



# HIGH-PERFORMANCE RF MODULE TXM-900-HP3-xxx



## HP3 SERIES TRANSMITTER MODULE DATA GUIDE DESCRIPTION

The HP3 RF transmitter module is the third generation of the popular HP Series. Like its predecessors, the HP3 is designed for the cost-effective, high-performance wireless transfer of analog or digital information in the popular 902-928MHz band. HP3 Series parts feature eight parallel selectable channels, and some versions also add direct serial selection of 100 channels. To ensure reliable performance, the transmitter employs FM / FSK modulation and a micro-processor controlled synthesized architecture. Both SMD and pinned packages are available. When paired with an HP3 receiver, a reliable link is created for the transfer of analog and digital information up to 1,000 feet. As with all Linx modules, the HP3 requires no tuning or additional RF components (except an antenna), making integration straightforward, even for engineers without prior RF experience.

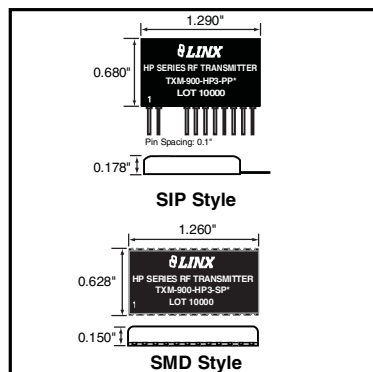


Figure 1: Package Dimensions

## FEATURES

- 8 parallel, 100 serial (PS Versions) user-selectable channels
- FM / FSK modulation for outstanding performance and noise immunity
- Precision frequency synthesized architecture
- Transparent analog / digital interface
- Wide-range analog capability including audio (50Hz to 28kHz)
- Wide temperature range (-30°C to +85°C)
- No external RF components required
- Compatible with previous HP Series modules
- Power-down and CTS functions
- Wide supply range (2.8 to 13.0VDC)
- High data rate (up to 56kbps)
- Pinned and SMD packages
- No production tuning

## APPLICATIONS INCLUDE

- Wireless Networks / Data Transfer
- Wireless Analog / Audio
- Home / Industrial Automation
- Remote Access / Control
- Remote Monitoring / Telemetry
- Long-Range RFID
- MIDI Links
- Voice / Music / Intercom Links

## ORDERING INFORMATION

PART #	DESCRIPTION
TXM-900-HP3-PPO	HP3 Transmitter (SIP 8 CH only)
TXM-900-HP3-PPS	HP3 Transmitter (SIP 8p / 100s CH)
TXM-900-HP3-SPO	HP3 Transmitter (SMD 8 CH only)
TXM-900-HP3-SPS	HP3 Transmitter (SMD 8p / 100s CH)
MDEV-900-HP3-PPS-USB	HP3 Development Kit (SIP Pkg.)
MDEV-900-HP3-PPS-RS232	HP3 Development Kit (SIP Pkg.)
MDEV-900-HP3-SPS-USB	HP3 Development Kit (SMD Pkg.)
MDEV-900-HP3-SPS-RS232	HP3 Development Kit (SMD Pkg.)

Transmitters are supplied in tubes of 15 pcs.

## ELECTRICAL SPECIFICATIONS

Parameter	Designation	Min.	Typical	Max.	Units	Notes
<b>POWER SUPPLY</b>						
Operating Voltage	$V_{CC}$	2.8	3.0	13.0	VDC	–
Supply Current	$I_{CC}$	–	14.0	17.0	mA	1
Power-Down Current	$I_{PDN}$	–	–	15.0	$\mu$ A	2
<b>TRANSMIT SECTION</b>						
Transmit Frequency Range	$F_C$	902.62	–	927.62	MHz	3
Center Frequency Accuracy	–	-50	–	+50	kHz	–
Available Channels	–	8 (Par.)	–	100 (Ser.)	–	4
Channel Spacing	–	–	250	–	kHz	–
Occupied Bandwidth	–	–	115	140	kHz	–
Output Power	$P_O$	-3	0	+3	dBm	5
Spurious Emissions	–	–	-45	–	dBm	6
Harmonic Emissions	$P_H$	–	-60	-47	dBm	6
Data Rate	–	100	–	56,000	bps	7
Analog / Audio Bandwidth	–	50	–	28,000	Hz	7
Data Input:						
Logic Low	–	0.0	–	0.5	VDC	–
Logic High	–	2.8	–	5.2	VDC	–
Data Input Impedance	–	–	200	–	$k\Omega$	–
Frequency Deviation @ 3VDC	–	60	70	110	kHz	8
Frequency Deviation @ 5VDC	–	90	115	140	kHz	8
<b>ANTENNA PORT</b>						
RF Output Impedance	$R_{OUT}$	–	50	–	$\Omega$	–
<b>TIMING</b>						
Transmitter Turn-On Time	–	–	7.0	10.0	mSec	–
Channel Change Time	–	–	1.0	1.5	mSec	–
<b>ENVIRONMENTAL</b>						
Operating Temperature Range	–	-30	–	+85	$^{\circ}$ C	–

