

R400

Digital Hybrid Wireless™ Diversity Receiver



Feature Highlights

- **Digital Hybrid Technology***
- **SmartSquelch™**
- **SmartNR™ noise reduction**
- **SmartDiversity™**
- **256 selectable UHF frequencies**
- **RF-controlled digital noise filters**
- **Low Noise, Robust RF Front End**
- **DSP-based pilot tone**
- **Graphics type backlit LCD display**
- **Balanced XLR audio output**
- **Compatibility modes for use with analog transmitters**

The R400 is a high performance, triple-conversion, frequency synthesized, UHF receiver fully compatible with all Lectrosonics 400 series transmitters, and a number of analog models. The proprietary audio processing includes a DSP (digital signal processor) for very low distortion and a superior signal to noise ratio. The DSP eliminates a compandor and its artifacts to provide exceptional audio quality when operating in its native hybrid mode. Special DSP algorithms also provide compatibility modes for use with Lectrosonics 100 and 200 Series analog transmitters.

The R400 features a powerful menu-driven LCD graphic display operated with a push-button switch and a dual function rotary encoder control as a convenient means of viewing and altering settings. The LCD main window displays the pilot tone indicator, diversity antenna activity, RF and audio levels, operating frequency, transmitter frequency switch settings and transmitter battery status. Settings can be changed using the MENU functions. A built-in RF spectrum analyzer is included to conduct site surveys to find interference-free operating frequencies. The analyzer quickly tunes the receiver across its 256 frequencies and records a marker on the LCD indicating the strength of any RF signals picked up. Within less than a minute, a complete display is generated showing the RF activity across the entire tuning range of the receiver. An area with little or no RF activity is then easy to locate and select.

**US Patent Pending*

TECHNICAL DATA

Digital Hybrid Technology*

The Lectrosonics Digital Hybrid Wireless™ uses a unique blend of technologies to deliver superior performance without some of the compromises inherent in purely digital or purely analog solutions.

Digital Audio Systems

Without question, digital audio systems produce stellar sound quality very inexpensively. Advances in processing speeds and storage media in recent years have made digital techniques the undeniable choice for professional audio applications.

Analog RF Links

While digital audio systems are obviously superior to analog audio systems, RF transmission system designs are challenged by limited bandwidth. Wireless microphone systems operate in designated channels defined by spectral bandwidth. The government in almost every country regulates the channel spacing and a spectral mask limiting the amount of energy that can be transmitted above and below the center of the channel. The transmitted energy must remain inside the spectral mask defined by the government in the country where the wireless system is to operate.

All else being equal, a digitized audio signal occupies a good deal more bandwidth than the original audio signal. The same applies to digital and analog RF signals. A digital transmission over the air requires some combination of additional power, more RF bandwidth and/or compression of the audio data to achieve adequate operating range and keep the energy inside the defined spectral mask. Because of this, digital wireless microphones typically lack the operating range of conventional FM systems.

With regard to using RF power and spectrum efficiently, an analog RF link has many advantages in wireless mic systems, among them long battery life, excellent range, and the ability to use many systems in close proximity without interference.

Putting it all together

An industry first, Lectrosonics Digital Hybrid Wireless™ uses a proprietary algorithm to encode the digital audio information into an analog format which can be transmitted in a robust manner over an analog FM wireless link. At the receiver, the encoded signal is captured and a DSP recovers the original digital audio. This combination offers the superb audio quality of a pure digital system and the outstanding operating range of the finest FM wireless systems. The digital audio chain eliminates a compandor and its artifacts, and provides audio frequency response flat to 20 kHz. The RF link takes advantage of the spectral efficiency characteristics of an aggressively optimized FM radio system.

This digital/analog hybrid technique has some very beneficial properties. Because the information being transmitted is digitally encoded, immunity to noise is much higher than a compandor can offer. Because the encoded audio is sent in analog format, spectral and power efficiency and operating range are not compromised. Under weak RF conditions, the received signal degrades gracefully, like an analog system, delivering as much usable audio as possible at maximum range.

