RC4 Wireless Dimming
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FlexTX 2.x

with FD Motion, and MICRO Receivers

RC4 System User Manual

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For 2.4GHz Systems

Soundsculpture - ***Solid State of the Arts.*™**
Soundsculpture Incorporated / RC4 Wireless Dimming & Motion
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RC4-RX4-Series receiver/dimmers are capable of controlling very large currents at up to 30VDC (typically 12V or 24V). RC4 non-metallic cases, used because they are transparent to radio signals, meet UL flame retardant requirements. Nonetheless, dimmers should not be allowed to operate at dangerous temperatures. Appropriately sized wire and connectors must be used, along with suitable ventilation and external fuses rated for the load being operated. Additional information is provided in this manual.

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RC4 FlexTX System Overview

The RC4 wireless dimmer system is an enhanced 4th-generation digital system for operating theatrical lighting, motors, solenoids, and more. It offers improved performance over previous RC-Series systems, with more channels and a user interface that allows receivers to be configured remotely from the transmitter. **Spread-spectrum RF technology** ensures a secure, robust, and high-speed wireless link between all system components, and does not require special licensing for use anywhere in North America and specific locations around the world.

The **FlexTX rack mount transmitter** is a digital DMX device, compliant with the USITT DMX512/1990 (4uSec) standard. Twelve 0-10V control voltage inputs are also provided: eight are linear inputs with 256-step resolution, the remaining four are switch inputs. Any DMX or CV input can be patched to any of up to 128 wireless control channels (referred to in this manual and on the transmitter display as "rf channels"). The user may select the total number of rf channels available, from 4 to 128 in increments of 4; the default is 64 channels.

Up to 128 RX4 receiver/dimmers (STANDARD, MINI, HO, or FD) can be configured and managed from the transmitter, and each provides **2 or 4 individually addressable dimmers built in**. Using the **Reference Voltage Dimming** feature, 12V lamps and other loads can be safely powered using batteries of a higher voltage. For example, 14.4V and 18V NiCad and NiMH batteries are readily available for portable power tools. Dimmers can be configured for **linear** dimmer output, **inverse-square-law** output (ideal for LEDs), or **switch mode**. The **Digital Persistence** feature is particularly useful with LEDs, smoothing their response for a very pleasing effect that mimics the fluid appearance of incandescent lamp dimming.

RX4-STANDARD receivers provide four pulse-width-modulated (PWM) dimmer outputs, each capable of delivering 150W into any resistive or inductive load (typically halogen lamps). Each dimmer can be individually assigned to any RC4 wireless control channel. Outputs assigned to the same channel can be externally wired in parallel to drive large loads. The total power handling of the RX4-STANDARD is limited to 500W.

RX4-HO high-output receivers are similar to standard receivers but have a higher power capacity thorough heavier copper on the printed-circuit board, a cooling fan, and larger MOSFET components (the power transistors that do the work). Each HO dimmer can deliver 250 watts, with a maximum power limit for the entire receiver of 1000W.

For tight spaces, the **RX4-RX2-MICRO** (with 2 dimmers) and **RX4-RX4-MICRO** (with 4 dimmers) are remarkably small. Ideal for tiny props or hiding in costumes, MICRO receivers can deliver up to 100 watts per channel, with a maximum total power limit of 200W per unit.

With the release of the **FlexTX 2.x** comes the **RX4-FD** Functional Diversity receiver with **built-in MSS Motion Safety System detector**. In **Dimmer Mode**, this receiver emulates a 4-channel standard dimmer. In **Motor Mode**, outputs 3 and 4 become bi-directional centre-off motor drivers. A connected motor will run forward at increasing speed for levels from 129 up to 255. The motor will run backwards at increasing speed for levels from 127 down to 0. In **Differential Mode**, two control channels are used for drive and steer. The FD receiver processes control information and powers two motors (one on each side of a vehicle) to drive and steer as intuitively expected. In **Servo Mode**, Output 4 becomes part of a sophisticated closed-loop PV (proportional/velocity) servo system. A rotary encoder provides position and velocity information. The motor can then be moved to specific absolute positions with single (8-bit) or double (16-bit) control channel precision (DMX or CV). Servo mode is ideal for rotary or linear position control, including rack-and-pinion steering position on a remote-control vehicle.

Getting Started – Setting Up RC4 Components

Items You Do NOT Need to Get Started

RC4 systems may ship with an RF Configuration kit consisting of a 12VDC power adaptor and a 25-pin D-Sub data adaptor cable. Put these items in a safe place where they can be found in the future. More information about these items can be found in the *Radio Settings* and *Updating RC4 Firmware* sections of this manual. If you have not received these items, don't worry – they are readily available if you need them in the future.

Parts of the RC4 System

The RC4 system consists of a rack-mount transmitter, transmitter transceiver, and one or more receiver/dimmers. Before the system can be used, each item must be properly set up and connected.

Transmitter

The FlexTX transmitter is a 4-inch deep 3U rack chassis. Control signals are sent to a remote spread-spectrum radio transceiver via a supplied 25-pin D-Sub cable, and this transceiver communicates with radio-dimmers on stage. The 25-pin cable carries both power and data to the transceiver. Connect the rack chassis to the transceiver with this cable, and position the transceiver so the top surface is facing towards the receiver/dimmers (usually towards the stage).

> *The transceiver antenna is under the top surface of the case, as indicated on the transceiver label. No AC adaptor is required to power the transceiver – it is powered by the D-Sub data cable.*

The spread-spectrum radios of the RC4 system will work through walls and other barriers to a distance of several hundred feet. This range will be reduced, however, by the density of obstructions, other radio activity in the same frequency band, and wide-band interference generated by nearby lamps, motors, etc. (including loads connected to RC4 receivers themselves). Line-of-sight from the transmitter transceiver to each RX4 receiver is great where possible, but is not essential.

> *The FlexTX includes a World-Voltage switching power supply that will operate safely with input voltage from 85VAC to 265VAC, 47 to 440Hz.*

The transceiver shown here is grey. Production units are usually black.

Connect a DMX source to the DMX input on the transmitter. The FlexTX DMX input is not terminated. A terminated cable or in-line termination connector must be used if termination is required (i.e. the transmitter is at the end of the DMX line). In general, a 120-ohm resistor between pins 2 and 3 of a DMX connector will provide adequate termination.

Analog 0-10V control voltage (CV) inputs are also provided. These inputs are indicated on the LCD as CV1 to CV12 with levels displayed similarly to DMX levels. The input impedance of the analog CV inputs is 20K-ohms. It is best to drive these inputs with a low-impedance source. DMX and CV inputs can be mapped to dimmers in any combination and used simultaneously.

Receiver/Dimmers

STANDARD HO FD (Functional Diversity)

Each receiver/dimmer must be set up with a charged battery and up to 4 lamps or other loads. For most applications, all of this can be done with a single 10-pin connector, or, on the MICRO receivers, a series of screw terminals. Please review the Receiver Operation section of this manual for pin-out details and other information. The most popular batteries are 12V, but any battery from 6V to 18V may be used.

Output channel assignments are configured from the transmitter.

Radio and dimmer control electronics will not operate properly with less than 5V of incoming power. This minimum voltage must be maintained under load. Choose appropriately sized batteries and keep them charged.

Receiver electronics may be damaged by over-voltage. Observe the voltage limits indicated on the face of each receiver unit. DO NOT EXCEED THE MARKED VOLTAGE.

FlexTX Transmitter Operation

The FlexTX Transmitter User Interface – Overview

All RC4-TXD-Series user-interfaces consist of a 16-key keypad, a 20-character x 2-line LCD display, and a rotary control. The rotary control can also be pressed as a button that clears the currently selected value to zero, or in the case of a menu list, selects the first list item).

Twelve of the keypad keys are used to select a function or function-group:

- The green keys invoke transmitter DMX channel assignment settings.
- The yellow keys invoke receiver settings.
- The blue keys are test functions.

The bottom 4 keys include **Exit** to escape any previously invoked function, generic user-interface functions **Left/-/No** and **Right/+/Yes**, and the **Select / Enter** key.

In most cases, the **Left/-/No** and **Right/+/Yes** increment and decrement the value currently displayed on the screen, much as the rotary control does. The increment/decrement amount will vary with the parameter being edited.

The value of the currently displayed or selected parameter is adjusted by turning the rotary control. In some cases, the new displayed settings are saved by pressing the **Enter** button on the keypad. In other cases, as when adjusting RX receiver parameters before sending them to a receiver, values will remain as displayed while you navigate through channel and parameter screens.

In some modes, as when editing a DMX/CV Assignment, the **Left/-/No** and **Right/+/Yes** keys increment or decrement a specific value on the screen, regardless of the cursor position. This is most often the case when there are only two parameters on screen – one adjusted with the rotary control and the other with the **Left/-/No** and **Right/+/Yes** buttons.

The rotary control provides adaptive response, which can at first be confusing. When turning the control slowly, step by step, it will increment and decrement displayed values by one count per step. When turning the control faster or for longer periods, the size of the increment or decrement will be greater. Also, when editing a value with a wider range, the size of the larger steps will be greater. This makes it easier to spin through, for example, the large Servo Mode Encoder Range from 0 to 32,767.

To escape any mode and return to the main *Watch Channels* screen, press **EXIT**.

TXD-Series Keypad Map

Set DMX Start Channel & Number of Channels	Edit Individual DMX and CV Channel Assignments	Save DMX Setup	Recall DMX Setup
Select Receiver RX Number / Get RX Status	Select RX Channel	Select RX Parameter (for Current Channel)	Send RX Config
Copy RX Setup to Scratchpad	Paste RX Setup from Scratchpad	Manual Channel Test & Channel Chase Enables	Auto-Chase Channel Test
Exit / Watch Channels	Move Left / Decrement / No	Move Right / Increment / Yes	Select/ **ENTER**

The Main Screen – Watch Channels

The FlexTX transmitter powers up to the *Watch Channels* screen. Using settings recalled from memory, the system immediately begins "spooling" the selected DMX and CV channels to the radio link. When RC4-RX4 receiver/dimmers see data with the correct system ID and channel, they respond as programmed.

In *Watch Channels* mode, the transmitter display indicates the number of wireless control channels currently configured (up to 128), and the real-time value of a selected DMX or CV input. The rotary control rolls through 512 DMX channels and 12 CV channels – a total of 524 possible settings. If the displayed channel is assigned to a radio channel, the assignment is displayed. To get to a distant numeric value more quickly, turn the rotary control more quickly for adaptive response.

> ***The Watch Channels screen lets you monitor any DMX channel in the connected DMX universe, not just those assigned to wireless control channels. This makes it useful as a general DMX data tester.***

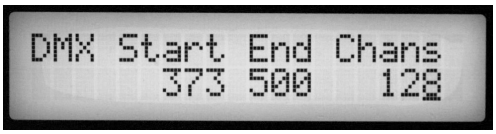
Set DMX Start and Number of Channels (Contiguous Block of Channels)

The quickest and easiest way to assign DMX channels to radio dimmers is to use a contiguous block of DMX channels. In this case, only the first channel and the total number of channels need be specified. CV inputs cannot be assigned this way, but can be added by editing individual assignments afterward (more information below).

Press **Set DMX Start.** The LCD screen will indicate the DMX start and end addresses, and the total number of channels being assigned for wireless use. The *Start* channel and total number of *Chans* can be set. The *End* channel is calculated and displayed the system.

You can exit this screen without making changes by pressing the Exit button.

Use the **Left/-/No** and **Right/+/Yes** keys to move the cursor between Start and Chans. Set the value of the selected parameter with the rotary control.



When the desired values are indicated, press the **Enter** key.

This action overwrites the current DMX channel assignments.
It does not affect saved DMX Setups.

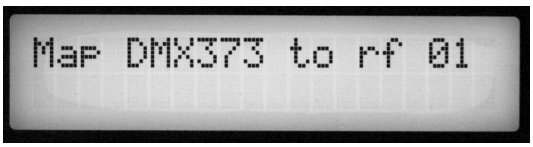
The screen will display a series of confirmations as the radio transceiver module is reconfigured, concluding with a confirmation of the selected settings.

Finally, the screen returns to the Watch Channels screen.

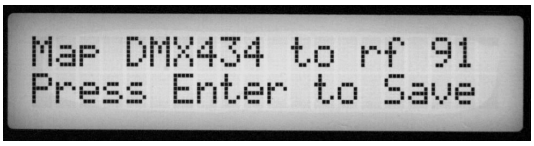
When setting high start addresses the channel assignments may wrap around from DMX512 to DMX001. In this case, CV channels are not included in the wrap around. CV channels cannot be assigned in this mode, they must be assigned using the **Edit DMX/CV Assigns** function (more info below).

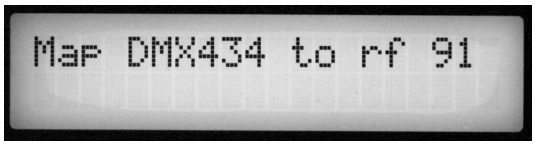
Edit Individual DMX and CV Channel Assignments

To create a more sophisticated channel map where assignments are not contiguous and CV inputs are also available, press the **Edit DMX/CV Assigns** key. The screen will display the current assignment for the first wireless control (rf) channel.

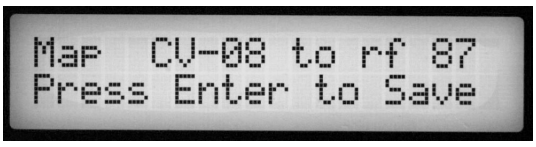


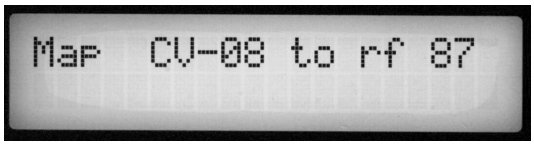
In this mode, the rotary control sets the DMX / CV source, while the **Left/-/No** and **Right/+/Yes** keys select the target wireless control (rf) channel. When a desired combination is displayed, press the **Enter** button to save the new assignment. Only one source can be assigned to each target rf channel.



…


Similar to *Watch Channels* mode, the rotary control will scroll through CV inputs above DMX 512 and below DMX 1. This makes it easy to assign any of the 12 available CV inputs to any rf dimmer channel, with the rotary control providing access to 524 sources (512 DMX channels and 12 CV channels).



…


Use* Set DMX Start *to create a map that is close to what you need. Then use* Edit DMX/CVAssigns *to add CV channels and adjust your channel assignments.

Save DMX Setup

Note: Current channel assignments are maintained even if you don't save them in a DMX Setup. Save and Recall of DMX Setups is provided to facilitate switching between different channel maps you may need for different shows, theatres, etc.

Three DMX/CV channel assignments can be saved. Each set of assignments is called *a DMX Setup*, even though they may also include CV inputs.