Table 1: HP3 Series Transmitter Specifications

### Notes

- Over the entire operating voltage range.
- With the PDN pin low.
- Serial Mode.
- 100 serial channels on the PS versions only.
- Does not change over the 3-13VDC supply.
- Into 50 ohms.
- The receiver will not reliably hold a DC level. See the HP3 Series Receiver Module Data Guide for the minimum transition rate.
- The voltage specified is the modulation pin voltage.

### \*CAUTION\*

This product incorporates numerous static-sensitive components. Always wear an ESD wrist strap and observe proper ESD handling procedures when working with this device. Failure to observe this precaution may result in module damage or failure.

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage $V_{CC}$	-0.3	to	+18.0	VDC
Any Input or Output Pin	-0.3	to	$V_{CC}$	VDC
Operating Temperature	-30	to	+85	$^{\circ}$ C
Storage Temperature	-45	to	+85	$^{\circ}$ C
Soldering Temperature	+260 $^{\circ}$ C for 10 seconds			

**\*NOTE\*** Exceeding any of the limits of this section may lead to permanent damage to the device. Furthermore, extended operation at these maximum ratings may reduce the life of this device.

## PERFORMANCE DATA

These performance parameters are based on module operation at 25 $^{\circ}$ C from a 5.0VDC supply unless otherwise noted. Figure 2 illustrates the connections necessary for testing and operation. It is recommended all ground pins be connected to the ground plane. The pins marked NC have no electrical connection.