SmartSquelch™

A conventional squelch design faces several compromises.

- Squelch too aggressively and audio may be lost.
- Squelch too little and excessive noise may be heard.
- Respond too rapidly and the audio will sound “choppy.”
- Respond too sluggishly and entire words or syllables can be cut off.

SmartSquelch™ achieves an optimal balance of these trade-offs by combining several techniques that remove distracting noise without the squelching action itself becoming a distraction. The circuitry performs the following functions:

- Wait for a complete word or syllable before squelching.
- Assess recent squelching history and RF signal strength.
- Assess audio content to determine available masking.

By adjusting squelching behavior dynamically for the optimal result under varying conditions, the receiver can deliver acceptable audio quality from otherwise unusable signals.

(Note: In the Pilot Tone Bypass mode, the squelch system is disabled. Received audio remains unmuted at all times with this setting.)

SmartDiversity™

Microprocessor controlled antenna phase combining is used for diversity reception to keep the receiver small, yet still deal effectively with multi-path dropouts. The embedded firmware analyzes RF level and the rate of change of RF level to determine the optimum timing for phase switching, and the optimum antenna phase. This adaptive technique operates over a wide range of RF levels to anticipate dropouts before they occur. The system also employs “opportunistic switching” to analyze and then latch the phase in the best position during brief squelch activity.

SmartNR™

The R400 has been meticulously designed using the best available low noise components and techniques. Nonetheless, the wide dynamic range of Digital Hybrid Technology™, combined with flat response to 20 kHz, makes it possible to hear the -120 dBV noise floor in the mic preamp, or the (usually) greater noise from the microphone itself. (To put this in perspective, the noise generated by the recommended 4 k bias resistor of many electret lavalier mics is -119 dBV and the noise level of the microphone’s electronics is much higher.) In order to reduce this noise and thus increase the effective dynamic range of the system, the R400 is equipped with a Smart Noise Reduction algorithm, which removes hiss without sacrificing high frequency response. The Smart Noise Reduction (SmartNR™) algorithm works by attenuating only those portions of the audio signal that fit a statistical profile for randomness or “electronic hiss.” SmartNR™ offers significantly increased transparency over the sophisticated variable low pass filters used in previous designs. Desired high frequency signals having some coherence such as speech sibilance and tones are not affected.

The SmartNR™ algorithm has three modes, selectable from a user setup screen. When switched **OFF**, no noise reduction is performed. When switched to **NORMAL (default)**, enough noise reduction is applied to remove most of the hiss from the mic preamp and some of the hiss from lavalier microphones. When switched to **FULL**, enough noise reduction is applied to remove most of the hiss from nearly any signal source of reasonable quality, assuming levels are set properly at the transmitter.

RF-Controlled Digital Noise Filter

In addition to SmartNR, the R400 contains an RF sensitive variable frequency filter, which reduces high frequency response under extremely weak RF conditions. This filter does nothing until the RF signal strength drops below 3 uV at which point it begins to roll off high frequencies. Usable audio remains unaffected, but noise-ups or “hits” occurring near the fringe of reception sound much less harsh.

Compatibility Modes

The R400 receiver was designed to operate with Lectrosonics 400 Series transmitters and will yield the best performance when doing so. However, thanks to the flexibility of digital signal processing, the R400 is also able to operate with Lectrosonics 200 Series, Lectrosonics 100 Series and certain non-Lectrosonics transmitters in special compatibility modes.

DSP-based Pilot Tone

The 400 Series system design uses a DSP generated ultrasonic pilot tone to control the receiver audio muting (squelch). By sensing the pilot tone and incorporating brief delays when a transmitter is turned on or off, thumps, pops or other transients that can occur when the transmitter is powered up or down are successfully eliminated. The pilot tone frequency is different for each of the 256 frequencies in the tuning range of a system (frequency block). This eliminates squelch problems in multi-channel systems where a pilot tone signal can appear in the wrong receiver via intermodulation products. Using the DSP to detect the pilot tone also eliminates the need for fragile crystals allowing the receiver to survive shocks and mishandling much better than older analog-based pilot tone systems.