To save the current assignments you have created using the **Set DMX Start** and/or **Edit DMX/CV Assigns** functions, press **Save DMX Setup**. Use the rotary control to select the destination memory location 1-3, then press the **Enter** key to execute the save.

…

Upon execution, any previously stored settings in the selected memory location are overwritten.

When the save is complete, you are returned to *Watch Channels* mode.

Recall DMX Setup

Note: Current channel assignments are maintained even if you don't save them in a DMX Setup. Save and Recall of DMX setups is provided to facilitate switching between different channel maps you may need for different shows, theatres, etc.

To recall an assignment map for current use, press **Recall DMX Setup**. Use the rotary control to select the source memory location 1-3. Press the **Enter** key to execute the recall.

Upon execution, previous settings are overwritten with the settings from memory.

Transmitter Channel Test Functions

It is often desirable to test dimmers at times when DMX data is not available. The FlexTX transmitter provides two very useful options to accomplish this.

DMX and CV inputs are not interrupted when test modes are invoked. Only the channel currently being tested is overridden. Test modes could, therefore, be used intentionally during a running show, in combination with the DMX and CV inputs.

It is important to be aware of any incoming DMX or CV data that may appear on live dimmers, even when a test mode is being used.

Manual Channel Test

Invoked by pressing the **Manual Channel Test** button, this mode allows a radio dimmer channel to be manually faded up and down. The channel is selected using the **Left/-/No** and **Right/+/Yes** keys. The level is adjusted in real-time with the rotary control. In addition, three levels of control resolution are provided: **c**oarse (25-step increments), **m**edium (5-step increments), and **f**ine (1-step increments). Pressing the rotary control button cycles through these three options.

The Manual Channel Test screen indicates the control resolution (c, m, or f), current level (0 – 255), current wireless control (rf) channel and corresponding DMX or CV input channel, and whether or not this channel will chase (Yes or No) in the Channel Chase Test (more information below).

The Chase parameter is used by the Channel Chase Test function (described below). Toggle between **Yes** and **No** for the currently displayed rf channel by pressing the **Select/Enter** key.

Escape test mode by pressing the **Exit** key.

Channel Chase Test

FlexTX transmitters also feature a built-in chaser, ideal for testing a series of RC4 dimmer channels automatically and continuously. The chase process smoothly fades up and down from zero to 255 and back to zero, stepping through channels with the Chase parameter enabled from Manual Channel Test mode.

The speed of the chase is set with the rotary control. At the slowest speed, each channel fade is clearly visible and takes 3 to 4 seconds. At the fastest speed, channel stepping occurs at approximately 4 channels per second.

Select which channels will be part of the chase by pressing the **Manual Channel Test** key and making changes there. You can then return to the chase by pressing **Channel Chase Test**. It is not necessary to press **Exit** between these modes.

Escape test mode by pressing the **Exit** key.

***Warning: Test functions may cause undesirable results with RX4-FD Motor Control outputs. Be aware that test levels may cause motors to turn, servo systems to relocate, etc. It is recommended that motor control channels not be used with Channel Chase Test – set their Chase setting to* No.**

RX4 Dimmer Settings (Done at Transmitter)

Each RX2 and RX4 radio-dimmer watches for two different kinds of data packets coming from the transmitter:
- dimmer levels
- control/setup information

In either case, a system ID number is also sent. If a receiver detects a packet with a different system ID than its own, it will ignore it. This ensures that other RC4 transmitters will not control your receivers.

Channel assignments and other settings for each radio dimmer are made at the transmitter, then uploaded to the corresponding receiver by using the **Send RX Config** function. To facilitate this, each receiver has its own RX number.

Dimmer configurations are stored only in the target receiver, not in the transmitter. Thus, editing the configuration of a receiver requires that receiver to be powered up and "Active".

The FlexTX 2.x transmitter provides a host of new setup features not available with previous RC4 systems. For each individual dimmer within a receiver, the following selections are available:

- **Channel** number
- **Dimmer Curve**: linear, inverse-square-law, or switch mode
- **Low Level Cut-Off**: levels below this setting are reduced to zero
- **Voltage Reference Dimming**: sets the maximum average output voltage from 0.1V to 24V, or Vin (no change)
- **Digital Persistence (Smoothing)**: inserts a high resolution vector fade between the last dimmer value and the next one, reducing visible stair-stepping when using very fast light sources (particularly LEDs)

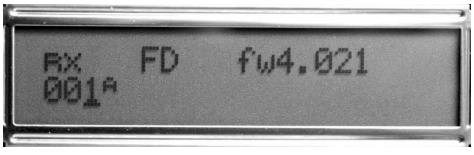
For FD receivers, many additional parameters are also available. For ease of access, an alternative user-interface is provided for FD modes other than Dimmer mode. Additional information is provided in **Configuring FD Motor Control Parameters**.

Select Receiver RX Number / Display Receiver Status (Battery Voltage)

Receivers are identified by their RX number, ranging from RX001 through RX128.

To select a receiver/dimmer for configuration, press **Select RX**. The block cursor will blink over the RX number on the transmitter LCD. Use the rotary control or the **Left/-/No** and **Right/+/Yes** buttons to set the RX number.

You will notice a short delay as the unit changes RX numbers. This is because the transmitter is sending query data, looking for live receivers. When it finds one, a small "A" is displayed beside the RX number to indicate the presence of an **A**ctive receiver, and the receiver type and firmware version are displayed on the top line of the LCD:



For any **A**ctive receiver, at any time, you can press and hold the **Select RX** button to display additional status information. This information may include battery voltage, temperature and current draw, depending on what is supported by the connected receiver. If no Active receiver is found, the message "NOT FOUND" is displayed.

or


Press **Exit** to return to *Watch Channels* mode.

> ***NOTE: Some receivers may contain customized firmware for special applications. A specific RXnum is required to activate these custom processes. For example, a custom fog controller might be activated by using RX128. Customized receivers usually default to their special functions if defaults are loaded using the receiver's recessed buttons. Refer to the documentation supplied with your customized receiver for additional information about your specific unit.***

RX Configuration – User Interface

RC4 receivers have various internal parameters which are configured remotely from the RC4 transmitter. Thus, the transmitter LCD, keypad, and rotary control are the remote User Interface for RC4 devices that might otherwise be difficult to access inside set pieces, trucks, props, etc.

The receiver you are configuring must be powered on, **A**ctive and working (i.e. connected to a charged battery in good condition).

On the RC4 transmitter, select the RX number of the receiver you want to configure using the **Select RX** function. The current configuration of the selected receiver will transfer by radio to the transmitter, ready for editing.

Parameters are grouped by channel. Cycle through channels by pressing **Select RX Chan** (on upgraded older transmitters, this button is labelled **Assign RX Chans**). Each press of the button increments to the next channel; after channel 4 you are returned to channel 1.

For each channel, step through all available parameters by pressing **Select RX Param** (or, on upgraded transmitters, **Set RX Params**). Each press of this button moves the cursor to the next parameter on screen.

The rotary control or **Left/-/No** and **Right/+/Yes** buttons will adjust the value of the parameter currently indicated by the blinking cursor. Clear the current parameter to zero by pressing the rotary button.

For RX4-STANDARD, HO, and MINI receivers, as well RX4-FD receivers in Dimmer Mode, all parameters for each channel are displayed on the screen at once. The top line of the display indicates the current RX (receiver) number, dimmer (output) channel, control channel (dmx or cv), low level limit, and smoothing. The bottom line indicated the receiver type (and mode, if applicable), dimming curve, and Voltage Reference Dimming (VRD) level.

In this example:
- RX001 is Active
- settings for dimmer 1 (d1) are shown
- the control channel is DMX channel 1 (dx001 – the cursor is blinking over the 1)
- Low Level limit is off (L00)
- Smoothing is off (s00)
- Voltage Reference Dimming is disabled (Vin)
- the dimming curve is Linear (/Lin), and
- the receiver is FD type in Dimmer mode (FDdim)

Set RX Channel Assignments

An RC4-RX2 receiver-dimmer has 2 physical outputs; an RC4-RX4 has 4 outputs. In both cases, the FlexTX transmitter allows 4 dimmers to be configured. ***On RX2 units, settings for dimmers 3 and 4 are saved and recalled, but are otherwise ignored.***

Dimmer outputs can be assigned to any DMX or CV control channel that is currently mapped to an rf channel. Even if you never adjust any other parameter, you will probably need to assign control channels.

Select the appropriate output dimmer channel by repeatedly pressing **Select RX Chans**. The currently selected dimmer is indicated on the top line of the display, immediately to the right of the RX number, as d1, d2, d3, or d4. (Remember that D3 and D4 will have no effect when editing channels for an RX2 unit.)

Select the channel assignment by repeatedly pressing **Select RX Param** until the blinking cursor is over the channel assignment immediately to the right of the dimmer number. Change the channel assignment by turning the rotary control or pressing the **Left/-/No** and **Right/+/Yes** keys. DMX channels are indicated with a small vertical dx symbol; control-voltage channels are indicated with a small vertical cv symbol.

> **To change which DMX and CV channels are available, review the previous sections *Set DMX Start and Number of Channels*, and *Edit Individual DMX and CV Channel Assignments*. It is those channels that are available for controlling remote dimmers.**

Set Other RX Parameters

In addition to control channel assignment, dimmer outputs have several other parameters, as outlined below. For simple applications of wireless dimming, the default settings for these parameters are probably adequate (perhaps even ideal). But if you are using very large lamps and/or motors, alternative types of batteries at various voltages, or LEDs, these additional parameters are very powerful and substantially enhance the performance of the RC4 system. At the time of this writing, no other wireless dimming system provides functionality even remotely comparable.

Parameters are selected by pressing **Set RX Params**, moving the cursor from value to value on screen. The value under the cursor can be edited by turning the rotary control or pressing the **Left/-/No** and **Right/+/Yes** keys.

Dimming Curve

When the cursor is blinking over a **dimmer curve** symbol, the curve can be changed by turning the rotary control or pressing the **Left/-/No** and **Right/+/Yes** keys. The options are linear dimming (indicated with a straight slant symbol), inverse square law dimming (indicated with a curved slant symbol), and switch mode (indicated with a stair step symbol.

Incoming dimmer data is mathematically converted from the 256-step DMX resolution to the much higher RX4 internal dimmer resolution in real-time. When enabled, this conversion also includes calculations for Voltage Reference Dimming and Digital Persistence smoothing (additional information below).

In some cases, dimmed power levels are not desirable. When turning on a relay or powering a DC device that requires clean constant power (like an inverter), a dimmer output can be set for switch mode. In this case, DMX dimmer levels of 127 or lower will turn the output off, while levels of 128 or higher will turn the output on.

> ***Voltage Reference Dimming is not available in Switch Mode. The FULL BATTERY VOLTAGE is output when a switch channel is turned on. Low Level Limit has no effect in this mode.***

Digital Persistence – "Smoothing"

Each RC4 dimmer has a much finer resolution that DMX. While DMX channels are limited to 256 levels, RC4 dimmers provide 16383 levels. This high internal resolution is the core of our very smooth square-law dimming and Digital Persistence smoothing features. In both of these cases, the RC4 dimmer operates at its full resolution: for square law dimming, tiny increments at the bottom of the curve avoid visible stepping; with smoothing, all available steps are used when transitioning from one DMX level to another.

The **Smoothing** parameter on RX4 receivers adjusts the rate of change between levels. There are 32 levels, where 0 is off (no smoothing) and 31 is comparable to the filament lag of a large incandescent lamp.

Low Level Limit

In some cases, large loads draw excessive currents for brief periods when driven at low power levels. This is because PWM applies full power for a short slice of time at the lowest level and longer slices of time as power levels increase. In some cases, particularly with loads that have a very low DC resistance at rest, short spikes at the lowest levels are stressful for the dimmer and create undesirable electrical noise and interference. For example, a large motor will remain stalled, and a large lamp filament will remain cold and unlit, until a significant amount of energy is delivered. In these states, large transient spikes are being generated at the PWM refresh rate, which varies from 60Hz up to 20Khz, depending on the model and revision of RX4 receiver.

The **Low Level Limit** parameter ensures that power levels below a user-selected limit are reduced to zero. For large loads, a recommended Low Level Limit is 15 or higher (the maximum selectable is 31). For small loads a limit of 5 or less can be used. The available range is 0 to 31, and the default is 0.

Voltage Reference Dimming

Voltage Reference Dimming (VRD) allows the use of batteries that provide a higher voltage than required by the load. For example, you can use a 14.4V or 18V NiMH battery with 12V MR16 lamps, a 10V water pump, or 4V LEDs.

In these cases is it very important to understand that the peak-to-peak voltage produced by the pulse-width-modulation (PWM) dimmer is still full battery voltage. Only the range of the pulse-width-modulation dimmer is adjusted with VRD. Thus, if you are using a fully charged 18V battery and have set a Voltage Reference of 9V, the dimmer will deliver an output range from 0 to 50% when receiving control signals of 0 – 100%. The actual range adjusts in realtime, compensating for a diminishing battery, as well as voltage changes caused by the load pulling the voltage down.

VRD may not be suitable for direct connection to some voltage sensitive loads. In some cases, an integrator (power smoother) circuit can be used to convert the choppy pwm signal to a steady DC voltage. In the simplest form, this can be done with a single resistor and capacitor. The resistor should be a low value high-power type. The capacitor will generally be a large capacity low-ESR electrolytic rated for approximately double the source battery voltage. Consult RC4 Wireless for assistance constructing power smoothers.

The default setting disables VRD so the dimmer uses the input battery voltage directly. This is indicated as **Vin** on the display, and is equivalent to a setting of zero. When the cursor is blinking in the Vref area of the display, the rotary control sets the VRD voltage. It increments in steps of approximately 0.2V, from 0V up to 24V. Press the rotary control button to clear the value to **Vin** (VRD disabled).

Data Timeout Period (not user adjustable)

For various reasons, rf dimmer data could be interrupted. When this happens, RC4 dimmer outputs will be maintained at their last known value for a short period while the receiver waits for valid data to reappear. This period is not user adjustable, but can be set at the factory. If good data does not arrive within this period, all dimmer levels are cleared to zero.

In most cases, RX4-STANDARD, HO, and MINI receivers have a timeout period of 2 seconds. RX4-FD motor drive receivers are programmed with a shorter timeout as an additional safety feature.

> ***The RC4 radio link is robust enough that single data packets are seldom lost, never mind the hundreds of packets sent in a 2 second period. Visible effects of radio interference are virtually non-existent with the RC4 system.***

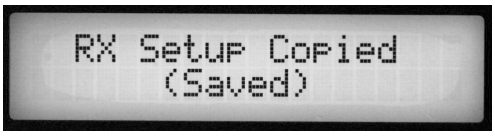
The DMX512/1990 specification published by the United States Institute for Theatre Technology requires DMX devices to have a loss of data tolerance of not less than 1 second. The FlexTX transmitter has a loss of data tolerance of just over 1 second on DMX inputs. There is no correlation between the DMX loss of data timeout, and the RC4 Data Timeout Period. A Faulty DMX link leads to the former; radio interference leads to the latter.

