can be used to increase or decrease the locomotive's acceleration and braking response whenever it is part of a consist (i.e., CV 19 is programmed with a valid address).

CV 23 controls the consist acceleration rate and CV 24 controls the consist braking rate. When the consist address is active a new acceleration rate is calculated by adding the value in CV 23 to the baseline acceleration rate in CV 3. Similarly, a new braking rate is calculated by adding CV 24 to the baseline braking rate in CV 4. When the consist address is set to 0, CV 23 and 24 have no effect.

Both CV 23 and 24 may be set to any value between -127 and +127. A positive value will produce a slower throttle response while a negative value will result in a quicker throttle response.

If the sum of consist and baseline rate exceeds 255, then the final rate is set to the maximum value of 255. If the sum of consist and baseline rate is negative, then the final rate is set to the minimum value of 0.

To set a positive value, simply program the CV with the desired number between 0 and 127. To set a negative value, first change the sign of the value back to positive and then add 128. Thus, to set -5, program the CV with 5 + 128 = 133. Note that a setting of 128 is the same as 0 and has no effect.

Step 5: Function Mapping

Function Mapping Explained

Function mapping allows the DSD to be reconfigured so that sound effects and function outputs can respond to a different function key input. This is especially useful for users who have throttles with less than thirteen function keys as now they can pick and choose what effects they can control instead of being restricted to an arbitrary assignment.

There are 14 function mapping CVs - twelve CVs, 35-46 are used to assign output control to function keys 1 through 12 respectively.

The other two CVs, 33 and 34 are both for the F0 function. CV 33 controls which outputs are on when F0 is on and the locomotive is moving forward. CV 34 controls which outputs are on when F0 is on and the locomotive is moving in reverse. If the same output is selected in both CV 33 and CV 34, that function will turn on when the F0 function is on regardless of locomotive direction.

Not all keys can control all outputs or effects. The table below shows which functions can be mapped to which outputs. Note that a function key can be set up to control more than one output.

Function Key	Control CV	HL	BL	WH	BEL	FX5	FX6	DYN	SHW	STM	WS	DIM	MUT	INJ	BRK	CPL
F0 (f)	33	**1**	2	4	8	16	32	**64**	128							
F0 (r)	34	1	**2**	4	8	16	32	**64**	128							
F1	35	1	2	4	**8**	16	32	64	128							
F2	36	1	2	**4**	8	16	32	64	128							
F3	37				1	2	4	8	**16**	32	64	128				
F4	38				1	2	4	8	16	**32**	64	128				
F5	39				1	**2**	4	8	16	32	64	128				
F6	40				1	2	**4**	8	16	32	64	128				
F7	41							1	2	4	8	**16**	32	64	128	
F8	42							1	2	4	8	16	**32**	64	128	
F9	43							1	2	4	**8**	16	32	64	128	
F10	44								1	2	4	8	16	**32**	64	128
F11	45								1	2	4	8	16	32	**64**	128
F12	46								1	2	4	8	16	32	64	**128**

Table F. Function Mapping Table

Bold Numbers indicate default settings.

Basic Programming

An output can be also be controlled by more than one function key. In the second case, if an output is mapped to two function keys, either key will turn that output on, however, the output will not turn off until both function keys have been turned off.

To determine the correct CV value,
1. Find the column in the Function-Mapping Table corresponding to the function or sound effect output you wish to control.
2. Next locate the row corresponding to the function key you wish to use for controlling the selected output.
3. Note the number located in the box at the intersection of the row and column you have selected.
4. Program the CV listed in the row chosen in step 2 with the value found in step 3.

Example 1, Swapping the Bell and Short Whistle functions:
Some DCC systems label Function 3 on their cab as the Bell control. However, Tsunami's default Bell control is Function 1. Fortunately, we can use function mapping to re-assign the controls so that the label on the cab matches the utility in the decoder. Since F3 controls the Short Whistle, we will simply swap it with F1 as follows:

Using Table F, we first re-assign Function 3 to the Bell. First, find the column corresponding to the Bell. Then find the row for Function 3. Note the value, 1, found in the box intersected by the row and column. Finally, program this value into the CV controlling Function 3, in this case CV 37.

Next, re-assign Function 1 to the Short Whistle following the same procedure. Locate the column corresponding to the Short Whistle. Then find the row for Function 1. Note the value, 128, found in the box intersected by the row and column and program this value into CV 35, the CV controlling Function 1.

Example 2, Independent Dynamo Control:
As shipped from the factory, Function 0 controls both the Headlight (or Backup Light when in reverse) and the Dynamo sound together. Let's suppose you desire to use another function to control the Dynamo sound so it can be turned on or off without affecting the headlight. This would be simple enough were it not for the fact that all the other function keys are already in use. The solution then, is to decommission another function so it may be re-assigned to the dynamo.

Looking over Table F, we see that any of Function F0 thru F9 may be remapped to include the Dynamo function. Functions 10-12 are not candidates since the boxes for these functions are blacked out under the Dynamo column. However, we could logically assign Function 5 to control both the FX5 and FX6 lights, which frees up Function 6 to control the Dynamo.

But first, we need to reprogram the mapping for F0 so that the Dynamo is no longer controlled with this function. Remembering that F0 uses two CVs, (CV 33 for forward and CV 34 for reverse), we program CV 33 to 1 so that F0

turns on the headlight in the forward direction. Then we program CV 34 to 2 so F0 turns on the Backup light in the reverse direction.

Next, setup Function 5 to control both FX5 and FX6. Using Table F, find the columns corresponding to FX5 and FX6. Then find the row for Function 5. Note the first value, 2, found in the box intersected by the F5 row and FX5 column. Then find the second value, 4, found in the box intersected by the F5 row and FX6 column. Add these two values together (2 + 4 = 6) and program the sum into CV 39, the CV controlling Function 5.

Finally, we set CV 40 to 8 so F6 turns the Dynamo on and off.

To summarize, program:

> CV 33 = 1 (sets F0(f) to headlight)
> CV 34 = 2 (sets F0(r) to backup light)
> CV 39 = 6 (sets F5 to FX5 and FX6)
> CV 40 = 8 (sets F6 to Dynamo)

Remember, if the lighting functions are still set to the Dyno-Light effect, both the F0 and F6 functions must now be turned on for the lights to illuminate!

Working with 8-Function Cabs

While Tsunami can support 12 function keys, many cabs are limited to only 8 or 9 functions and you may feel as though you will lose some ability to enjoy your new Tsunami Digital Sound Decoder. Most of the time, some clever function mapping will allow you to access and use all of the available features.

Instant Function Swapping

By setting CV 30 to 4, the function assignments for F5-F8 are instantly swapped with the function assignments for F9-F12. Think of CV 30 as sort of a 'shift' key so that when it is set to 4,

F5 = Water Stop	F9 = FX5
F6 = Injector	F10 = FX6
F7 = Brake Release/Squeal	F11 = Dimmer
F8 = Coupler	F12 = Mute

And when it is set back to 0,

F5 = FX5	F9 = Water Stop
F6 = FX6	F10 = Injector
F7 = Dimmer	F11 = Brake Release/Squeal
F8 = Mute	F12 = Coupler

If you do not need the mute, dimmer or extra lighting functions, you can set CV 30 to 4 and simply be done with it. Otherwise, programming CV 30 back and forth between 0 and 4 is a little inconvenient and a more sophisticated solution is needed.

Basic Programming

A Better Method
In order to more fully utilize the Tsunami with an 8 Function cab, it is necessary to free up some function keys by doubling up on some functions and/or turning other functions over to automatic control.

We begin by noting which sound functions may be relegated to automatic control (see page 62 for details):

> Short Whistle (F3)
> Steam Release (F4)
> Brake Squeal (F11)

The Injector sound (F10) may also be automatically triggered by Fireman Fred (see page 48).

The Mute function (F8) may be automatically set by way of the Quiet Mode (page 48).

Next, we look to see which outputs could be combined so that they are controlled with a single function. There aren't too many of these but it might be reasonable to decide to use F0 to turn on all lighting outputs including FX5 and FX6 as well as the Dynamo sound. Or you could use one function to control both FX5 and FX6 as was done in Example 2.

Finally, we could decide that some functions aren't needed and simply discard them.

We now have seven or so functions that can be juggled about. Since we need to make room for only four, this provides us some flexibility to pick and choose to best meet our requirements.

Example 3:
In this example, we will let Fireman Fred run the injectors so we no longer need F10. We'll also set up the Short Whistle for automatic signaling so F3 is now available. Let's presume that FX5 will be used for number board lights and FX6 for a cab light. We can gang up FX5 and FX6 with Function 0 so that these lights are on whenever the headlight or backup light is on freeing up functions F5 and F6.

Using Table F, we can proceed to re-map functions as follows. Starting with F0, configure the forward direction to control the Headlight, FX5, FX6 and Dynamo:

Set CV 33 = 1 + 16 + 32 + 64 = 113

For the reverse direction, set F0 to control the Backup light, FX5, FX6 and Dynamo:

> Set CV 34 = 2 + 16 + 32 + 64 = 114

Then configure F3 to control the Water Stop Sound:

     Set CV 37 = 64

Next, we configure F5 and F6 to control the Brake Squeal and Coupler respectively. But wait! Looking at Table F, it appears that this can't be done. The trick is to use the Instant Function Swapping feature so Function 5 now controls the output assigned to Function 9, Function 6 now controls the output of Function 10, and so forth.

To activate Function Swapping, set CV 30 to 4. Once this is done, the control CVs for a particular function also get swapped so that the function mapping CVs are assigned as follows:

     Function 5 is now mapped with CV 43
     Function 6 is now mapped with CV 44
     Function 7 is now mapped with CV 45
     Function 8 is now mapped with CV 46
     Function 9 is now mapped with CV 39
     Function 10 is now mapped with CV 40
     Function 11 is now mapped with CV 41
     Function 12 is now mapped with CV 42

Now use Table F to remap F5 to control the Brake Squeal:

     Set CV 43 = 128

Then map F6 to control the coupler:

     Set CV 44 = 128

We would like to keep the original function assignments for F7 (dimmer) and F8 (mute). By turning on the Function Swapping feature, however, the outputs for these functions are now mapped through CV 45 and 46 which, by default, are set to control some other output. It is necessary to reprogram these CVs as well to get the desired functionality:

Re-map F7 to control the dimmer:

     Set CV 45 = 8

Re-map F8 to control the mute:

     Set CV 45 = 16

Finally, we must activate the automatic whistle signals by setting CV 198 to 2. The injectors are already part of Fireman Fred's repertoire so there is nothing else needing change.

Basic Programming

Working with 4 Function Cabs

With a 4-function cab (actually in most cases, five functions - F0 plus F1-F4), you will have to give something up! By using Tsunami's automatic sound controls, hopefully it doesn't need to be much.

Example 4:

In this example, we will use automatic control for the Short Whistle, Mute, Injector, Brake Squeal, and Steam Release. FX5 and FX6 will be ganged up with F0 as was done for the 8-Function Cab example. F1 and F2 will continue to be used for the Bell and Whistle.

This frees up F3, which we can assign to the water stop, and F4, which we can use to control the dimmer. The only effect we must completely give up under this scenario is the coupler sound since it only maps to F10 -F12 (or F6-F8 with Function Swapping turned on). Sorry.

Using Table F, we can proceed to re-map functions as follows. Starting with F0, configure the forward direction to control the Headlight, FX5, FX6 and Dynamo:

> Set CV 33 = 1 + 16 + 32 + 64 = 113

For the reverse direction, set F0 to control the Backup light, FX5, FX6 and Dynamo:

> Set CV 34 = 2 + 16 + 32 + 64 = 114

Then configure F3 to control the Water Stop Sound:

> Set CV 37 = 64

Set F4 to control the dimmer function:

> Set CV 38 = 128.

To activate the automatic whistle signal, brake squeal and steam release, program CV 198 to 26. To activate auto-mute, program CV 113 to 120 which will shut the sounds off after 30 seconds once the train is brought to a stop and all the functions are turned off (See page 48).

You can see that function mapping allows you a great degree of flexibility to solve a variety of problems even if your cab is limited to less than 14 functions.

Step 6: Configuring the Lighting Outputs

Tsunami has four function outputs used for controlling the locomotive lights.

Each can be set for a variety of effects or as simple on/off lights. In addition, you can use the Grade Crossing Logic to automatically activate the selected lighting effect when you blow the whistle.

Tsunami provides six CVs for customizing the lighting effects:

CV 49, Headlight Configuration
CV 50, Backup Light Configuration
CV 51, FX5 Light Configuration
CV 52, FX6 Light Configuration
CV 59, Lighting Effect Flash Rate
CV 60, Grade Crossing Effect Hold Time.

Setting the Hyperlight Effects
Each lighting output has a corresponding CV that determines its operating characteristics:

Bit 7   **Bit 0**

LED	R17	XING	PHSE	HYPERLIGHT SELECTION		

Hyperlight Select - Each output can be programmed to one of several Hyperlight™ Lighting Effects as listed in Table G. Most effects are self-descriptive and primarily warning beacons used for diesel locomotives. Some effects, such as the Mars Light, were used in some steam engines as well.

