RS data

Remote control i.c.'s

A range of remote control i.c.'s consisting of one transmitter (308-073), an infra-red pre-amplifier (301-527) and five receivers, (303-826, 308-089, 309-981, 309-997 and 305-248) with individual characteristics to suit many control requirements.

The system is based on the transmission of coded P.P.M. (Pulse Position Modulation) signals over a wide variety of transmission media e.g. sound, ultrasonics, infra-red, fibre optics, cable links. Provision is made for carrier frequency generation where required to suit the medium employed. Processing of the received P.P.M. signal is performed by a discrete amplifier or for infra-red an i.c. is available. The restored signal is passed to one, or a combination, of the five receiver i.c.'s where an error checking system inspects the P.P.M. data before activating the appropriate output. The output functions available include parallel 4-bit binary, in either latched or momentary forms, analogue output controls and discrete outputs.

The ability of one transmitter to control a combination of different receivers enables this system to satisfy the majority of remote control applications including sound systems, light displays, machine control, security devices etc.

Printed circuit boards to suit an infra-red link are available (434-807/813/835/891).

Remote control transmitter RS490 (308-073)

The RS490 is a remote control transmitter i.c. which produces a binary coded pulse position modulated (P.P.M.) waveform. The code generated is dependent on the operation of any one single pole switch from a matrix of up to 32 switches and the device will produce a corresponding number of different P.P.M. codewords.

A feature of the i.c. is its ability to generate, if required, a carrier frequency over the range 0 to 200kHz which may be subsequently modulated by the P.P.M. codeword, thereby enabling modulated carriers to be directly produced. The P.P.M. rate can also be adjusted over a wide range to suit transducer response times.

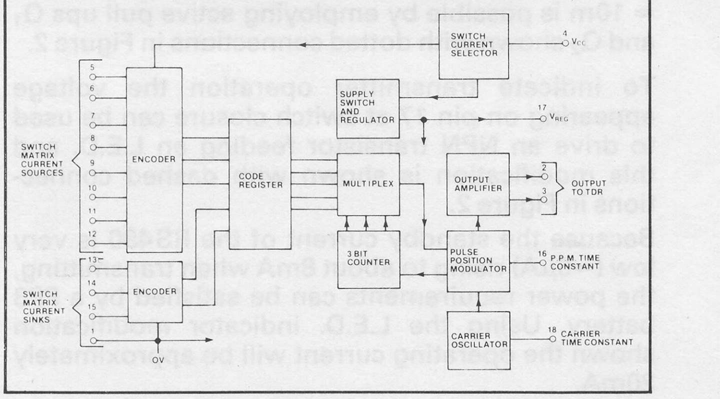
Absolute maximum ratings

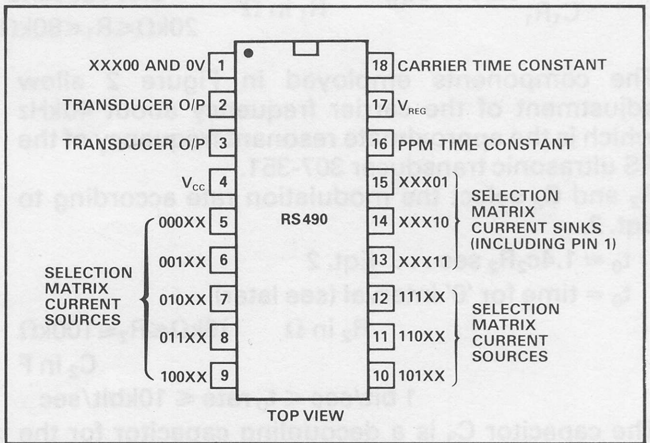
Max. supply voltage	9.5V
Operating voltage range, V_{CC}	7V to 9.5V
Maximum power dissipation	600mW
Operating temperature range	−10°C to +65°C
Storage temperature range	−55°C to +125°C

Features

- Ultrasonic or infra-red transmission
- Direct drive for ultrasonic transducer
- Direct drive of visible LED when using infra-red
- Lower power consumption
- Pulse position modulation gives excellent immunity from noise and multipath reflections
- Switch resistance up to 5kΩ tolerated

Figure 1 **RS490 Transmitter block diagram**





Electrical characteristics

Test conditions (unless otherwise stated): $T_{amb} = 25°C$ $V_{CC} \doteq +7V$ to $+10.5V$

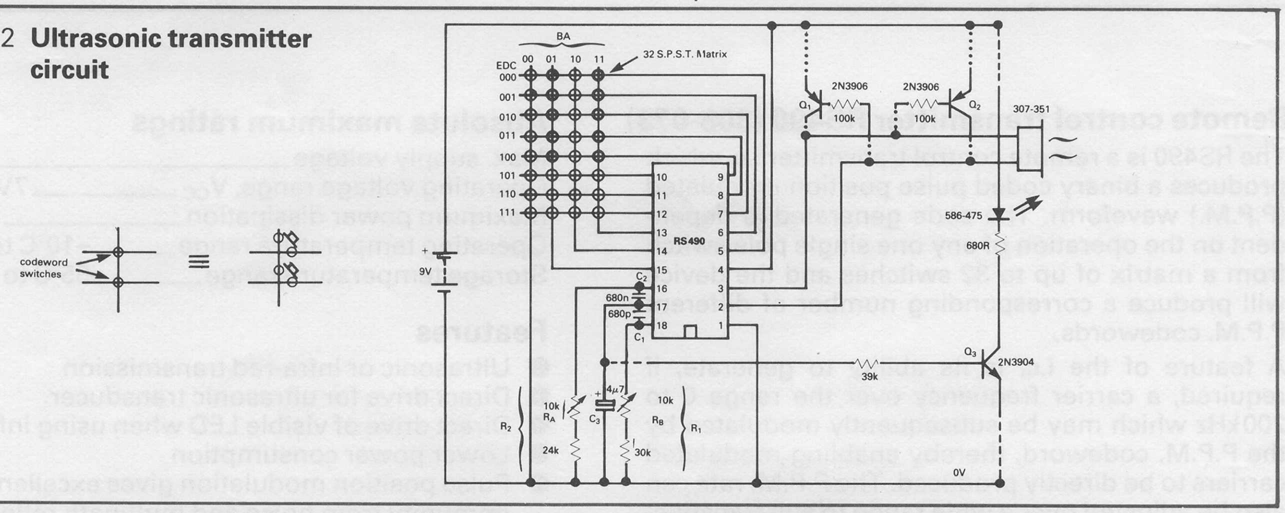
Characteristic	Pin	Value			Units	Conditions
		Min.	Typ.	Max.		
Operating supply current	4		9.5	16	mA	$V_{CC} = 9.5V$
Standby supply current	4			10	μA	
Stabilized voltage	17	4.1		4.9	V	
Output current available from stabilized supply	17			1	mA	
Output voltage swing	2, 3	V_{CC}-1			V	Unloaded
Output voltage	2			1	V	$I_2 + 10mA$ } Peak value < 1ms
Output voltage	3			1	V	$I_3 = 5mA$ } Peak value < 1ms
External switch resistance	5-15			5	kΩ	
External carrier resistor R_1	18	20	40	80	kΩ	C2 = 680pF fc = 40kHz
t_1 deviation from calculated value using fixed timing components	2,3			±10	%	$t_1 = 0.95\, C_2R_2$
PPM resistor	16	15	30	60	Ω	
Variation of t_1 and t_0 with V_{CC}						
t_1 with $V_{CC} = 7V/t_1$ with $V_{CC} = 10.5V$	2,3			±4	%	
t_0 with $V_{CC} = 7V/t_0$ with $V_{CC} = 10.5V$	2,3			±4	%	
Ratio t_0/t_1	2,3	1.4		1.6		
Pulse width t_0	2,3	$0.11 \pm t_1$		$0.22 \pm t_2$		
Interword gap	2,3		3			The interword gap is 3 times t_1 derived by counting

Typical applications

RS 490 Transmitter (ultrasonic)

The internal structure of the RS 490 remote control i.c. is illustrated in Figure 1 and Figure 2 shows the complete circuit of an ultrasonic transmitter.

Figure 2 **Ultrasonic transmitter circuit**



Thirty-two momentary switches are used to programme the transmitter into producing a pulse position coded signal. The components R_1 and C_1 define the carrier frequency according to Eqt. 1.

$$f \approx \frac{1}{C_1R_1} \text{Hz} \quad \text{. . . Eqt. 1} \qquad C_1 \text{ in F}, \; R_1 \text{ in } \Omega \qquad 0 \leq f \leq 200\text{kHz} \qquad 20k\Omega \leq R_1 \leq 80k\Omega$$

The components employed in Figure 2 allow adjustment of the carrier frequency about 40kHz which is the approximate resonant frequency of the RS ultrasonic transducer 307-351.