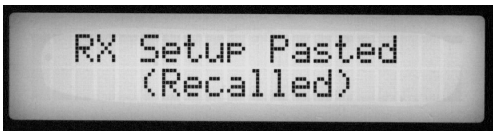
RX Setup Copy / RX Setup Paste

When configuring many receivers, several are often programmed identically or very similarly. To speed the process of setting up and programming these receivers, an RX Setup scratchpad memory is provided.

From any receiver parameter editing screen, current settings can be saved to the scratchpad be pressing **RX Setup Copy**. All parameters are saved, including those not currently displayed.

Similarly, the settings currently in scratchpad memory can be recalled to overwrite the current RX setup by pressing **RX Setup Paste**. All parameters are overwritten, including those not currently displayed.



and


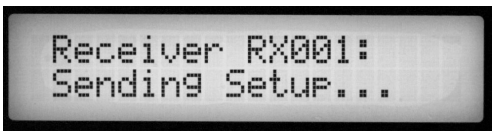
Use the **Select RX** key and rotary control to select source and destination RX numbers for Copy and Paste.

Receivers must be powered and **A**ctive at the time they are accessed by the cut or paste functions, but they do not both need to be active at the same time. For example, you could power RX010, select it, and copy its setup. You could then disconnect it, replacing it with RX005. You can now select RX005 and paste the stored setup to it.

The copied RX setup is stored in non-volatile memory and remains available even after the RC4 transmitter has been turned off and on.

Send RX Config

When the **Send RX Config** key is pressed, all settings for the selected RX number are uploaded by radio to the corresponding receiver/dimmer.



If the corresponding receiver is not available (**A**ctive), the transmitter LCD will report `RX`*xxx* `Not Found`. Otherwise, the confirmation process verifies every parameter sent. If all parameters match, the LCD will report `Setup Confirmed`.

Please be patient – the confirmation process can sometimes take several seconds.

or

A receiver/dimmer will assume a new RX number if it receives a control packet while the **Set RX** recessed button on the receiver itself is held down. In this case, the RX value of that packet will become the new RX number for that receiver. Subsequent control packets for this RX number will be accepted and acknowledged with no need to hold down the Set RX button. (See the Receiver Operation section for additional information.)

> ***In a properly functioning system, it is never necessary to use the Set RX button on a receiver. Every receiver should have its own RX number for the entirety of its service life. The only time the Set RX function should be used is when adding a new receiver to an existing system, or resetting a receiver after default settings have been loaded.***

Configuring FD Motor Control Receivers

FD – Functional Diversity – receivers are far more versatile than STANDARD, HO, or MINI receivers. Designed from the ground up for sophisticated motor control, numerous FD setup parameters are divided amongst various operating modes.

For ease of access, an alternate user-interface display format is provided for FD modes other than 4-channel dimming. FD parameters are accessed in the same manner as standard dimmer parameters: the **Select RX Chan** button cycles through the 4 outputs of the FD receivers, and the **Select RX Param** button cycles through setup parameters available for the selected output.

Rather than displaying multiple parameters on screen at one time, each FD parameter is displayed individually. The descriptive name of the parameter is shown on the top line, and its value displayed on the bottom line.

The first two output channels are referenced as dimmers **d1** and **d2**. The remaining two outputs are referenced as motor drivers **m3** and **m4**.

In this example, an FD receiver RX001 is being configured:
- this FD receiver is currently in differential mode (FDdif)
- output 2 has been selected, dimmer d2
- the parameter currently being edited is the control channel (d2 Channel)
- The current value of this parameter is CV input 7 (cv07)

At all times, the receiver RX number is displayed at the far left of the top line, and the FD receiver mode is displayed at the far left of the bottom line.

RC4-MSS Motion Safety System Support

FD receivers include an RC4-MSS Motion Safety System heartbeat decoder module. This module looks for an MSS heartbeat signal, activating an output only when the heartbeat is within acceptable tolerances. Dimmer output d1 can operate as either an RX4 dimmer output, or an MSS decoder power driver. This selection is made with a small hardware jumper positioned near the power connectors on the top of the FD receiver. The MSS decoder uses the same control channel as RX4 dimmer output 1, appropriately named *d1/mssHB Chan*. If the MSS decoder is being used, a MSS heartbeat must be generated at the transmission end of the RX4 system. This heartbeat can come from:

- a standalone MSS Sender plugged into the transmitter CV input
- an RC4-HH handheld controller, which includes an MSS Sender
- an RC4-Joystick handheld controller, which includes an MSS Sender
- an optional internal heartbeat generator available on some models of RC4 transmitter, or
- a DMX or CV controller, such as a lighting console, programmed to produce an alternating signal that meets MSS heartbeat specifications.

In addition to the heartbeat, MSS decoder devices (particularly including FD receiver with firmware 4.026 or higher) also requires a CV-Centre signal. This is a separate control channel indicating the centre position (stop) for motion control. The Speed-Centre decoder will not allow motor outputs to activate unless the CV-Centre is within a small tolerance of absolute centre. This ensures that motors will not move under the following circumstances:

- A CV source is connected that uses 0V (zero volts) as the idle or off position. in RC4 motor controllers, this voltage is full-speed reverse.
- A center-off CV controller has been disconnected, and the signal has fallen to 0V (zero volts).
- A CV cable has been cut, or other fault has resulted in no signal on the CV input.

In all cases above, the CV-Centre will also fall to 0V (zero volts), disabling motor output. Outputs are also disabled if CV-Centre goes too high, again ensuring that motors will not run if an appropriate centre-off controller is not connected.

The source for the CV-Centre level *must* be the rf control channel immediately above the channel used for the MSS Heartbeat. Control channels are best viewed with the Edit DMX/CV Assigns function.

We recommend setting up the MSS-Joystick controller or other centre-off controller to use the top 4 rf control channels in your system.

Within the MSS-Joystick, a forward/back motion varies the voltage on CV-01. A side-to-side motion varies the voltage on CV-02. The internal MSS Heartbeat Generator produces the HB pulse on CV-12, an on/off switch channel. The CV-Centre signal of approximately 5V is on CV-3.

If you have configured your RC4 Motion system for 64 rf channels, you would use the following assignments with an MSS-Joystick:

Map CV-12 to rf 61 (heartbeat)
Map CV-03 to rf 62 (CV-Centre, *must* be 1 rf channel above heartbeat)
Map CV-01 to rf 63 (speed signal)
Map CV-02 to rf 64 (steer signal)

The complimentary setup of the FD receiver, is:

D1/mssHB Chan = CV12 (which is mapped to rf 61, as noted above)
CV-Centre is automatically mapped to rf 62, one rf control channel higher than the HB)
d2 Channel can be any channel, does not affect motion
Speed Chan = CV01
Steer Chan = CV02

If you have configured your RC4 Motion transmitter for a different number of channels, or you are not mapping MSS-Joystick channels to the top of your channel range, you still* must *be sure that the mapping of the CV-Centre is 1 rf channel above the HB. For example, if you map CV-12 (the HB) to rf 10, then CV-3 (CV-Centre)* must *be mapped to rf 11.

FD Modes

FD receivers have four modes. In all cases, output channels 1 and 2 are identical to the dimmers on RX4-STANDARD receivers. They can drive resistive or inductive loads and support all regular dimmer parameters (channel, curve, low level, voltage reference, smoothing, etc.)

Dimmer mode emulates the RX4-STANDARD dimmer. Output channels 3 and 4 are also identical to the dimmers in RX4-STANDARD receivers. All four channels behave identically. Parameters for Dimmer mode are edited in the same manner as STANDARD, HO, and MINI receiver/dimmers, using the same user interface that displays all settings for a single channel on the same screen.

Motor mode is the simplest enhanced FD mode. Output channels 3 and 4 are bidirectional centre-off motor drives. When the assigned control channel is centered at level 128, the motor driver output is off. Levels above 128 run the motor in the forward direction. Levels below 128 run the motor in the reverse direction. Level 255 is full speed forward; level 0 if full speed reverse. Parameters are available to damp the response of fast control changes, and limit the maximum output power from 0 – 100%.

Differential mode provides an effective way to control an electric vehicle with a two-motor differential drive. The vehicle frame should be built with a drive motor/wheel on each side, such that powering both motors together will drive straight ahead, and varying the power ratio to each motor will steer the vehicle to one side or the other. This is sometimes referred to as a "tank drive". One control channel is used for speed/direction (forward/backward, where center is stop), another for direction (left/right, where center is straight). The ideal physical control is a joystick that rests at centre, like the RC4 MSS-Joystick. Pushing the joystick forward moves the vehicle forward; pulling the joystick back moves the vehicle backward. Moving the joystick left or right while moving will steer the vehicle. As an additional driving feature, moving the joystick left/right while in the centre stopped position will spin the vehicle on centre, increasing speed as the joystick is pushed further to either extreme.

> ***The FD receiver with firmware 4.026 or higher requires a CV-Centre signal to operate motors in Differential Mode. It is also recommended that the MSS Heartbeat be used. See previous page for additional information.***

Servo mode provides a closed-loop motor positioning system. In this mode, Output channel 3 functions identically to Motor mode. Servo functions are provided only for output channel 4. This mode uses the largest number of parameters, allowing system performance to be tailored to a wide variety of applications and target machines.

Control channels (rf channels) set the top speed of the servo system, and the position the servo system should move to (the *target position*). Position and velocity information are derived from a quadrature rotary encoder attached to the mechanical system being driven by motor 4.

A servo positioning system looks at the difference between the present position of a motor (or motor-powered mechanism) and the target position. This difference, referred to as positional "error", is used to control the motor to reduce the difference to zero. When the target position changes, the servo system follows by moving the motor to the new target position. Similarly, if the present position changes due to outside forces, the servo system will attempt to compensate to eliminate positional error.

The RC4-FD servo system uses a combination of two popular servo processes: *Proportional* feedback, and *Velocity* feedback. The result is sometimes called a *PV Servo*. The P (proportional) process provides more power to the motor when the error is larger, and less power as the error diminishes, in the correct polarity to reduce positional error. In other words, *power is applied in* proportion *to the magnitude of the position error*. Thus, the motor will slow down as it approaches the target position. The V (velocity) process is influenced by the target machine's *rate of change*. Velocity compensation reduces overshoot and improves stability as the servo approaches the target position, having the greatest influence if positional error is small but velocity is high. If the motor passes and is now moving away from the target position, the V process compensates much more quickly that the P process: the influence of the P process is small because the machine is close to the target, while the influence of the V process is great because the machine is moving quite quickly in the vicinity of the target.

The damping parameter (also provided in Motor mode and Differential mode), is effectively a low-pass filter, limiting the rate of change for the motor driver. If the motor driver is told, for example, to change from full speed forward to full speed reverse, damping will introduce a smooth vector through zero (stopped) from one state to the other. The higher the damping value, the longer the damping period. This adds an important safety net for the large power level changes that might be called by the Velocity process.

Various parameters for the FD in Servo Mode configure the servo system to operate over the desired speed range, while avoiding overshoot (where the motor passes the target), and hunting (where the motor oscillates back and forth around the target, unable to accurately stop at the target position). The FD system must be "tuned" to the target machine by carefully adjusting these parameters for the best possible performance.

Two limit switch inputs are provided. User programmed encoder positions can be assigned to these switch closures to index the servo system to a physical path or area.

Safe Start

Safe Start is an FD feature that helps prevent unexpected motor movement when the receiver is first powered on or first enters a new mode. Safe Start prevents power output until all input control channels are simultaneously at *zero motion level*. For Motor and Differential mode, zero motion is a data value of 128. In Dimmer mode, zero motion corresponds to data value zero. In Servo mode, output 3 is center zero (128), while the Servo Speed channel is off at data zero.

RC4 standard dimmer configuration does not accommodate enabling/disabling Safe Start. Thus, Safe Start is always enabled for FD receivers in Dimmer mode. In all other FD modes, a parameter is provided to enable/disable the Safe Start feature. It is recommended that Safe Start be ON.

> ***Note:* Safe Start *is NOT provided in STANDARD, HO, or MINI receivers. All outputs will always deliver power immediately to connected loads on these receiver models*.**

FD Motor Control Parameters

When configuring the RX4-FD motor control receiver, available parameters vary with the selected mode. A core set of common parameters are available in all modes, including mode setting, safe start setting, and parameters for dimmer channels d1 and d2.

> ***In some cases it is necessary to change the FD mode and send this configuration to an Active receiver. After confirmation of the new mode, the appropriate parameters will be available for editing.***

Parameters Common to All FD Motion Modes (Motor, Differential, Servo)

FD Mode

Select the required mode: Dimmer, Motor, Differential, or Servo. See previous section for details.

Safe Start

On/Off. See previous section for details. It is recommended that Safe Start be On.

d1/mssHB Chan

Choose from any currently patched rf channel. (Patching of DMX and CV channels is done using transmitter setup functions for **Set DMX Start** and **Edit DMX/CV Assigns**. See earlier section for additional information.)

The same channel assignment is used for dimmer output d1 and the integrated RC4-MSS Motion Safety System decoder. Only one of these sources may control power driver 1, selected with a hardware jumper on the FD receiver near the power connectors.

> ***The FD receiver with firmware 4.026 or higher requires a CV-Centre signal to operate motors in Differential Mode. It is also recommended that the MSS Heartbeat be used.***

d1 Curve

Select Linear, Inverse-Square-Law (isl), or Switch mode. FD dimmers provide 2048 steps for exceptionally smooth isl output. In switch mode, dimmer output will be fully on for control levels above 127, fully off for control levels of 127 or less.

d1 Low Lev Limit

Set from 0 to 31. DMX or CV levels below the selected setting will be reduced to zero.

d1 Smoothing

Set from 0 to 31. Larger values increase the transition time between dimmer levels. Setting 0 (zero) turns smoothing off.

d1 Voltage Ref

Select Vin, or set a VRD (Voltage Reference Dimming) voltage from 0.1V to 24.0V. To be effective, the receiver power source (usually a battery) must be a higher voltage than the selected reference. The output power level will be scaled to provide the selected dimmer curve from zero to the selected voltage. Voltage Reference Dimming is a dynamic process that adjusts for decaying battery charge and voltage reductions caused by the draw of large loads. If the battery voltage is less than the selected VRD voltage, full voltage will be passed by the dimmer; the FD dimmer does not have voltage boost capability.

d2 Channel

Identical to similarly named d1 parameter described above.

d2 Curve

Identical to similarly named d1 parameter described above.

d2 Low Lev Limit

Identical to similarly named d1 parameter described above.

d2 Smoothing

Identical to similarly named d1 parameter described above.

d2 Voltage Ref

Identical to similarly named d1 parameter described above.

Motor Mode Parameters

m3 Channel

Choose from any currently patched rf channel. (Patching of DMX and CV channels is done using transmitter setup functions for **Set DMX Start** and **Edit DMX/CV Assigns**. See earlier section for additional information.)