> *Dimmable Headlight* - The function output is normally an on/off output. If the output is on, the output level will be reduced about 60% whenever the dimmer function is on.

> *Mars Light* - This effect simulates the sweeping figure-8 pattern of this popular warning beacon.

> *Pyle National Gyralite* - The Gyralite is similar to the Mars Light, but generates a slow, wide, oval headlight sweep pattern.

> *Dual Oscillating Headlights* - Similar in appearance to the common twin-sealed-beam headlight, the oscillating headlight uses a moving reflector to sweep the headlight beam in a tight circular motion.

> *Single and Dual Strobes* - The Strobe effects simulate the white-hot burst of light associated with the Xenon Strobe.

Basic Programming

Western-Cullen D312 Rotary Beacon - This effect provides a spectacular rendition of the revolving reflector and bulb assembly of the prototype warning beacon found atop many diesels of the 60's and 70's.

Prime Stratolite - The Stratolite was a newer version of the rotary beacon, with the prototype consisting of a revolving reflector with four individual lamps arranged in a circular pattern which are electronically flashed in a clockwise sequence. The Stratolite flashes in a rather mechanical 'stepped' fashion, as opposed to the smooth motion of the Rotary Beacon.

Type I and Type II Ditch Lights - These are identical when operating. However, if the grade crossing logic is enabled, the Type I ditch light will revert to a steady on state when it is not flashing whereas the Type II lights will turn off.

Exhaust Flicker - This effect produces a random flicker whose intensity increases with locomotive speed. This effect is best used by placing a red/orange LED in the firebox or in the smokestack. As the locomotive increases speed, it will glow brighter, imitating an increase in sparks and exhaust gases.

Firebox Flicker - This effect produces a random flicker whose intensity resembles a burning fire and can be used with a lamp placed in the firebox area. The effect is improved when two lights are used, one yellow and one red or orange and each connected to a separate function output.

Smart Firebox Flicker - This effect produces a random flicker whose intensity is synchronized with the sound of Fireman Fred shoveling coal. Whenever Fred 'opens' the firebox door and begins shoveling, the lighting effect increases in brightness and then returns to a subdued level when the firebox doors are 'closed'.

Dyno-Light - This effect for steam locomotives synchronizes the lamp brightness to the "output" of the dynamo such that the lamp brightness gradually increases as the dynamo builds up speed.

Phase Select - Alters the timing of the effect so that it is 180 degrees out of phase with the other effects. This allows you to have two light effects that blink back and forth if desired. Set one effect to phase A and the other to phase B.

Grade Crossing Logic - Causes the lighting effect to become active only when the whistle has been sounded (and the corresponding lighting function key is also on). A typical use would be to cause the ditch lights to flash at a grade crossing. The grade crossing logic can be used with almost all the Hyperlight effects. The on/off, dimmable headlight, Dyno-Light, FRED, exhaust flicker, and firebox flicker effects will not be affected. The other effects will either turn off (strobes and beacons) or revert to a steady on state (mars light, ditch lights, etc.) as appropriate to prototype practice.

Basic Programming

Rule 17 Headlight Operation - Converts the headlight and backup light to independent, non-directional functions. When enabled, the headlight is controlled as if it were FX5, Function 5 and the backup light as FX6, Function 6.

LED Compensation Mode - Tsunami's lighting effects can be used with either incandescent bulbs or LEDs. However, because of their differences in brightness characteristics, some lighting effects will appear less life-like when initially set up with an LED. To correct this, Tsunami's LED compensation mode should be enabled which will improve the contrast of the lighting effect by automatically adjusting the function output level to correct for the different brightness characteristics of an LED.

To set the Hyperlight configuration CVs, proceed as follows:

1. First find the CV value in Table G on the next page for the desired lighting effect and operating mode.
2. If you wish to enable Rule 17 Mode, add 64 to the table value shown, otherwise, proceed to Step 3.
3. If you're using incandescent bulbs, skip to Step 4. If you are using LEDs, enable the LED Compensation Mode by adding 128 to the sum computed in Step 2.
4. Program the sum computed in Step 3 into the CV corresponding to the appropriate function output. Use CV 49 to set the headlight, CV 50 for the backup light, CV 51 for Function 5 and CV 52 for Function 6.

Setting the Flash Rate and Hold Time

CV 59 is used to adjust the flash rate of the Hyperlight effect and has a range of 0-15 with 15 being the slowest flash rate. When the Grade Crossing Logic feature is enabled, CV 60 is used to adjust the length of time (in seconds) an effect will remain active after the whistle key is released. CV 60 can be programmed with any value between 0 and 15.

Example 1, Mars Light with Grade Crossing Logic
In this example, we will configure the headlight output for use with an incandescent bulb as a Mars Light with Grade Crossing Logic enabled. Following the steps outlined above, we proceed as follows:

1. We first look up the initial CV value in Table G for a Mars Light under the column labeled 'Crossing Logic On' and find it is 34 for Phase A and 50 for Phase B. Since we are only setting up one light, we do not care about the Phase and choose to the value for Phase A, 34.
2. Since we are not using Rule 17, we skip to Step 3.
3. Since we are not using LEDs, we skip to Step 4.
4. CV 49 (Headlight Configuration) is programmed with the value found in Step 1 or 34.

Lastly, we need to set the grade crossing hold time to about six seconds by programming CV 60 to 6.

Basic Programming

Example 2, LED Firebox Flicker
In this example, we will configure the FX5 and FX6 outputs for a firebox flicker effect using LEDs.

1. We first look up the initial CV value in Table G for a Firebox Flicker under the column labeled 'Crossing Logic Off' and find it is 13 for Phase A and 29 for Phase B. Since we are setting up two lights, the overall effect will be enhanced if one LED flickers differently from the other. So for FX5 we use the Phase A value, 13, and for FX6 we use the Phase B value, 29.
2. Since we are not using Rule 17, we skip to Step 3.
3. Since we are using LEDs, we add 128 to the values found in Step 1 and get: FX5 = 13 + 128 = 141
              FX6 = 29 + 128 = 157

4. CV 51 (FX5 configuration) is programmed with the value found in Step 3 or 141. CV 52 (FX6 configuration) is likewise programmed with 157.

Table G. Hyperlight Control Mode Settings				
Effect Type	**CV Value**			
	Crossing Logic Off		**Crossing Logic On**	
	Phase A	**Phase B**	**Phase A**	**Phase B**
On-off	0	16	32	48
Dimmable	1	17	33	49
Mars Light	2	18	34	50
Gyralite	3	19	35	51
Oscillating Headlight	4	20	36	52
Single Flash Strobe	5	21	37	53
Double Flash Strobe	6	22	38	54
D312 Rotary Beacon	7	23	39	55
Prime Stratolite	8	24	40	56
Type I Ditch Light	9	25	41	57
Type II Ditch Light	10	26	42	58
FRED	11	27	43	59
Exhaust Flicker	12	28	44	60
Firebox Flicker	13	29	45	61
Smart Firebox Flicker	14	30	46	62
Dyno-Light	15	31	47	63

Example 3, Alternating Ditch Lights with Crossing Logic
In this example, we will configure the FX5 and FX6 outputs for use with bulbs as Type I Ditch lights that flash when the whistle is blown (our steam loco is being operated on a modern day railroad as a restored excursion train!).

1. We first look up the initial CV value in Table G for a Type I Ditch Light under the column labeled 'Crossing Logic On' and find it is 42 for Phase A and 58 for Phase B. To get the lights to flash back and forth, FX5 is set to the Phase A value and FX6 is set to the Phase B value.
2. Since we are not using Rule 17, we skip to Step 3.
3. Since we are using bulbs rather than LEDs, we skip to Step 4.
4. CV 51 (FX5 configuration) is programmed with the value found in step A or 42. CV 52 (FX6 configuration) is likewise programmed with 58.

Lastly, we need to set the grade crossing hold time to about five seconds by programming CV 60 to 5. Initially, the FX5 and FX6 lights should be steady on (***Note:*** use Function 5 and 6 to turn FX5 and FX6 on first!). When the whistle is sounded, the two lights will flash back and forth. The lights will revert back to a steady on state after about five seconds following the release of the whistle key.

Sound Programming

Step 7: Modifying the Sound Effects

One of the great things about Tsunami Digital Sound Decoders is the ability to adjust the various sound effects to suit your ear and respond in the manner that you prefer.

Audio Mixer Controls

The Tsunami sound decoder provides up to 25 independent controls for setting the volume levels of each sound effect much like that of a modern sound studio mixing board. To set the sound level for a particular effect, set the corresponding CV to any value between 0 (zero volume) and 255 (maximum volume).

For the best sound quality, you will want to run the mixer as "hot" as possible (audio jargon for maximizing the volume level). First determine which sound you want to be the loudest (usually the whistle) and set its volume level to around 225. Then adjust all the other sound levels relative to the whistle volume. Finally, use the Master Volume Control, CV 128, to set the overall volume of the decoder to the desired level.

A certain level of prudence is needed when adjusting the mixer levels to avoid a condition known as 'clipping' or 'limiting' which occurs when the sum of two or more signals exceeds the capacity of the output channel. As its name implies, clipping results in the lopping off of the sound signal peaks and manifests itself as distortion accompanied with a level of clicking or popping sounds.

To avoid a clipping condition, consider which sounds are likely to be played at the same time and take care to ensure that their corresponding mixer levels are not set too high. For example, the whistle and exhaust chuff are usually heard together and you will likely want both to be as loud as possible. Rather than simply crank both sounds up to the maximum level, start with one mixer channel near, but not quite at maximum (this provides a little extra 'headroom') and then gradually bring up the second mixer channel setting to the desired level. If you start to hear some distortion, simply back down one mixer channel or the other until the distortion goes away.

Your Tsunami sound decoder has a 96dB dynamic range which is plenty for most audio work and as long as you keep the sound levels balanced in a prototypical fashion, you should have no problems.

Note that the **Primary Mixer CVs** are real time controls, meaning that any changes to their settings will be immediately reflected in the sound level. On the other hand, the **Secondary Mixer** levels are *not* real time. If you change their setting while the respective sound effect is playing, you will not hear a change in volume until the sound is turned off and started again.

CV 128, Master Volume Control

Primary Audio Mixer CVs are as follows:
CV 129, Whistle mixer level
CV 130, Bell mixer level
CV 131, Exhaust mixer level
CV 132, Airpump mixer level
CV 133, Dynamo mixer level
CV 134, Blower mixer level
CV 135, Rod clank mixer level
CV 136, Steam hiss mixer level

Secondary Mixer CVs:
CV 137, Coupler Clank mixer level
CV 138, reserved
CV 139, Brake squeal mixer level
CV 140, Brake release mixer level
CV 141, Snifter valve mixer level
CV 142, Johnson Bar/Power reverse mixer level
CV 143, Pop Valve mixer level
CV 144, reserved
CV 145, Blower draft mixer level
CV 146, Water stop mixer level
CV 147, Injector mixer level
CV 148, Coal Shoveling mixer level
CV 149, Wrenches mixer level
CV 150, Oilcan mixer level
CV 151, Grease gun mixer level
CV 152, reserved

Using the Tsunami Equalizer

Tsunami's built-in equalizer (or "EQ" as the audio guys like to call it) is much like that you'd on your home stereo system. The equalizer allows you to selectively cut and boost sound levels by +/-12dB over seven selected frequency ranges and provides the "ultimate" tone control.

When most people hear about Tsunami's equalizer, their first reaction is "Great, now I can really crank up the bass!" What they don't realize is that the equalizer is also there to cut out the low frequencies as well.

Every speaker has a limit to the lowest frequency it can efficiently reproduce. This is determined by a number of factors and in particular, the speaker's physical size. To reproduce a low frequency sound at high volume requires the ability to move a lot of air, and hence a large diameter diaphragm.

On the other hand, the electromagnet at the base of the speaker cone will react just fine to even the deepest bass. So if we try to drive a low frequency sound signal thru a small speaker, the speaker still physically reacts to the signal - we just don't hear it very well because only a small amount of air is

being pushed about. If we turn up the volume, things will not likely improve much and what's worse, the speaker cone will eventually be pushed against its physical travel limits resulting in annoying clicking and popping sounds.

This is where the equalizer's ability to "cut" frequencies out becomes important. By removing the inaudible low frequency sound components, the speaker is now able to work more efficiently (i.e. louder) in the audio range it was designed for.

EQ Presets

Using the equalizer begins with CV 153, the EQ Control Register. This CV may be programmed with any value between 0 and 7. A setting of 0 disables the EQ as if it were never there. Settings 1 thru 6 select a factory preset which tailors the frequency response to several of SoundTraxx's more popular on-board speakers. The table below shows the presets and their equivalent settings which may be used as the basis for developing your own settings.