R_2 and C_2 select the modulation rate according to Eqt. 2.

$$t_0 \approx 1.4 c_2 R_2 \text{ sec} \quad \text{. . . . Eqt. 2}$$

t_0 = time for '0' interval (see later)

R_2 in Ω $15k\Omega \leq R_2 \leq 100k\Omega$

C_2 in F

1 bit/sec $\leq t_0$ rate $\leq$ 10kbit/sec

The capacitor C_3 is a decoupling capacitor for the internal voltage used to provide a constant voltage for the two CR networks. The regulator voltage on pin 17 is not established until a codeword switch has been closed.

The RS 490 is capable of driving the RS ultrasonic transmitter directly from pins 2 and 3 providing an effective range of ≈8m. An increase in range up to ≈ 10m is possible by employing active pull ups Q_1 and Q_2 shown with dotted connections in Figure 2.

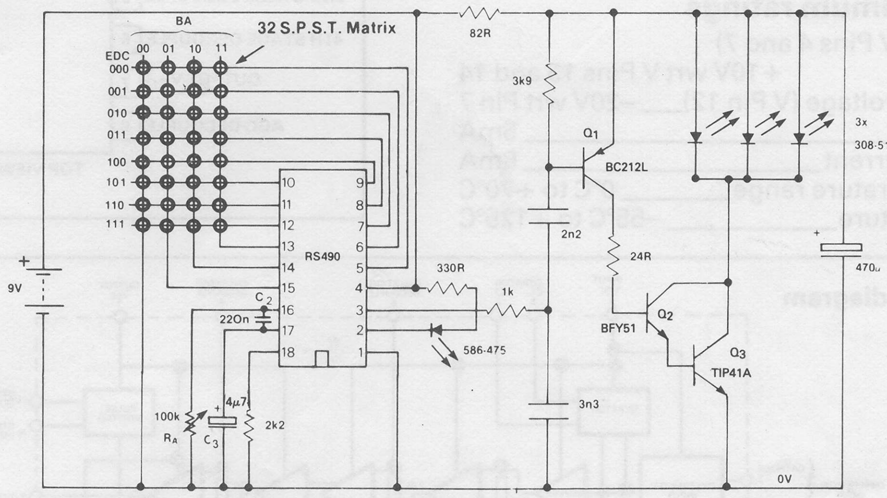
To indicate transmitter operation the voltage appearing on pin 17 at switch closure can be used to drive an NPN transistor feeding an L.E.D. and this modification is shown with dashed connections in Figure 2.

Because the standby current of the RS 490 is very low (≈6μA) rising to about 8mA when transmitting, the power requirements can be satisfied by a PP3 battery. Using the L.E.D. indicator modification shown the operating current will be approximately 20mA.

RS 490 Transmitter (infra-red)

Operating a remote control system on an infra-red link offers some advantages over the previously discussed ultrasonic mode. The important gains are less multipath interference, lower spurious radiation, a higher modulation rate capability and more robust transducers. Figure 3 shows the complete circuit of an infra-red transmitter.
The modulation rate formula by Eqt. 2 is applicable to the infra-red transmitter circuit. A visual indication of transmitter operation can be provided by employing the unused output on pin 2 to drive an L.E.D. via a pull up resistor as shown in Figure 3.
The programming of the infra-red transmitter is identical to the ultrasonic system in employing 32 S.P.S.T. switches to produce a pulse position coded signal. No carrier frequency is required by the infra-red transducers hence C_1 is omitted and a 2.2kΩ resistor substituted for R_1.

Figure 3 **Infra-red transmitter circuit**



The positive pulses appearing on pin 3 are amplified by Q_1, Q_2 and Q_3 to provide high current pulses to supply 3 RS infra-red sources, 308-512.
All wiring to the transmitters should be short with thick conductors and the 470μF electrolytic mounted close to minimise lead inductance.
A suitable p.c.b. (434-807) is available (see current RS catalogue for details).

RS 490 Output and coding

Figure 4a shows the output voltage waveforms from pins 2 and 3 with respect to 0V. A carrier wave is shown as it depicts a typical output for the ultrasonic system. The carrier wave frequency is shown lower than normal for clarity. The RS 490 transmits a codeword as a group of 6 carrier or d.c. pulses (depending on the system being used) continuously for as long as a programme switch is operated. The minimum switch closing time is 6ms and the transmitter will transmit until the end of a codeword even if the switch is released during a word. On completion of the word the device reverts to standby mode. Each of the five intervals between the start of these pulses may take up 2 possible values, a short interval corresponding to a '1' or a long interval corresponding to a '0'. Figure 4b shows the timing relationship between the carrier pulses '1' and '0'. At the end of each word a synchronising interval 'S' is generated to define a codeword ending. The transmitter maintains a fixed relationship between the '1', '0' and 'S' intervals of 2:3:6. Also the width of the carrier pulse is approximately 1/6th of a '1' interval or 1/3:2 on the above ratio scale. From the possible combination of the 5 bit codeword up to 2^5 or 32 different words can be generated.
A carrier burst of 3ms duration is shown in Figure 4b as an example of the timing relationships.

Figure 4a **P.P.M. output showing ultrasonic carrier frequency**

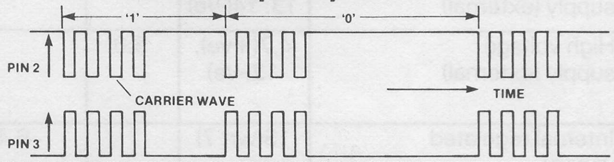
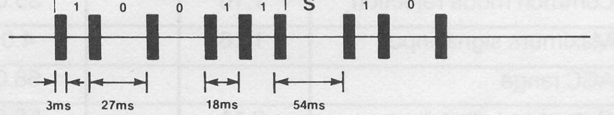


Figure 4b **Ultrasonic transmitter output (for a '1' period of 18ms)**



Infra-red pre-amplifier RS 486 (301-527)

A high gain pre-amplifier designed to form an interface between an infra-red receiving diode (308-506) and the digital input of remote control receiving circuits. This i.c. features a fast acting A.G.C. circuit which together with the differential inputs reduce noise pick-up and hence improve performance in noisy environments. An on-chip gyrator circuit allows operation with high brightness background light levels. The device contains two other circuit elements, one to provide a stretched output pulse facility and a voltage regulator to allow operation from a wide range of supplies. 16-pin d.i.l. plastic package.

A suitable p.c.b. (434-891) is available (see current RS catalogue for details).

Absolute maximum ratings

Supply voltage (V Pins 4 and 7) +10V wrt V Pins 13 and 14
Regulator input voltage (V Pin 12) —20V wrt Pin 7
Output current 5mA
Stretch output current 5mA
Operating temperature range 0°C to +70°C
Storage temperature —55°C to +125°C

Features

- Fast acting AGC reduces effects of noise
- Differential inputs reduce noise pick-up and improve stability
- Output pulse stretcher for use with microprocessor decoders
- On chip stabiliser
- Low noise input

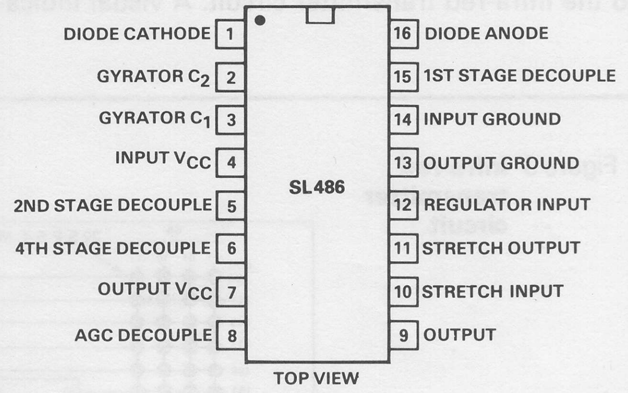
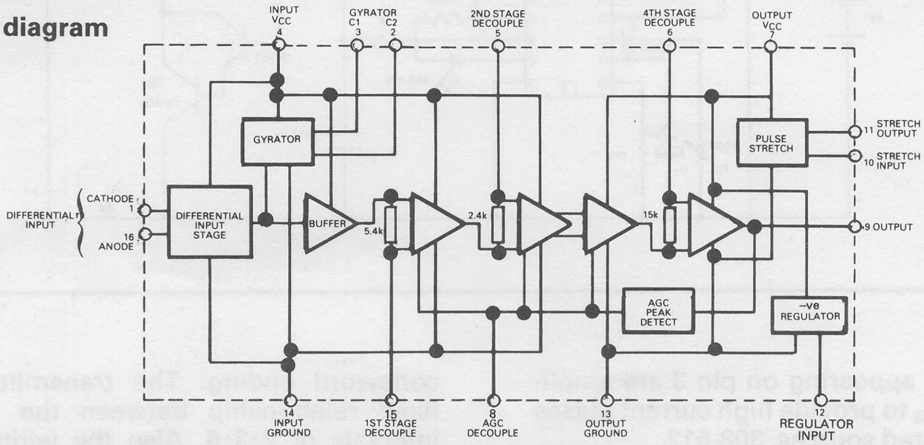