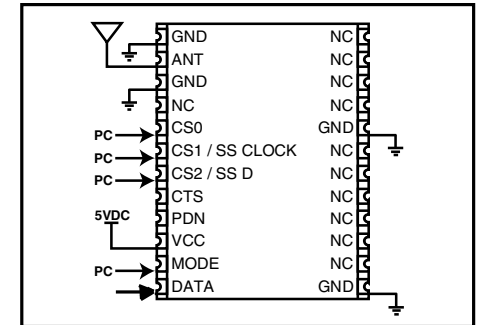


Figure 2: Test / Basic Application Circuit

## TYPICAL PERFORMANCE GRAPHS

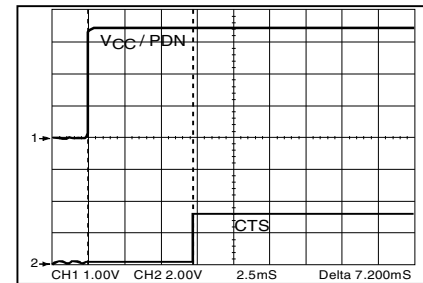


Figure 3: Power-up to CTS

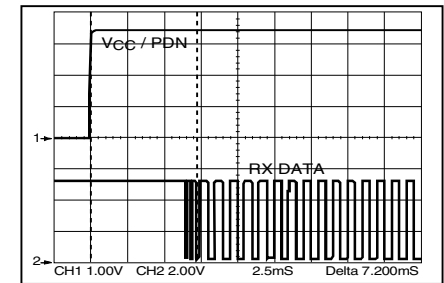


Figure 4: TX Power-up to Valid RX Data

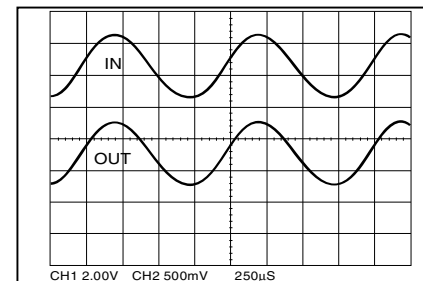


Figure 5: Sine Wave Modulation Linearity

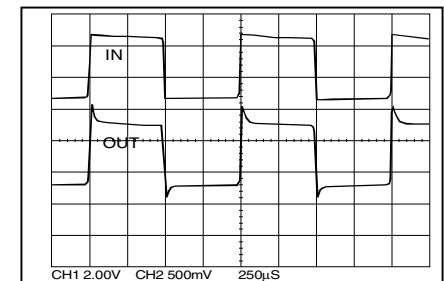


Figure 6: Square Wave Modulation Linearity

# PIN ASSIGNMENTS

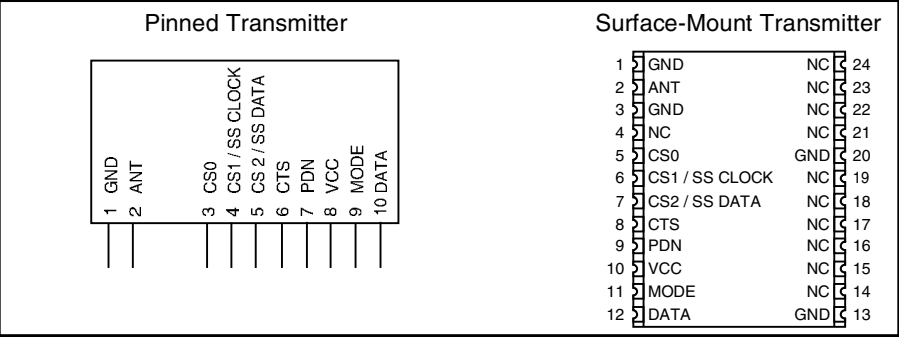


Figure 7: HP3 Series Receiver Pinout

Pin #		Name	Description
SMD	SIP		
1	1	GND	Analog Ground
2	2	ANT	50-ohm RF Output
3		GND	Analog Ground (SMD only)
4		NC	No Electrical Connection. Soldered for physical support only.
5	3	CS0	Channel Select 0
6	4	CS1 / SS CLOCK	Channel Select 1 / Serial Select Clock. Channel Select 1 when in parallel channel selection mode, clock input for serial channel selection mode.
7	5	CS2 / SS DATA	Channel Select 2 / Serial Select Data. Channel Select 2 when in parallel channel selection mode, data input for serial channel selection mode.
8	6	CTS	Clear-To-Send. This line will go high when the transmitter is ready to accept data.
9	7	PDN	Power Down. Pulling this line low will place the transmitter into a low-current state. The module will not be able to transmit a signal in this state.
10	8	V <sub>CC</sub>	Supply Voltage
11	9	MODE	Mode Select. GND for parallel channel selection, V <sub>CC</sub> for serial channel selection
12	10	DATA	Digital / Analog Data Input. This line will input the modulated digital data or analog signal.
13, 20		GND	Analog Ground (SMD only)
14-19, 21-24		NC	No Electrical Connection. Soldered for physical support only. (SMD only)

# PIN DESCRIPTIONS

Pin #		Name	Equivalent Circuit	Description
SMD	Pinned			
1, 3, 13, 20	1	GND		Analog Ground
2	2	ANT		50-ohm RF Output
5	3	CS0		Channel Select 0
6	4	CS1 / SS CLOCK		Channel Select 1 / Serial Select Clock
7	5	CS2 / SS DATA		Channel Select 2 / Serial Select Data
8	6	CTS		Clear-to-Send Output
9	7	PDN		Power Down (Active Low)
10	8	V <sub>CC</sub>		Voltage Input 2.8-13V
11	9	MODE		Mode Select
12	10	DATA		Digital / Analog Input
4, 14-19, 21-24		NC	SMD (Only)	No Electrical Connection

Figure 8: Pin Functions and Equivalent Circuits



## ADJUSTING THE OUTPUT POWER

Depending on the type of antenna being used, the output power of the transmitter may be higher than FCC regulations allow. It is intentionally set high to compensate for losses resulting from inefficient antennas. Since attenuation is often required, it is generally wise to provide for its implementation so that the FCC test lab can easily attenuate the transmitter to the maximum legal limit.