Table H. Equalizer Presets
(Numbers in Red indicate equivalent CV Value)

Preset No.	Description	62Hz	125Hz	250Hz	500Hz	1Hz	2Hz	4Hz
0	Flat	0 dB 128	0 dB 128	0 dB 128	0 dB 128	0 dB 128	0 dB 128	0 dB 128
1	Micro Speaker < 1" Diameter	-12 dB 0	-12 dB 0	+7.12 dB 200	+3 dB 160	+1.5 dB 140	+0.8 dB 132	0 dB 128
2	Small Speaker 1-2" Diameter	-6 dB 60	-3 dB 96	+4.1 dB 168	+3 dB 160	0 dB 128	0 dB 128	+0.8 dB 132
3	Medium Speaker 3-4" Diameter	-3 dB 96	+4.1 dB 168	+2.3 dB 148	+1.1 dB 136	0 dB 128	0 dB 128	+6 dB 128
4	Large Speaker >4" Diameter	+6 dB 192	+3 dB 160	+1.5 dB 140	0 dB 128	0 dB 128	0 dB 128	0 dB 128
5	Edgeport Speaker	-12 dB 0	-12 dB 0	0 dB 128	-3 dB 96	-3 dB 96	-5.2 dB 68	-3.8 dB 84
6	Micro Speaker < 1" Diameter	+6 dB 192	+3 dB 160	+1.2 dB 136	0 dB 128	+1.2 dB 136	+3 dB 160	+6 dB 192
7	User Customizable	CV 154	CV 155	CV 156	CV 157	CV 158	CV 159	CV 160

Custom EQ Settings

Finally, a setting of 7 allows you to customize the EQ response using CVs 154 thru 160, each which controls a different frequency band as follows:

CV 154, 62.5Hz
CV 155, 125Hz
CV 156, 250Hz
CV 157, 500Hz
CV 158, 1KHz
CV 159, 2Khz
CV 160, 4Khz

Sound Programming

Think of these CVs as slider control like those you might find on the front of an equalizer for your home stereo. Each CV may be programmed between 0 and 255. A value of 0 corresponds to full cut or -12dB*. A value of 128 corresponds to moving the slider to the middle or 0dB (no effect) and a value of 255 corresponds to full boost or +12dB. Table I shows CV settings for common boost/cut levels.

Table I. Using The Equalizer	
CV Value	**dB Value**
255	+12 dB
224	+9 dB
192	+6 dB
160	+3 dB
128	0 dB
96	-3 dB
64	-6dB
32	-9 dB
0	-12dB

The graph below depicts the minimum and maximum frequency response for each of the seven CVs. Note that there is some overlap so adjusting one CV will raise or lower sounds with nearby frequencies as well.
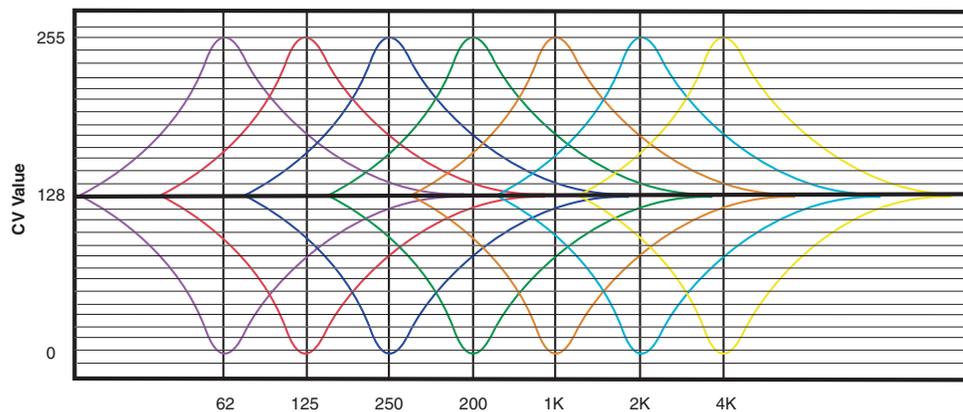
The easiest way to set the EQ is to simply use your ears and adjust the CV settings while the sounds are playing. Starting with the lowest frequency band, adjust CV 154 up or down until you get the desired response. Then adjust the next band using CV 155 and so forth. Depending on the speaker you have installed, you may find that the lowest frequency bands have or no little effect. In this case, the audio frequencies are out of the speaker's reproduction range and we suggest you set the corresponding CV to 0 (i.e., full cut).

*For those not familiar with dB, it stands for decibel. Every +6dB change represents a doubling in the audio signal while a -6dB change is the same as cutting it in half. Thus a +12dB increase quadruples the signal level and -12dB cuts it in fourth.

Sound Programming

Reverb

The Reverb effect allows you to add a bit of reverb (not echo!) and presence to Tsunami's sound effects. Be forewarned - unless you are a trained audio technician, adjusting the reverb effects can easily result in some strange or unpleasant results. We recommend you take your time and experiment cautiously.

There are eight CVs associated with the Reverb module:

> CV 161, Reverb Control Register
> CV 162, Reverb Output Level
> CV 163, Reverb Delay Time
> CV 164, Reverb Feedback Level
> CV 169, Mixer Ch 0 Reverb Send Level
> CV 170, Mixer Ch 1 Reverb Send Level
> CV 171, Mixer Ch 2 Reverb Send Level
> CV 172, Mixer Ch 3 Reverb Send Level

Reverb Control Register
CV 161 is the Reverb Control Register which allows you to select one of several Reverb Presets or to choose the User Adjustable Reverb.

The presets contain predetermined values for the Reverb Output Level, Reverb Delay, Reverb Feedback Gain level, and Reverb Send Levels. Table J lists the available presets and the corresponding value for CV 161.

Table J. Using The Reverb	
CV 161 Value	**Description**
0	Reverb Disabled
1	Additional Reverb for Whistle
2	Light Reverb Added to Exhaust
3	Medium Reverb Added to Exhaust
4	Heavy Reverb Added to Exhaust
5	Reserved
6	Reserved
7	User Adjustable

User Adjustable Reverb
The Reverb works by simulating the effect created when a sound wave is heard along with a delayed version of the sound that has been reflected off of some other hard surface. Tsunami's reverb is designed to produce a reverb effect due to early sound reflections off a nearby surface such as a rock cut or a canyon wall.

The User Adjustable Reverb provides three controls plus an input mixer (described in the next section). The Reverb Controls are as follows:

> *CV 162, Reverb Output Level*
> This CV determines the amount of reverb signal that is mixed back with the original audio signal. CV 162 may be set to any value between 0 (minimum) and 255 (maximum).

CV 163, Reverb Delay Time

This CV sets the overall Reverb Delay time from 0 to 64 milliseconds. CV 163 may be set anywhere between 0 (zero delay) to 255 (maximum delay) and the corresponding delay time may be calculated as:

Delay time = CV 163 X 0.25mS

A longer delay time corresponds to a greater distance between the sound source and the reflecting surfaces and will generally result in an increased level of reverb.

CV 164, Reverb Feedback Level

This CV specifies the percentage of the Reverb's output that is mixed back into its input and creates the effect of multiple sound reflections each diminishing in amplitude over time. CV 164 may be set to any value between 0 and 255 where 0 = no feedback and 255 = 100% feedback.

Caution: High feedback settings (> 200) should be avoided as they can result in very high audio levels and can potentially damage miniature speakers. Adjust this CV starting with a low initial value and increase in small steps.

Reverb Mixer

The Reverb mixer allows you to apply the reverb effect to only the desired sound effect or effects. There are four reverb inputs each with a corresponding Reverb Send Level CV that controls the percentage of the original audio level that is to be mixed into the Reverb. Each send level may be set between 0 and 255 where 0 = Minimum level (0%) and 255 = Maximum level (100%).

The Reverb Send Levels are each pre-assigned to the first four channels of the primary mixer channel as follows:

> CV 169, Whistle Reverb Send Level
> CV 170, Bell Reverb Send Level
> CV 171, Exhaust Reverb Send Level
> CV 172, Air Pump Reverb Send Level

The Reverb is most effectively used with the Whistle and Exhaust sound effects. Some whistles have a certain amount of reverb intrinsically built in as part of the original recording and may not noticeably respond to any additional reverb added.

Setting up the Reverb

Setting up the reverb involves a bit of trial and error and is best done while the sounds are playing using operations mode programming to make the adjustments.

Sound Programming

Start by Setting CV 161 to 7 to enable the user-adjustable reverb.

Next, set the Reverb Output Level (CV 162), Reverb Delay Time (CV 163), and Reverb Feedback Level (CV 163) to some nominal initial value. We like to start with the default settings of 128 for CV 162, 255 for CV 163 and 64 for CV 164.

Then determine which sounds you wish to apply the reverb to and set the corresponding Reverb Mixer Send Level CV to some nominal value between 50% to 75% of the original signal (corresponding to a CV setting between 128 and 192). If you are using multiple reverb inputs, each can be set to a different value so that more or less reverb is added to a particular sound effect as desired.

With the default reverb control settings, you should notice a definite amount of reverb added to the sound and can begin making adjustments.

Adjusting CV 162 will vary the amount of reverb's output signal that is mixed back with the original signal. Remember, in real life, the reflected signals that create the reverberation are usually lower in volume than the original signal so generally, you will want just enough output to notice the effect but not so much as to overwhelm the original signal.

Adjusting CV 163 will vary the delay time corresponding approximately to the extra distance a reflected sound wave needs to travel in order to reach the listener. Thus, the further away a reflecting surface is from the listener, the longer the delay time becomes.

Adjusting CV 164 simulates the effect of multiple sound reflections taking place. When set to 0, only one reflection occurs and this does not make for a very interesting effect (Ordinarily, we would call this an echo but the maximum delay time for Tsunami's reverb is not long enough for such an effect as might be heard across a mountain range for example.) Increasing CV 164 increases the number of reflections and adds a certain 'springiness' to the sound.

Like any sound effect, it is possible to over-adjust a particular setting and create an artificial and unnatural sound. Make adjustments in small steps and let your ears be the judge!

Whistle Selection and Control

Tsunami uses three CVs to adjust and control the whistle:

> CV 115, Whistle Select
> CV 129, Whistle Volume
> CV 47, Playable Whistle Control

As set from the factory, Tsunami uses Function F2 to control the primary whistle and Function F3 to control a shorter signal whistle. Each Tsunami decoder comes with up to eight* whistles pre-installed. To select a particular whistle, simply program CV 115 with any value between 0 and 7 as indicated in Table K. Refer to the SoundTraxx website for a detailed list of which whistles are contained in your particular decoder.

Table K. CV 115, Whistle Selection	
Whistle Number	**CV Value**
Whistle 1	0
Whistle 2	1
Whistle 3	2
Whistle 4	3
Whistle 5	4
Whistle 6	5
Whistle 7	6
Whistle 8	7

*Note: Depending on the prototype and available memory storage, some Tsunamis may have less than eight whistles installed. In such cases, selecting an unavailable whistle will default to Whistle 0.

Whistle Volume

CV 129 sets the whistle volume and may be set between 0 and 255. See Audio Mixer for more details.

Dual Whistle Mode

On occasion, a locomotive was equipped with two different whistles. The Southern Pacific, in particular, was noted for its practice of equipping some locomotives with an air horn. Tsunami has the ability to select between two different whistles, if desired, using the Dual Whistle Mode feature. When this mode is enabled, Function F2 continues to work as the primary whistle control. Function F3 becomes the whistle select key. When F3 is OFF, F2 controls Whistle Selection A and when F3 is ON, F2 controls Whistle Selection B. Note that when the dual whistle mode is enabled, the signal (short) whistle is unavailable.

To activate the dual whistle mode, program CV 115 as follows:

1. Select Whistle 'A' and find the corresponding CV Value from Table K.
2. Select Whistle 'B' and find the corresponding CV Value from Table K.

3. Multiply the CV value for Whistle B by 8 and add it to the value for Whistle A.
4. Add 128 to the sum computed in step 3 and program this value into CV 115.

Example:
Let's set up the Tsunami Heavy Steam Decoder with an SP 4449 whistle on 'A' and an airhorn on 'B'.

1. As noted on the product packaging, the SP 4449 whistle is Whistle 4. From Table K, this is selected with a CV setting of 3.
2. Similarly, the SP 4449 horn is Whistle 5 and from Table K, this is selected with a CV setting of 4.
3. The CV value from step 2 is multiplied by 8 and added to the CV value from step 1 to get:

$$35 = (4 \times 8) + 3$$

4. Then 35 is added to 128 to get the final value for CV 115:

$$CV\ 115 = 35 + 128 = 163$$

Playable Whistle

Tsunami has a unique feature called a Playable Whistle which allows you to set the whistle for a pressure or position response to an analog control. This could be a pressure-sensitive key, thumbwheel or some other analog control, depending on your command station.

In some cases, each cab must be individually set up to use this feature; you will need to see the documentation that came with your command station for this information, as well as the value to program into CV 47. The default value for CV 47 is 0, which disables the playable whistle function.

Hint: the effect of the playable whistle is greatly enhanced if you enable the Whistle Reverb by setting CV 161 to 1.

Note: Once you've programmed the decoder to respond to the playable whistle function, if you switch to different cab not programmed in this manner you will find that F2 and F3 will no longer respond.