Figure 5 **Block diagram**



Electrical characteristics

Test conditions (unless otherwise stated): $T_{amb} = 25°C$, $V_{CC} = 4.5V$ to $7.0V$

Characteristic	Pin	Value Min.	Typ.	Max.	Unit	Conditions
Supply current	4,7 4		6.0 5.0 + 3 I_D	10.0	mA mA	$V_{CC} = 5.0V$, $I_{DIODE} = 1.0\mu A$ $V_{CC} = 4.5V$, $I_{DIODE} = 1.5mA$
Low voltage supply (external)	4,7(+ve), 13, 14(-ve)	4.5		9.0	V	Input and output V_{CC} commoned input and output ground commoned
High voltage supply (external)	4,7(+ve), 12(-ve)	9.0		18.0	V	Input and output V_{CC} commoned, input and output ground at internal regulated voltage
Internal regulated voltage	13(wrt 7)		−6.4		V	V Pin 7 (+) to V Pin 12(-) = +16V
Voltage between input and output V_{CC}	4,7			1.5	V	At room temperature
Minimum sensitivity of differential input	1,16		5.0		nA	For 4V output pulse, $I_{DIODE} = 1.0\mu A$
Common mode rejection	1,16		35.0		dB	
Maximum signal input	1,16		4.0		mA(peak)	
AGC range			68.0		dB	
Output and stretch output pull-up resistance (internal)	9,11		55.0		kΩ	At 25°C

Characteristic	Pin	Value Min.	Typ.	Max.	Unit	Conditions
Stretch output pulse width (T_p) coefficient on Rx	11		2.4 0.7		ms %/°C	Capacitance Pin 9 to Pin 10 = 10nF; $T_p \simeq -Rx\ C\ ln \frac{1.5}{V_{CC}}$ where Rx = 200kΩ±25% (internal resistance)
Output low	9			Output ground +0.5	V	Output open circuit
Output high	9	Output V_{CC} −0.5			V	Output open circuit
Stretch output low	11			Output ground +0.5	V	Output open circuit
Stretch output high	11	Output V_{CC} −0.5			V	Output open circuit
Sink current stretch output	11			1.8	mA	Low state
Supply rejection, input V_{CC}	4		1.5 0.8		V(peak) V(peak)	Ripple amplitude at 100 Hz, Pin 12 ground Ripple amplitude at 100 Hz, Pins 13 & 14 ground

Application notes (see Figure 6)

Diode anode and cathode (pins 1 and 16) The infra-red receiving diode is connected between pins 1 and 16. The input circuit is configured so as to reject signals common to both pins. This improves the stability of the device, and greatly reduces the sensitivity to radiated electrical noise. The diode is reverse biased by a nominal 0.65V.

Gyrator C2 and C1 (pins 2 and 3) The decoupling, provided by gyrator C2 and C1, rolls off the gain of the feedback loop which balances the d.c. component of the infra-red diode current. The values of C2 and C1 are chosen to produce a low frequency cut-off characteristic below a nominal 2kHz. Hence, the gyrator produces approximately 20dB rejection at 100Hz.

The gyrator consists of two feedback loops operating in tandem. Only one feedback path is functional when the d.c. component of the diode current is less than 200μA. This loop is decoupled by gyrator C2. For diode currents between 200μA and 1.5mA the second control loop is operative, and this is decoupled by gyrator C1.

The decoupling capacitors, gyrator C2 and C1, must be connected between pins 2 and 3, to pin 4. The series impedance of C2 and C1 should be kept to a minimum.

First stage decouple (pin 15) The capacitor on pin 15 decouples the signal from the non-inverting input of the first difference amplifier (see also Figure 5). The capacitance of 15nF is chosen to produce a 2kHz low frequency roll-off.

The capacitor must be connected between pins 15 and 14 (the input ground).

Second stage decouple (pin 5) The capacitor on pin 5 decouples the signal from the non-inverting input of the second difference amplifier. The capacitance of 33nF is chosen to produce a 2kHz low frequency roll-off. The capacitor must be connected between pins 5 and 4 (the input V_{CC}).

Fourth stage decouple (pin 6) The capacitor on pin 6 decouples the signal from the non-inverting input of the fourth difference amplifier. The capacitance of 4.7nF is chosen to produce a 2kHz low frequency roll-off. The capacitor must be connected between pins 6 and 7 (the output V_{CC}).

A.G.C. decouple/delay adjust (pin 8) The output of the fourth difference amplifier is followed by a peak detector, which is used to provide an A.G.C. control level. This produces a current source which is limited to 10mA at pin 8. The A.G.C. decouple capacitor (C5 normally 150nF) filters the pulsed input, and the resultant level controls the gain of the first three difference amplifiers.

The A.G.C. control level exhibits a fast attack/slow decay characteristic. Immediately infra-red pulses are detected, the gain will be reduced, so that any weaker noise pulses that are also received will not be seen at the output. Thus, provided the infra-red pulses are the most intense, it is possible to receive data in noisy environments. The slow decay keeps the A.G.C. level intact during data reception, and produces a delay before any received noise may become present at the output, when transmission ceases.

Output (pin 9) The output will be low, pulsing high with a source impedance of a nominal 55kΩ, for a received infra-red pulse. It is a linear amplification of the input and swings between output ground and output V_{CC}.

Stretch input and stretch output (pins 10 and 11) A typical infra-red P.P.M. system transmits very narrow pulses. The duration of these pulses is typically 15μs, so in order to utilise a microprocessor based decoder system it is necessary to lengthen the received pulse. This stretched output can be obtained from pin 11 when a capacitor is connected between pins 9 and 10.

The width of the pulse is determined by the value of this coupling capacitor (C8 in Figure 7) and is given by:

$$T_p = -Rx\ C_8\ ln \frac{1.5}{(V_4 - V_{13})}$$

where T_p = pulse width in ms
R_x = 200kΩ (see electrical characteristics)
C_8 = coupling capacitance
and $(V_4 - V_{13})$ = potential between input V_{CC} and ground (pins 4 and 13)

The stretch output is normally high pulsing low for a received infra-red pulse, and swings between output V_{CC} and output ground.

Regulator input (pin 12) The device can be operated with supplies of between 4.5V and 9.0V connected between input/output ground (pins 14 and 13) and input and output V_{CC} (pins 4 and 7) as shown in Figure 6.

The device can be operated with supplies in excess of 9.0V by utilising the on-chip regulator. In this case connections are made between output V_{CC} (pin 7) and the regulator input (pin 12) as shown in Figure 5. A supply voltage of between 9.0V and 18V will then cause the output ground to be regulated at a level nominally 6.4V below the output V_{CC} (pin 7).

The regulator will, however, lose control with a potential difference of less than 9.0V. Below this level the voltage on pin 13 will track nominally 1.5V below the output V_{CC} (pin 12).

When the regulator is not used (low voltage operation), pin 12 must be shorted to output ground (pin 13).

Operational notes (see Figures 6 and 7)

Gyrator C1 (pin 3) If the environment in which the device is operating, limits the background light such that the d.c. component of the diode current has a maximum of 200μA, it may be desirable to omit (see Figure 6) the more bulky and costly 68μF capacitor, gyrator C1 shown in Figure 7. In this case pin 3 can be left open circuit. The resultant application will then have a characteristic of greatly reduced gain when the ambient light causes the d.c. current to rise above this threshold.

The 68μF capacitor can alternatively be replaced by a resistor. The outcome of this is to further reduce the gain in ambient light levels above the 200μA threshold. Below this threshold the overall gain is slightly enhanced as the light level approaches the threshold value. If chosen this resistance should lie between 10kΩ and 200kΩ.