When the assigned control channel is centered at level 128, the motor driver output is off. Levels above 128 run the motor in the forward direction. Levels below 128 run the motor in the reverse direction. Level 255 if full speed forward; level 0 if full speed reverse.

m3 Damping

Set from 0 to 31. This parameter prevents overly fast level transitions that would strain power drivers and mechanical components. It sets a minimum rate of change. This is particularly valuable in preventing instantaneous changes of direction when the control value changes from a value above 128 to a value below 128, or vice-versa. With a higher damping level in this case, the motor driver will "glide" from one speed and direction, through zero, to the other speed and direction, in a smooth and safe manner. Damping is a form of digital low-pass filter.

m3 Top Speed

Set from 0% to 100%. Note that 0% will result in no movement, and very low levels may not be able to overcome the stall condition. This parameter linearly scales the incoming control level to the programmed range. Unlike VRD for dimmer channels, Top Speed does not scale to battery voltage, it is simply a percentage of available incoming power.

m4 Channel

Identical to similarly named m3 parameter described above.

m4 Damping

Identical to similarly named m3 parameter described above.

m4 Top Speed

Identical to similarly named m3 parameter described above.

Differential Mode Parameters

Differential mode provides an effective way to control an electric vehicle. The vehicle frame should be built with a drive motor/wheel on each side. One RC4 control channel is used for speed/direction (forward/backward), another for direction (left/right). The ideal control is a joystick that rests at centre. Pushing the joystick forward moves the vehicle forward; pulling the joystick back moves the vehicle backward. Moving the joystick left or right steers the vehicle. As an additional driving feature, moving the joystick left/right while in the centre stopped position will spin the vehicle on centre, increasing speed as the joystick is pushed further to either extreme.

Speed Chan

Choose from any currently patched rf channel. (Patching of DMX and CV channels is done using transmitter setup functions for **Set DMX Start** and **Edit DMX/CV Assigns**. See earlier section for additional information.)

Speed Damping

Set from 0 to 31. This parameter prevents overly fast level transitions that would strain power drivers and mechanical components. It sets a minimum rate of change. This is particularly valuable in preventing instantaneous changes of direction when the speed control channel changes from a value above 128 to a value below 128, or vice-versa. With a higher damping level in this case, the motor driver will "glide" from one speed and direction, through zero, to the other speed and direction, in a smooth and safe manner.

A fairly high setting is recommended for smooth vehicle control, particularly if the vehicle is large.

Speed Range

Set from 0% to 100%. Note that 0% will result in no movement, and very low levels may not be able to overcome the stall condition. This parameter linearly scales the incoming control level to the programmed range, affecting overall speed of both motors equally in the differential drive system.

Steer Chan

Choose from any currently patched rf channel. Patching of DMX and CV channels is done using transmitter setup functions for **Set DMX Start** and **Edit DMX/CV Assigns**. See earlier section for additional information.

Steer Damping

Set from 0 to 31. This parameter prevents overly fast level transitions that would strain power drivers and mechanical components. It sets a minimum rate of change for steering.

Less critical than Speed Damping, a moderate to low setting is recommended.

Steer Range

Set from 0% to 100%. Note that 0% will result in no steering. This parameter linearly scales the depth of steering differential between the two drive motors.

Servo Mode Parameters

Servo mode provides a closed-loop motor positioning system. Servo functions are provided only by output channel 4. Output channel 3 functions identically to Motor mode, and is *not* a servo drive. This mode uses the largest number of parameters, allowing system performance to be tailored to a wide variety of applications and target machines.

RC4 control channels set the servo system top speed and target position. Position can be set with a single control channel (8-bit) or double channel (16-bit).

The servo process uses position and velocity information derived from a quadrature rotary encoder. It determines the difference between current position and target position (i.e. positional "error"), as well as velocity of the machine, powering the motor to reduce the error and compensate for external disturbances.

m3 Channel

Identical to m3 parameter of the same name in Motor mode described above.

m3 Damping

Identical to m3 parameter of the same name in Motor mode described above.

m3 Top Speed

Identical to m3 parameter of the same name in Motor mode described above.

m4 Channel (or m4 Start Channel)

Choose from any currently patched rf channel. (Patching of DMX and CV channels is done using transmitter setup functions for **Set DMX Start** and **Edit DMX/CV Assigns**. See earlier section for additional information.)

Servo mode uses either 2 or 3 control channels, depending on the setting for Precision (see below). The first channel controls the speed of servo movement in real time. The remaining single or double channel sets the servo destination position. The *m4 Channel* parameter sets the first channel in a contiguous series of 2 or 3. For example, selecting rf channel 4 will use channels 4 and 5 and possibly 6 (depending on Precision).

> ***Note: rf channels may or may not be patched to contiguous sources – this is done using transmitter setup functions* Set DMX Start *and* Edit DMX/CV Assigns*. For example, rf channel 5 might be assigned to DMX channel 10, while rf channels 6 and 7 are assigned to DMX channels 400 and 500 respectively. In this case, channel 10 will control Servo speed, while channel 400 will determine servo target position. In double-precision mode, target position will be determined by channel 400 (coarse) and 500 (fine).***

For ease of setup, contiguous control channels are recommended. If Precision is set to Double, two contiguous channels are required to make use of double-channel precision on most lighting consoles. (Double-precision channels are frequently used to control various parameters of moving lights.)

m4 Damping

Similar to m3 parameter of the same name in Motor mode described above. In the context of servo control, Damping is a digital low-pass filter, preventing control changes above a certain rate. This filtering occurs in the last stage of the servo process, after Proportional and Velocity calculations, immediately before the hardware power driver.

m4 Top Speed

Similar to m3 parameter of the same name in Motor mode described above. In the context of servo control, Top Speed sets the maximum speed demanded by the Proportional feedback process – that is, the power level used when the positional error is greatest, or outside the Slow Window (additional info below).

m4 V Polarity

To ensure an appropriate directional relationship between an external rotary encoder and the motor being driven, this parameter sets the output voltage polarity driving the motor. A setting of Normal runs the motor forward for high values (129 to 255). A setting of Reverse runs the motor backwards for high values.

> ***Incorrect setting of m4 V Polarity is the most common cause of a servo system that runs continuously, sometimes slowing down but not stopping.***

m4 Precision

Single (8-bit) or Double (16-bit).

Target servo position can be specified with single-channel or double-channel precision. For long servo travel distances, double-channel precision is recommended. The first position control channel is m4 Channel + 1. When using double precision, the most significant channel (coarse) is m4 Channel + 1, the least significant channel (fine) is m4 Channel + 2.

m4 V Pulse Div

1:1, 1:4, 1:16, 1:64.

To measure the velocity of the rotary encoder, the FD receiver must measure the time period between each pulse. Depending on where the encoder is placed within a machine design, the velocity range can vary greatly. For example, the encoder could be mounted directly to a motor shaft and be spinning at high speed; or it could be mounted after a gear reducer and be spinning quite slowly.

Pulse Div stands for "Pulse Divider". When set to 1:1, the receiver measures the period between every encoder pulse. At 1:4 it measures the period between every fourth pulse. At 1:16 it measures between every 16 pulses, and so on. When the encoder is spinning very fast, use a higher divider (i.e. 1:16). For slow-turning encoders, use a low divider (i.e. 1:1).

> ***Note that* m4 V Pulse Div *and* m4 Rot Enc Res *are interdependent. When* Rot Enc Res *is set to high, twice as many velocity pulses are generated at double the frequency, using the same encoder.***

m4 Min Speed

0 to 127.

As the servo system approaches the target, the Proportional servo process reduces power to the motor. m4 Min Speed sets the lowest allowed power level, to ensure the motor does not stall before the servo process completes. This setting must be high enough to ensure motor movement under the highest loads typical of the machine being controlled, but slow enough to avoid overly high velocities near the target position.

m4 Rot Enc Res

Normal or High resolution.

The quadrature rotary encoder used for position tracking provides two interleaved signals that pulse as the servo machine moves. Counting pulses from only one of these signals results in Normal encoder resolution. Counting pulses from both signals results in twice as many pulses in a given distance, which is High resolution. High resolution provides higher positional accuracy but reduces the maximum distance the servo system can resolve.

> ***Some encoder manufacturers specify pulses-per-revolution (ppr) based on one signal only; others expect the two signals to be combined for the specified ppr.***
>
> ***Note that* m4 V Pulse Div *and* m4 Rot Enc Res *are interdependent. When* Rot Enc Res *is set to high, twice as many velocity pulses are generated at double the frequency, using the same encoder.***

m4 Enc Range

0 to 32767.

Sets the range, in rotary encoder pulses, for the desired full movement of the servo system.

For example, if a rotary encoder has been mounted at a point where it provides 1200 encoder pulses per foot of machine movement, and you want to control the position of this machine within a 7 foot range, you should set the Encoder Range to 8400.

The full range of the position control channel will be mapped to *Enc Range*. In the example above, single channel precision (8-bit, 256 steps) will provide a resolution of 7 feet / 256 = 0.328 inches per step; each step represents approximately 33 rotary encoder pulses. In double-channel precision (16-bit, 65535 steps), the resolution is now limited by the rotary encoder itself: one encoder pulse = 0.01 inches; there will be approximately 8 control channel steps per encoder pulse.

m4 Stop Window

0 to 32767.

To avoid hunting, a servo system must be allowed a certain tolerance for stopping. If the system is within *Stop Window* encoder counts of the target position, the servo will stop; if it is outside the window, it will continue trying to reduce the error amount.

In the example of 8400 pulses across a 7 foot span, a stopping window of ½ inch would be a *Stop Window* of 50.

The *Stop Window* must be considered relative to, and somewhat greater than, any mechanical play in the machine being controlled.

m4 Slow Window

To avoid overshooting, a servo system must reduce speed as it approaches the target position. *Slow Window* is the range, in encoder counts, within which a proportional speed reduction will occur from *Top Speed* down to *Min Speed*. If the servo is running at less than *Top Speed*, the *Slow Window* used will be proportionally smaller.

The size of *Slow Window* should be greater than *Stop Window*, and less than *Enc Range*. This parameter effectively sets the gain of the P (proportional) feedback loop. When the window is smaller, response must be faster (over a shorter distance), thus the gain is higher.

If *Slow Window* is set short, the machine is likely to overshoot the target position. Using only the P process, this can only be alleviated by lengthening the Window. The V (velocity) process can, however, reduce overshoot and/or hunting when using a short Slow Window (see below).

m4 Vel Mult

0 to 65535, but low levels (less than 100) are generally appropriate.

Velocity Multiplier adds the V (velocity) servo process to the P (proportional) process. At a level of zero (0), no velocity component is used. As the multiplier is increased, a greater V component is used. Thus, this parameter directly sets the gain of the V feedback loop.

As the name implies, the Velocity Multiplier scales the current velocity measurement. Low values are generally most appropriate. Large values may cause servo instability and other unwanted behaviour.

> ***Note that* m4 V Pulse Div *and* m4 Rot Enc Res *directly influence the affect of* m4 Vel Mult*. When pulses are faster and/or more frequent, the measured period will be shorter, and the velocity value higher. Higher values require a lower* Velocity Multiplier *to similarly impact servo performance.***

m4 LimSw1 Pos

0 to 32767, where 0 disables this function

When external limit switch 1 closes, the servo system assumes the programmed encoder position. This allows the servo system to index itself to physical limits.

m4 LimSw2 Pos

0 to 32767, where 0 disables this function.

When external limit switch 2 closes, the servo system assumes the programmed encoder position. This allows the servo system to index itself to physical limits.

The combination of limit switches 1 and 2 allow the top and bottom of a servo field to be defined. Alternatively, a single switch closure could be used to define a mid-point. Together with the Encoder Range, this defines the servo field.

Tuning the FD Servo – a Starting Point

The Relationship between *Rot Enc Res*, *V Pulse Div*, and Rotary Encoder ppr

Velocity Measurement Timer

The FD uses a *velocity measurement timer* to determine the time period between pulses from a rotary encoder. The timer has a 16-bit resolution, providing 65,535 measurement steps, with each step representing approximately 101.73ns (billionths of a second). Thus, the longest period that can be measured with the timer is approximately 6.66ms (thousandths of a second).

> *For reference, the velocity of a 256 pulse-per-revolution (ppr) encoder can be accurately measured from 35.2 rpm all the way up to over 230,000 rpm. When using a drive with a top speed of 1000 rpm, this allowed system velocity to be measured down to 3.5% of full power.*

Pulse Divider

V Pulse Div is short-form for *Velocity Pulse Divider*. It is used to scale the pulses from a rotary encoder to accommodate the resolution of the velocity measurement timer. The correct setting depends on (a) the ppr of the encoder being used, and (b) the rpm of the shaft where the encoder is mounted.

For example, a 1024 ppr encoder mounted on the output of an 8:1 gearbox would yield 128 encoder pulses for every rotation of the motor driving the gearbox; a 64 ppr encoder mounted directly to the motor shaft would provide only half that resolution and twice the time period between pulses. Obviously, a 5000 rpm motor spins almost three times faster than an 1800 rpm motor, producing pulses that are closer together and thus yielding a much shorter period to be measured.

Thus, when the encoder has a higher ppr and/or is spinning at higher rpm, encoder pulses may need to be divided to yield a period more appropriate for the measurement timer. With a *V Pulse Div* of 1:4, the period between every 4th encoder pulse is measured. At 1:16, the period between every 16 pulses is measured, and so on.

> *A* V Pulse Div *setting of 1:1 is suitable for most applications.*

ppr and Rotary Encoder Resolution

Different rotary encoder manufacturers specify ppr differently. Some count the number of complete quadrature cycles, corresponding to pulses from *either* the A *or* the B data line. Others count the total number of pulses from *both* the A *and* the B data lines, for double the ppr value. Any quadrature encoder can be used either way. If you use an encoder that is 100 ppr on a single data line, it will yield 200 ppr when decoded using both lines. Similarly, if you use an encoder that is 100 ppr using both data lines, it will yield 50 ppr when decoded using a single data line.

In the FD servo system, the *Rot Enc Res* parameter determines how an encoder is read. *Normal* resolution reads a single data line, *High* resolution reads both data lines.

> *A* Rot Enc Res *of* Normal *is suitable for most applications.*

Velocity Measurement Jitter

All mechanical systems suffer from jitter. This is caused by play in bearings, bearings that are not perfectly centered, flexible or universal joints, slipping belts, shaft twist, and much more. Thus, the velocity measurement from a rotary encoder is never perfectly steady -- it bounces up and down, even when a machine appears to be running smoothly and steadily. In the case of universal joints and off-center bearings, encoder timing shifts from a

circular to an elliptical pattern – the pulses spread apart for some parts of the rotation, and compress together for other parts.