Bell Control

By default, Tsunami uses Function F3 to turn the bell on and off. There are two CVs to adjust the bell:

CV 114, Bell Ring Rate
CV 130, Bell Volume

Bell Ring Rate

The bell ring rate may be adjusted over 16 steps to simulate the sound of an air-rung bell or a hand-rung bell by setting CV 114 between 0 and 15. A setting of 0 yields the fastest ring rate (like an air-ringer) while higher values produce increasingly slower ring rates. The default setting for CV 114 is four, but as each Tsunami decoder features a different bell recording you may find that tweaking this value a bit improves the overall sound effect on some models.

Bell Volume

CV 139 sets the bell volume and may be set between 0 and 255. See Audio Mixer for more details.
.

Exhaust Control

Tsunami provides several CVs for setting up the Steam Exhaust Chuff sound effect:

> CV 112 Exhaust Configuration
> CV 116 Auto Exhaust Rate
> CV 131 Exhaust Volume
> CV 135 Side Rod Clank Volume

In addition, there are the Dynamic Digital Exhaust (DDE) CVs covered in a later section.

Exhaust Configuration

The first decision to make is whether or not to synchronize the exhaust chuffs to the driver wheel rotation using a mechanical cam switch or to use Tsunami's Auto-Exhaust. Cam synchronized exhaust has the advantage in that the precise timing and number of chuffs are correctly delivered regardless of locomotive speed or load. The disadvantage is one of a more complex installation.

Also, be aware that if you select cam-synchronized exhaust, the Tsunami will automatically revert to auto exhaust when operating in analog (DC) mode. This is because the cam sensor circuit requires an alternating voltage polarity such as found on a DCC track in order to work properly.

Auto Exhaust

Tsunami's auto-exhaust feature simply produces an (adjustable) exhaust chuff cadence that is proportional to the locomotive speed. Since there is no mechanical switch to worry about, the installation is much easier and ideal for use in locomotives where space is extremely limited. The primary drawback is that the chuff rate is tied to the throttle's speed setting and not to the actual locomotive speed. If the engine slows down due to a grade for example, the speed change is not reflected in the chuff rate. The solution, then, is to use the Auto-Exhaust in conjunction with Tsunami's Load Compensation feature (see Step 9), so speed changes due to load and grades are minimized.

Sound Programming

Articulated Mode

Tsunami provides an auto-exhaust mode to simulate the cadence of a simple* articulated locomotives. When this mode is enabled, the exhaust sound will have chuff-chuff-pause rhythm simulating two cylinder sets that are out of sync with each other. You can also set a variable wheel slip rate that causes the two sets of exhaust chuffs to go in and out of sync with each other as if one set of drivers were continuously slipping**. It is also useful for generating a double-header sound effect, especially if the second engine is not equipped with a sound system.

Once you have determined which Exhaust Mode you want, use Table L to find the proper value to program into CV 112. Note that you will also have to decide on how many airpumps to set (see next section) before finalizing a value for this CV.

Table L. CV 112, Exhaust Mode and Airpump Selection			
Exhaust Mode	**Wheel Slip Rate**	**Airpump**	**CV Value**
Conventional Rod Engine	None	Single Airpump	0
Conventional Rod Engine	None	Dual Airpump	1
Articulated Engine	None	Single Airpump	64
Articulated Engine	None	Dual Airpump	65
Articulated Engine	Slow	Single Airpump	80
Articulated Engine	Slow	Dual Airpump	81
Articulated Engine	Medium	Single Airpump	96
Articulated Engine	Medium	Dual Airpump	97
Articulated Engine	Fast	Single Airpump	112
Articulated Engine	Fast	Dual Airpump	113
Cam Synchronized	None	Single Airpump	128
Cam Synchronized	None	Dual Airpump	129

*Compound articulated engines recycled the steam from one cylinder set, the high-pressure side, into the second cylinder set, the low-pressure side, and thus produce the same exhaust cadence as a simple two-cylinder engine. You can readily identify a compound type engine by the observing that the low-pressure cylinder are substantially larger in diameter than the high-pressure cylinders.

**Technically, this did not likely occur often in prototype practice except perhaps when a train was first started as it would result in rapid wear of the slipping drive wheels but it does make for an interesting sound effect.

CV 116, Auto Exhaust Rate

CV 116 is used to adjust the exhaust chuff rate when using Auto-Exhaust synchronization. Auto-Exhaust automatically generates an exhaust chuff rate proportional to the throttle setting. Since every locomotive is different, CV 116 is used to match up the Auto-Exhaust rate to the locomotive speed and may

be loaded with any value between 0 and 255. Higher values will yield higher chuff rates for a given throttle setting. A typical synchronization rate may be computed as:

$$\text{CV Value} = 115.9 \times \frac{\text{SPD}}{\text{DIA}} \times \text{Gear Ratio}$$

where SPD is the locomotive's top speed in scale miles-per-hour at full throttle and DIA is the locomotive's driver wheel diameter in scale inches, and Gear Ratio is the gear ratio for shays and other geared engines. For conventional steam engines, use a Gear Ratio = 1. The driver diameter can be easily measured with a scale ruler but remember to convert the measurement to scale inches.

If you don't know your locomotive's top speed, you can also estimate it and still get pretty good results. A good rule of thumb is to use 45 MPH for freight locomotives and 70 MPH for passenger engines.

Hints for Setting Engine Exhaust Chuff Rate

Because most locomotives do not respond linearly (i.e., straight line) to the throttle settings, it can sometimes be difficult finding the magic auto-exhaust chuff rate setting that works across the locomotive's full speed range. We have two procedures for setting the chuff rate that have worked well. The first method is easy to implement and produces good results that should satisfy all but the stodgiest of nitpickers. The second method takes more effort but produces more accurate results.

Method 1
Begin by setting the starting voltage (CV 2) such that the engine begins to barely move at speed step 1. Then increase the throttle setting until the engine is moving at 10-15 scale MPH. Then adjust CV 116 up or down until the chuff rate corresponds to approximately four chuffs per wheel revolution.

Method 2
This procedure uses the loadable speed curve to compensate for the locomotive's non-linearities. Begin by setting CV 25 = 16, CV 29 = 18 (50 if you are using a long address- see Table A) and CV 116 to the value calculated from the formula above. Set your command station to use 28 speed-step mode. Set the throttle to speed step 1 and adjust the first entry in the speed table, CV 67 until the locomotive speed matches the chuff rate. Increase the throttle to speed step 2 and adjust the second entry in the speed table, CV 68 until the locomotive speed once again matches the chuff rate. Repeat this process until you have adjusted the locomotive speed across all 28 speed steps using CVs 67-94.

Exhaust and Rod Clank Volume Control

CV 131 controls the exhaust chuff volume while CV 135 controls the side rod

clank volume. Either CV can be set between 0 and 255. See Audio Mixer for more details. If you are installing the Tsunami in a geared engine, you may wish to disable the rod clank by setting CV 135 down to zero.

If you are using the DDE feature, remember that these CVs set the baseline (i.e., zero-load) volume level so take care not to set either volume level too high or too low as it will limit the range over which the DDE module can make adjustments. For example, if you maximize the exhaust chuff volume with CV 131, the DDE will not be able to increase it further when the engine is subjected to a greater load.

Airpump Control

There are two CVs to adjust the Airpump:

> CV 112, Airpump Select Register
> CV 132, Airpump Volume

Airpump Select

Most small and medium sized locomotives had a single airpump while heavy and articulated steam engines often had two airpumps. To select between single or dual airpumps, use Table L to find the proper setting for CV 112 in conjunction with the exhaust control mode (see previous section) you would like to use.

If you are modeling a locomotive that did not have an airpump at all, you can turn the airpump off by setting the volume down to zero.

Airpump Volume

CV 135 sets the Airpump volume and may be set between 0 and 255. See Audio Mixer for more details.

Dynamo Configuration

The Dynamo volume is set using CV 133 which may be set to any value between 0 and 255 as discussed under Audio Mixer.

By default, Tsunami Steam decoders map the Dynamo sound control to the Headlight and Backup Light functions. See Function Mapping for information on how to change the Dynamo control over to another function. If you prefer to turn the Dynamo off altogether, you must also reconfigure the headlight and backup light to use a different effect (see Lighting Effects) as the Dyno-Light lighting effect will not turn on when the Dynamo sound is disabled.

Fireman Fred

Fireman 'Fred' keeps the engine running by performing a variety of important

tasks. His most important task is to keep the fire hot by periodically shoveling coal into the firebox. He also has charge of the injectors and the blowers. His routing maintenance includes inspecting the engine at various stops and using the pneumatic grease gun or his oil can, checking the various nuts and bolts, and tightening them as needed with his wrenches. Occasionally, the engine will get the better of him and you will hear the locomotive 'pop off'.

The Event Probability Generator
One of the fun things about Tsunami is the ability to program what we call the 'Event Probability Generator'. As terrific as Fred is, having him constantly performing all the above tasks can get a bit busy, especially when you have multiple engines and multiple Freds! The Event Probability Generator allows you to set the *likelihood* that these activities will occur.

Each of the following CVs can be set from 0 to 255 and specifies the probability that the selected sound effect will occur the next time the locomotive is stopped. Setting the CV to 0 disables the sound effect since it has a 0% chance of occurring. Setting the CV to 255 means that the effect will occur every time the locomotive is stopped.

> CV 201, Fireman Fred Shovels Coal
> CV 202, Fireman Fred Fills the Tender with Water
> CV 203, Fireman Fred Uses His Wrenches
> CV 204, Fireman Fred Uses His Pneumatic Grease Gun
> CV 205, Fireman Fred Uses His Oil Can
> CV 206, Fireman Fred Uses the Injectors
> CV 207, Fireman Fred Uses the Firebox Blower
> CV 208, Pop Valve Blowoff

Fred's Volume Controls
Like the Event Probability Generator, there are several volume CVs for the above sound effects. Choose a number between 0 (off) and 255 (maximum volume) for the following CVs.

> CV 143, Pop Valve Volume
> CV 145, Blower Draft Volume
> CV 146, Water Stop Volume
> CV 147, Injector Volume
> CV 148, Fireman Fred's Shovel Volume
> CV 149, Fireman Fred's Wrench Volume
> CV 150, Fireman Fred's Oil Can Volume
> CV 151, Fireman Fred's Grease Gun Volume

Using the Quiet Mode

Tsunami's Quiet Mode is used to turn the sound on only after the decoder is placed into service. It will also automatically turn the sound effects off when the decoder is not being used. This is particularly useful when you have a large number of sound equipped engines on your layout and don't wish to have them turn all at once!

Sound Programming

To activate the Quiet Mode, simply program CV 113 to any non-zero value between 1 and 255. This value sets the amount of time in tenth second increments, that the decoder will wait before it turns the audio off. Thus, a setting of 120 corresponds to 12.0 seconds.

When the Quiet Mode is active, the decoder will remain quiet when it is first powered up and then automatically turn on the audio whenever it receives a non-zero speed command or any function is turned on (except Mute). It will automatically mute the audio when the locomotive speed is returned to zero, all functions are turned off and the time set in CV 113 has elapsed.

Setting CV 113 to 0 disables this feature and the sounds will turn on immediately when the decoder is powered up and remain turned on for the duration of the operating session.

Advanced Programming

Step 8: Configuring the Dynamic Digital Exhaust (DDE)

One of the more exciting features found in Tsunami is the Dynamic Digital Exhaust or DDE. With the DDE properly set up, the timbre and volume of the exhaust chuff as well as the side rod clank will vary in response to changes in the locomotive load. Now, when your locomotive is climbing a steep grade, the exhaust chuff will be deep and powerful only to turn into a soft hissing when drifting downgrade! The DDE is also sensitive to throttle changes much in the same way that an automobile's exhaust note changes when the accelerator pedal is pressed down or let up.

As every locomotive and installation is different, the DDE may not work perfectly straight of the box even using Tsunami's default settings and some care and patience will be needed on your part to get the desired results. In the text that follows, you will be guided through each of the DDE's features a step at a time such that you should be able achieve satisfactory results in relatively short order.

Important: The DDE effect will work best when Tsunami is used in conjunction with as large a speaker as possible. Small speakers (especially those under 1" diameter) have a limited bass response and cannot reproduce the low frequency effects the DDE is capable of creating.

DDE Control CVs

The first step is to become acquainted with the DDE CVs. There are 12 of them:

> CV 177, DDE Throttle Sensitivity
> CV 178, DDE Load Sensitivity

CV 177 is used to set the DDE's sensitivity to changes in the throttle position and CV 178 set the sensitivity to changes in the motor load. Either CV can be set between 0 and 255 with larger numbers equating to a greater sensitivity to a given throttle/load change.

A value of 0 disables the corresponding DDE control input. Setting both CV 177 and 178 to 0 disables the DDE altogether.

Take care to not make the DDE overly sensitive, especially to the motor load signal. Doing so may result in "saturation" of the DDE effect whereby the DDE will simply appear to be unresponsive. This is because even a slight load signal can be amplified to a point that sends the DDE to the extreme end of its settings and thus any additional increase in motor load will have no further effect on the sound.