Noise immunity The stretch output can also be used as a means of improving performance relating to a receiver system, over and above its main purpose of providing a stretched output facility. Including C8 (Figure 7) causes the output pulses (from pin 9) to be subjected to the stretch input threshold. Thus any noise pulses from pin 9 that are below this threshold will not be seen at the stretch output (pin 11).

A further improvement can be made, utilising this stretch input threshold by including some additional filtering of the output (C10 in Figure 7). This can be adjusted in value (typically 100pF) to reduce some of the noise pulses that otherwise cross the threshold, to a level below the threshold.

It must be noted that the stretch output logic sense is inverse (for microprocessor applications) from that of the output (pin 9), and the cost of re-inversion may be deemed uneconomical for the improvements gained.

Screening Use of screening for the device, and associated components, improves the performance and immunity to externally radiated noise. The screening method used must protect the sensitive front-end of the device; provided that the diode, pin 1, pin 16, C2 (pin 2) and the first stage decouple (pin 15) are screened, it may be found that for the application considered, the remaining circuitry need not be so protected.

In applications where externally radiated noise is minimal, it may be possible to reduce any screening to pins 1 and 16, and the diode connections, only. In some instances, no screening may be necessary, but this largely depends on the level of radiated noise, the decoupling/filtering employed and the receivers decoding technique.

Decoupling Typical decoupling arrangements for use with or without the regulator, are given in Figures 6 and 7 respectively. When using the

Figure 6 **Circuit diagram of minimum component application (showing low voltage operation)**

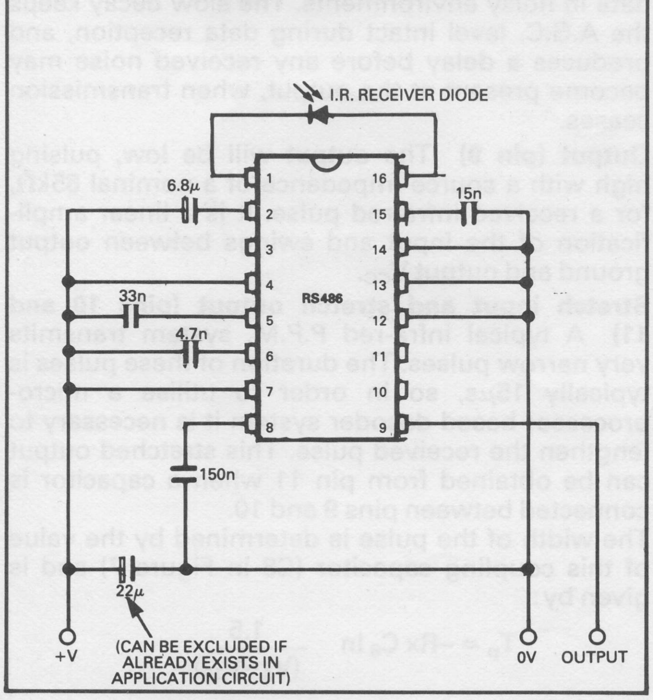
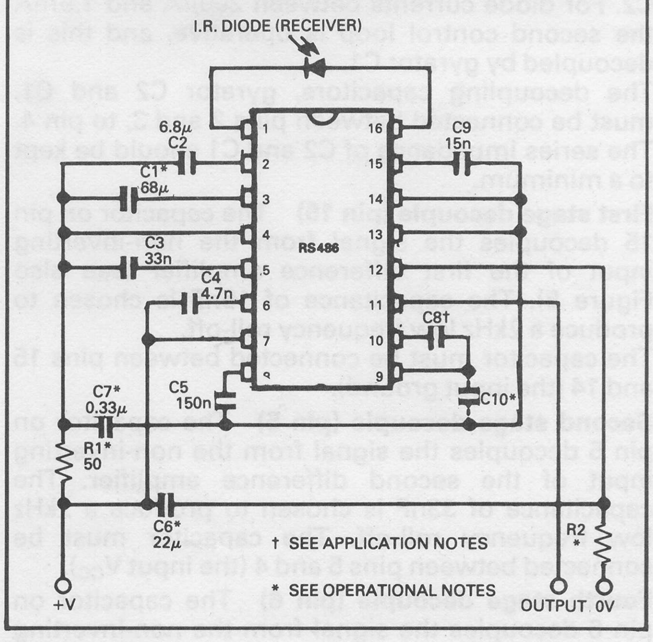
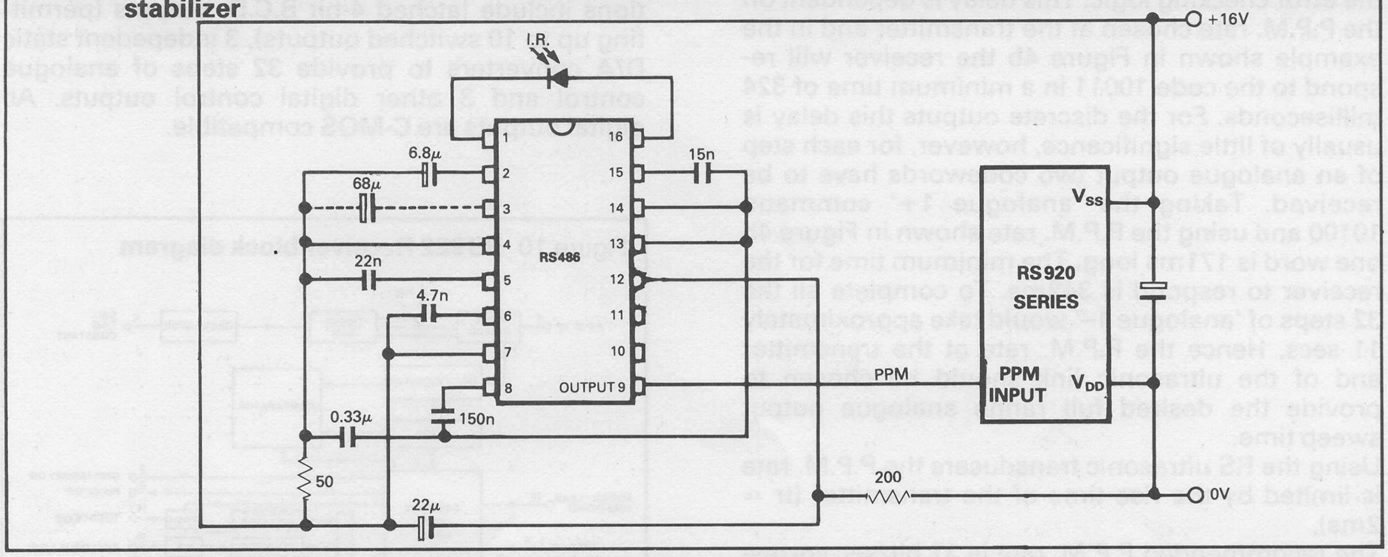


Figure 7 **RS 486 application diagram showing all optional circuitry**
(Note: Supply decoupling and connections for use of voltage regulator; also pulse stretched output)



regulator, further improvements in high frequency supply rejection are possible by the inclusion of R2. The value can be chosen so as to keep the pin 12 end of R2 within the –9.0 to –18V (w.r.t. pin 7) specified voltage range. For example if using the 920 series remote control receivers, on a supply of 16V, a typical value for R2 would be 200Ω. Note that the regulator is a low impedance point between pins 12 and 13. C7 thus maintains a low impedance path between pins 4 and 12 at high frequencies.

Figure 8 **Application diagram for use with RS920 series remote control receivers, utilising on-chip supply stabilizer**



Remote control receivers: introduction

All of the five remote control receiver i.c.'s have similar signal reception and decoding circuits. The receiver differences are fundamentally confined to the number of P.P.M. codewords to which each responds and the different output functions available.

A general discussion of the circuit operation common to all receivers is given below and each receiver's capabilities are covered later.

Receiver oscillator

After processing by the receiver amplifier the processed P.P.M. signal is transferred to the P.P.M. input of the remote control receiver i.c.

An internal oscillator uses the external components R_1 R_2 and C_1 (see Figures 11 and 13) to generate a frequency in accordance with Eqt. 3.

$$f_{OSC} = \frac{1}{0.15\ C_1 R_T} \quad \text{Hz . . . Eqt. 3}$$

C_1 in F

$25k\Omega \leq R_1 \leq 200k\Omega$ — R_T is the total resistance of R_1 and R_2 in Ω

The set frequency of this oscillator is dependent on the received P.P.M. rate from the RS490 transmitter. The importance of this setting is apparent when the internal operation of the receiver is considered.