Over time, the Velocity process averages period measurements to reduce the impact of jitter. Ideally, the velocity measurement timer should be able to measure periods beyond the theoretical range of a given encoder and machine, to accommodate the highest and lowest jitter values that may arise.

Resolution of the Measurement Timer

When the FD velocity measurement timer overflows, the rotary encoder is turning too slowly to be measured. In this case, the Velocity servo process assumes a period of 65535 counts and a velocity of zero (encoder not turning). (This has no impact on the Proportional process, which continues to register every encoder pulse, regardless of velocity, to update current machine position.)

When the FD velocity measurement timer is interrupted by a rotary encoder pulse before it has incremented one count, the rotary encoder is turning too fast to be measured. In this case, the Velocity servo process assumes a period of 1count and the maximum velocity.

Although the velocity measurement timer provides a maximum range of 65,535 counts, this far exceeds the range required by the Velocity servo process. A range of 500 steps or more, from the slowest to the highest motor speed being used, will result in excellent servo performance. Higher ranges do not improve performance; lower ranges may produce a "grainy" or stepped servo response.

RC4-RX4-FD Servo Setup Helper Spreadsheet

RC4 Wireless has created an Excel spreadsheet to assist in choosing mechanical components and configuring FD servo parameters. This spreadsheet, *RC4-RX4-FD Servo Setup Helper,* starts with five values from the user:

- maximum rpm of the encoder shaft
- ppr of the encoder being used (using A+B resolution)
- user setting for *Rot Enc Res* (High or Normal)
- user setting for *V Pulse Div* (1:1, 4, 16, or 64)
- distance that the target machine will travel with one rotation of the encoder

Experimenting with these settings makes it easier to understand what the servo controller is doing. The spreadsheet calculates values for:

- decoded (internal) ppr being used (based on High or Normal resolution)
- minimum rpm that can be measured by the servo controller, and it's percentage of full speed
- maximum rpm that can be measured by the servo controller
- the number of velocity measurement timer counts for the user-specified maximum rpm of the encoder shaft
- the maximum number of encoder rotations within the Proportional servo range (32767 counts)
- the maximum distance the target machine may travel within the Proportional servo range
- a recommended starting value for *Vel Mult* when tuning the Velocity servo process

To assist in finding optimal values, flags indicate when the minimum and maximum measurable rpm are in an optimal range. Experiment with various input values to achieve the **USEABLE** flag in all categories, along with a suitable servo travel distance.

The rpm of an encoder is easily calculated from the frequency of pulses on one data line. Many digital multimeters include a frequency measurement feature (the B&K Precision 2704B is a good example). The *Servo Setup Helper* spreadsheet includes a frequency-to-rpm converter: enter the ppr of the encoder, and the frequency measured on data line A (or B), and the spreadsheet calculates the rpm of the encoder shaft.

Contact RC4 Wireless to obtain the latest version of the RC4-RX4-FD Servo Setup Helper spreadsheet.

A Simple Servo Tuning Procedure

All servo systems require some effort to tune them to the machine they are controlling. This is true of all servo drives and controllers, from all manufacturers. Tuning servos gets easier, and the results get better, with experience.

Here are a few steps to follow when getting started:

1. Use the *RC4-RX4-FD Servo Setup Helper* spreadsheet to choose the most appropriate rotary encoder ppr, and settings for *Rot Enc Inc* and *V Pulse Div*.

2. Set *Vel Mult* to zero (0), and *Min Speed* to 15. Set *Enc Range* and *Top Speed* to appropriate values for your application. If unsure about what is required, set *Top Speed* to a low value for initial testing. Set *m4 Damping* to 10, *Stop Window* to 5% of *Enc Range*, and *Slow Window* to 50% of *Enc Range*. *Stop Window* must always be less than *Slow Window*, which must always be less than *Enc Range*.

3. From your controller (DMX or CV inputs, as assigned at the RC4 transmitter), set the destination position to one extreme. Slowly bring up the servo speed channel and watch the performance of the system. If the motor runs continuously without stopping, the drive polarity may be backwards. You can either change *V Polarity*, or switch the wires to the motor, but *not* both. Either change will reverse the direction that the motor turns relative to encoder position increments.

4. Adjust *Top Speed* so the target machine runs at the desired speed when the servo speed control channel is at maximum. Readjust *Enc Range* if required, to fine tune the range of motion.

5. If the machine overshoots or hunts at the end of travel, increase the size of the *Slow Window*, and reduce *Min Speed*. However, ensure *Min Speed* is always high enough to avoid a stall condition. If *Min Speed* is too low and the machine stalls, the machine will stop before reaching the intended position. It is easiest to adjust Min Speed when *Slow Window* is set quite high. It may also help to set *Top Speed* and *Min Speed* to the same value to find the optimum setting for *Min Speed*.

6. Find the smallest useable setting of *Stop Window*. The smaller the setting for *Stop Window*, the more accurate and repeatable the servo stop positions will be.

7. Reduce the size of *Slow Window* until the machine smoothly decelerates with a small amount of overshoot and hunting or ringing to find final position. (Rringing is a decaying oscillation around the stop location, and will be further minimized in the next step.) If the unit oscillates continuously, you may (a) increase *Stop Window*, (b) reduce *Min Speed*, and/or (c) increase *Slow Window*.

8. Introduce a small amount of *Vel Mult***,** starting with the value recommended by the *RC4-RX4-FD Servo Setup Helper* spreadsheet. At the ideal setting, *Vel Mult* will reduce overshoot and hunting for a more immediate stop. If *Vel Mult* has no apparent affect, double the setting and test again. Continue this until an affect is observed. For best results, set *Vel Mult* to the lowest value that suitably improves performance. Note that some servo applications are most pleasing with no Velocity process at all, in which case *Vel Mult* should remain at zero (0).

Repeat steps 4 through 8 to further fine-tune parameters and improve performance with various control speeds and target positions. Experiment with different relationships of the various parameters. Often, there is more than one suitable setup for an application, and different setups may be more or less appropriate for the way you will be using the servo system in your application.

RX2 / RX4 Receiver Buttons and Indicators

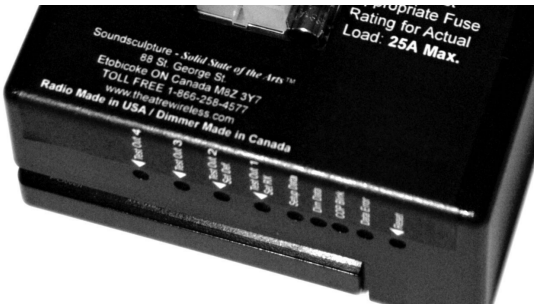
As noted in previous sections, RX2 and RX4 radio-dimmers are configured and controlled remotely from a TXD-Series transmitter, using the transmitter's user interface. This is the only way to configure each output, selecting the control channel, dimmer curve, etc.

Inside the receiver enclosure are two circuit boards: the radio board, and the dimmer or power output board.

Each receiver also has a simple user-interface intended to help with wiring and load testing, and restoring internal settings to default values. Various LEDs indicate the status of the dimmer and radio boards.

On the RX4 dimmer board there are five recessed push buttons, three (MICRO) or four (STD, HO, FD) function LEDs, and four additional LEDs directly connected to the four dimmer outputs. From left to right, the switches and function LEDs on the RX4-STANDARD, RX4-HO, and RX4-FD are:

```
Button: Output 4 Test
Button: Output 3 Test
Button: Output 2 Test / Power Up Load Default Settings
Button: Output 1 Test / Assume RX Number of Incoming Setup Packet
LED: Setup Data Receive Indicator (green)
LED: Dimmer Level Receive Indicator (green)
LED: Computer Operating Properly (COP) / Battery Voltage Indicator
LED: Data Error Indicator (red)
Reset Button: Hardware Reset
```



The RX2-MICRO dimmer board has 2 recessed push buttons corresponding to the first 2 buttons on RX4 units, and 3 indicator LEDs corresponding to the first 3 LEDs on RX4 units.

Changing the RX Number

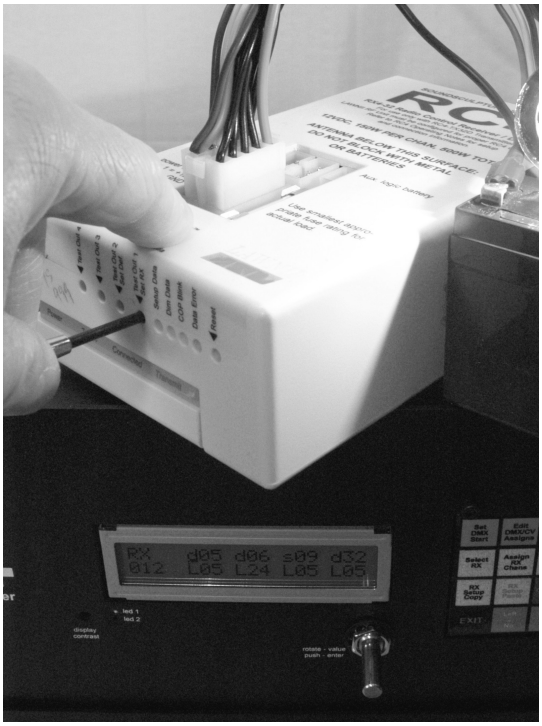
To change the RX number of a receiver, select the desired RX number while simultaneously holding down the **Assume RX Number** button on the receiver (4th button from the left). The RX number of the sent data packet will be assumed by the receiver and stored in non-volatile eeprom memory.

The receiver MUST be powered on and Active during this process.

The radio board must be programmed with the correct system number.

Subsequent configurations for this RX number will be accepted without holding any button down.

When a receiver accepts new configuration data, it displays a short "light show" on its four LEDs, and sends a digital acknowledgement back to the transmitter. The light show is displayed only if (a) a configuration message comes in for the current RX number, (b) a configuration message comes in while the **Assume RX Number** button is down, or (c) the internal default settings are loaded. When the **Assume RX Number** is held down, the new RX number becomes the current RX number for future configurations.



The receiver shown here is white. Production units are black.

NOTE: Some receivers may contain customized firmware for special applications. A specific RXnum is required to activate these custom processes. For example, a custom fog controller might be activated by using RX128. Customized receivers usually revert to their special functions if defaults are loaded using the receiver's recessed buttons. Refer to the documentation supplied with your customized receiver for additional information about your specific unit.

Default Settings – Standard, HO, and MINI Receivers

To restore receiver default settings, hold down the recessed **Test Out 2 / Set Def** button while powering up the receiver or pressing the recessed **Reset**[1] button immediately to the left of the Data Error LED. This will load the following settings in Standard, HO, and MINI receivers:

```
RX Number = 1

Output 1 Assigned to rf Channel 1[2]
      Linear Dimmer
      Low Level 0 (zero)
      Voltage Reference Dimming disabled (Vin)
      Smoothing disabled (0)

Output 2 Assigned to rf Channel 2[2]
      Linear Dimmer
      Low Level 0 (zero)
      Voltage Reference Dimming disabled (Vin)
      Smoothing disabled (0)

Output 3 Assigned to rf Channel 3[2]
      Linear Dimmer
      Low Level 0 (zero)
      Voltage Reference Dimming disabled (Vin)
      Smoothing disabled (0)

Output 4 Assigned to rf Channel 4[2]
      Linear Dimmer
      Low Level 0 (zero)
      Voltage Reference Dimming disabled (Vin)
      Smoothing disabled (0)
```

To change these settings, send a new configuration from the transmitter.

It is likely that you will also need to restore the RX number to a value other than RX001. If so, follow the procedure in the proceeding section.

NOTE: Some receivers may contain customized firmware for special applications. A specific RXnum is required to activate these custom processes. For example, a custom dual-motor speed control might be activated by using RX128. Customized receivers usually default to their special functions if defaults are loaded using the receiver's recessed buttons. Refer to the documentation supplied with your customized receiver for additional information about your specific unit.

1. This is ***not*** the reset button on the rear/back of the radio, which resets only the radio board.
2. The DMX or CV input control channel assigned to these rf channels is determined by the user and may vary.

RX4 Receiver Power Wiring and Fusing

WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

Beside the main power connector on RX4 receiver-dimmers is a pair of clips for a *load fuse*. Standard AGC fuses fit easily into these clips. This fuse is in the positive side of the dimmer output circuit.

To effectively protect the load, wiring, and electronics, and to reduce potential hazards, one of the following dimmer fusing techniques MUST be used:

1. Choose a load fuse that accurately reflects the total load for all four channels. This technique is best when loads are relatively small, i.e. one MR16 on a single channel.

2. Use external fuses for each individual output, appropriately sized for each load. Put the fuse in the positive side of the load circuit, returning directly to the positive side of the supply battery, rather than the positive output terminals on the dimmer. RX4 dimming is done on the negative side***. This option is recommended for high currents.*** A small fuse should still be installed on the RX4 board to drive the indicator LEDs. A positive lead must still come to the receiver to power the logic circuitry.

DO NOT OPERATE LOADS WITHOUT FUSES. YOU MUST FUSE EVERY CIRCUIT.

DO NOT simply install the largest fuse you can find and forget about it. This can result in an unsafe situation, possibly a fire or burn hazard. It is not recommended to internally fuse any RX4 receiver above 25A.

DO NOT fuse any single RX4 dimmer above 25A. With all 4 dimmers individually fused at 25A, a total of 100A can flow. At 12V this is 1200W, substantially beyond the maximum rating of the product. Continuous current exceeding 500W requires the RX4-HO receiver. In any case, be sure to use appropriate connectors and large wire gauges, and monitor the system closely – particularly the operating temperature – at all times.

Here are some typical fuse values:

75 watt MR16 halogen lamp: draws 6.25A at 12VDC. Use an 8A fuse.

1/4HP 12VDC motor: typically draws 20A when operated smoothly, but could surge to 40A on a fast start-up. Use a 25A fast-blow fuse and avoid rapid start-up (ramp up the power level slowly).
Do not use slow-blow fuses. They do not protect semiconductors in a fault condition.

It is difficult to apply typical safety standards to these devices, because of the unusual circumstances of theatrical prop construction. The "rule of thumb" is that nothing should be allowed to operate at a dangerous temperature. Appropriately sized wire gauges and connectors must be used, along with suitable ventilation and external fuses rated for the load being operated.