> CV 179, DDE Attack Time Constant
> CV 180, DDE Release Time Constant

Advanced Programming

The Attack and Release Time Constant CVs determine how quickly the DDE reacts to a change in load or throttle. The Attack CV sets how fast the effect turns on when the load or throttle is increased while the Release CV set how fast the effect turns off when the load/throttle is decreased.

Each CV may be set between 1 and 255 with higher values producing faster response times. Generally, you will want to set CV 179 and 180 to the same value. Be careful not to set these CVs too high as it will allow the DDE to react to even minor changes in load such as occurs when traversing a turnout or slight change in track radius. This can result in rapid or erratic changes of the chuff volume and is quickly solved by lowering the attack and release CV settings.

> CV 181, DDE Exhaust Low Volume Limit
> CV 182, DDE Exhaust High Volume Limit
> CV 183, DDE Side Rod Clank Low Volume Limit
> CV 184, DDE Side Rod Clank High Volume Limit

These four CVs determine how much the exhaust and side rod clank sound volumes will be boosted or cut in response to the motor load and throttle.

Each CV may be set anywhere between 0 and 255. A setting of 0 results in no change to the volume level while a setting of 255 corresponds to roughly a 12dB or 4X increase or decrease in volume level.

It is important to remember that these CVs do not set the actual volume level but rather control the percentage of change. The baseline volume level of exhaust or rod sound effects must still be set with the audio mixer level CVs (CV 131 for exhaust chuff and CV 134 for the rod clank).

Be careful not to set the baseline volume level too high or too low as the DDE cannot increase or decrease the volume beyond its maximum or minimum settings of 0 and 255 regardless of how high you set CV 181 thru 184. In other words, even though the DDE can increase the exhaust volume by up to 4 times (400% or +12dB), if the mixer level is set to 255, no further increase will occur. Similarly, if the mixer is set to 128, then the maximum volume change possible with the DDE is 255/128 or about 199% (+6dB).

> CV 185, DDE Baseline Frequency
> CV 186, DDE Control Gain
> CV 187, DDE Filter Damping

These CVs influence the DDE's ability to modify the exhaust chuff pitch and timbre.

CV 185 sets the baseline or 'no load' timbre of the exhaust chuff and can be set between 1 and 255. Lower values will give the exhaust chuff a 'boomier' sound but only to the extent that your speaker can handle the increased bass levels.

CV 186 determines how much the exhaust chuff pitch/timbre will vary in

response to a load or throttle change. This CV can be set between 0 and 255 with larger numbers equating to a greater sensitivity to a given change.

CV 187 sets the damping factor of the DDE's filter bank and can be used to modify the exhaust chuff's overall tonal shape. Normally, this CV should be set between 200 and 255. Lower settings may be used but you will find that the exhaust chuff will begin to take on an unpleasant and 'alien' characteristic as the CV value is reduced.

CV 188, DDE Tracking Coefficient

When load compensation is disabled, the DDE senses the load on the motor load by comparing the motor's back-emf signal to a zero-load reference level as set by CV 188. The setting for CV 188 is based on the motor's efficiency level, typically 70% to 80%) and may be calculated as:

CV 188 = Motor Efficiency X 128

Thus, a 75% efficient motor would use a CV setting of:

CV 188 = 0.75 * 128 = 96

Determining a motor's efficiency requires instrumentation not available to the average hobbyist so it must be determined via trial and error as will be discussed shortly.

Now that you have some idea of what each of the DDE control CVs does, the next step is get familiar with the range of sounds that are possible by actually trying the DDE out. As the DDE is easier to setup to respond to throttle changes, it is best to start there.

Throttle Controlled DDE

The DDE responds to changes in the throttle by comparing the throttle setting to the current locomotive speed. The greater the difference between the two, the greater the change in the exhaust and side rod sound that will be heard.

When the throttle is increased, the locomotive will begin to accelerate. During this period of acceleration, the exhaust chuff will grow deeper and louder while the rod clank volume will become lower. Likewise, if the throttle is decreased, the locomotive will begin to reduce speed. During this period of braking, the exhaust chuff will drop while the rod clank volume will increase. As the locomotive's speed approaches the throttle set point, the exhaust and rod clank volume will gradually return to their normal values as set by the audio mixer.

For this effect to work, some nominal value must be programmed into the acceleration and braking rate CVs (CV 3 and CV 4). Otherwise, the locomotive speed will quickly follow the throttle setting and the braking and acceleration periods will be so short that the DDE will be unable to work its 'magic'.

Advanced Programming

For the purposes of setting up the DDE, we suggest you start with the DDE CVs set to their default values. Set the exhaust (CV 131) and rod clank (CV 135) volume levels to their default values of 128 and 32 respectively. Then set CV 3 and 4 to a value of 40 to enable the momentum. For the time being, disable the DDE by setting CV 177 and CV 178 to zero. *Note:* The value for CV 3 and CV 4 is selected for demonstration purposes only. Once you have the DDE 'tuned up', you can go back and set CV 3 and CV 4 to a lower or higher value as desired.

Next, place your locomotive on a section of track that is sufficiently long enough for it to "stretch its legs" and get up to speed without worry of running into something. If you have them, a set of stationary test track rollers also works well. Crank the throttle up and take note of the exhaust chuff volume and tone.

Bring the engine to a stop and re-enable the DDE by setting CV 177 to 10. Crank the throttle up again this time to a speed step somewhere around 40 or so. Now, as the engine accelerates, the exhaust chuff should have considerably more volume and a deeper tone.

Allow the engine to get up to speed and notice that the exhaust sound gradually returns to its previous level. Then quickly turn the throttle down. You should hear a sudden drop in the exhaust chuff volume along with a reduction in bass level and an increase in the rod clank volume. As the engine slows, the sound levels will gradually return to their normal level. This is the basic Throttle Controlled DDE action. Once you have the DDE responding to the throttle, you can begin experimenting with the various CVs.

Throttle Sensitivity

Try changing CV 177, Throttle Sensitivity to a value of 1 (low sensitivity). Turn up the throttle to speed step 40 and allow the engine to reach 'cruising' speed. You can modulate the exhaust sound volume by turning the throttle up or down but observe that a relatively large throttle change is needed to get a big change in volume. Now set CV 177 to 50 and again, bring the locomotive up to speed. Note that this time, with a high sensitivity setting, only a slight wiggle of the throttle around step 40 is needed to bring about a large change in exhaust volume.

Attack and Release Times

As previously mentioned, CV 179 and CV 180 control how fast the DDE can react to a load or throttle change. Try setting these CVs to 250 for a very fast attack/release time. Set the throttle around 40 and allow the engine to reach speed. Vary the throttle above and below speed step 40 and you will hear the volume levels change almost instantly in response to changes in the throttle setting. Now set CV 179 and 180 to a more moderate value of 5 and try again. This time when the throttle is changed, you should hear the sound transition more gradually from one level to another and very rapid changes of the throttle are almost ignored.

Volume Limits

Advanced Programming

Hopefully you've noticed that when the engine is accelerating, the exhaust volume increases and the rod clank volume decreases. And when the engine is braking, the opposite occurs - the exhaust volume decreases and the rod clank volume increases. You can use CVs 181 thru 184 to limit how much the volume levels will increase or decrease. During acceleration, CV 182 controls the rise in exhaust volume and CV 183 controls the drop of rod clank volume. A value of 255 for either CV produces the maximum amount of volume change. Lower values result in correspondingly smaller levels of change and a value of zero results in no change at all.

When the locomotive is braking, CV 181 determines the reduction of exhaust volume and CV 184 controls the rise of rod clank volume. As with the other two Volume Limit CVs, a value of 255 results in the maximum amount of volume change. Thus, the upper and lower volume limits of a given effect can be independently adjusted. You could for example, set CV 183 and CV 184 to zero so the rod clank volume is always constant. Setting CV 181 to 250 and CV 182 to 64 results in an exhaust sound that increases volume four times under acceleration but only drops 30% during braking. Try experimenting with different settings to see what the results are.

DDE Timbre and Cutoff Control
By changing the value in CV 185, you can change the tone or timbre of the exhaust chuff. A lower CV setting results in a deeper chuff.

Note that the exhaust cutoff automatically increases as the throttle increases. This helps keep the individual exhaust chuffs crisp and distinct as the chuff rate increases. You can control how much change to the basic chuff occurs by varying the setting of CV 186. A low value results in only minimal change and maintains a strong deep chuff regardless of locomotive speed. At higher speeds however, the chuffs may begin run into each other resulting in a strange whirring sound. This can be corrected by programming a higher value into CV 186. In general, the faster you are planning on operating your engine or the higher you have set CV 116 (Auto Exhaust Rate), the higher a setting you will need for CV 186 to maintain the proper exhaust cutoff over the locomotive's speed range. Try setting CV 186 with different values and observe the effect on the exhaust sound over a range of throttle settings. When properly set, you will get a nice clear exhaust bark over the entire speed range of your locomotive starting with a deep "woof-woof-woof" at low speeds that gradually transitions to a light "chi-chi-chi" sound at high speeds.

Load Sensitive DDE
The DDE and its effect on the exhaust sound can also be varied by changes in the locomotive's load such as the number of cars being pulled or the grade being climbed. The DDE accomplishes this by measuring the motor's back-emf voltage which is proportional to the locomotive speed. When the locomotive load increases, the motor speed drops as does the back-emf voltage drops and the DDE interprets this change by increasing the exhaust chuff volume and deepening the exhaust tone. When the load is reduced

as might happen when going downhill, the motor speed rises along with the back-emf voltage and the DDE lowers the exhaust volume (and raises the side rod clank volume).

Before you can use the Load Sensitive DDE feature, you will need to decide if you are going to use Tsunami's load compensation feature or not (see next section) as the set up procedure is slightly different depending on your choice. On most locomotives, the Load Sensitive DDE effect will be more dramatic when load compensation is disabled. This is because load compensation, by design, keeps the motor speed stable and thus the DDE does not detect much of a load change.

Setting the DDE with Load Compensation On

If you decide to keep the load compensation enabled, then setting up the DDE to react to load changes is mostly a matter of adjusting CV 178, Motor Load Sensitivity. You can demonstrate that the feature is working by setting the throttle to some nominal speed and slowing down the motor by rubbing your finger against the flywheel (or a driver wheel if you can't reach the flywheel). As the motor slows down, you should hear the exhaust chuff deepen and increase in volume. Increasing the setting of CV 178 will make the exhaust sound more sensitive to a given change in the motor load and speed.

You will likely find that in practice, your finger is able to exert a much greater load on the motor than will be experienced when the locomotive is simply running around the layout. This is due in part to the relatively high gear ratios and light weights found in the average model locomotive. On a layout, when too great a load is encountered the locomotive will slow down only slightly and then the wheels will break loose and simply start spinning away. Thus, Tsunami only senses a slight change in the motor load.

This means to get a reaction in the DDE, you will need a relatively high setting for CV 178. As you increase the sensitivity setting, you may also notice the DDE starts to react to minor variations in track or even slight binds in the locomotive mechanism. To counter these effects, you will need to reduce the attack and release time constant settings in CV 179 and 178 which will slow the DDE's reaction time enough to ignore minor 'hiccups' in the motor load.

The following procedure may be helpful in finding the correct DDE settings:

1. Use the throttle Controlled DDE setup described above to find the desired settings for CVs 181-184 and CVs 185-186. Set CV 179 and 180 to about 30 for a relatively quick attack and release time.
2. Set CV 178 to an initial value of 5 and use the 'finger test' to see how the DDE reacts to a large motor load change.
3. Once you are satisfied the DDE is reacting to the motor load, place the locomotive on your layout, connect up a medium size train and drive it around and listen for a response to changes in grade and load. If no response is forthcoming, increase the setting of CV 178 by about 5. Continue to increase CV 178 until you can detect a change in the exhaust sound.

4. Once you have found a setting for CV 178, adjust CV 179 and 180 to smooth out the change in sound and tone levels if needed. Usually, this means reducing the CV setting.

Setting the DDE with Load Compensation Off

To get the DDE to respond properly when the load compensation is turned off, you must also find the proper setting for CV 188 which sets the reference point for the back emf voltage when no motor load is present.

When properly set, you will get a much wider variation in the exhaust sound, particularly on down-grades. The following procedure may be helpful in finding the correct DDE settings:

1. Use the throttle Controlled DDE setup described above to find the desired settings for CVs 181-184 and CVs 185-186. Set CV 179 and 180 to about 30 for a relatively quick attack and release time. Set CV 178 to an initial value of 5.
2. Turn off the load compensation by setting CV 212 to 0.
3. Set CV 188 to an initial value of 100. While running the locomotive light (i.e., not pulling any cars) on flat level track, gradually reduce the setting of CV 188 until you hear a drop in exhaust volume and perhaps a reduction in the bass tones. At this point you can fine tune the setting in CV 188 up or down to establish what you would like the exhaust sound to be for the no-load condition.
4. Once you have established the setting for CV 188, connect up a medium size train and drive it around and listen for a response to changes in grade and load. If no response is forthcoming, increase the setting of CV 178 by about 5. Continue to increase CV 178 until you can detect a change in the exhaust sound due to a change in the load.
5. Once you have found a setting for CV 178, adjust CV 179 and 180 to smooth out the change in sound and tone levels if needed. Usually, this means reducing the CV setting.