Internal operation

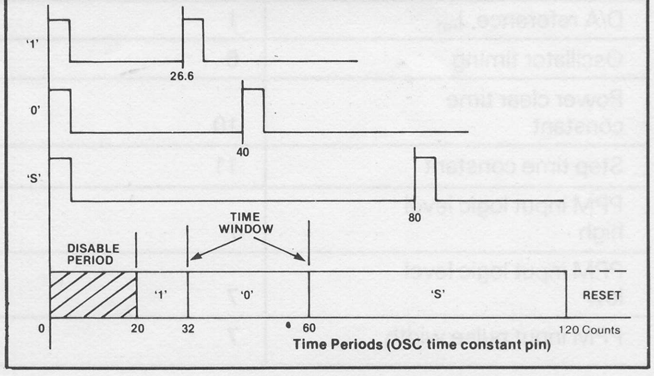
Whenever a P.P.M. pulse is received by the receiver an internal counter is reset. This counter defines timing windows for the following pulses as shown in Figure 9.

After receipt of the first P.P.M. pulse the counter is reset and disabled for 20 periods of the internal oscillator frequency. This is to reduce the possibility of pulse echoes from multipath reflections between the transmitter and receiver upsetting the correct transmission. If a pulse is received after the counter reaches 20 periods the internal logic examines the spacing or time interval between the receipt of the first pulse and the second and depending on this interval assigns the value '0' or '1' to the pulse spacing. This second pulse again resets the counter and disables it for 20 periods before repeating the above process with the next pulse. In this way the receiver reconstructs the transmitted P.P.M. code, the receipt of an 'S' interval defining the end of the codeword. On receipt of 'S' the receiver verifies that 6 pulses have been received before accepting the code.

The receiver stores this code while receiving another set of P.P.M. pulses. At the end of the second codeword a comparison is made; if the codewords are the same the data is accepted and passed on to a decoder to produce the output function defined by the code; if they are different the first codeword is rejected and the second code used as a reference for comparison with the next code received and no change in an output function occurs. This sequential codeword comparison coupled with P.P.M. and time window checking provides the system with a high degree of noise immunity against producing an incorrect output.

As can be seen from Figure 9 for correct interpretation of the transmitted code each pulse interval for a '0' or '1' must lie within the timing windows defined. This is achieved by setting the 'on chip' oscillator so that 40 periods at the oscillator time constant pin are equal to a '0' interval received at the P.P.M. input. This places a '0' interval at approx-

Figure 9 **P.P.M. Demodulator timing**



imately the centre of the '0' time window hence providing some allowance for oscillator drift both in the transmitter and receiver.

P.P.M. rate selection

The minimum time taken for any receiver to respond to a transmitter command is twice the time to transmit the appropriate codeword, because of the error checking logic. This delay is dependent on the P.P.M. rate chosen at the transmitter and in the example shown in Figure 4b the receiver will respond to the code 10011 in a minimum time of 324 milliseconds. For the discrete outputs this delay is usually of little significance, however, for each step of an analogue output two codewords have to be received. Taking the 'analogue 1+' command 10100 and using the P.P.M. rate shown in Figure 4b one word is 171 ms long. The minimum time for the receiver to respond is 342 ms. To complete all the 32 steps of 'analogue 1–' would take approximately 11 secs. Hence the P.P.M. rate at the transmitter end of the ultrasonic link should be chosen to provide the desired full range analogue output sweep time.

Using the RS ultrasonic transducers the P.P.M. rate is limited by the rise time of the transmitter ($t_r \approx$ 2 ms).

The recommended P.P.M. rate is 37 bit/sec corresponding to a t_0 time of 27 ms as shown in Figure 4b. This rate can be increased to approximately 74 bit/sec, by using a t_0 time of 13 ms, with some loss of range caused by the transducer rise time limitation. The spread in the characteristics of the transducers may increase or reduce this figure.

The infra-red system can be operated up to the maximum P.P.M. rate of the transmitter i.e. 10 kbit/sec.

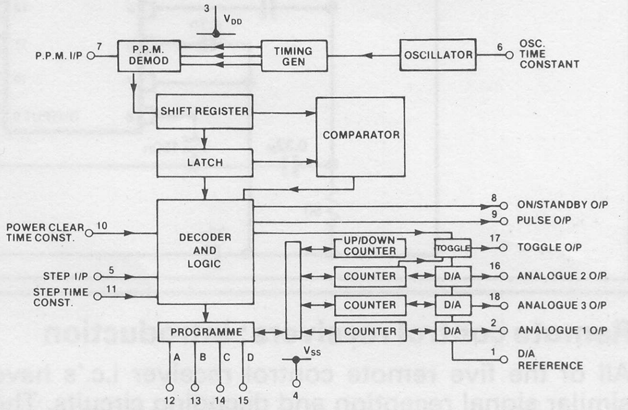
Each receiver i.c. responds to a specific set of codewords from the RS 490 transmitter. A description of each receiver type follows.

Remote control receiver RS 922 (308-089)

The RS 922 is the remote control receiver i.c. for use with the RS 490 transmitter.

The P.P.M. codewords transmitted by the 490 are interpreted by the 922 receiver and double checked for timing or codeword errors before being translated into particular control functions. These functions include latched 4-bit B.C.D. outputs (permitting up to 10 switched outputs), 3 indepedent static D/A converters to provide 32 steps of analogue control and 3 other digital control outputs. All digital outputs are C-MOS compatible.

Figure 10 **RS 922 Receiver block diagram**



Absolute maximum ratings (V_{DD} = 0V)

Supply voltage V_{SS} ______ +0.3V to –25V
Voltage at any input ______ +0.3V to –25V
Maximum power dissipation ______ 600mW
Operating temperature range ______ –10°C to +65°C
Storage temperature range ______ –55°C to +125°C

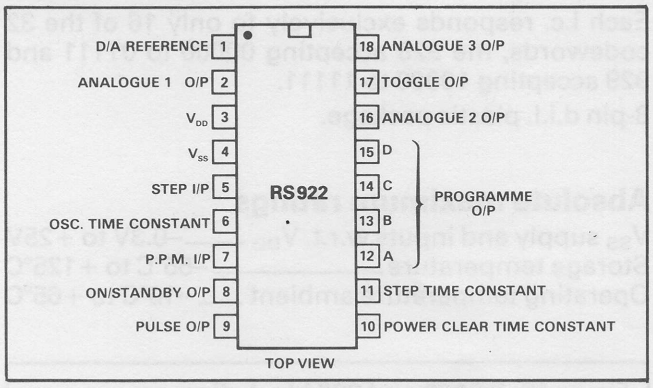
Electrical characteristics

T_{amb} = 25°C, V_{DD} = 0V, V_{SS} = +16V

Characteristic	Pin	Value			Units	Conditions
		Min.	Typ.	Max.		
Operating voltage	4	–14		–18	V	
Supply current	3		8	14	mA	
Input logic level '0'	5	15		16	V	
'1'		0		3.5	V	
Output logic level '0'	8, 9, 12, 15, 17	15		16	V	50k to V_{DD}
'1'		V_{DD}		0.5	V	50k to V_{DD}
Analogue outputs current range	2, 16, 18	0		$\frac{31}{8}$	I_{ref}	3k9 to V_{DD}
Analogue step size	2, 16, 18	0	1/8	1/4	I_{ref}	V_{out}<(V_{SS}–5) V
D/A reference, I_{ref}	1	–250	–345	–455	μA	33k to V_{DD}
Oscillator timing	6		1.6		kHz	C = 82n, R = 50k
Power clear time constant	10		400		ms	C = 4μ7 R = 100k
Step time constant	11		2		s	C = 470n R = 3M3
PPM input logic level high	7	15		16	V	
PPM input logic level low	7	0		10	V	
PPM input pulse width	7	1		$22T_{OSC}$	μs	

Features

- Accepts 5 bit P.P.M.
- All timing from on-chip oscillator
- Suitable for ultrasonic or infra-red systems
- Up to 10 programmes with latched binary outputs
- Incorporates error protection
- Negative logic



This receiver accepts 21 of the transmitted codewords. The command set and output functions for each pin are given in Tables 1 and 2 respectively. The RS 922 receiver features a parallel 4-bit latched binary output with 10 output codes, 3 independent analogue outputs and 3 other digital outputs.