A T-pad is a network of three resistors that allows for variable attenuation while maintaining the correct match to the antenna. An example layout is shown in the adjacent figure. For more details on T-pad attenuators, please see Application Note AN-00150.

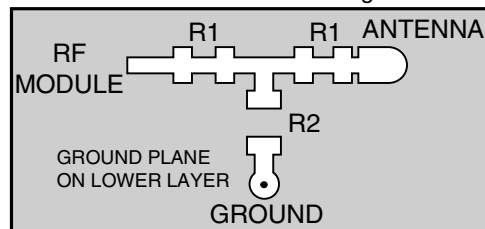


Figure 12: T-Pad Attenuator Example Layout

## INPUTTING DIGITAL DATA

The DATA line may be directly connected to virtually any digital peripheral, including microcontrollers, encoders, and UARTs. It has an impedance of 200k $\Omega$  and can be used with any data that transitions from 0V to a 3 to 5V peak amplitude within the specified data rate of the module. While it is possible to send data at higher rates, the internal filter will cause severe roll off and attenuation.

Many RF products require a fixed data rate or place tight constraints on the mark / space ratio of the data being sent. The HP3 transmitter architecture eliminates such considerations and allows virtually any signal, including PWM, Manchester, and NRZ data, to be sent at rates from 100bps to 56kbps.

The HP3 does not encode or packetize the data in any manner. This transparency gives the designer great freedom in software and protocol development. A designer may also find creative ways to utilize the ability of the transmitter to accept both digital and analog signals. For example, an application might transmit voice, then send out a digital control command. Such mixed mode systems can greatly enhance the function and versatility of many products.

## INPUTTING ANALOG SIGNALS

Analog signals from 50Hz to 28kHz may be connected directly to the transmitter's DATA line. The HP3 is a single supply device and, as such, is not capable of operating in the negative voltage range. Analog sources should be within 0 to 5V<sub>P-P</sub> and should, in most cases, be AC-coupled into the DATA line to achieve the best performance. The size of the coupling capacitor should be large enough to ensure the passage of all desired frequencies and small enough to allow the start-up time desired. Since the modulation voltage applied to the DATA line determines the carrier deviation, distortion can occur if the DATA line is over-driven. The actual level of the input waveform should be adjusted to achieve optimum in-circuit results for your application.

The HP3 is capable of providing audio quality comparable to a radio or intercom. In applications where higher quality audio is required, a compandor may be employed to increase dynamic range and reduce noise. If true high-fidelity audio is required, the HP3 is probably not the best choice, as it is optimized for data.

## TIMING CONSIDERATIONS

Timing plays a key role in link reliability, especially when the modules are being rapidly turned on and off or hopping channels. Unlike a wire, allowance must be made for the programming and settling times of both the transmitter and receiver, or portions of the signal will be lost. There are two major timing considerations the engineer must consider when designing with the HP3 Series transmitter. These are shown in the table below. The stated timing parameters assume a stable supply of 2.8 volts or greater. They do not include the charging times of external capacitance on the module's supply lines, the overhead of external software execution, or power supply rise times.

Parameter	Description	Max.
T1	Transmitter turn-on time	10.0mS
T2	Channel change time (time to valid data)	1.5mS

T1 is the maximum time required for the transmitter to power-up and lock on-channel. This time is measured from the application of V<sub>CC</sub> to the CTS line transitioning high.

T2 is the worst-case time needed for a powered-up module to switch between channels after a valid channel selection. This time does not include external overhead for loading a desired channel in Serial Channel Select Mode.

Normally, the transmitter will be turned off after each transmission. This is courteous use of the airwaves and reduces power consumption. The transmitter may be shut down by switching its supply or the PDN line. When the transmitter is again powered up, allowance must be made for the requirements above.

In many cases, the transmitter will lock more quickly than the times indicated. When turn-around time or power consumption are critical, the CTS line can be monitored so data may be sent immediately upon transmitter readiness.