Tip: You will have better luck adjusting the DDE by adjusting one CV at a time and only in small steps. Making big adjustments to several CVs at once will usually only make it more difficult to find the optimum setting.

Step 9: Setting Up the Hyperdrive

Tsunami's Hyperdrive system features high-frequency PWM drive for silent motor control along with load compensation (or back-emf) to improve low speed operation and maintain constant speed regardless of changes to the motor load.

The PWM frequency is fixed at 22.000Khz and there are no adjustments.

Tsunami uses back EMF and a PI control loop to sense and control motor speed. There are four CVs associated with the load compensation feature:

> CV 10, Back EMF Cutout
> CV 209, Kp Coefficient
> CV 210, Ki Coefficient
> CV 212, BEMF Feedback Intensity

Control Loop Coefficients

Tsunami compensates for load changes by comparing the locomotive's speed, as measured by the motor's back-emf voltage, with the current throttle setting. When a difference is detected, the motor voltage is adjusted up or down so that locomotive speed stays constant. This is done using a P-I (proportional-integral) control loop that is tuned using two CVs:

CV 209, Kp, controls the Proportional gain of the control loop and compensates for dynamic changes in the motor load by applying a correction based on the difference between the throttle setting and the current motor speed. This CV may be set between 1 and 255. Higher values produce an increasing level of compensation. However, setting this value too high can lead to irregular and rough performance.

CV 210, Ki, controls the Integral gain of the control loop and compensates for static motor load by applying a correction based on the historical (or integral) difference between the throttle setting and the current motor speed. This CV may be set between 0 and 255. Higher values produce an increasing level of compensation and set the 'snappiness' of the control loop. However, setting this CV value too high can lead to oscillations in locomotive speed and we suggest you use the lowest possible setting that still provides optimal performance.

Note: Setting both Kp and Ki to zero will cause the motor to stop.

Strategy for CV Optimization

Finding the right combination of CV settings requires a certain amount of experimentation and patience to get the best performance. Be aware that these settings will also vary from one locomotive to another. Take notes of your CV settings so you can use them as starting points when configuring other locomotives.

Overdoing a particular setting can actually degrade performance so changes should be made in small increments (+/- 10 or so) until the desired performance is attained. The default settings should provide satisfactory performance when used with most HO and N scale motors.
We suggest the following procedure to help fine tune the CV settings:

1. Begin with each CV set to its default value: CV 10 = 0, CV 209 = 25, CV 210 = 20, and CV 212 = 255. In addition, set CV 2 (Vstart) to 0.
2. With the locomotive on level track, set the throttle to around speed step 20.
3. Adjust the value in CV 209 (Kp) with increasingly higher values just until you begin to notice some jerkiness in the locomotive speed. Reduce the setting in CV 209 to the value just before the jerkiness started.
4. Adjust the value in CV 210 (Ki) with increasingly higher values until you begin to notice some oscillation in the locomotive speed whenever the throttle setting is changed. Reduce the setting in CV 210 to the value just before the oscillation started.

Note: When using load compensation, it is unnecessary to set large values into CV 2 (Start Voltage). This is because the load compensation algorithm will automatically adjust the motor power up to reach desired throttle setting. Therefore CV 2 can usually be set to 0 when load compensation is enabled.

Setting the Load Compensation Curve

Tsunami provides two degrees of freedom for controlling the amount of load compensation applied to the motor over the throttle range using CV 10, Back-Emf Cutout and CV 212, Back-Emf Feedback Intensity.

CV 212 sets the amount of load compensation that is initially applied to the motor and may be set anywhere between 0 and 255. A value of 0 disables load compensation altogether while a value of 255 corresponds to full (100%) compensation.

CV 10, Back-Emf Cutout, determines the degree by which the load compensation is reduced as the throttle speed is increased.

When CV 10 is set to 0, the amount of load compensation set by CV 212 is constant over the entire speed range. Setting CV 10 between 1 and 127 will determine the speed step at which the load compensation is reduced to zero as illustrated in the graph on the next page.

Setting CV 10 between 128 and 255 selects a partial reduction of load

compensation at full speed such that the minimum load compensation level at speed step 128 is:

$$\text{Full Speed Load Compensation} = \frac{(CV\ 10 - 128)}{128}$$
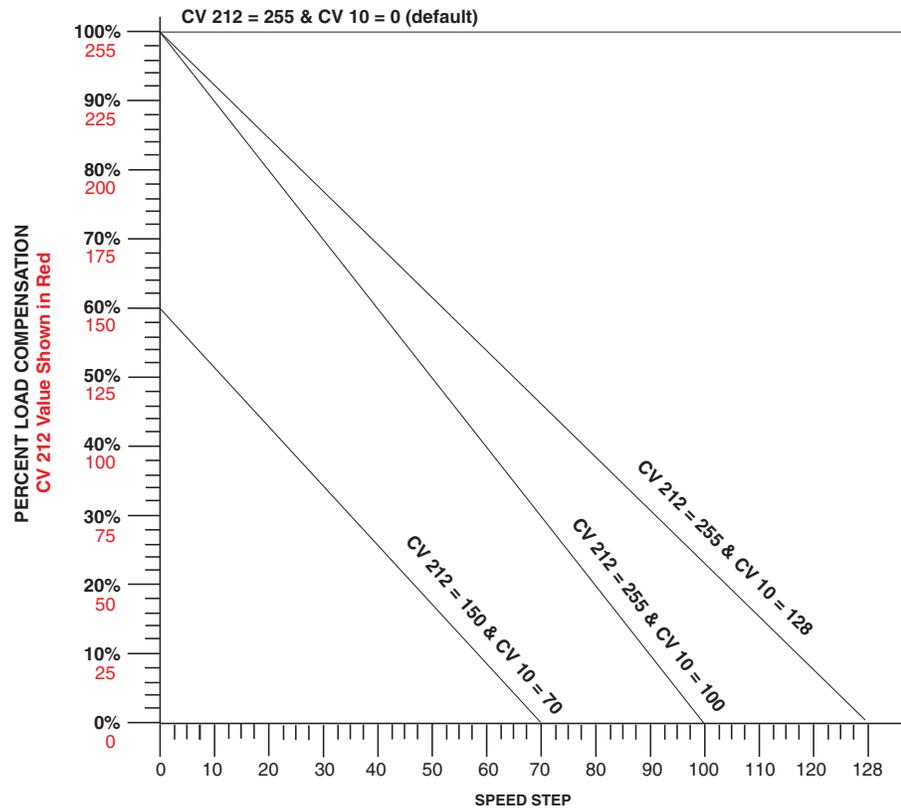
In general, you will want full load compensation at low speeds which gradually reduces to zero load compensation at full throttle and may be achieved by setting CV 10 to 126.

When operating in a consist, you may need to reduce the value in CV 212 which will reduce the low speed load compensation and avoid working the locomotives against each other due to slightly different running characteristics.
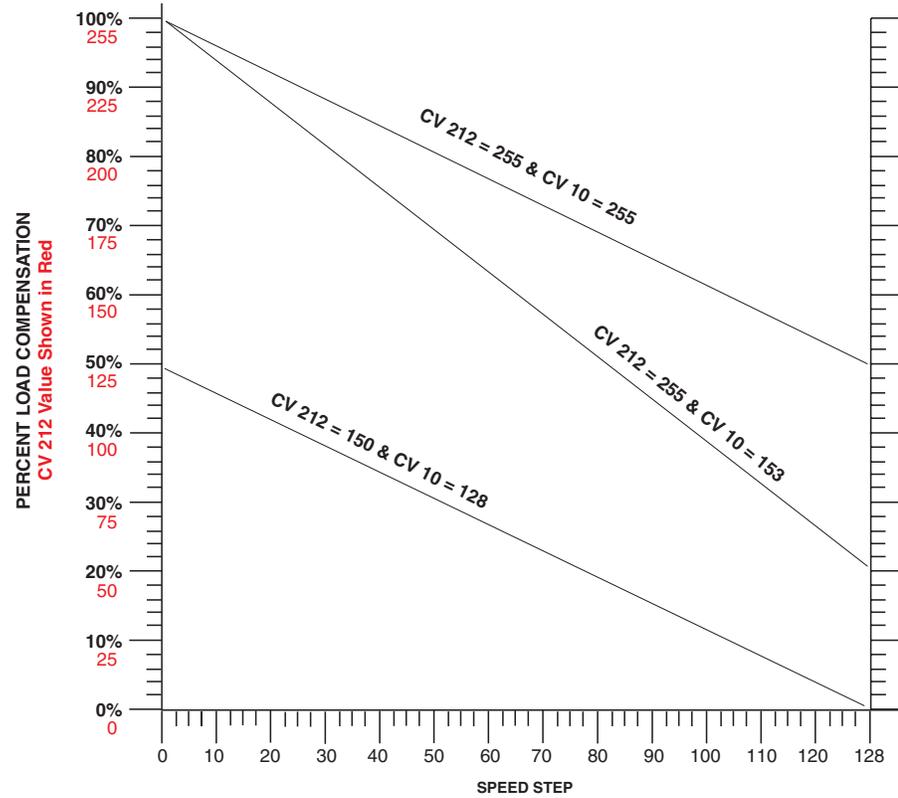
Miscellaneous Features

Step 10: Floobydust - Configuring Tsunami's Miscellaneous Features

F11 Train Brake

By now you've no doubt discovered that Function F11 can be used to turn Tsunami's brake squeal sound on and off. What you may not realize is that F11 can also be used to slow your train down as if the brakes really are applied!

To achieve this effect, you will need to first program some momentum into Tsunami using CV 3 and CV 4 to set the acceleration and braking rate respectively. The exact value is unimportant but should be large enough to produce a noticeable delay in the throttle response. A setting of 20 or so will do the trick. The reason for programming CV 3 (acceleration rate) is so the train does not immediately resume its old speed when the F11 function is released.

Next, program CV 61 (F11 Brake Rate) to adjust the rate at which the train will slow down when F11 is turned on. A value of 1 to 128 is added to the value programmed in CV 4 which has the effect of slowing the train more gradually than by simply turning the throttle down. Values of 129 thru 255 translate to -1 thru -127 which have the opposite effect as they subtracted from the setting in CV 4 and slow the train more aggressively than turning the throttle down (as a brake would be expected to do).

Be careful not to set F11 too high - if you do, the net braking rate will be zero and you will have effectively turned F11 into an emergency stop button!

Note that setting CV 61 to a value of 0 or 128 has no effect on the brake rate and basically disables this feature.

DC Braking

The DC Braking feature allows you to configure Tsunami to bring the locomotive to a gentle stop whenever DC power is present on the track. In this manner you can implement an inexpensive 'braking section' for stopping locomotives in front of a red block signal. This is done by using a relay or other switch to supply a section of track ahead of the signal with DC when the signal is red and DCC power when the signal is green. Then, configure Tsunami decoder as follows:

1. Set CV 11, Packet Time Out Value. CV 11 determines the amount of time, in 0.25 second increments, that elapses between when Tsunami first detects the loss of the DCC control signal and when it begins to bring the locomotive to a stop. For DC Braking, we suggest using a small value of 1 or 2 corresponding to a detection time of a 1/4 to 1/2 second.
2. Set CV 3 (Acceleration Rate) and CV 4 (Braking Rate). Since you won't want your train to come to a sudden stop, you'll need to set these CVs so

your train slows down and starts up smoothly. Be sure to pick a braking rate value that's high enough to bring the train to a smooth stop but not so large that it over runs the length of the braking section and starts up again! See Step 3, 'Configuring the Throttle', for more information.

3. Disable Analog Mode. This prevents Tsunami from taking off at full speed when it encounters DC power. Analog mode can be disabled two ways. Program CV 12 (Alternate Power Mode) to 0 or select a proper value for CV 29 where Analog Mode is off. See Step 2 and Table A for selecting the proper value for CV 29.

Now, whenever Tsunami encounters a DC powered section of track it will slow to a stop and wait. Lighting and sound functions will remain on as they where prior to entering the braking section. When DCC power is restored, the decoder will accelerate back to its current throttle setting.

Automatic Sound Functions
Tsunami provides the ability to generate several sound functions automatically. This is especially useful when your controller lacks a sufficient number of function keys to control all of Tsunami's sound effects or when using Tsunami on a (DC powered) where there are no function controls at all!

There are six CVs associated with the Automatic Sound Functions:

> CV 193, Automatic Bell On Set Point
> CV 194, Automatic Bell Off Set Point
> CV 195, Grade Crossing Whistle Sensitivity
> CV 196. Brake Squeal Sensitivity
> CV 197, Analog Mode Automatic Sound Configuration
> CV 198, Digital Mode Automatic Sound Configuration

Automatic Sound Configuration Register
CV 197 selects which automatic sound functions are enabled when the decoder is operating in analog or DC mode. CV 198 similarly configures the automated sound functions for DCC operation.