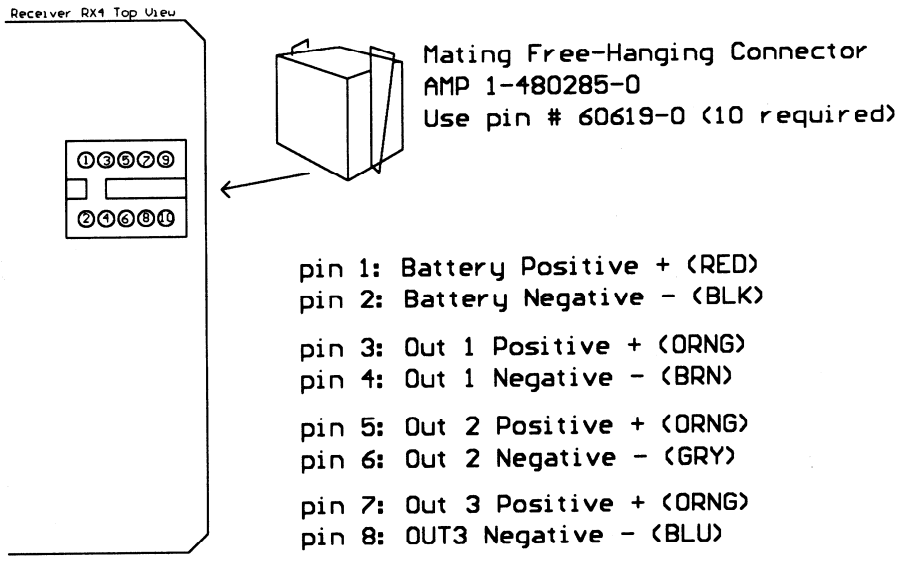
WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

RC4 devices are operated at the user's own risk and Soundsculpture accepts no liability, either direct or consequential, arising from the use of RC4 equipment.

RX4 Receiver Power Connection Diagram (STANDARD, HO)

The RX4-STANDARD is remarkably versatile and powerful for its small size. Four outputs deliver pulse-width-modulated power capable of driving high current motors, lamps, and other inductive or resistive loads. Each output is rated for 150W, equivalent to approximately 12.5amps at 12 volts. The four outputs can be combined in any combination to drive larger loads, to a maximum of 500W into a single load (40A).

Total receiver power handling is limited by circuit-board traces (copper trace thickness and width) and connector pins. For higher power handling, use the RX4-HO (high output) which is directly interchangeable with the RX4-STANDARD and can deliver up to 1000W (with caution, and adequate ventilation).



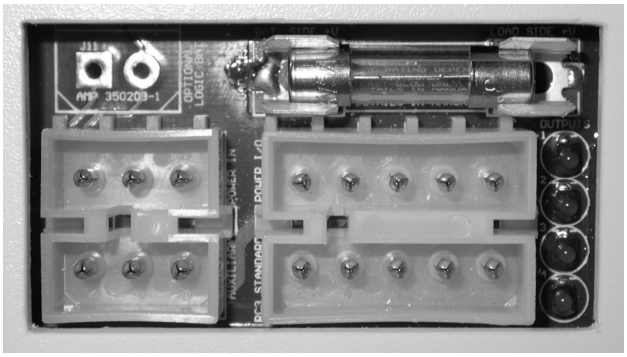
The recommended AMP tool for these connector pins is **part number 91504-1**. A discontinued AMP tool that can sometimes be found used is **part number 90124-2**. Shells, pins, and tools are available from most electronic component suppliers, including www.digikey.com, or from Soundsculpture Incorporated.

Channels connected in parallel must have their channel-select and Low Level limit switches set identically to avoid one channel taking a heavy load on its own. Damage resulting from inappropriate configurations will not be covered under warranty.

WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

The RX4-STANDARD and RX4-HO (high output) receivers includes a 6-pin auxiliary power input connector:

Pins 1, 3, and 5 are wired in parallel with pin 1 on the 10-pin connector. This is +V in.
Pins 2, 4, and 6 are wired in parallel with pin 2 on the 10-pin connector. This is GND in.



In some cases, the 6-pin connector can be used for high-power battery input, while the 10-pin connector can be used just for outputs. If all pins of both connectors are used, eight wires are available for both power in and dimmer out. This results in symmetrical current carrying capacity on both sides of the dimmers.

Some models of RX4 receiver include an optional 2-pin logic battery connection. Pin 1 is positive (+), pin 2 is negative (-). This connector can be used as a 12V unregulated power output to external electronics, or be used for a 12V lead-acid battery or large storage capacitor. This allows the logic and RF circuitry in the RC4 receiver to continue functioning even if the load-bearing batteries run down.

If a non-rechargeable battery is used with this connector, it should be protected from reverse current with a diode. Significant output currents are present on this connector.

Note: Connections on FD Functional Diversity receivers are NOT the same. Please see the appropriate wiring diagram elsewhere in this manual, or in documentation accompanying your FD receiver.

RX4-HO High Output Receivers

The high output (HO) version of the RX4 receiver features upgraded MOSFET power components and a cooling fan. Even with these enhancements, high-current power handling can be dangerous and should not be sustained indefinitely.

At 12VDC, a 1000W load demands over 80 Amps of power. The batteries, wires, connections, and fuses required to handle this kind of load are very large.

WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

To accommodate large loads, both the RX4-STANDARD and the RX4-HO feature a 6-pin auxiliary power input connection. Used together with the 10-pin power input/output connector, there are four separate connections in parallel to bring power in, and another four to carry power out to the load(s). Thus, each wire and connection can carry up to 20A at 12V, provided it is of an appropriately large gauge.

The fuse on RX4 receiver boards cannot carry 80 Amps. When wiring large loads, the positive (+) side of the circuit should be completely external to the RX4 receiver, and it should be carefully and safely fused. A small-gauge wire can be used to bring the positive supply to the RX4 internal control electronics, and the fuse on the RX4 can be 1A or even smaller, since it will only supply the indicator LEDs.

All RX4 dimmers introduce pulse-width modulation on the negative (-) side of the circuit, acting as a dimmer on the negative line to the load. This is where you need heavy wire and you should utilize all 4 input and output connections across both power connectors.

If you are using the RX4 as one large dimmer on a single channel, you can wire the outputs of each channel in parallel. For this to work effectively, circuit impedance and resistance for each channel must be closely controlled. More current will flow through shorter circuits, thicker wires, and tighter connections, and this can cause more than a fair share of the total load to be flowing through a particular dimmer channel.

This kind of overloading causes overheating and damage that is not covered under warranty, and can be a fire hazard. For optimal safe performance, resistances of each parallel circuit should be as close to identical as possible. Beware of faulty or worn connectors adding substantial resistance.

Damage caused by not configuring parallel channels identically is not covered under warranty, and can be a fire hazard. When ganging output channels together, they must be set to the same data channel, and have the same Low Level cut-off value. Otherwise, one or more channels could switch off while other channels are still operating, causing damage to channels that remain on and causing too much current to flow through single conductors and connections.

It is also advised to set the Low Level cut-off quite high when loads are large. This prevents high EMI/RFI when dimmers attempt to drive a cold filament or stalled motor.

Before using any RX4 receiver at high power levels, please re-read this manual and double-check your choices of battery, wire, fuses, and connectors. Nothing should run hot; if something does run hot, it is under-rated or improperly applied and should be replaced with a component that does not run hot.

If the receiver itself is running hot, then either:

- additional ventilation is required
- running time is too long (it needs time to cool off)
- load current are too high
- any combination of the above

DO NOT continue to operate the receiver under these conditions.

WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

Be careful –high power loads are operated at your own risk, and Soundsculpture cannot be held responsible for any damages whatsoever, whether direct of consequential.

RX2 MICRO and RX4-MICRO Receivers

MICRO receivers are the smallest, most portable receivers for the RC4 wireless dimming system. They can be used in small props, costumes, and anywhere else with limited space. Just like the larger RX4 receivers, MICRO units provide up to four channels of dimming. They are configured from an RC4-TXD-Series transmitter, just like the other RC4 receivers.

Summary of Differences Between RX2/RX4-MICRO and other RX4 Receiver-Dimmers

- Screw terminal connections, rather than shells/pins
- Connections on side, rather than top
- Uses small automotive plastic ATC fuse, rather than glass AGC fuse
- Much smaller
-

Connections and Wiring

MICRO units use screw terminals for power input and dimmer outputs. All terminals are clearly marked.

Maximum power handling is 100W per channel, 200W total maximum. When running at maximum power, it is recommended to limit the maximum time the channel is activated to avoid overheating.

The highest fuse rating that should ever be used in a MICRO receiver is 15A. In practice, the smallest appropriate fuse should be used for the connected load(s) and will typically be much smaller than 15A. If you are running a single 50W MR15 lamp, use a 5A fuse. Use fast-blow fuses to protect the power driver electronics.

WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

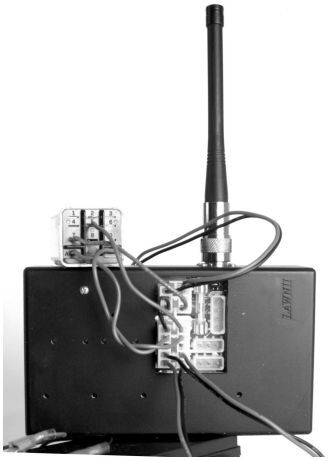
Configuring Channels

Programming channels, Low Level cut-off, and dimmer/switch mode is done the same way for all RC4 receivers.

Buttons and LEDs

The positions of the recessed buttons and LEDs are different but clearly marked on MICRO units. The same functions and indications are provided – they operate the same way as the buttons and indicators on other RC4 receiver-dimmers.

FD Functional Diversity Receiver Operation



The RX4-FD Functional Diversity receiver may be used for lighting or motion control. It is ideal for driving lamps (Dimmer mode), motors in two directions (Motor mode), a pair of motors to control the speed and direction of a vehicle (Differential mode), or a servo positioning system (Servo mode). It can be used with motors over a range of sizes and voltages to a maximum of 30V (24V typical + headroom). Just like the RX4-STANDARD and RX4-HO receivers, the RC4-FD is configured from an RC4-TXD-Series transmitter.

Summary of Differences Between the RX4-FD and the RX4-STANDARD

Although some of the same connectors are used, the wiring diagram of the FD receiver is ***not*** the same as the diagram for the STANDARD and HO receivers. The pin-out has been designed to avoid receiver damage if a wiring harness for one type of receiver is plugged into another, but operation will not be as expected if this error is made.

The circuit board traces in the FD are a primary current limiting factor. Under overly high loads, traces may fail before the protected power outputs shut themselves down. If this happens, burned traces can be repaired with copper wire, resulting in higher current capacity than originally provided.

Programming and diagnostics of the radio module in the FD is identical to that of the STANDARD receiver.

The FD receiver uses an external whip antenna. This is to ensure the best possible radio link between the transmitter and receiver, avoiding electrical interference from the power drivers within the receiver.

Connections and Wiring

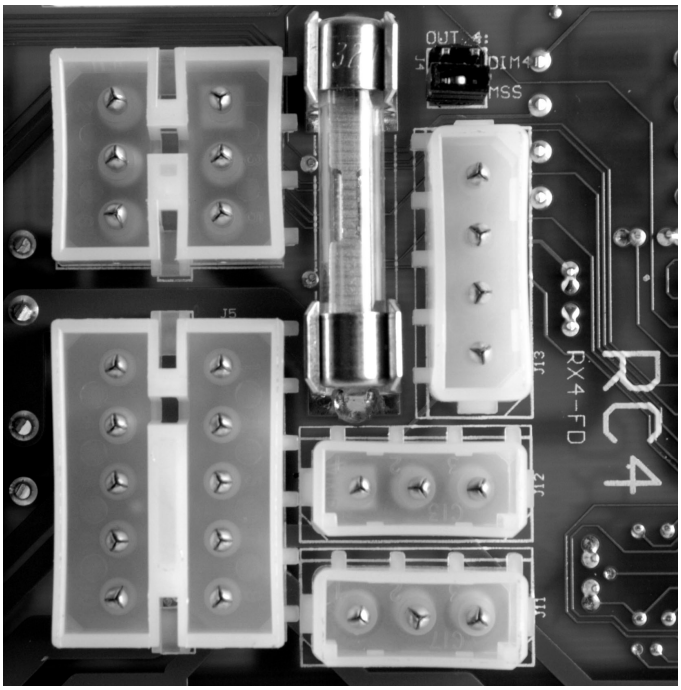
The six-pin connector is used for incoming battery power, and provides fused battery power out to an optional (recommended) external main contactor relay. Switched power from the main contactor relay returns to the top of the 10-pin connector.

The main contactor relay opens power to the m3 and m4 output channels, but not the d1 and d2 dimmer channels. When the MSS is enabled (recommended) the d1 channel drives the coil of the main contactor relay.

Refer to the FD Typical Wiring Diagram for hookup details.

Maximum power handling is 200W per channel, 800W maximum, but circuit board traces may require bolstering with copper wire to sustain these power levels. When running at maximum power, it is recommended to limit the maximum time the channel is activated. In a fault condition, circuit board traces may fail, acting like a fuse. Otherwise, the protected power driver circuitry will shut down, avoiding damage from over-heating or over-current.

Use external fuses for fault isolation on each power driver circuit. The smallest suitable fuse should be used for each load.



Note: Some revisions of the FD circuit board (including the one shown above) have the MSS selection jumper mislabelled as OUT4. It controls OUT1, NOT OUT4.

WIRING AND INSTALLATION OF BATTERIES, DIMMERS, AND LOADS MUST BE IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES.

Sensor Inputs

The FD receiver provides input connectors for a quadrature rotary encoder and two limit switches. Suitable encoders will operate on 5VDC and provide quadrature A and B data signals. The FD receiver does not use an index input; if an index data signal is provided by your encoder, leave it unused.

Limit switch inputs are pulled low by a current limiting resistor. Thus, a contact closure needs only to short the 5V supply to the switch input line. The common (ground, -V) connection is provided for use with solid-state sensors that require power. For example, infra-red proximity sensors or hall-effect sensors could be used, provided they will operate on 5VDC.

To reduce susceptibility to electrical noise, sensor inputs have a 1K-ohm input impedance. Thus, sensors must be capable of sourcing 5mA at 5V. If you are using a higher impedance sensor, such as some* US Digital *encoders without their optional cable driver, a resistor in the FD receiver can be changed to increase the input impedance. Contact RC4 technical support for additional information.

Refer to the FD Typical Wiring Diagram for hookup details.

Configuring Channels

In dimmer mode, parameters are programmed in the same manner as other RX4 receivers. In Motor, Differential, and Servo modes, additional parameters are accessible using the transmitter (these are described in detail earlier in this manual).

In some cases it is necessary to change the FD mode (at the transmitter) and send this configuration to an Active receiver. After confirmation of the new mode, the appropriate parameters will become available for editing.

MSS Motion Safety System

The FD receiver includes a built-in MSS Detector. This circuit monitors the MSS Motion Safety System heartbeat and outputs a security signal indicating that the heartbeat is present and within specification.

The small OUT1 jumper (mislabelled as OUT4 on some FD circuit board revisions) is positioned to the right of the on-board fuse, above the rotary encoder connector. To use the MSS Motion Safety System, this jumper should be in the lower position, marked MSS. In this position, the MSS security signal controls the d1 power driver, which can be used to control an external main-contactor relay. This configuration is recommended and is shown in the FD Typical Wiring Diagram.