## TRANSMITTING DATA

Once an RF link has been established, the challenge becomes how to effectively transfer data across it. While a properly designed RF link provides reliable data transfer under most conditions, there are still distinct differences from a wired link that must be addressed. Since the modules do not incorporate internal encoding or decoding, the user has tremendous flexibility in how data is handled.

It is important to separate the types of transmissions that are technically possible from those that are legally allowed in the country of operation. Application Notes AN-00126, AN-00140 and Part 15, Section 249 of the FCC rules should be reviewed for details on acceptable transmission content in the U.S.

If you want to transfer simple control or status signals (such as button presses) and your product does not have a microprocessor or you wish to avoid protocol development, consider using an encoder / decoder IC set. These chips are available from several manufacturers, including Linx. They take care of all encoding and decoding functions and provide a number of data lines to which switches can be directly connected. Address bits are usually provided for security and to allow the addressing of multiple receivers independently. These ICs are an excellent way to bring basic remote control products to market quickly and inexpensively. It is also a simple task to interface with inexpensive microprocessors or one of many IR, remote control, DTMF, or modem ICs.

## CHANNEL SELECTION

### Parallel Selection

All HP3 transmitter models feature eight parallel selectable channels. Parallel Mode is selected by grounding the MODE line. In this mode, channel selection is determined by the logic states of pins CS0, CS1, and CS2, as shown in the table.

CS2	CS1	CS0	Channel	Frequency
0	0	0	0	903.37
0	0	1	1	906.37
0	1	0	2	907.87
0	1	1	3	909.37
1	0	0	4	912.37
1	0	1	5	915.37
1	1	0	6	919.87
1	1	1	7	921.37

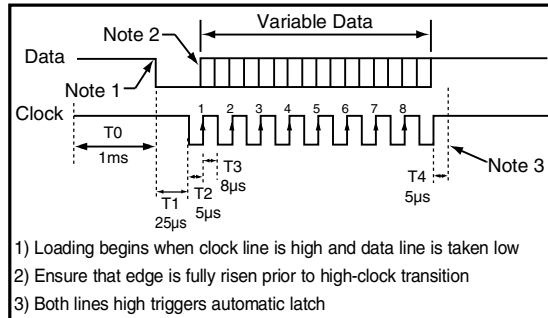
Table 2: Parallel Channel Selection Table

A '0' represents ground and a '1' the supply. The on-board microprocessor performs all PLL loading functions, eliminating external programming and allowing channel selection via DIP switches or a product's processor.

### Serial Selection

In addition to the Parallel Mode, PS versions of the HP3 also feature 100 serially selectable channels. The Serial Mode is entered when the MODE line is left open or held high. In this condition, CS1 and CS2 become a synchronous serial port, with CS1 serving as the clock line and CS2 as the data line. The module is easily programmed by sending and latching the binary number (0 to 100) of the desired channel (see the adjacent Serial Channel Selection Table). With no additional effort, the module's microprocessor handles the complex PLL loading functions.

The Serial Mode is straightforward; however, minimum timings and bit order must be followed. Loading is initiated by taking the clock line high and the data line low as shown. The eight-bit channel number is then clocked-in one bit at a time, with the LSB first.



(T0) Time between packets or prior to data startup .....	1mS min.
(T1) Data-LO / Clock-HI to Data-LO / Clock-LO .....	25µS min.
(T2) Clock-LO to Clock-HI .....	5µS min.
(T3) Clock-HI to Clock-LO .....	8µS min.
(T4) Data-HI / Clock-HI .....	5µS min.
Total Packet Time .....	157µS min.

Figure 13: PLL Serial Data Timing

There is no maximum time for this process, only the minimum times that must be observed. After the eighth bit, both the clock and data lines should be taken high to trigger the automatic data latch. A typical software routine can complete the loading sequence in under 200µS. Sample code is available on the Linx website.

NOTE: When the module is powered up in the Serial Mode, it will default to channel 50 until changed by user software. This allows testing apart from external programming and prevents out-of-band operation. When programmed properly, the dwell time on this default channel can be less than 200µS. Channel 50 is not counted as a usable channel since data errors may occur as transmitters also default to channel 50 on startup. If a loading error occurs, such as a channel number >100 or a timing problem, the receiver will default to serial channel 0. This is useful for debugging as it verifies serial port activity.