Low Noise, High Gain RF Front End

The receiver is frequency agile and can be set to operate on any one of 256 frequencies within its tuning range. The R400 front end uses two tuned HI-Q ceramic transmission line resonators, a low noise high current RF amplifier and a first mixer using new GaAs technology that has a very high third order intercept point. The result is significantly reduced interference and intermodulation problems, increased stability and the precise gain needed to handle stronger RF signals without output overload. In short, the R400 has a robust front-end that is as selective as fixed single frequency designs with the added feature of extremely low susceptibility to intermodulation interference.

Microprocessor Controlled PLL and VCO

An 8-bit microprocessor monitors user command inputs from the front panel control buttons and numerous other internal signals such as RF level, audio levels, pilot tone levels and external power voltages. The microprocessor also drives the LCD display, controls the squelch and audio output attenuator, and operates the PLL/VCO circuits and the antenna phase switch. Innovative design and advanced microprocessor controlled technology arguably set the 400 Series as the new standard in wireless development.

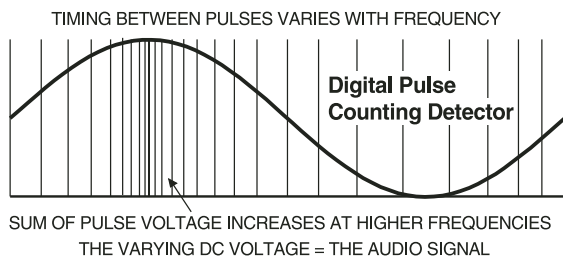
Surface Acoustic Wave (SAW) Filter

SAW filters in the first IF section operating at 244 MHz combine sharp skirts, constant group delay, and wide bandwidth in one filter. These quartz filters offer excellent temperature stability, far superior to conventional LC filters. The filters allow primary filtering as early as possible, at as high a frequency as possible and before high gain is applied to the signal. After the sharp

filtering action of the SAW filters, the signal is converted to the second IF at 10.7 MHz, then finally to the third IF at the low frequency of 300 kHz, where the counting detector generates the audio signal.

Digital Pulse Counting Detector

An advanced digital pulse counting detector is used to demodulate the FM signal at 300 kHz. This eliminates the thermal drift common in conventional quadrature type of detectors, plus it provides additional AM rejection. A stream of precision pulses is generated at 300 kHz and locked to the FM signal coming from the third IF section. The pulse width is constant but the timing between pulses varies with the frequency shift of the FM signal. The integrated voltage of the pulses in a given time interval within the waveform varies in direct proportion to the frequency modulation of the radio signal. Closely spaced pulses produce a higher voltage and widely spaced pulses a lower voltage. The resultant varying DC voltage is the audio signal. (See diagram below.)



Rear Panel Features

A standard XLR balanced audio output jack is provided configured with pin 2 “positive” with reference to hand-held and plug-on transmitters. With lavalier microphones and belt-pack transmitters, however, phase will vary with different types of microphones (2-wire vs. 3-wire for example). The audio output is balanced but not floating, so an unbalanced signal is available using pin 1 as ground and pin 2 as signal, leaving pin 3 open.



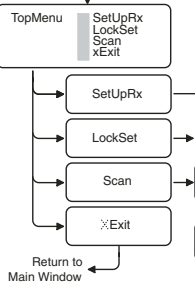
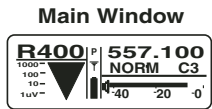
Also featured are a power input jack that can accept 8-18 VDC (center pin positive), and two antenna inputs. The power jack input is diode protected to prevent damage if the power is applied with reversed polarity.

The receiver is supplied with two UHF antennas with right angle BNC connectors.