The external relay must be rated for the operating voltage of batteries and motors being used, not exceeding 30V. It should be capable of opening the power circuit under full load (all loads on at 100%). It is recommended that this relay be rated for double the maximum anticipated load, and be a mechanical relay, rather than a solid-state device. Under normal circumstances, this relay will never switch the load – it comes into play only in the event of an MSS fault condition.

The external relay must open the circuit between the MOTOR V OUT +/- pins on the 6-pin power connector, and the MOTOR V IN +/- pins on the 10-pin connector. As these labels imply, the relay will ***not*** disconnect power to the DIMMER OUT channels, one of which is driving main contactor relay coil. When using a mechanical contactor relay (recommended) it should be inserted in the ***positive(+)*** MOTOR V lines.

> ***In some revisions of the FD circuit board,*** **negative(-)** ***is common for all power connections. Thus, inserting a main contactor relay between negative power contacts may not open the motor power circuit.***

When the MSS Decoder is controlling OUT1, dimmer 1 is not available. Thus, d1 parameters will have no affect on the operation of the d1 output. In this case, only the **d1 Channel** setting is used, since the same data channel is sent to the MSS Decoder carrying the MSS heartbeat signal.

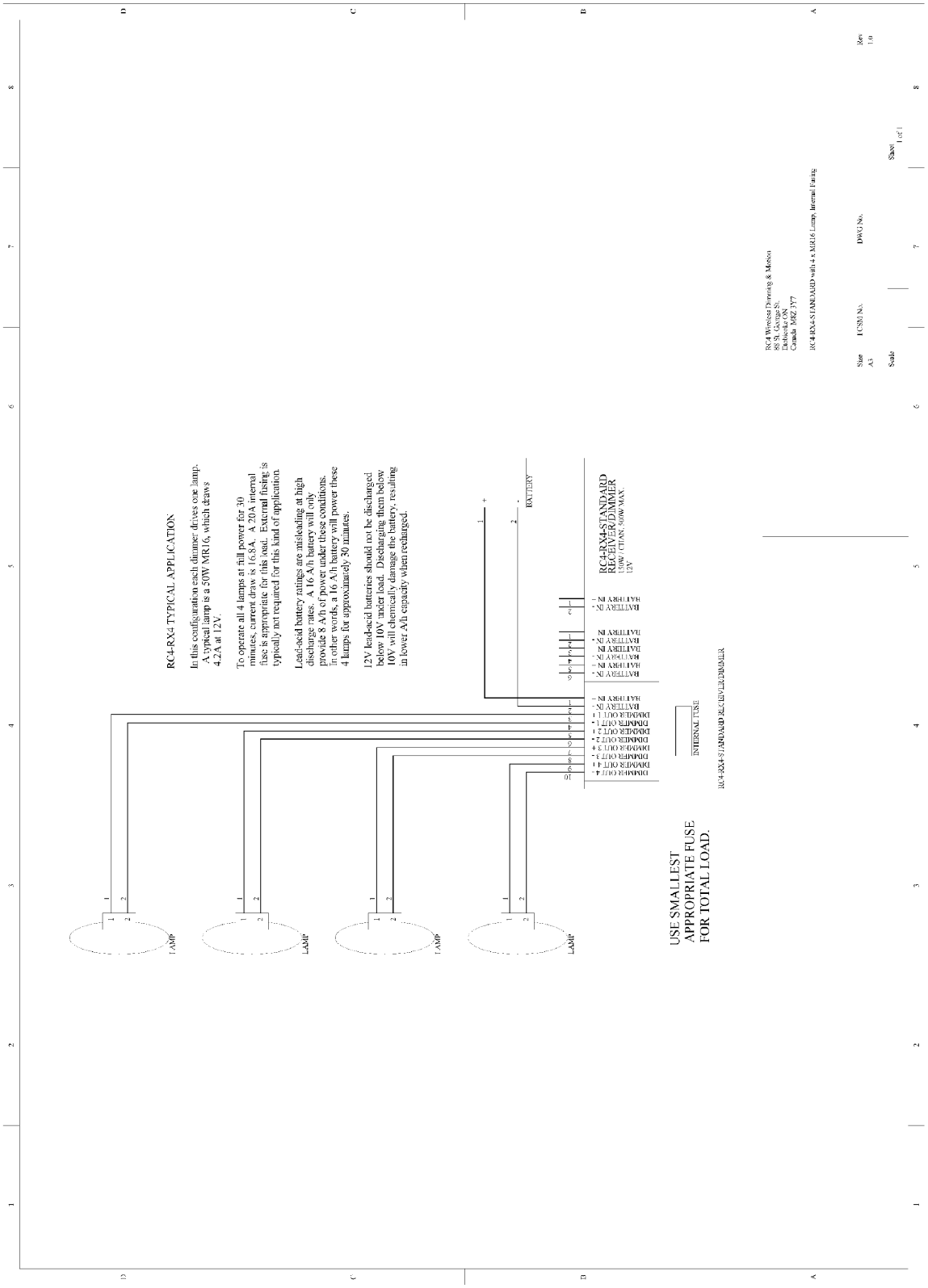
> ***The FD receiver with firmware 4.026 or higher requires a CV-Centre signal to operate motors in Differential Mode. It is also recommended that the MSS Heartbeat be used.***

Buttons and LEDs

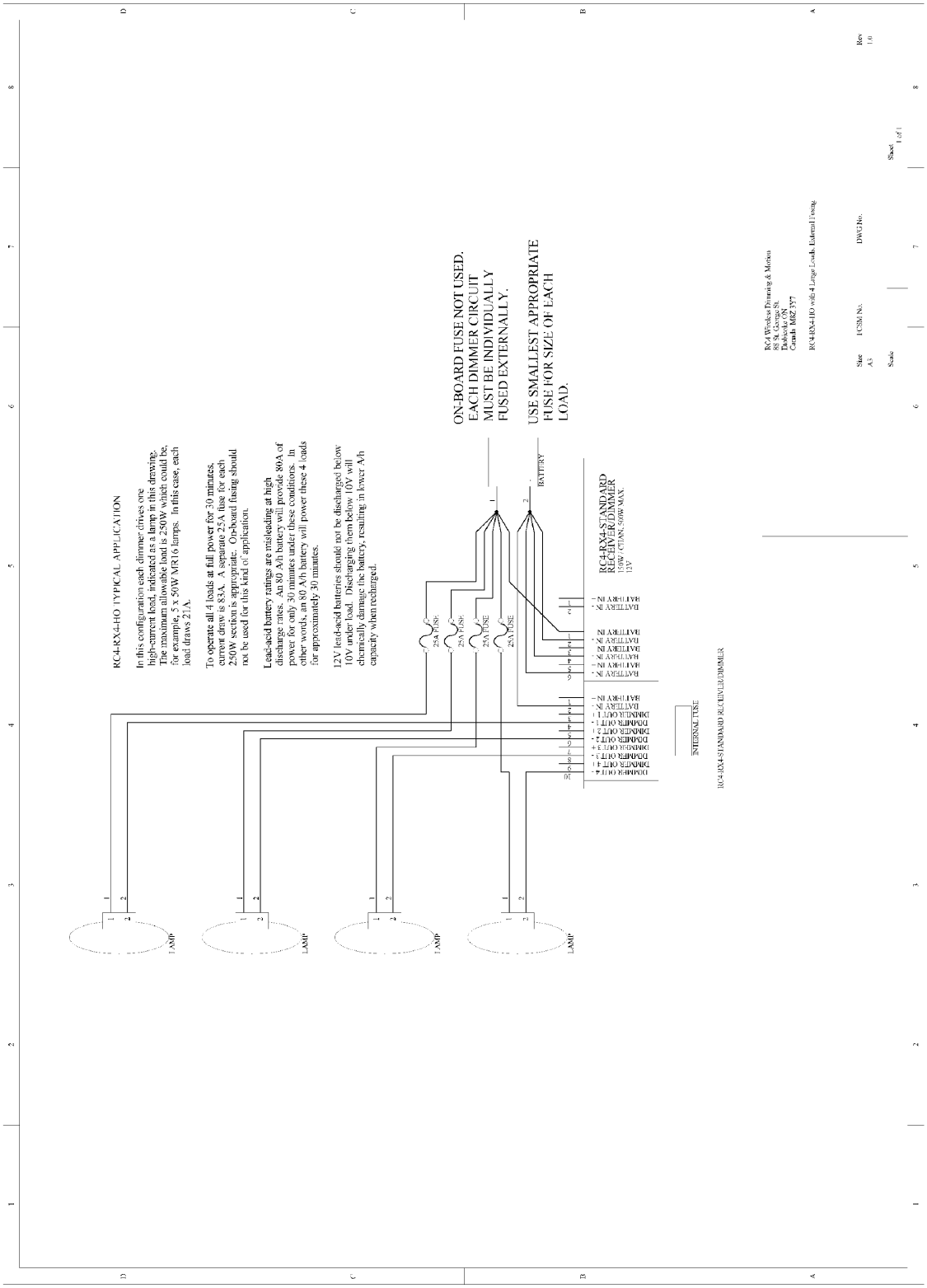
The positions and functions of the recessed buttons and LEDs are identical to those of the RX4-STANDARD.

> ***Test levels are*** **not** ***produced for motor modes. Motor levels*** **must** ***be produced at the RC4 transmitter.***

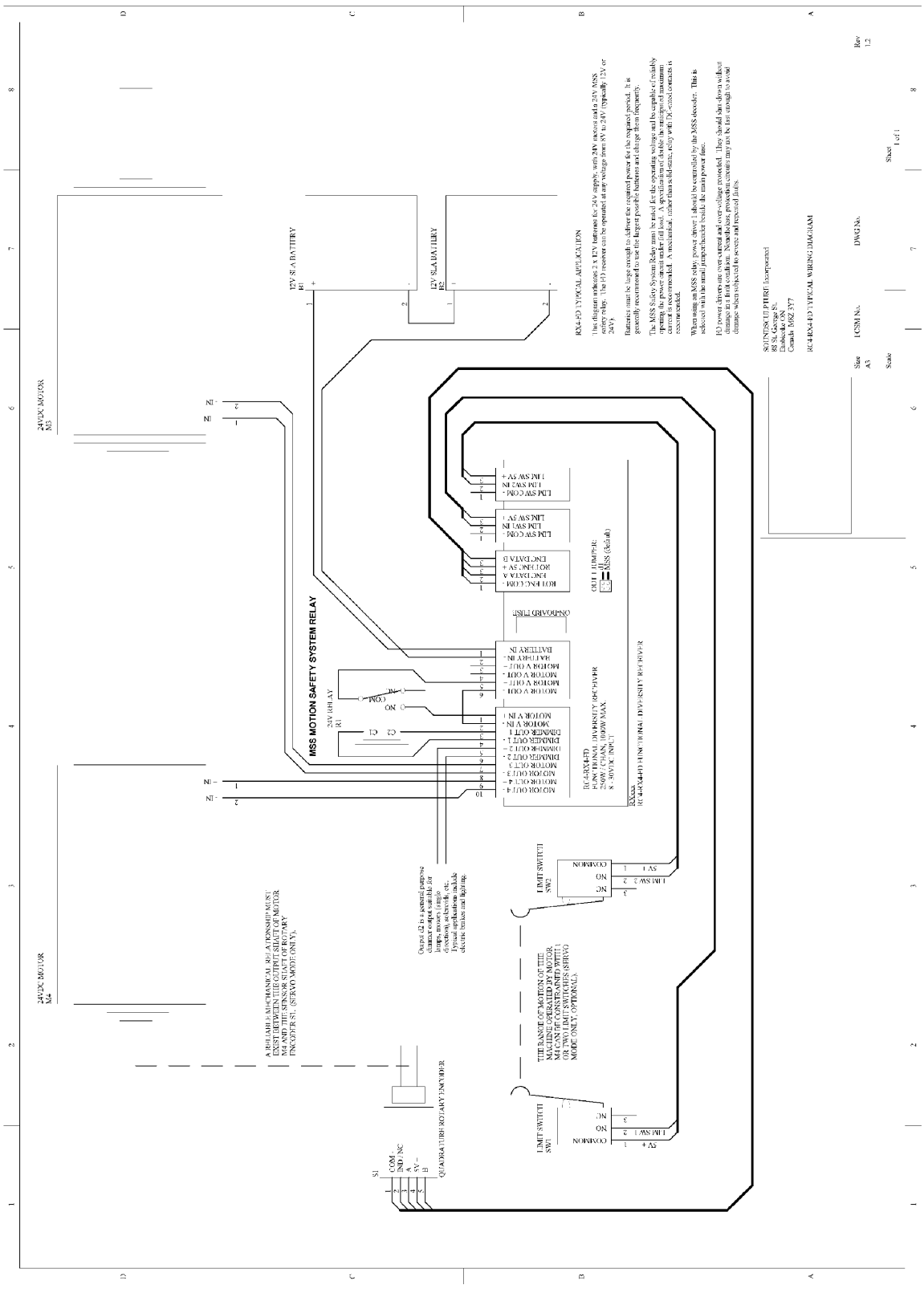
RC4-RX4 Receiver-Dimmer Typical Wiring Diagram



RX4-STANDARD / RX4-HO Typical High-Power Wiring Diagram



RX4-FD Typical Motor-Control Wiring Diagram

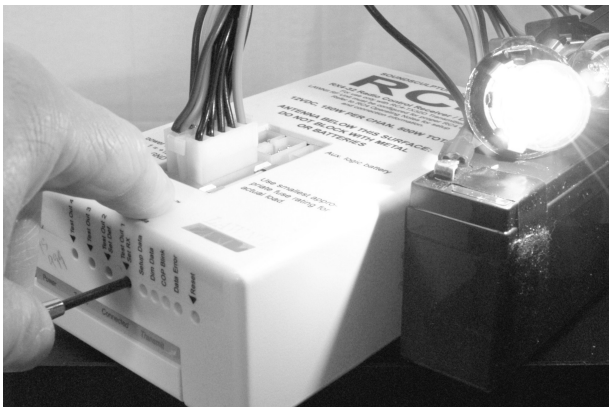


Receiver Load Testing – Receiver Test Buttons

All RC4 receiver-dimmers have a channel test button for each on-board dimmer. These buttons are recessed to avoid accidental activation and can be pressed with any slender object (a bent paperclip is ideal). Test buttons override incoming levels only while pressed. Any combination of the four channels may be tested simultaneously.

> ***Note: For safety reasons, test buttons on the FD receiver work* only *in Dimmer Mode.***

For outputs configured as dimmers, the test channel will fade up or jump to 50% (depending on the model and firmware version of the receiver being used) when the test button is pressed. For dimmers configured as switches, they will cleanly switch on to full when the test button is pressed. FD receivers in Motor, Differential, or Servo mode will not respond to the test buttons.



Receiver Battery Voltage Indication

The Computer Operating Properly (COP) blinking LED on RC4-RX4 receivers also indicates battery voltage. At 10.5V or higher, this LED is green and blinks slowly. Below 10.5V it is red and blinks rapidly. (Some models do not have bicolour LEDs; in this case, only the blink speed will change.)