There are five automated sound functions available:

Automatic Whistle Signals - Whenever the locomotive is stopped or started, Tsunami will produce the correct whistle signal appropriate for the direction of travel:

> One short toot = Stop
> Two Medium Toots = Forward
> Three Short Toots = Reverse

Automatic Grade Crossing Signal - When enabled, Tsunami will play a grade crossing signal (two long whistle blasts followed by a short and another long) triggered by a sudden upward spike in the throttle.

Miscellaneous Features

Automatic Bell - Tsunami can be programmed to turn the bell on and off at preset speed points such as might occur when passing through a yard or station platform.

Automatic Steam Release - This feature causes a short steam release to sound whenever Tsunami is brought to a stop.

Automatic Brake Squeal - The brake squeal is activated by slowing the train down by a predetermined amount.

These functions may be enabled by referring to Table M below and circling the numbers corresponding to the sound function you want to enable. Then add up the circled numbers and program this value into CV 197 (analog mode) and or CV 198 (DCC mode). You can configure Tsunami so some or all automated sounds work in one mode and not the other in any combination as needed.

Table M. Automatic Sound Function Enable CV 197 (Analog Mode) or CV 198 (DCC Mode) Suggested Settings				
Automatic Steam Blowdown	**Automatic Brake Squeal**	**Automatic Bell Enable**	**Automatic Whistle Signal**	**Automatic Grade Crossing Enabled**
16	8	4	2	1

Then go on to set CVs 193-196 to fine tune the operation of each enabled function.

Automatic Bell Set Points

CV 193 and 194 determine the speed steps (or equivalent throttle voltages when operating in analog mode) at which the automatic bell turns on and off respectively and may be set anywhere between 1 and 126 corresponding to the speed step of the same value. CV 194, the bell off set point, must be set to a value greater than CV 193 or else the bell will not turn on.

Example: Set CV 193 to 5 and CV 194 to 10. With these settings the bell will initially be off when the engine is stopped. As the locomotive speed is increased, the bell will turn on once the throttle setting reaches speed step 5. The bell will remain on so long as the engine is operated between speed steps 5 and 10. Increasing the throttle beyond speed step 10 or below speed step 5 will turn the bell back off. Once the bell has been turned off, it can be turned back on by lowering the speed to the same setting as in CV 193.

Crossing Whistle Sensitivity

The automatic grade crossing whistle is activated whenever Tsunami senses a sudden increase in the throttle setting (or track voltage in analog mode) as set by the value in CV 195. This CV can be set to any value between 0 and 126 but for practical purposes, you will likely want a value between 3 and 10. Too low a setting will result in the whistle going off at every speed increase and too high a setting will require an extreme change in the throttle to trigger the sound.

A CV setting of 5, for example, requires you to quickly increase the throttle by at least five speed steps before the whistle will sound off.

Tip: Use the momentum CVs 3 and 4 to help minimize any sudden changes in locomotive speed when the throttle is turned up. A quick flick of the throttle knob (i.e., turn it up and then immediately back down) will usually sufficient to activate the whistle without causing any undo change in actual speed.

Brake Squeal Sensitivity

The automatic brake squeal is activated whenever Tsunami senses a sudden decrease in the throttle setting (or track voltage in analog mode) as set by the value in CV 196. This CV can be set to any value between 0 and 126 but as with CV 195, you will want to use a value between 3 and 10. Too low a setting will result in the brakes squealing with speed decrease and too high a setting will require an extreme change in the throttle to trigger the sound.

As an example, a CV setting of 3, requires you to quickly lower the throttle by at least three speed steps before the brake squeal comes on

Analog Mode

While Tsunami is first and foremost a DCC decoder, it may be used on a DC powered layout, within certain limitations, by enabling the Analog Mode feature. First set CV 12 to 1 and then set CV 29 to a value that enables analog mode as well as any desired DCC parameters such as the address range and so forth as discussed under Step 2, 'Configuring the Decoder' earlier in this manual.

Analog Mode Operation

When analog mode is enabled, you may control your locomotive using an ordinary power-pack though operation will be a bit different than when running non-decoder equipped locomotives.

With the power pack's throttle set to zero, Tsunami will be silent as it has no power. The throttle must be turned up to around 5 volts or so to provide sufficient voltage to power up Tsunami's internal circuitry. At this point, you will begin to hear the background sounds such as the blower and airpump start.

Increasing the throttle further to around 7.5 volts or so will set the locomotive in motion, increasing speed as the throttle is increased. Note that the direction can only be changed when the locomotive is stopped. Load compensation is also disabled when operating in analog mode, as is the cam-synchronized exhaust chuff. When in analog mode, the Tsunami always reverts to auto exhaust using the chuff rate setting in CV 116.

When operating in analog mode, be careful not exceed Tsunami's input voltage rating of 27 volts. When your track voltage exceeds 21 volts, Tsunami will automatically shut down and begin flashing Error Code 10 on both its diagnostic light as well as the headlight and backup light. When you see this

condition, back down on the throttle immediately.

👉 **Important:** Tsunami will work best in analog mode when using a high quality, electronically regulated power pack, preferably one that supplies smooth, filtered DC power. Older rheostat style power packs and pulse power packs will result in erratic and unreliable operation and should not be used with the Tsunami sound decoder. If your power pack provides a Pulse power switch, leave it in the 'Off' position.

Depending on the quality of the power pack's track voltage, some automatic sound functions such as the grade crossing whistle may require a higher sensitivity setting than needed for DCC operation to avoid continual triggering of the sound effect.

Analog Mode Options
In addition to CV 12 and CV 29 discussed earlier, there are four other CVs related to analog mode operation:

Analog Function Enables
        CV 13, Analog Function Enable 1
        CV 14, Analog Function Enable 2

These CVs allow you to force a function input to the ON state whenever Tsunami switches over to analog mode. This is most useful for turning on lighting effects when running on a DC powered layout. Sound functions may be turned on in analog mode as well but this is less useful as they will either run continuously or sound just once when the decoder is powered up - instead, use automatic sound functions discussed earlier to generate sound effects.

To enable any of Functions F1 thru F8, refer to Table N below and circle the numbers corresponding to the function inputs you want to enable. Then add up the circled numbers and program this value into CV 13.

Table N. Analog Function Enable 1							
CV#	F1	F2	F3	F4	F5	F6	F7	F8
13	1	2	4	8	16	32	64	128

Similarly, to enable Function F9 thru F8 or F0, refer to Table O below and circle the numbers corresponding to the function inputs you want turned on. Then add up the circled numbers and program this value into CV 14.

Table O. Analog Function Enable 2						
CV#	F0(f)	F0(r)	F9	F10	F11	F12
14	1	2	4	8	16	32

Miscellaneous Features

Note that when you enable a particular function input for analog mode operation, it has the same effect as pressing the equivalent function key on your DCC cab. Tsunami's function mapping settings will ultimately determine which output or sound effect is activated by the enabled function. Assuming you have not changed the default function mapping, then enabling the F0(f) function in analog mode will not only turn on the headlight, but the dynamo sound as well.

Analog Mode Motor Control Parameters

CV 63, Analog Mode Motor Start Voltage
CV 63 allows you to increase the voltage difference between when the decoder first powers up and when the locomotive starts to move.

Normally, Tsunami will power up in Analog mode around 5 volts or so and the engine will begin moving around 7.5 volts. Under certain circumstances you may experience a condition where the decoder cycles back and forth between start up sounds and locomotive movement. The problem is usually due to a poorly regulated power pack output. The sudden increase in load due to the motor starting causes the track voltage to droop which in turn resets the sound decoder. By increasing the setting of CV 63, you can adjust the decoder so that when the motor starts, the track voltage will be sufficiently high so that any droop that occurs will not turn off or reset the decoder.

CV 63 may be set to any value between 0 and 255 corresponding to tenths of a volt. Thus, a setting of 23 adds 2.3 volts to Tsunami's default start voltage of 7.5 volts.

CV 64, Analog Mode Maximum Motor Voltage
CV 64 allows you to set the maximum average voltage that will be applied to the motor when operating in analog mode. This is useful for limiting a locomotive's top speed as well as providing some margin of safety against burning out a motor whose voltage rating may be lower than your power pack's maximum output

CV 64 may be set to any value between 0 and 255 corresponding to tenths of a volt. A setting of 180 therefore sets the maximum average motor to 18.0 volts.

Caution: Tsunami only limits the average voltage to the motor. The peak voltage applied to the motor will still be the same as the track voltage.

Transponding

If you are using Tsunami on a layout equipped with Digitrax transponding block detection, you will need to configure Tsunami for transponding-friendly operation. Be aware that the Tsunami itself does not transpond - you will need to install an external transponding decoder in your locomotive to achieve this functionality.

Simply program CV 62 to 1 to configure Tsunami for compatibility with external transponding devices. To disable transponding compatibility (default mode), program CV 62 to 0.

Note: Power to the decoder must be cycled before any changes to this CV will take effect.

Troubleshooting

Troubleshooting

If you should have any difficulties with the operation of your Tsunami Digital Sound Decoder, first check this section for hints on trouble shooting. We have found that most problems are caused by an errant CV value and are easily corrected. When all else fails, try resetting the CV values back to their defaults (see the section 'Basic Programming') and try again.

Locomotive doesn't run but was working
Address has been accidentally changed.
Consist address (CV 19) was accidentally set.
CV 29 has been changed to select other address.
Acceleration and braking CVs set to very high values.
Broken motor wire or track pickup wire.
Tip: Check the decoder's Pilot Light to confirm presence of track power.

Locomotive never ran
See all the above.
Decoder wired incorrectly.

Locomotive runs but makes no sound
Mute function (F8) is on.
Another function is re-mapped to the Mute function.
Sound Volume CVs have been set to zero.
Speaker wire is broken.
Speaker is burned out.

Locomotive runs in a consist but lights and sound effects don't work
Consist functions are disabled. Set CV 21 and 22 to activate desired functions (see Step 4, 'Configuring for Consist Operation').

Lights flicker on and off
Decoder is in 14 speed step mode and command station is set to 28 speed steps.

Lights do not work
Decoder is in 28/128 speed step mode and command station is set to 14 speed steps.
Function mapping is improperly set.
Burned out light bulbs.
If using 1.5 volt micro-bulbs, resistor value is too large.
Broken lamp wires.
Tip: Check the decoder's Diagnostic Light to confirm that the decoder is responding to the headlight command when locomotive is going forward.

Locomotive just sits and flashes both headlights.
See next section, 'Diagnostic Lamps'.

Troubleshooting

Sound works for a while then quits
> Amplifier is overheating, lower sound volume.
> Decoder is overheating, lower track voltage.
> Speaker is damaged. Replace speaker.

Speaker sounds 'crackly'.
> Sound volume is too high for speaker.
> Speaker is not properly baffled.
> Speaker wire is loose.
> Speaker is damaged.

Decoder will not program.
> Insufficient power on program track - try using Ops Mode or PTB-100 Programming Track Booster.
> CVs are locked - see 'Basic Programming'.

Diagnostic Lamps

Tsunami has two red LEDs on the circuit board which may be helpful for resolving potential difficulties.

Pilot Light

The pilot light indicates that the decoder is receiving power. If this light does not come on, it may indicate an improperly wired decoder. It could also indicate a loose wire, poor track pickups, no output from the command station or other problem with your layout wiring.
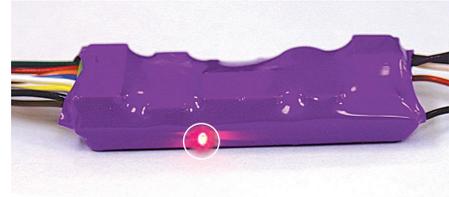
Fault Light

During normal operation, the fault light will turn on and off with the headlight, and is useful for establishing basic control of the decoder. Additionally, Tsunami monitors a number of its input signals and if a fault is found, reports an error code by flashing the fault light as well as the headlight and backup light (if connected). The number of times the light flashes corresponds to the number of the error code. Error codes whose conditions can usually be solved by the user are as follows:
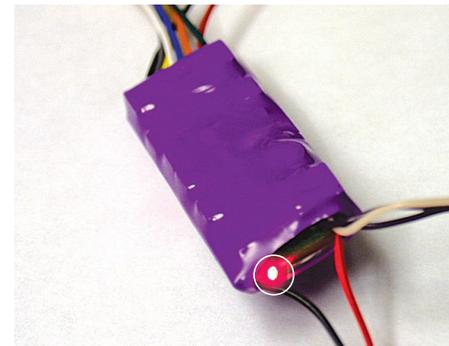
Error 9 - Over temperature fault
> An over-temperature fault indicates the core temperature of the decoder has exceeded safe limits. When this error occurs, motor control and sound will be shut off and the error code will continue to flash until the

temperature has fallen back to a safe level. An Over-temperature fault is usually due to inadequate ventilation or using a motor load that exceeds the decoder's rating.