Table 1 **Basic 21 command set for RS 922 receiver**

Transmitter code	Function	Programme O/P's D	C	B	A
EDCBA					
0000X	Programme 1	0	0	0	0
0001X	Programme 2	0	0	0	1
0010X	Programme 3	0	0	1	0
0011X	Programme 4	0	0	1	1
0100X	Programme 5	0	1	0	0
0101X	Programme 6	0	1	0	1
0110X	Programme 7	0	1	1	0
0111X	Programme 8	0	1	1	1
1000X	Programme 9	1	0	0	0
1001X	Programme 10	1	0	0	1
10100	Analogue 1 +				
10101	Programme Step +				
10110	Analogue 2 +	x = Don't care digit			
10111	Analogue 3 +				
11000	Standby				
11001	Toggle O/P (Analogue 2)				
11011	Normalise	i.e. 00110 and 00111 both produce programme 4			
11100	Analogue 1 –				
11101	Programme Step –				
11110	Analogue 2 –				
11111	Analogue 3 –				

N.B. LOGIC CONVENTION RS922
Logic 'O' – output transistor ON - pulls output to V_{SS} **Logic '1' – output transistor OFF i.e.: NEGATIVE LOGIC**

The 'Initial' condition

This describes the state of the outputs of the RS 922 receiver every time power is applied and no P.P.M. data has been received.

Programme O/P's – ABCD 0000
Analogue O/P's – All at 12/8 I_{ref}
On/Standby O/P – Logic 0
Pulse O/P – Logic 0
Toggle O/P – Logic 1

Note: Logic '0' is ≈ +14 to +15V
Logic '1' is 0 to +0.5V
measured w.r.t. V_{DD} (0V)

The 'Normalised' condition

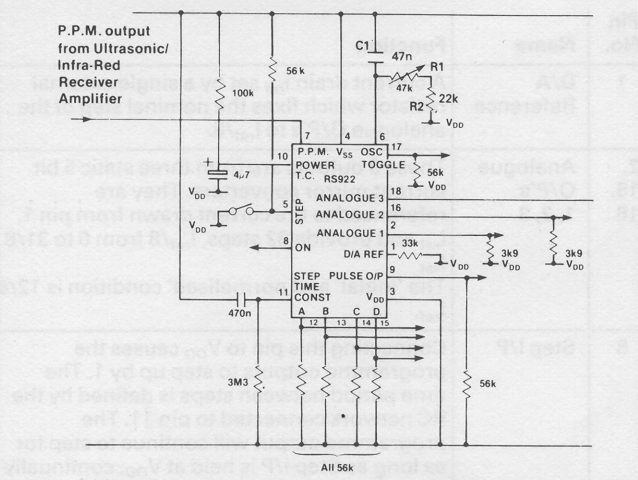
Reception of the 'Normalise' command 11011 affects the following outputs only:

Analogue O/P's – Taken to 12/8 I_{ref}
Toggle O/P – Taken to 1 or 0 (see Table 2)

Table 2 **Pin functions of RS 922**

Pin No.	Name	Function
1	D/A Reference	A current drain I_{ref} set by a single external resistor which fixes the nominal step of the analogue O/P's to $I_{ref}/8$.
2, 16, 18	Analogue O/P's 1, 2, 3	These 3 outputs are from three static 5 bit current mirror converters. They are referenced to the current drawn from pin 1, I_{ref} and provide 32 steps, $I_{ref}/8$ from 0 to 31/8 I_{ref}. The 'initial' and normalised' condition is 12/8 I_{ref}.
5	Step I/P	Connecting this pin to V_{DD} causes the programme outputs to step up by 1. The time period between steps is defined by the RC network connected to pin 11. The programme output will continue to step for as long as Step I/P is held at V_{DD}, continually cycling.
6	Osc. time	An RC time constant connected to this pin defines the internal oscillator frequency. This frequency controls the timing windows for the incoming P.P.M. pulses from the RS 490 transmitter.
7	P.P.M. I/P	The output of the receiver amplifier provides positive P.P.M. pulses which supply the data input to this pin. With no signal this I/P is held low.
8	On/Standby O/P	An open drain O/P with an initial condition of logic 0. This output remains at this level until a programme codeword or programme step is received whereupon it changes to a logic 1. The 'standby' codeword 11000 returns the output to logic 0 until a programme change is commanded. No other codes affect this output.
9	Pulse O/P	This is an open drain O/P with an initial condition of logic 0. A logic 1 pulse is produced on receipt of a programme codeword or programme step command. The width of the 1 pulse is equal to the periodic time of the internal oscillator which can be monitored on pin 6. This pulse is repeated as long as the programme codeword or programme step command is activated. The repetition period is equal to the time taken to transmit the appropriate programme codeword or step command.
10	Power Clear Time Constant	A single RC network connected to this pin defines the time delay before the 'initial' conditions are established, nominally set to 2 sec. by the components indicated in Figure 4.
11	Step Time Constant	An RC network connected to this pin defines the time period between increments of the channel number when the programme step codewords are transmitted.
12, 13, 14, 15	Programme O/P's	These are latched 4 bit binary outputs which respond to the programme transmitter codes and the programme codes. When power is first applied to the receiver programme 1 is established ie. ABCD outputs are all at logic 0 corresponding to programme 1.
17	Toggle O/P	This pin has an 'initial' condition of logic 1 and the only changes to logic 0 when Analogue 2 O/P is at the zero level. Transmission of the 'toggle' command 11001 changes this output to 0 or 1 for each separate transmission of toggle, provided Analogue 2 O/P is not at the zero level.

Figure 11 **RS922 Receiver circuit**



RS922 Analogue O/P's

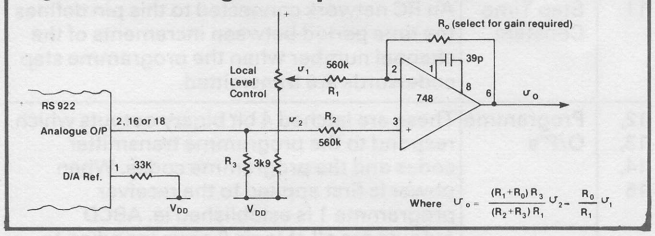
Analogue 1, 2, 3 '+' transmitter codes cause the respective analogue outputs to step up for as long as the transmitter code is being received until the maximum value of I_{ref} is reached at which point continued receipt of the analogue '+' codes have no effect. Similarly the analogue '–' transmitter codes cause the respective output to step down until I_{ref} reaches zero where it remains even under further transmitter command.

The step for the analogue outputs is typically 1/8 I_{ref} and the analogue output current range is 0 to 31/8 I_{ref} hence 32 discrete levels (typically 0 to 1.3mA) are possible from each analogue output.

The analogue outputs are current sources and should normally feed 3.9kΩ sink resistors connected to the V_{DD} and 0V rail. Greatest linearity is obtained if the current sink resistors do not exceed 3.9kΩ giving a 0 to 5V D/A output control range. However a 0 to 10V range may be obtained with higher resistor values if some reduction in linearity of step size can be tolerated. The simplest form of local adjustment of analogue control levels is to make the current sink resistors variable. An analogue output interface circuit is shown below which increases the analogue O/P current and voltage capability without loss of linearity.

A suitable p.c.b. (434-813) is available.

Figure 12 **Analogue output interface**



Remote control receivers RS928 and 929 (309-997 and 305-248)

The RS928 and RS929 are general purpose remote control receiver i.c.'s which function in a similar way to the RS922 device. They each respond to 16 of the possible 32 p.p.m. codewords transmitted by the 490 transmitter i.c. to provide 16 latched, 4-bit binary outputs.

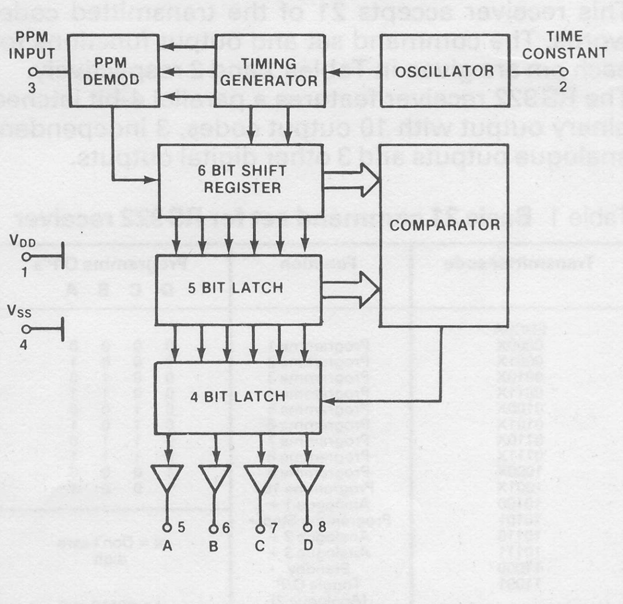
Each i.c. responds exclusively to only 16 of the 32 codewords, the 928 accepting 00000 to 01111 and 929 accepting 10000 to 11111.