These voltage thresholds have been selected with 12V rechargeable lead-acid batteries in mind. A 12V lead-acid battery should never be discharged below 10V or it will be chemically damaged, leaving it unable to fully recharge to original capacity.

> ***Note: This indicator is not useful when using batteries of a higher voltage. When using 24V lead-acid batteries, avoid discharging below 21V. Use the battery voltage display feature on the RC4 transmitter, or check your batteries with a volt meter.***

RX4 electronics will work correctly with battery voltage down to 5V (a 6V battery with room to drop over time). This makes it suitable for use with various alternative batteries, including NiCad and NiMH battery packs. These battery types will usually not be harmed by discharging below 10V.

When using RX4-STANDARD or RX4-HO receivers, an auxiliary logic battery can be used to ensure radio and logic circuitry continues to operate when the load battery is severely discharged.

Radio Settings

Note that RC4 radios never require configuration under normal circumstances.

Some RC4 system settings reside in the radio modules used at each end of the wireless link – the transmitter transceiver and the radio boards in the receivers. These settings are stored in EEPROM memory and do not require adjustment under normal circumstances. Nonetheless, it may some day be necessary to adjust a System ID or other parameter. This is done using an RS-232 data terminal, or terminal emulator software on a PC with a COM port. When making changes to radio settings, power and data connections must be made at the rear of the transceiver or receiver unit (with the exception of MICRO units, which do not have a direct connection method for radio configuration).

A 12VDC power adaptor, along with a short 25-pin D-Sub adaptor cable are required. These items may have been supplied with your RC4 system but are rarely (if ever) used.

Do not attempt to change system settings while powering the receiver from the 10-pin RC4 power connection. This powers both the radio board and the dimmer logic board, and does not leave the radio board available for data on the rear 25-pin port.

The data cable observes RS-232 standards with data on pins 2/3, handshaking on pins 4/5/6/20, and common on pin 7. Readily available cables can be used if the supplied cable is lost or damaged.

Set System ID

The System ID is a number from 0 to 65535. Values below 1000 are reserved for older 16-channel RC3 systems. RC4 systems are assigned System IDs of 1000 or higher.

Every RC4 user is assigned a unique System ID when their system is shipped, and a database of these numbers is carefully managed and maintained. To avoid data collision with other users, system numbers should NOT be changed. Some users have multiple RC4 systems, however, and may wish to change the System ID in receivers to move between systems.

Do not change a transmitter System ID without authorization from Soundsculpture Incorporated. Do not use System IDs not assigned to you.

Set System Baud Rate

The default baud-rate is 38.4kbps (kilobits per second).

Additional System Parameters

Each radio module must be configured for proper operation in the RC4 architecture. Each System ID should have only one transmitter (master), and any number of receivers (slaves).

The radio settings used for the RC4 system create a low-latency master-slave network. The microprocessors at each end of the RC4 dimmer control system use real-time cyclical-redundancy to ensure reasonable accuracy without introducing varying delays. The coding for this technique is proprietary to the Soundsculpture RC4 system.

Radio settings can be made using an RS232 terminal, or a PC running a terminal emulation program with a COM port.

The Microsoft Windows Operating system comes bundled with the HyperTerminal terminal emulation program. It can be used to configure RC4 radios. Be sure to use the following settings:

- Direct connect to any available COM port
- VT100 emulation
- Control keys act as Terminal keys (very important)
- Standard ASCII character set

Additional information about connecting to the radio with HyperTerminal is available on an as-needed basis.

Updating RC4 Firmware

Although some releases/versions of RC4 hardware are capable of in-the-field firmware updates using a PC and "bootloader" software, firmware updates should be completed only by RC4 technicians. In most cases, units must be returned to RC4 for testing and service in this case.

> ***Regardless of firmware and hardware version, not all RC4 hardware is shipped with bootloader support. Contact RC4 Wireless for additional information.***

A General Discussion of Radio Reliability

The Soundsculpture RC4 system is exceptionally reliable when properly set up. For distances of less than 300 feet between transmitter and receiver, problems are rare. For greater distances, the most critical factor is transceiver and receiver placement, since these units house high-frequency radio antennas. Consider the following guidelines when installing the transmitter and all receivers:

- The antenna surfaces must not be obstructed by metal objects. Remember that lead-acid batteries have lead inside, and count as an obstruction.

- Internal antennas are most effective when facing other units in the system (i.e. receivers should face towards the transmitter and vice-versa). Alternatively, all antennas can face in the same direction towards a reflective surface like a ceiling or rear wall. Reflections of nearby surfaces usually deliver a solid radio link.

- Avoid many solid obstructions between the transmitter and receivers, especially as the distance between them is extended. Stage sets, flats, etc., generally cause very little degradation of signal. Cinderblock and concrete walls and fire doors, however, will cause greater attenuation.

In an environment with a continuous solid reflective surface (like a ceiling) and a minimum of obstructions (no walls), RC4 spread spectrum receivers work flawlessly for indoor point-to-point distances exceeding 300 feet, covering thousands of square feet. Transceivers facing each other with unobstructed line-of-sight can operate across thousands of feet.

A typical theatre environment with the transmitter transceiver secured overhead, and receivers on stage (less than 100 feet away) is ideal. No user-detectable errors should occur, regardless of electrical noise from nearby equipment. Set pieces in the house area should also perform correctly via reflections off the stage floor (i.e. the chandelier in The Phantom of the Opera).

Errors will generally not sustain more than 1/75th of a second, the maximum amount of time before every channel has been reset by redundant data transmissions. However, if errors are caused by consistent multi-path interference or insufficient signal level, problems may persist or repeat.

The RC4 software protocol has been designed to be tolerant of the kinds of interference and interruptions that are typical of RF data links, while being optimized for realtime performance. Moderate interference should not cause user-detectable errors.

Troubleshooting

The RC4 system is VERY tolerant of radio signal degradation and electrical noise. Most users have no problems... in fact, at the time of this writing only one radio interference problem has ever been reported with an RC4 system, and was corrected when the transmitter was moved away from an unusually noisy lamp. If you think you are suffering from radio interference problems, FIRST be absolutely certain your batteries are good.

Simple Solutions to Common Problems

Problem:

When channel levels are brought up, the load (lamp, motor, etc.) operates for a brief moment then goes off. A second or so later, it comes back on. The problem appears cyclical or intermittent.

Cause:

When a lead-acid battery is measured with no load it reads approximately 12V. This is true even for a substantially discharged battery. RC4 electronics require very little current to operate, and a discharged battery still provides enough power for the receiver to come on and indicate traffic.

Here's the problem cycle:

1. When RF control data indicates an output level, the output driver delivers battery power to the load. If the battery is under-rated or under-charged, voltage will drop substantially under load.

2. When the battery voltage drops below 8V the RC4 receiver will shut down. This disconnects the load from the battery.

3. With the load disconnected, battery voltage drifts back up. (It eventually drifts back up to 12V, unless the battery is seriously damaged). When battery voltage climbs above 9V, the RC4 receiver comes back on and starts monitoring control data again.

...And the cycle starts all over again.

In some cases, exactly the same symptoms are caused by undersized wire or poor connections between the battery and the RC4 receiver. These cause resistance, resulting in a voltage drop at the receiver when the load increases (Ohm's Law).

This cycle through steps 1, 2, 3 and back to 1 results in the symptom described. The actual cycle time varies with battery size, battery charge, the size of the load, power levels selected, and wire sizes used. Eventually the battery is damaged and fails to drift back up enough to continue the cycle.

To prove this is happening, put a volt-meter across the power input terminals at the RC4 receiver. The voltage will drop when the load comes on. When the voltage drops enough, the load will go off. When the voltage drifts back up enough, the load will switch back on.

If these voltage fluctuations are apparent at the receiver but not at the battery terminals, then wire and connections are at fault – you must conduct adequate current from the battery to the receiver to avoid these unwanted voltage drops.

Solution:

Ensure the battery is fully charged using a smart charger that accurately indicates the condition of the battery. Be sure the battery is rated large enough for the intended load for the operating time you require. Be sure wire gauges are large enough, especially between the battery and the receiver/dimmer. Be sure connections are tight and strong. Hot wires or connections are probably causing problems.

Problem:

Fades are not smooth, channels intermittently black-out for a second or more.

Cause:

The RC4 system depends on RF signals getting from the transmitter to the receivers. An antenna is under the top cover of each 7" x 4" x 2" enclosure -- one at the transmitter, and one in each receiver.

The RC4 system operates in the 2.4Ghz band using Direct Sequence Spread-Spectrum (DSSS) digital radio. Although output power is quite low, high frequency signals bounce easily and receivers are very sensitive. This means that receivers can find good data most of the time.

The system will not work, however, if the tops of the plastic enclosures are blocked with batteries or metal coverings. Signals must be able to get in and out of the top of each box, both at the transmitter and at each receiver.

Solutions:
Make sure the top area of each plastic enclosure is not blocked by batteries or metal obstructions. These block radio signals.
Small clusters of wiring, gridwork, bars across the top of the enclosures, etc. generally DO NOT cause problems. Make sure there is a path for SOME signal to get through and the system should work fine.
Where quasi-line-of-sight is attainable:

1. Position the transmitter tranceiver overhead, above the stage or other area where receivers are positioned. The top of the transceiver should be facing down, towards the receivers.

2. Position receivers facing up, towards the transmitter tranceiver.

Where line-of-site cannot be acheived, or there are numerous obstructions between transmitter and receiver:

1. Position the transmitter transceiver so the top of the box is facing the ceiling above the stage. Signals will bounce back down and flood the stage. Avoid metal obstructions or large harnesses of wiring in the signal path.

2. Position receivers so the top of each box is facing the ceiling of the stage. Reflected signals will bounce directly into the receiver antennas.

The RC4 system is VERY tolerant of signal degradation and electrical noise. Most users have no problems... in fact, at the time of this writing only one radio interference problem has ever been reported with an RC4 system, and the problem was corrected when the transmitter was moved away from an unusually noisy lamp. If you think you're suffering radio interference problems, FIRST be absolutely certain your batteries are good.

Problem:

You only have one RC4 system but you suspect there might be another one operating nearby.

Solution:

RC4 2.4GHz technology automatically scans for other systems and avoids them. No action is required. Up to 15 RC4 systems can operate in the same space without interference.

Reset and Initialize to Factory Defaults

All transmitter internal memories can be cleared to factory defaults by powering on the unit while holding down the **Set DMX Start** and **EXIT** buttons together. The LCD will ask you to confirm, do so by pressing **Right/+/Yes**.

WARNING: This action overwrites all eeprom memory, including DMX Setups and RX Configurations.

RC4 Specifications

RC4 2.4GHz RF Specifications

Indoor/Urban Range:	300’ or more (100 m), 200’ (66 m) typical
Outdoor Line-of-Sight Range:	Up to 1 mile (1.6 km)
Transmit Power Output:	Up to 100 mW (20 dBm) EIRP 1
Receiver Sensitivity:	-100dBm
Operating Frequency:	2.4 GHz band
Agency Approvals:	United States FCC OUR-XBEEPRO Canada IC 4214A XBEEPRO Europe CE ETSI Japan 005NYCA0378

RC4 2.4GHz radios must be factory configured for 10dBm output in Europe, Japan and some other jurisdictions.

RC4-FlexTX Transmitter Specifications

Input Power: World Voltage 85VAC to 265VAC, 47-440Hz
DMX Input: USITT DMX512/1990 (4uSec)
Number of Wireless Control Channels: 4 to 128, user configurable in increments of 4
Analog CV Inputs: 0 – 10V x 8 channels (256-step): CV1 to CV8
0 or 10V x 4 channels (switch): CV9 to CV12
CV input inpedance 20K-ohm

RC4 Dimmer Specifications

RC4-RX4 Standard

Continuous current, per channel: 12.5A (150W at 12V)
Intermittent peak current, per channel: 20A (240W at 12V) [1]
Total current, sum of all channels: 42A (500W at 12V) [1]
Over-Current Protection on Dimmer Outputs: YES
Over-Temperature Protection on Dimmer Outputs: YES
Maximum input voltage: 30V, 12V or 24 typical
Minimum input voltage: 8V
Suitable for inductive loads (motors, solenoids, etc.): YES

RC4-RX4-HO (High Output)

Continuous current, per channel: 21A (250W at 12V)
Intermittent peak current, per channel: 30A (360W at 12V) [1]
Total current, sum of all channels: 83A (1000W at 12V) [1]
Over-Current Protection on Dimmer Outputs: Physical Fusing Only
Over-Temperature Protection on Dimmer Outputs: No
Maximum input voltage: 30V, 12Vor 24V typical
Minimum input voltage: 8V
Suitable for inductive loads (motors, solenoids, etc.): YES

RC4-RX2-MICRO, RC4-RX4-MICRO

Continuous current, per channel: 8.3A (100W at 12V)
Intermittent peak current, per channel: 10A (120W at 12V)
Total current, sum of all channels: 15A (200W at 12V)
Over-Current Protection on Dimmer Outputs: NO
Over-Temperature Protection on Dimmer Outputs: LIMITED
Maximum input voltage: 18V, 12V typical
Minimum input voltage: 6V (electronics will operate down to 5V)
Suitable for inductive loads (motors, solenoids, etc.): LIMITED [2]

RC4-RX4-FD Functional Diversity Motor Control Receiver

Continuous current, per channel: 12.5A (200W at 12V)
Intermittent peak current, per channel: 20A (400W at 12V) [1]
Total current, sum of all channels: 42A (500W at 12V) [1]
Over-Current Protection on Dimmer Outputs: YES
Over-Temperature Protection on Dimmer Outputs: YES
Maximum input voltage: 30V, 12V or 24V typical
Minimum input voltage: 8V
Suitable for inductive loads (motors, solenoids, etc.): YES, both dimmer and motor outputs
Quadrature Rotary Encoder Interface:
- Supply Voltage: 5V, 50mA max.
- Data A/B Input Impedance: 1K-ohm (can be increased, contact technical support)
- Surge Protection: YES

Limit Switch Inputs:
- Supply Voltage: 5V, 50mA max.
- Input Impedance: 1K-ohm (can be increased, contact technical support)
- Surge Protection: YES

Servo Controller Constraints:
- Maximum servo range: 32767 encoder pulses
- Servo Processes: P (proportional), V (velocity), user configurable

[1] Wiring instructions must be closely followed and adequate ventilation must be provided. Individual circuits must each be individually protected with fast-blow fuses.

[2] Can be used with small inductive loads with the addition of an external back-EMF snubber diode.

Specifications subject to change without notice. Soundsculpture assumes no liability or responsibility for safe operation of receivers, dimmers, batteries, wiring, fuses, and/or any other components or materials that may be connected or in proximity. Safe operation of high-current systems is the sole responsibility of the purchaser and/or user.

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