Data Library

Remote control ic's

A range of remote control ic's consisting of one transmitter RS490, an infra-red pre-amplifier RS486 and five receivers, RS922, 926, 927, 928 and 929 with individual characteristics to suit many control requirements.

The system is based on the transmission of coded PPM (Pulse Position Modulation) signals over a wide variety of transmission media eg. 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 PPM signal is performed by a discrete amplifier or for infra-red an ic is available. The restored signal is passed to one, or a combination, of the five receiver ic's where an error checking system inspects the PPM 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). Further information is available at the back of this data sheet.

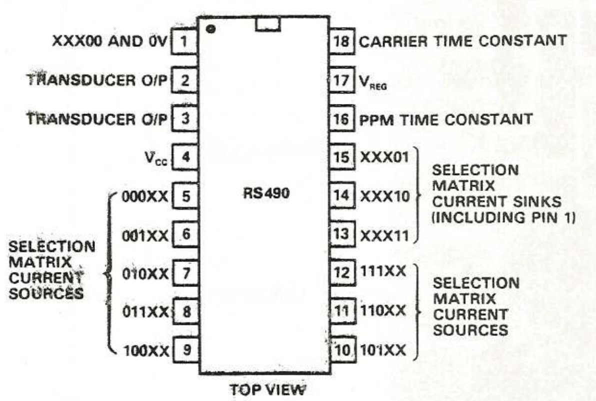
Remote control transmitter RS490 (308-073)

The RS490 is an easily extendable, 32 command, pulse position modulation transmitter drawing negligible standby current. It may be used with the RS920 series of remote control receivers.

Absolute maximum ratings

Supply voltage	12V
Maximum power dissipation	600mW
Operating temperature range	−10°C to +65°C
Storage temperature range	−55°C to +125°C

Pin connections



Features

- Ultrasonic or infra-red transmission
- Direct drive for ultrasonic transducer
- Direct drive of visible LED when using infra-red
- Very low power requirements
- Pulse position modulation gives excellent immunity from noise and multipath reflections
- Single pole key matrix
- Switch resistance up to 1kΩ tolerated
- Few external components
- Anti-bounce circuitry on chip.

Quick reference data

- Power supply: 9V, standby 6μA, operating 8mA
- Modulation: pulse position with or without carrier
- Coding: 5 bit word giving a primary command set of 32 commands
- Key entry: 8 x 4 single pole key matrix
- Data rate: selectable 1 bit/sec to 10k bit/sec
- Carrier frequency: selectable 0Hz (no carrier) to 200kHz.

Electrical characteristics Test conditions (unless otherwise stated) $T_{amb} = 25°C$, $V_{CC} = +7V$ to $+10.5V$

Characteristic	Pin	Conditions	Value Min.	Value Typ.	Value Max.	Units
Operating supply current	4	$V_{CC} = 9.5V$		9.5	16	mA
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	Unloaded	V_{CC}-1			V
Output voltage	2	$I_2 = 10mA$ } Peak value < 1ms			1	V
Output voltage	3	$I_3 = 5mA$ } Peak value < 1ms			1	V
External switch resistance	5-15				5	kΩ
External carrier resistor R2	18	C2 = 680pF $f_C = 40kHz$	20	40	80	kΩ
t_1 deviation from calculated value using fixed timing components	2,3 2,3	R1 = 15k } $t_1 = 0.95$ C1 R1 R1 = 60k } See Figure 3			±10	%
PPM resistor	16		15	30	60	kΩ
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_p	2,3		0.11 t_1		0.22 t_1	
Interword gap	2,3	The interword gap is 3 times t_1 derived by counting		3 t_1		