## SERIAL CHANNEL SELECTION TABLE

CHANNEL	TX FREQUENCY	RX LO	CHANNEL	TX FREQUENCY	RX LO
0	902.62	867.92	51	915.37	880.67
1	902.87	868.17	52	915.62	880.92
2	903.12	868.42	53	915.87	881.17
3	903.37	868.67	54	916.12	881.42
4	903.62	868.92	55	916.37	881.67
5	903.87	869.17	56	916.62	881.92
6	904.12	869.42	57	916.87	882.17
7	904.37	869.67	58	917.12	882.42
8	904.62	869.92	59	917.37	882.67
9	904.87	870.17	60	917.62	882.92
10	905.12	870.42	61	917.87	883.17
11	905.37	870.67	62	918.12	883.42
12	905.62	870.92	63	918.37	883.67
13	905.87	871.17	64	918.62	883.92
14	906.12	871.42	65	918.87	884.17
15	906.37	871.67	66	919.12	884.42
16	906.62	871.92	67	919.37	884.67
17	906.87	872.17	68	919.62	884.92
18	907.12	872.42	69	919.87	885.17
19	907.37	872.67	70	920.12	885.42
20	907.62	872.92	71	920.37	885.67
21	907.87	873.17	72	920.62	885.92
22	908.12	873.42	73	920.87	886.17
23	908.37	873.67	74	921.12	886.42
24	908.62	873.92	75	921.37	886.67
25	908.87	874.17	76	921.62	886.92
26	909.12	874.42	77	921.87	887.17
27	909.37	874.67	78	922.12	887.42
28	909.62	874.92	79	922.37	887.67
29	909.87	875.17	80	922.62	887.92
30	910.12	875.42	81	922.87	888.17
31	910.37	875.67	82	923.12	888.42
32	910.62	875.92	83	923.37	888.67
33	910.87	876.17	84	923.62	888.92
34	911.12	876.42	85	923.87	889.17
35	911.37	876.67	86	924.12	889.42
36	911.62	876.92	87	924.37	889.67
37	911.87	877.17	88	924.62	889.92
38	912.12	877.42	89	924.87	890.17
39	912.37	877.67	90	925.12	890.42
40	912.62	877.92	91	925.37	890.67
41	912.87	878.17	92	925.62	890.92
42	913.12	878.42	93	925.87	891.17
43	913.37	878.67	94	926.12	891.42
44	913.62	878.92	95	926.37	891.67
45	913.87	879.17	96	926.62	891.92
46	914.12	879.42	97	926.87	892.17
47	914.37	879.67	98	927.12	892.42
48	914.62	879.92	99	927.37	892.67
49	914.87	880.17	100	927.62	892.92
50*	915.12	880.42			

= Also available in Parallel Mode

\*See NOTE on previous page.

## PROTOCOL GUIDELINES

While many RF solutions impose data formatting and balancing requirements, Linx RF modules do not encode or packetize the signal content in any manner. The received signal will be affected by such factors as noise, edge jitter, and interference, but it is not purposefully manipulated or altered by the modules. This gives the designer tremendous flexibility for protocol design and interface.

Despite this transparency and ease of use, it must be recognized that there are distinct differences between a wired and a wireless environment. Issues such as interference and contention must be understood and allowed for in the design process. To learn more about protocol considerations, we suggest you read Linx Application Note AN-00160.

Errors from interference or changing signal conditions can cause corruption of the data packet, so it is generally wise to structure the data being sent into small packets. This allows errors to be managed without affecting large amounts of data. A simple checksum or CRC could be used for basic error detection. Once an error is detected, the protocol designer may wish to simply discard the corrupt data or implement a more sophisticated scheme to correct it.

## INTERFERENCE CONSIDERATIONS

The RF spectrum is crowded and the potential for conflict with other unwanted sources of RF is very real. While all RF products are at risk from interference, its effects can be minimized by better understanding its characteristics.

Interference may come from internal or external sources. The first step is to eliminate interference from noise sources on the board. This means paying careful attention to layout, grounding, filtering, and bypassing in order to eliminate all radiated and conducted interference paths. For many products, this is straightforward; however, products containing components such as switching power supplies, motors, crystals, and other potential sources of noise must be approached with care. Comparing your own design with a Linx evaluation board can help to determine if and at what level design-specific interference is present.