Error 10 - Over voltage fault

An Over-voltage fault indicates that the track voltage is greater than 22 volts. When this error occurs, motor control and sound will be shut off and the error code will continue to flash until the voltage is brought below 22 Volts. ***Note: Tsunami's absolute maximum voltage input is 27 volts! Track voltages exceeding 27 volts may cause permanent damage to the decoder.***

Error 11 - Motor Connection Fault

This error indicates a faulty motor connection has been detected and typically occurs when the motor lead is shorted to a track pickup wire. The motor will not respond until the error is corrected.

Error 12 - Motor Overload Fault

This error indicates the motor load has exceeded the decoder's current rating. *Supported on Models TSU-4000 and TSU-8000 only.*

Error 16 - CVS reset to default

This code is informational only and indicates that all CVs have been reset to their factory defaults.

On rare occasion, the Tsunami Decoder may also report the following error codes which cannot be remedied by the user and require a return to the factory for repair:

Error 1 - COP Fault
Error 2 - Software Fault
Error 5 - EEROM Checksum failure
Error 6 - Lower Calibration Voltage Error
Error 7 - Upper Calibration Voltage Error

If you are still having difficulties, contact our customer service department for guidance.

SoundTraxx Service Department
210 Rock Point Drive
Durango, CO 81301
Telephone (970) 259-0690
Fax (970) 259-0691
Email: support@soundtraxx.com

Appendix A

Decimal-Hex-Binary Conversion Table

DECIMAL	HEX	BINARY (76543210)	DECIMAL	HEX	BINARY (76543210)	DECIMAL	HEX	BINARY (76543210)	DECIMAL	HEX	BINARY (76543210)
0	00	00000000	64	40	01000000	128	80	10000000	192	C0	11000000
1	01	00000001	65	41	01000001	129	81	10000001	193	C1	11000001
2	02	00000010	66	42	01000010	130	82	10000010	194	C2	11000010
3	03	00000011	67	43	01000011	131	83	10000011	195	C3	11000011
4	04	00000100	68	44	01000100	132	84	10000100	196	C4	11000100
5	05	00000101	69	45	01000101	133	85	10000101	197	C5	11000101
6	06	00000110	70	46	01000110	134	86	10000110	198	C6	11000110
7	07	00000111	71	47	01000111	135	87	10000111	199	C7	11000111
8	08	00001000	72	48	01001000	136	88	10001000	200	C8	11001000
9	09	00001001	73	49	01001001	137	89	10001001	201	C9	11001001
10	0A	00001010	74	4A	01001010	138	8A	10001010	202	CA	11001010
11	0B	00001011	75	4B	01001011	139	8B	10001011	203	CB	11001011
12	0C	00001100	76	4C	01001100	140	8C	10001100	204	CC	11001100
13	0D	00001101	77	4D	01001101	141	8D	10001101	205	CD	11001101
14	0E	00001110	78	4E	01001110	142	8E	10001110	206	CE	11001110
15	0F	00001111	79	4F	01001111	143	8F	10001111	207	CF	11001111
16	10	00010000	80	50	01010000	144	90	10010000	208	D0	11010000
17	11	00010001	81	51	01010001	145	91	10010001	209	D1	11010001
18	12	00010010	82	52	01010010	146	92	10010010	210	D2	11010010
19	13	00010011	83	53	01010011	147	93	10010011	211	D3	11010011
20	14	00010100	84	54	01010100	148	94	10010100	212	D4	11010100
21	15	00010101	85	55	01010101	149	95	10010101	213	D5	11010101
22	16	00010110	86	56	01010110	150	96	10010110	214	D6	11010110
23	17	00010111	87	57	01010111	151	97	10010111	215	D7	11010111
24	18	00011000	88	58	01011000	152	98	10011000	216	D8	11011000
25	19	00011001	89	59	01011001	153	99	10011001	217	D9	11011001
26	1A	00011010	90	5A	01011010	154	9A	10011010	218	DA	11011010
27	1B	00011011	91	5B	01011011	155	9B	10011011	219	DB	11011011
28	1C	00011100	92	5C	01011100	156	9C	10011100	220	DC	11011100
29	1D	00011101	93	5D	01011101	157	9D	10011101	221	DD	11011101
30	1E	00011110	94	5E	01011110	158	9E	10011110	222	DE	11011110
31	1F	00011111	95	5F	01011111	159	9F	10011111	223	DF	11011111
32	20	00100000	96	60	01100000	160	A0	10100000	224	E0	11100000
33	21	00100001	97	61	01100001	161	A1	10100001	225	E1	11100001
34	22	00100010	98	62	01100010	162	A2	10100010	226	E2	11100010
35	23	00100011	99	63	01100011	163	A3	10100011	227	E3	11100011
36	24	00100100	100	64	01100100	164	A4	10100100	228	E4	11100100
37	25	00100101	101	65	01100101	165	A5	10100101	229	E5	11100101
38	26	00100110	102	66	01100110	166	A6	10100110	230	E6	11100110
39	27	00100111	103	67	01100111	167	A7	10100111	231	E7	11100111
40	28	00101000	104	68	01101000	168	A8	10101000	232	E8	11101000
41	29	00101001	105	69	01101001	169	A9	10101001	233	E9	11101001
42	2A	00101010	106	6A	01101010	170	AA	10101010	234	EA	11101010
43	2B	00101011	107	6B	01101011	171	AB	10101011	235	EB	11101011
44	2C	00101100	108	6C	01101100	172	AC	10101100	236	EC	11101100
45	2D	00101101	109	6D	01101101	173	AD	10101101	237	ED	11101101
46	2E	00101110	110	6E	01101110	174	AE	10101110	238	EE	11101110
47	2F	00101111	111	6F	01101111	175	AF	10101111	239	EF	11101111
48	30	00110000	112	70	01110000	176	B0	10110000	240	F0	11110000
49	31	00110001	113	71	01110001	177	B1	10110001	241	F1	11110001
50	32	00110010	114	72	01110010	178	B2	10110010	242	F2	11110010
51	33	00110011	115	73	01110011	179	B3	10110011	243	F3	11110011
52	34	00110100	116	74	01110100	180	B4	10110100	244	F4	11110100
53	35	00110101	117	75	01110101	181	B5	10110101	245	F5	11110101
54	36	00110110	118	76	01110110	182	B6	10110110	246	F6	11110110
55	37	00110111	119	77	01110111	183	B7	10110111	247	F7	11110111
56	38	00111000	120	78	01111000	184	B8	10111000	248	F8	11111000
57	39	00111001	121	79	01111001	185	B9	10111001	249	F9	11111001
58	3A	00111010	122	7A	01111010	186	BA	10111010	250	FA	11111010
59	3B	00111011	123	7B	01111011	187	BB	10111011	251	FB	11111011
60	3C	00111100	124	7C	01111100	188	BC	10111100	252	FC	11111100
61	3D	00111101	125	7D	01111101	189	BD	10111101	253	FD	11111101
62	3E	00111110	126	7E	01111110	190	BE	10111110	254	FE	11111110
63	3F	00111111	127	7F	01111111	191	BF	10111111	255	FF	11111111

Appendix B

List of Configuration Variables (CVs)

The following is a quick reference list of CVs used by Tsunami. See the Tsunami Technical Reference for detailed information about their uses.

CV 1	Primary Address Control	CV 137	Coupler Volume
CV 2	Vstart	CV 138	Reserved
CV 3	Baseline Acceleration Rate	CV 139	Brake Squeal Volume
CV 4	Baseline Braking Rate	CV 140	Brake Release Volume
CV 7	Manufacturer Version ID (Read Only)	CV 141	Snifter Valve Volume
CV 8	Manufacturer ID	CV 142	Johnson Bar/Power Reverse Volume
CV 10	BEMF Cutout	CV 143	Pop Valve Volume
CV 11	Packet Time Out Value	CV 145	Blower Draft Volume
CV 12	Power Source Conversion	CV 146	Water Stop Volume
CV 13	Analog Function Enable 1	CV 147	Injector Volume
CV 14	Analog Function Enable 2	CV 148	Fireman Fred's Shovel Volume
CV 15	CV Unlock Register	CV 149	Fireman Fred's Wrench Volume
CV 16	CV Lock ID Code	CV 150	Fireman Fred's Oil Can Volume
CV 17,18	Extended Address	CV 151	Fireman Fred's Grease Gun Volume
CV 19	Consist Address	CV 153	Equalizer Control
CV 21	Consist Function Group 1	CV 154	62 Hz Equalizer Cut/Boost
CV 22	Consist Function Group 2	CV 155	125 Hz Equalizer Cut/Boost
CV 23	Consist Acceleration Rate	CV 156	250 Hz Equalizer Cut/Boost
CV 24	Consist Braking Rate	CV 157	500 Hz Equalizer Cut/Boost
CV 25	Speed Table Select Register	CV 158	1K Hz Equalizer Cut/Boost
CV 29	Configuration Register 1	CV 159	2K Hz Equalizer Cut/Boost
CV 30	Error Information/Alternate Mode Selection	CV 160	4K Hz Equalizer Cut/Boost
		CV 161	Reverb Control
CV 33	FL(f) Output Location	CV 162	Reverb Output Level
CV 34	FL(r) Output Location	CV 163	Reverb Delay
CV 35	F1 Output Location	CV 164	Reverb Gain
CV 36	F2 Output Location	CV 169	Whistle Reverb Effect Send Level
CV 37	F3 Output Location	CV 170	Bell Reverb Effect Send Level
CV 38	F4 Output Location	CV 171	Exhaust Reverb Effect Send Level
CV 39	F5 Output Location	CV 172	Air Pump Reverb Effect Send Level
CV 40	F6 Output Location	CV 173	Reserved
CV 41	F7 Output Location	CV 174	Reserved
CV 42	F8 Output Location	CV 175	Reserved
CV 43	F9 Output Location	CV 176	Reserved
CV 44	F10 Output Location	CV 177	DDE Throttle Gain
CV 45	F11 Output Location	CV 178	DDE Motor Load Gain
CV 46	F12 Output Location	CV 179	DDE Attack Time Constant
CV 47	Analog Whistle Control	CV 180	DDE Release Time Constant
CV 49-52	Hyperlight Effect Select (for FL(f), FL(r), Function 5, 6)	CV 181	Exhaust Low Volume Limit
		CV 182	Exhaust High Volume Limit
CV 59	Flash Rate	CV 183	Side Rod Clank Low Volume Limit
CV 60	Crossing Hold Time	CV 184	Side Rod Clank High Volume Limit
CV 61	F11 Braking Rate	CV 185	DDE Filter Initial Frequency
CV 62	Transponding Control	CV 186	DDE Filter Control Gain
CV 63	Analog Mode Motor Start Voltage	CV 187	DDE Filter Initial Frequency
CV 64	Analog Mode Max Motor Voltage	CV 188	DDE Tracking Coefficient
CV 66	Forward Trim	CV 193	Automatic Bell-On Set Point
CV 67-94	Loadable Speed Table	CV 194	Automatic Bell-Off Set Point
CV 95	Reverse Trim	CV 195	Grade Crossing Whistle Sensitivity
CV 105	User Identifier #1	CV 196	Brake Squeal Sensitivity
CV 106	User Identifier #2	CV 197	Analog Mode Automatic Sound Configuration
CV 112	Sound Configuration 1	CV 198	Digital Mode Automatic Sound Configuration
CV 113	Quiet Mode Timeout Period	CV 201	Event Probability: Fireman Fred Shovels Coal
CV 114	Bell Ring Rate	CV 202	Event Probability: Fireman Fred Fills the Tender
CV 115	Whistle Select	CV 203	Event Probability: Fireman Fred Turns His Wrench
CV 116	Engine Exhaust Control	CV 204	Event Probability: Fireman Fred Uses His Grease Gun
CV 119	Effect Processor Select	CV 205	Event Probability: Fireman Fred Uses His Oil Can
CV 128	Master Volume Control	CV 206	Event Probability: Fireman Fred Uses the Injectors
CV 129	Whistle Volume	CV 207	Event Probability: Fireman Fred Uses the Firebox Blower
CV 130	Bell Volume	CV 208	Event Probability: Pop Valve Blow Off
CV 131	Exhaust Volume	CV 209	Kp Coefficient
CV 132	Air Pump Volume	CV 210	Ki Coefficient
CV 133	Dynamo Volume	CV 212	Motor Control Intensity
CV 134	Blower Volume	CV 213	Motor Control Sample Period
CV 135	Rod Clank Volume	CV 214	Motor Control Sample Aperture Time
CV 136	Steam Release Volume		

Appendix C

License Agreement

License Agreement
Please read carefully this license agreement before opening the package which contains the Tsunami Sound Decoder. Breaking the seal on the package indicates your acceptance of these license terms. If you have received the Tsunami Sound Decoder pre-installed from your Dealer, then use of the product indicates your acceptance of the agreement. If you do not agree with the terms, you should return the package unopened to the dealer from whom you received the package within thirty (30) days and your money will be refunded.

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