Figure 1 **RS490 transmitter block diagram**

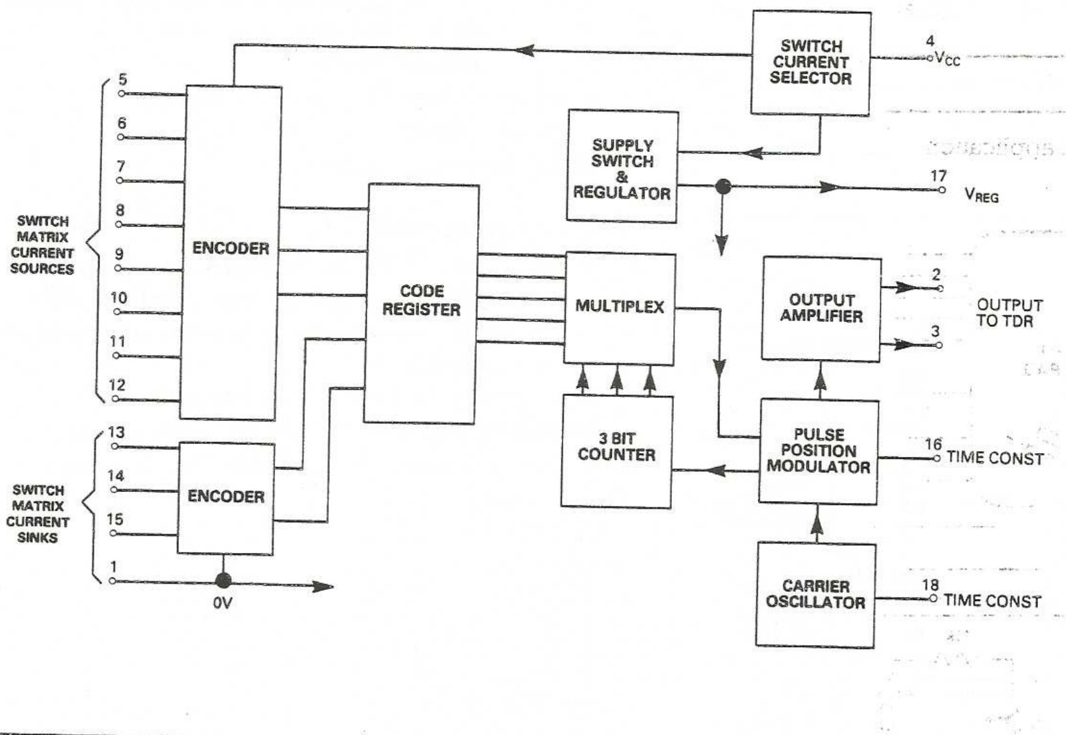


Figure 2 **PPM word notation**

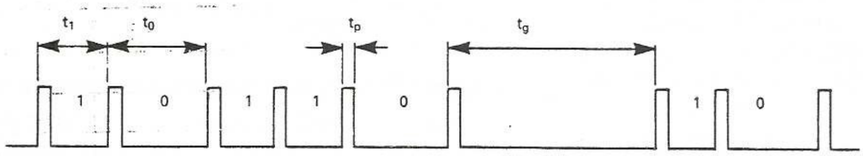


Figure 3 **Test circuit**

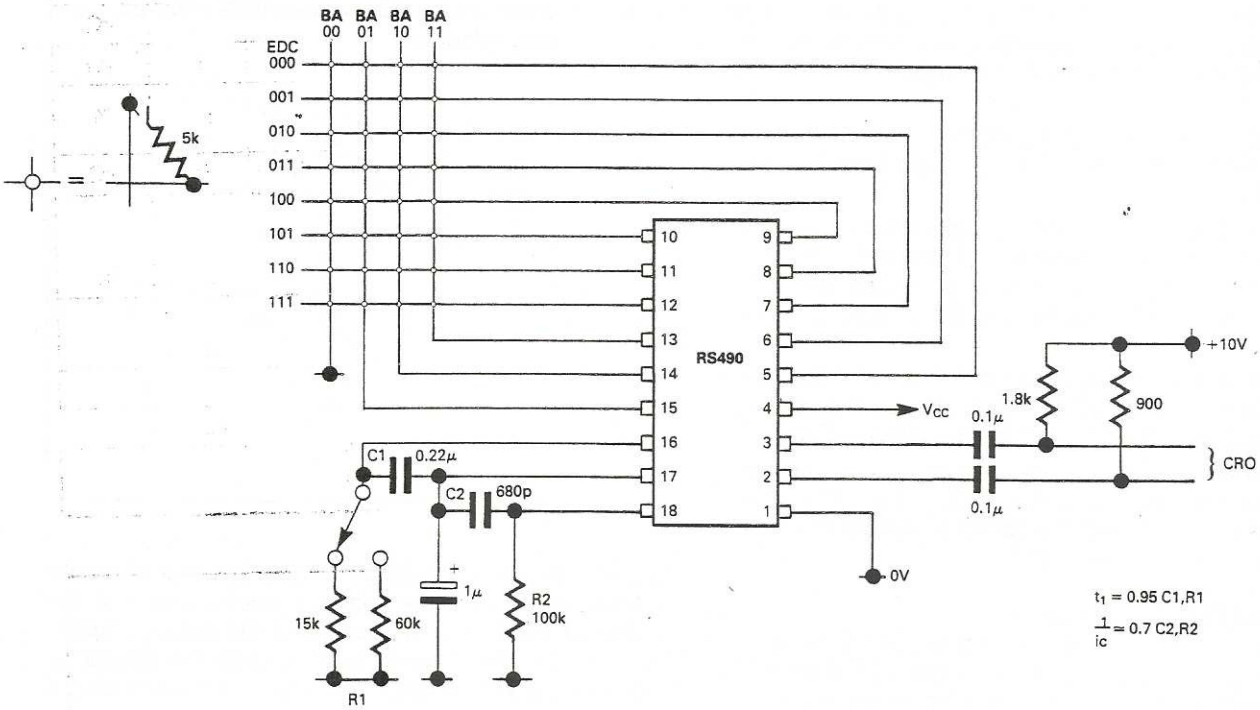
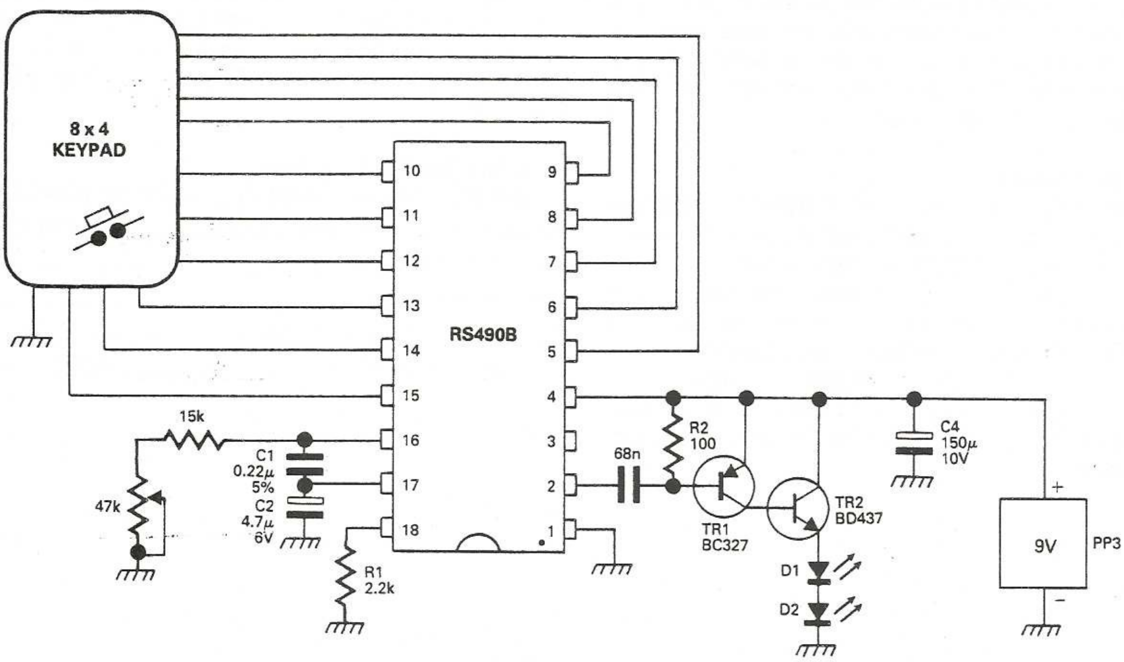


Figure 4 **Typical application**



Operating notes

Figure 4 shows the circuit for a simple infra-red transmitter where the PPM output from pin 2 of the RS490 is fed to the base of the PNP transmitter TR1, producing an amplified current pulse about 15μ sec wide. This pulse is further amplified by TR2 and applied to the infra-red diodes D1 and D2.

The current in the diodes and the infra-red output is controlled by the quantity, type, and connection method of the diodes and also by the gain at high currents of the transistors.

The most common solution where cost is important is to use 2 single-chip diodes.

Improved output can be obtained by using four single chip diodes in a series parallel arrangement, but it is usually simpler to use 2 multichip diodes connected in parallel.

A significant increase in range can be obtained by using diodes in conjunction with a plated plastic parabolic reflector.

When building the transmitter, care should be taken with the choice of the capacitor C4 and with the circuit layout, particularly when multi-chip diodes are being used, as the current pulses can be as high as 6 to 8 amps.