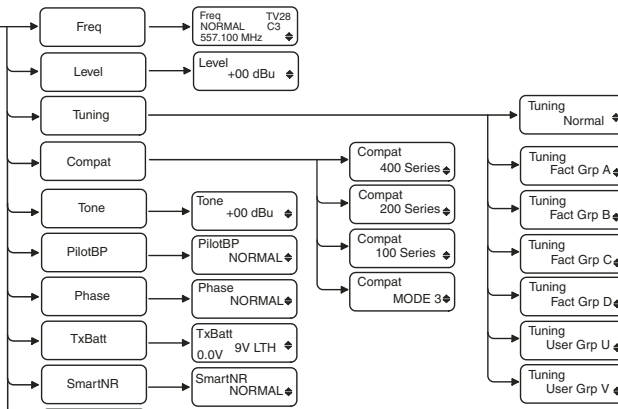
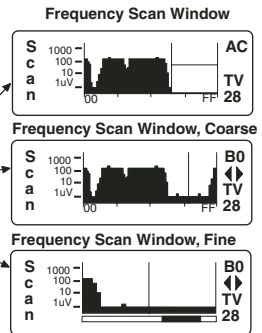
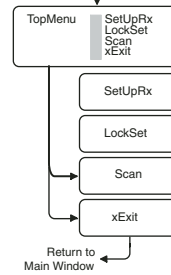
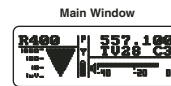
Backlit LCD Graphics Display

The LCD graphics displays a Main window after the completion of the Power On sequence. A series of setup and operational menus are accessed from this window.

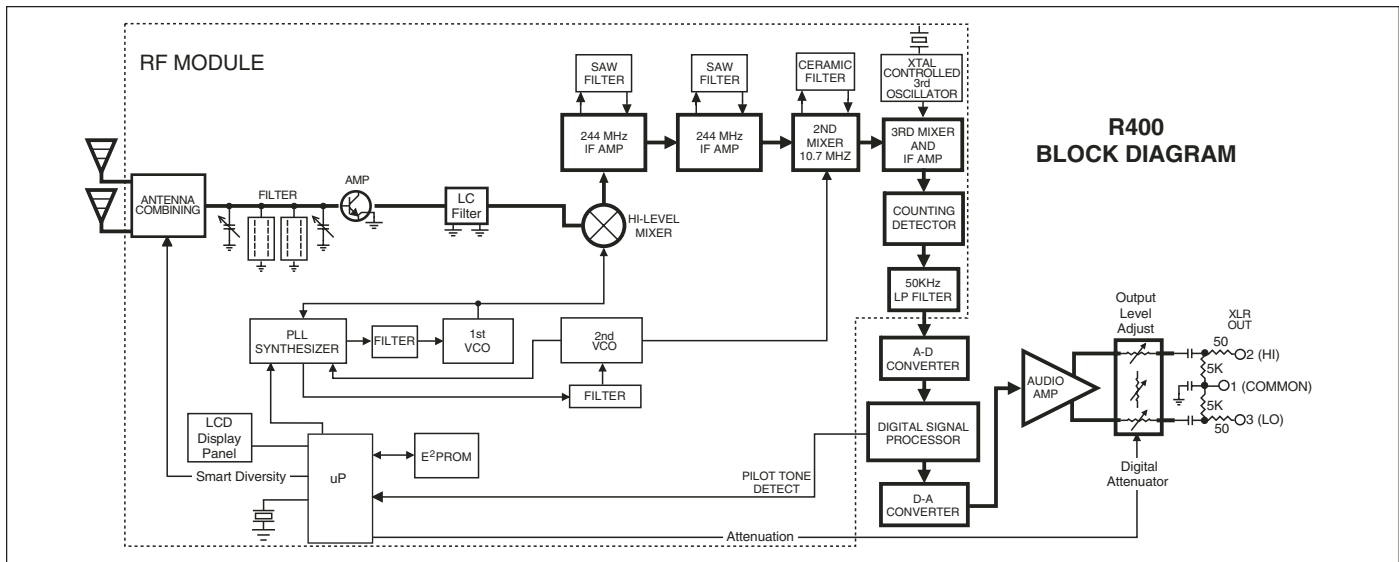
The Main window displays the RF frequency, channel and switch settings, plus a Pilot Tone Indicator, Antenna Phase Indicators, RF level, audio level, transmitter battery status (400 and 200 Series only) and transmitter battery timer. Pressing the PUSH FOR MENU/ROTATE TO SELECT control opens the TopMenu. Alternately rotating and pushing the PUSH FOR MENU/ROTATE TO SELECT control allows users to navigate the operating modes and adjust settings accordingly.