8-pin d.i.l. plastic package.

Absolute maximum ratings

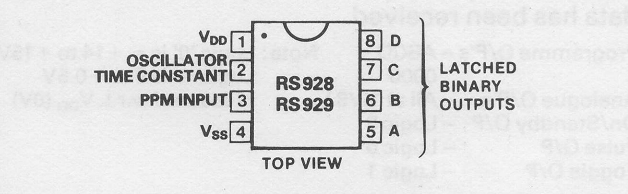
V_{SS} supply and inputs w.r.t. V_{DD}	−0.3V to +25V
Storage temperature	−55°C to +125°C
Operating temperature ambient	−10°C to +65°C

Figure 13 **RS928 and 929 block diagram**



Features

- Accepts 5 bit P.P.M.
- On chip oscillator
- Four high drive outputs
- 16 latched stages
- Negative logic



Electrical characteristics

Test conditions (unless otherwise stated):
$V_{SS} = 0V$
$V_{DD} = -16V$
$T_{amb} = +25°C$

Characteristic	Pin	Value Min.	Value Typ.	Value Max.	Unit	Conditions
Current Consumption V_{DD}	1	3	4	5	mA	
Supply voltage	1	−12		−18	V	
PPM input	3					
Logic '0' level		−1		0	V	
Logic '1' level		V_{DD}		−6	V	
Input pulse width		1		$22T_{OSC}$	μs	$T_{OSC} = \frac{1}{f_{OSC}}$
Oscillator timing	2					
Frequency		15		150k	Hz	
			3k		Hz	Typical TC: 22 nF to V_{SS}, 100kΩ to V_{DD}
Variation w.r.t. V_{DD}			1		%/V	
Latched binary output	5, 6, 7, 8					
Logic '0' output voltage		−1.5		0V	V	RL = 3.0k to VDD
Output leakage in logic '1' state				1	μA	

Note 1: R_{OSC} (pin 2) is 56k-156k Ω. $f_{osc} \simeq \frac{1}{0.15CR} \pm 20\%$.

Remote control receivers RS926 and 927 (309-981 and 303-826)

The RS926 and RS927 are remote control receiver i.c.'s which each respond to 15 of the 32 p.p.m. codewords from the 490 transmitter to provide 15 unlatched, 4-bit binary outputs. The outputs remain in an activated state for as long as a valid code is being received and are switched off when no valid code is detected. Codeword response: 00001 to 01111 (926), 10001 to 11111 (927).
8-pin d.i.l. plastic package.

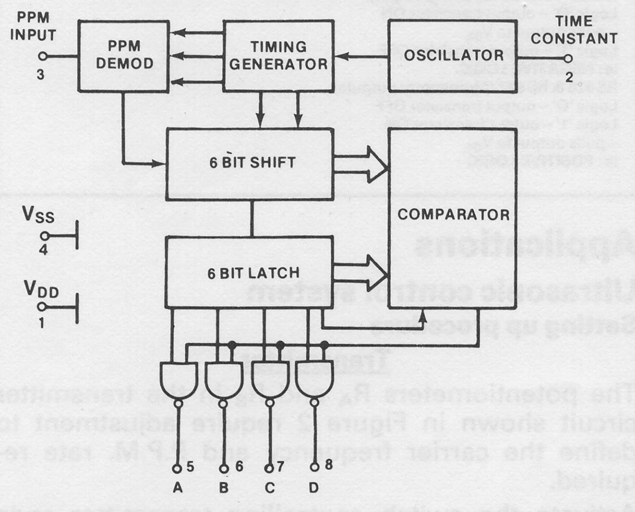
Absolute maximum ratings

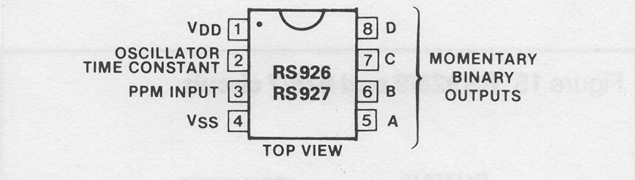
V_{SS} supply and inputs w.r.t. V_{DD} ____ +0.3V to −25V
Storage temperature ____ −55°C to +125°C
Operating temperature ambient ____ −10°C to +65°C

Features

- Accepts 5 bit P.P.M.
- Four outputs indicate in binary the code currently being received, and are switched off when no valid code is detected
- On chip oscillator
- High power, free drain, output buffers
- Positive logic

Figure 14 **RS926 and 927 block diagram**





Electrical characteristics

Test conditions (unless otherwise stated):
V_{SS} = 0V
V_{DD} = −16V
T_{amb} = +25°C

Characteristic	Pin	Value			Unit	Conditions
		Min.	Typ.	Max.		
Operating supply voltage range		−12	−14	−18	V	
Current consumption	1	2	3	4	mA	
PPM input						
Input level high	3	−1		0	V	
Input level low	3	V_{DD}		−6	V	
Input pulse width	3	1		$22T_{OSC}$	μsec	$T = \frac{1}{f_{OSC}}$
Oscillator time constant See Note 1						
Oscillator frequency	2	15		150k	Hz	
			3k		Hz	Typical TC: 22nF to V_{SS} 100k to V_{DD}
Variation wrt V_{DD}			1		%/V	
Output voltage high	5-8	−1.5		0	V	R_L = 3.0k to VDD
Output device leakage (Output OFF)	5-8			1	μA	

Note 1: R_{OSC} (pin 2) is 56k-156k Ω. $f_{OSC} \simeq \frac{1}{0.15CR} \pm 20\%$.

RS 928, 926, 927 and 929 receivers

The RS 928 and 929 have parallel 4-bit binary latched open drain outputs only and respond to 16 codewords each. They are identical in circuit operation and application and differ only in their command sets, as shown in Table 3.

The RS 926 and 927 respond to 15 codewords each as shown in Table 3. The circuit applications for the RS 928 and 929 are equally applicable to the RS 926 and 927. The outputs of the 926 and 927 differ from the 928 and 929 by being 4-bit parallel momentary outputs and not latched and are of opposite logic convention. The outputs are activated for as long as a valid code is being received and return to their inactive 'off' state under no signal conditions.

A typical basic circuit application is given in Figure 15. The outputs are capable of driving visible L.E.D.'s, opto-coupled thyristors/triacs or alternatively the 4-bit binary outputs can be decoded using a 4028B CMOS logic i.c. to provide up to 10 outputs or a 4514B to produce the full 16 outputs.

Figure 15 **RS 928/9 and 926/7 circuit**

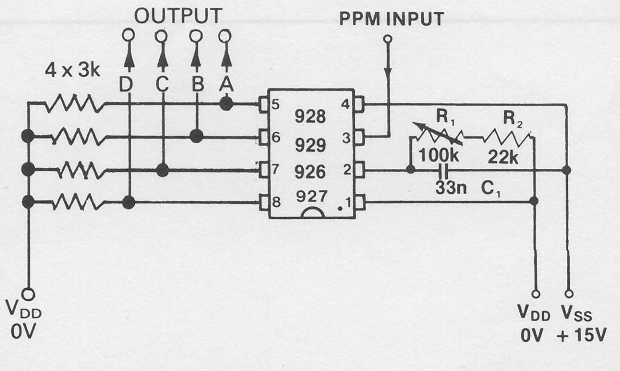


Table 3 **Command set 928/9 & 926/7**

RS 490 Transmitter Code	RS926/8	RS927/9
E D C B A	D C B A	D C B A
0 0 0 0 0	0 0 0 0	
0 0 0 0 1	0 0 0 1	
0 0 0 1 0	0 0 1 0	
0 0 0 1 1	0 0 1 1	
0 0 1 0 0	0 1 0 0	
0 0 1 0 1	0 1 0 1	
0 0 1 1 0	0 1 1 0	
0 0 1 1 1	0 1 1 1	
0 1 0 0 0	1 0 0 0	
0 1 0 0 1	1 0 0 1	No change
0 1 0 1 0	1 0 1 0	
0 1 0 1 1	1 0 1 1	
0 1 1 0 0	1 1 0 0	
0 1 1 0 1	1 1 0 1	
0 1 1 1 0	1 1 1 0	
0 1 1 1 1	1 1 1 1	
1 0 0 0 0		0 0 0 0
1 0 0 0 1		0 0 0 1
1 0 0 1 0		0 0 1 0
1 0 0 1 1		0 0 1 1
1 0 1 0 0		0 1 0 0
1 0 1 0 1		0 1 0 1
1 0 1 1 0		0 1 1 0
1 1 1 1 1		0 1 1 1
1 1 0 0 0	No change	1 0 0 0
1 1 0 0 1		1 0 0 1
1 1 0 1 0		1 0 1 0
1 1 0 1 1		1 0 1 1
1 1 1 0 0		1 1 0 0
1 1 1 0 1		1 1 0 1
1 1 1 1 0		1 1 1 0
1 1 1 1 1		1 1 1 1