Transistor choice is also important and any substitutes should have high current gain characteristics and switching speeds similar to those specified in Figure 2.

An increase in output can be obtained by connecting TR2 in common emitter configuration, but care should be taken not to exceed the rating of the diodes. (This principle is used on the RS pcb.)

Choice of PPM frequencies

Although the RS920 series of remote control receivers is designed to work over a wide range of PPM frequencies, the actual usable range may be restricted by the application. The analogue outputs on the RS922 serve as a good example, since the outputs will step up or down, one step for each pair of PPM words received. This in turn fixes the rate of increment or decrement of the volume or colour controls of a TV set.

When the transmitter is being used with an infra-red link, with high current pulses fed to the diodes as in Figure 4, power consumption will increase with frequency. It is thus advisable that with a battery power supply, the slowest PPM rate consistent with adequate response time should be chosen.

Setting up procedure

When designing a remote control system using the RS490 in conjunction with the RS920 range of receiving circuits it is important from a manufacturing point of view for all transmitters to be interchangeable. The timing capacitor C1 should be chosen to give the required T1 time calculated from the formula T1 = 1.4 CR with R — 33k. The R value should be made up of a series potentiometer resistor combination with sufficient adjustment to compensate for the ic and component tolerances.

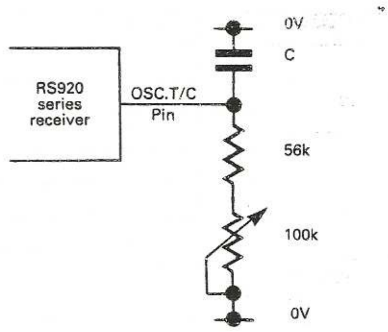
The timing components on the receiver can be selected using the formula

$$f_{RX} = \frac{1}{0.15CR} \pm 20\% \text{ where } f_{RX} = \frac{40}{t_0}$$

t_0 being the PPM logic 0 time from the transmitter.

If the recommended value of potentiometer and fixed resistor, as shown in Figure 5, are used, then the value of R in the above formula should be 84kΩ. This gives the maximum frequency adjustment range, which is needed to cope with component and ic tolerances.

Figure 5 **Recommended receiver time constant components**



Final adjustment is made by setting the period on the receiver oscillator time constant pin to 1/40th of the transmitter PPM logic 0 time using the potentiometer. Connection to the receiver time constant pin should be made using a x10 oscilloscope probe to reduce circuit loading.

Infra-red pre-amplifier RS486 (301-527)

The RS486 is a high gain preamplifier designed to form an interface between an infra-red receiving diode and the digital input of remote control receiving circuits. 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.

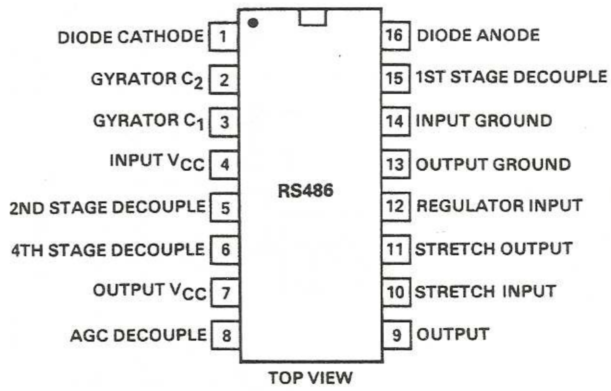
Absolute maximum ratings

Supply voltage (pins 4 and 7)	+10V wrt pins 13 and 14
Regulator input voltage (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 improves operation in noisy environments
- Differential inputs reduce noise pick-up and improve stability
- Gyrator circuit allows operation in environments with high brightness background light levels
- Output pulse stretcher for use with microprocessor decoders
- On-chip stabilizer allows operation with a wide range of supply voltages
- Direct interface to RS920 series remote control receivers
- Low noise output.