The examples illustrate the Main window and the actions required to display the built-in spectrum analyzer used to identify and select open frequencies.



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Specifications

Operating Frequencies (MHz):

Block 21: 537.600 - 563.100	Block 26: 665.600 - 691.100
Block 22: 563.200 - 588.700	Block 27: 691.200 - 716.700
Block 23: 588.800 - 607.900	Block 28: 716.800 - 742.300
614.100 - 614.300	Block 29: 742.400 - 767.900
Block 24: 614.400 - 639.900	Block 944: 944.100 - 951.900
Block 25: 640.000 - 665.500	

Frequency Adjustment Range: 25.5 MHz in 100 kHz steps

Receiver Type: Triple conversion; superheterodyne

IF frequencies: 244 MHz, 10.7 MHz and 300 kHz

Frequency Stability: $\pm 0.001\%$

Front end bandwidth: ± 30 MHz, @ -3dB

Sensitivity:

20 dB Sinad: 1 μ V (-107 dBm), A weighted

60 dB Quieting: 1.5 μ V (-104 dBm), A weighted

Squelch Quieting: > 100 dB

AM rejection: >60 dB, 2 μ V to 1 Volt

(Undetectable after processing)

Modulation acceptance: 85 kHz

Image and spurious rejection: 85 dB

Third order intercept: 0 dBm

Diversity method: Phased antenna combining (SmartDiversity™)

FM Detector: Digital pulse counting detector operating at 300 kHz

Antenna inputs: Dual BNC female jacks; 50 Ohm impedance

Audio output: Rear panel XLR connector; adjustable from -50 to +5 dBu in 1dB steps (into nominal 10k bal. load). Can drive 600 ohm load

Audio Performance:

(These audio performance specs apply only to 400 Series compatibility mode.)

Frequency Response: 70 Hz to 20 kHz (+/-1dB) when used with the LM transmitter. System frequency response will vary depending on transmitter used

THD: 0.2% (typical)

SNR at receiver output (dB):

SmartNR	No Limiting	w/Limiting
OFF	103.5	108.0
NORMAL	107.0	111.5
FULL	108.5	113.0

Input Dynamic Range: 125 dB (with full Tx limiting)

Audio Test Tone: 1 kHz, -50 to +5 dBu, <1%THD

Front Panel Controls and Indicators:

Menu/Select knob: Push for menu selection. Rotate to adjust settings

Power/Prev Menu Button: Momentary press for Power On, or, if power is already applied, momentary press to return to previous menu
Press and hold for several seconds to power off unit

LCD Display:

Power On: Displays power on sequence consisting of firmware version and current frequency tuning block range

Main Window: Displays RF frequency, pilot tone status, antenna phase, RF level, audio output level, transmitter battery status (400 and 200 Series only) and battery timer

Setup Menus: Displays set up information according to menu selected

Rear Panel Features:

XLR audio output jack

External DC input

BNC antenna connectors

External Power:

8 VDC min. to 18 VDC max., 1.6 W; 200 mA max.

Weight:

13.0 oz.

Dimensions:

5.50" w x 1.75" h x 4.75" d (6.25" deep including knob and connectors)

14 cm w x 4.5 cm h x 12 cm d (16 cm deep including knob and connectors)

R400-0604



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Specifications subject to change without notice