N.B. LOGIC CONVENTION
RS928 & RS929 (Latching output)
Logic '0' – output transistor ON
– pulls output to V_{SS}
Logic '1' – output transistor OFF
ie: **NEGATIVE LOGIC**
RS 926 & RS 927 (Momentary outputs)
Logic '0' – output transistor OFF
Logic '1' – output transistor ON
– pulls output to V_{SS}
ie: **POSITIVE LOGIC**

Applications

Ultrasonic control system

Setting up procedure

Transmitter

The potentiometers R_A and R_B in the transmitter circuit shown in Figure 2 require adjustment to define the carrier frequency and P.P.M. rate required.

Activate the switch controlling transmitter code

0000X and monitor the output waveform of the transmitter i.c. appearing at pins 2 and 3. Expanding one of the pulses displayed, adjust R_B to produce a carrier period of approximately 24.5μs corresponding to a frequency of 40.8kHz. Display several pulses of the transmitter code and by adjusting R_A alter the time interval for a '0' to provide the required P.P.M. rate (see Figure 4b).

Receiver

A)
Position the transmitter and receiver transducers 3m apart. Activate the transmitter to produce the codeword 0000X continuously and monitor the P.P.M. I/P pin on the receiver i.c.

B)
Re-adjust R_B controlling the carrier frequency on the transmitter circuit to provide a maximum signal at the P.P.M.. I/P of the receiver i.c. Finally monitor the oscillator waveform on the oscillator time constant pin of the receiver i.c. and adjust R_1 so that the periodic time is 1/40th of the time of a '0' interval on the received P.P.M.

Infra-red control system

Setting up procedure

Transmitter

The potentiometer R_A shown in Figure 3 should be adjusted for the required P.P.M. rate, following the same procedure outlined for the ultrasonic system.

Receiver

Follow part A of the setting up procedure for the ultrasonic system. Monitor the oscillator waveform on the osc time constant pin of the receiver i.c. and adjust R_1, so that the periodic time is 1/40th of the time of a '0' interval on the received P.P.M. of the appropriate input pin.

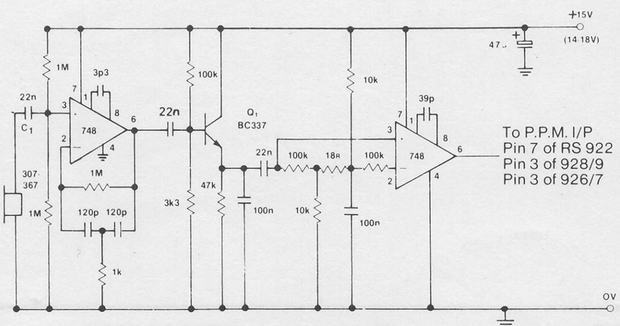
Additional circuits

Receiver amplifier (ultrasonic)

At the receiving end of the ultrasonic link a gain and bandwidth defining system will be required before the incoming signal is suitable for reception by the remote control receivers.

Figure 16 shows a suitable two stage amplifier designed for receiving signals from the RS ultrasonic transducer, 307-367.

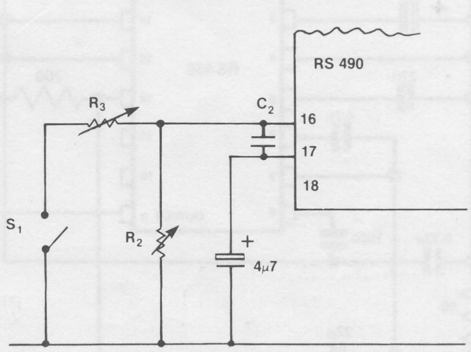
Figure 16 **Ultrasonic receiver amplifier**



Transmitter control for 2 receivers

Figure 17 illustrates a method of employing one RS 490 transmitter to control two independent receivers. The P.P.M. rate for one receiver is selected by the potentiometer R_2. The second receiver should be adjusted to receive the P.P.M. rate defined by the parallel combination of R_2 and R_3. The two different P.P.M. rates can be chosen such that data accepted by one receiver is outside the timing windows defined by the oscillator time constant of the other. The P.P.M. rates should be within the limitations of the transducer, only one receiver amplifier being required to directly feed the P.P.M. inputs on the two receivers.

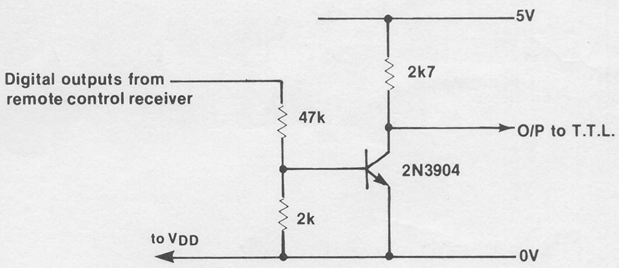
Figure 17 **Transmitter modification for controlling two receivers**



T.T.L. interface

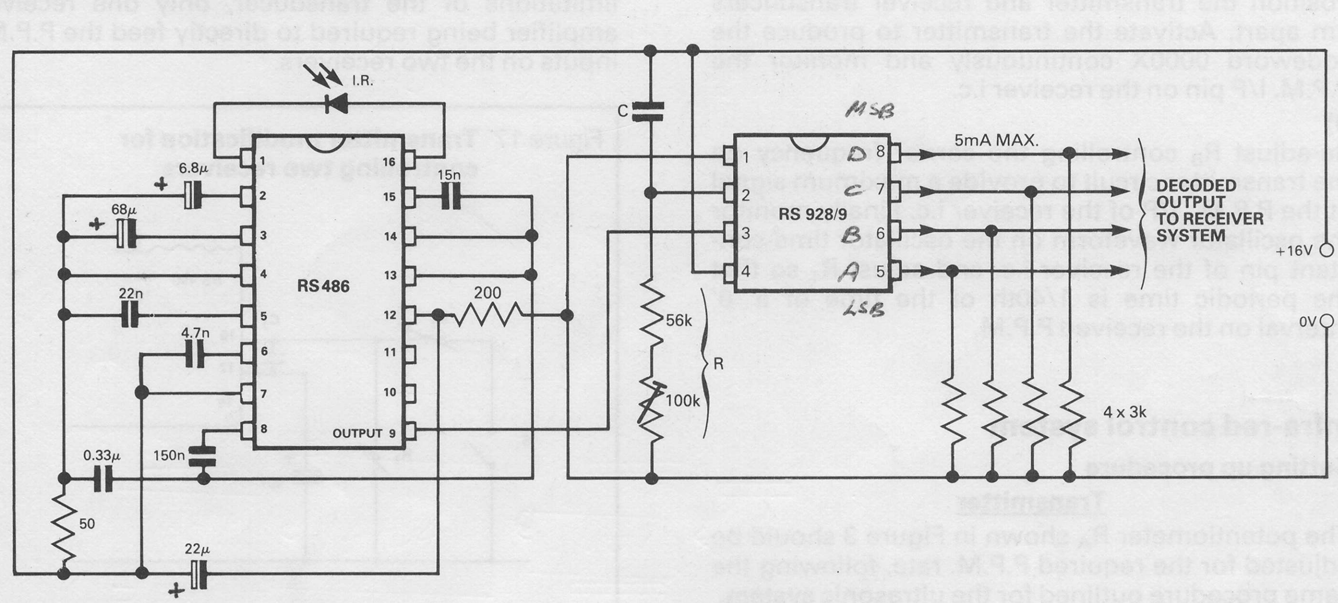
Figure 18 shows a simple interface between logic level outputs of the remote control receiver i.c.'s, to standard T.T.L. inputs. This circuit also inverts the logic levels, a logic 1 from the receiver producing a logic 0 T.T.L. output.

Figure 18 **T.T.L. interface**



RS data

Figure 19 **Typical application circuit**



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