External interference can manifest itself in a variety of ways. Low-level interference will produce noise and hashing on the output and reduce the link's overall range.

High-level interference is caused by nearby products sharing the same frequency or from near-band high-power devices. It can even come from your own products if more than one transmitter is active in the same area. It is important to remember that only one transmitter at a time can occupy a frequency, regardless of the coding of the transmitted signal. This type of interference is less common than those mentioned previously, but in severe cases it can prevent all useful function of the affected device.

Although technically it is not interference, multipath is also a factor to be understood. Multipath is a term used to refer to the signal cancellation effects that occur when RF waves arrive at the receiver in different phase relationships. This effect is a particularly significant factor in interior environments where objects provide many different signal reflection paths. Multipath cancellation results in lowered signal levels at the receiver and, thus, shorter useful distances for the link.

## TYPICAL APPLICATIONS

The figure below shows a typical RS-232 circuit using the HP3 Series transmitter and a Maxim MAX232. The MAX232 converts RS-232 compliant signals to a serial data stream, which the transmitter then sends. The MODE line is grounded, so the channels are selected by the DIP switches.

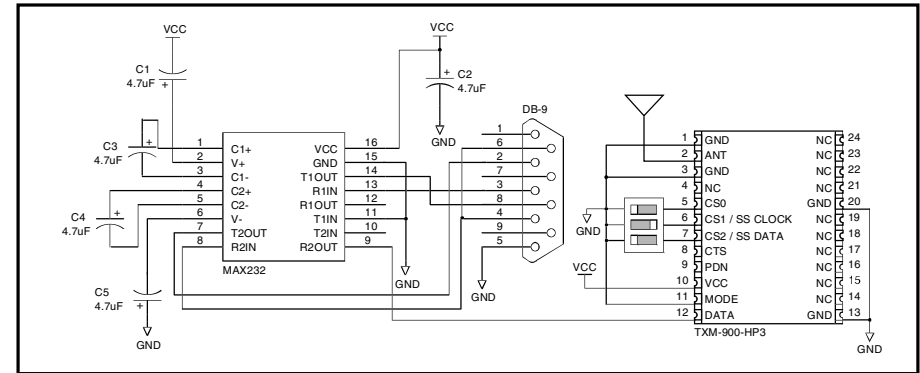


Figure 14: HP3 Transmitter and MAX232 IC

The figure below shows a circuit using the QS Series USB module. The QS converts USB compliant signals from a PC to serial data to be sent to the transmitter. The MODE line is high, so the module is in Serial Channel Select Mode. The RTS and DTR lines are used to load the channels. Application Note AN-00155 shows sample source code that can be adapted to use on a PC. The QS Series Data Guide and Application Note AN-00200 discuss the hardware and software set-up required for QS Series modules.

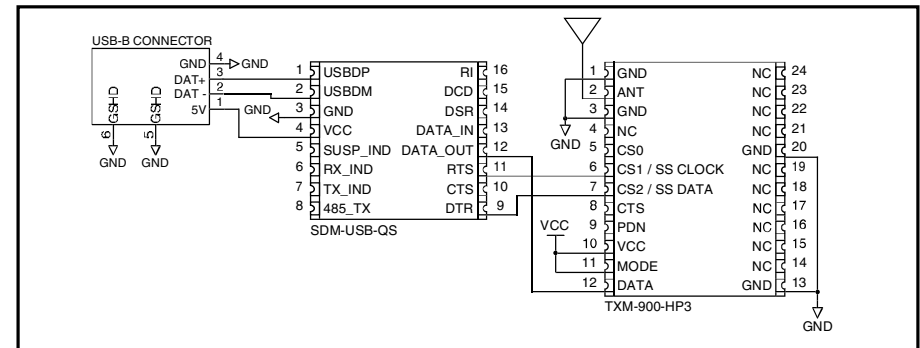


Figure 15: HP3 Transmitter and Linx QS Series USB Module

The transmitter can also be connected to a microcontroller, which will generate the data based on specific actions. A UART may be employed or an I / O line may be "bit banded" to send the data to the transmitter. The transmitter may be connected directly to the microcontroller without the need for buffering or amplification.