Pin connectors

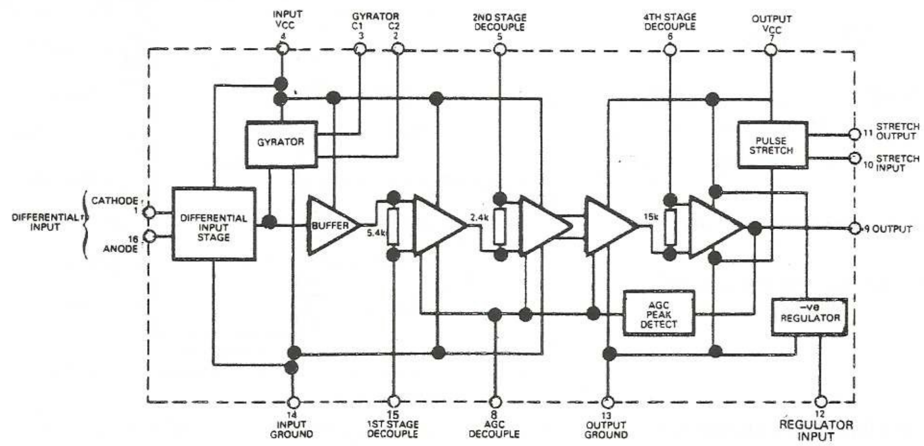


Electrical characteristics Test conditions (unless otherwise stated) T_{AMB} = 25°C, V_{CC} = +4.5V to +7.0V

Characteristic	Pin	Conditions	Value			Unit
			Min.	Typ.	Max.	
Supply current (See note 1)	4,7	V_{CC} = 5.0V, I_{DIODE} = 1.0µA } pins 13 & 14 ground		6.5	9.0	mA
	4	V_{CC} = 4.5V, $I_{DIODE} \leq$ 1.5mA	3.5+3xI_D	4.2+3xI_D	5+3xI_D	mA
	4,7	V_{CC} = 18V, I_{DIODE} = 1.0µA pin 12 ground		8.5	10	mA
Low voltage supply (external)	4,7(+ve), 13,14(−ve)	Input and output V_{CC} commoned, input and output ground commoned	4.5		9.5	V
High voltage supply (external)	4,7(+ve) 12(−ve)	Input and output V_{CC} commoned, input and output ground at internal regulated voltage	8.4		18.0	V
Internal regulated voltage	13(wrt 7)	V pin 7 (+) to V pin 12(−) = +16V	5.9	6.2	6.5	−V
Voltage between input and output V_{CC}	4,7	At room temperature			1.5	V
		At 70°C			1.1	V
Minimum sensitivity of differential input	1,16	I_{DIODE} = 1.0µA	9.0		2.3	nA
		I_{DIODE} = 100µA	74.0		18.5	nA
		I_{DIODE} = 0.5mA	168.0		42.0	nA
Common mode rejection	1,16			35.0		dB
Maximum signal input	1,16		3.0	4.0		mA(peak)
AGC range				68.0		dB
Output and stretch output pull-up resistance (internal)	9,11	At 25°C		55.0		kΩ
Stretch output pulse width (Tp)	11	Capacitance pin 9 to pin 10 = 10nF; $T_p \simeq R_X C \ln \left\{ \frac{1.5}{V_{CC}} \right\}$		2.4		ms
T co-efficient on R_X		Where Rx = 200kΩ ± 25% (internal resistance)		0.7		%/°C
Output low	9	0.2mA sink, max			Output ground +0.35	V
Output high	9	5µA source	Output V_{CC} −0.5			V
Stretch output low	11	1.6mA sink, max			Output ground +0.5	V
Stretch output high	11	Output open circuit 5µA source	Output V_{CC} −0.1			V
Supply rejection, input V_{CC}	4	Ripple amplitude at 100Hz, pin 12 ground		1.5		V(peak)
		Ripple amplitude at 100Hz, pins 13 and 14 ground		0.8		V(peak)

Note. 1. I_D = I_{DIODE} = IR diode forward current.

Figure 6 **Block diagram**



Application notes (see Figure 7)

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 dc 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 dc 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 6). 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 15) 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}).

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

The AGC 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 AGC 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 PPM 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 8) and is given by:

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

The stretch output is not required when driving the RS920 series receivers.

where Tp = pulse width in ms
Rx = 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 7.

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 6. 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 7 and 8)

Gyrator C1 (pin 3) If the environment in which the device is operating, limits the background light such that the dc component of the diode current has a maximum of 200μA, it may be desirable to omit (see Figure 7) the more bulky and costly 68μF capacitor, gyrator C1 shown in Figure 8. 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 dc 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 8) 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 8). 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 reinversion 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 7 and 8 respectively. When using the 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 (wrt pin 7) specified voltage range. For example if using the RS920 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 7 **Circuit diagram of minimum component application (showing low voltage operation)**

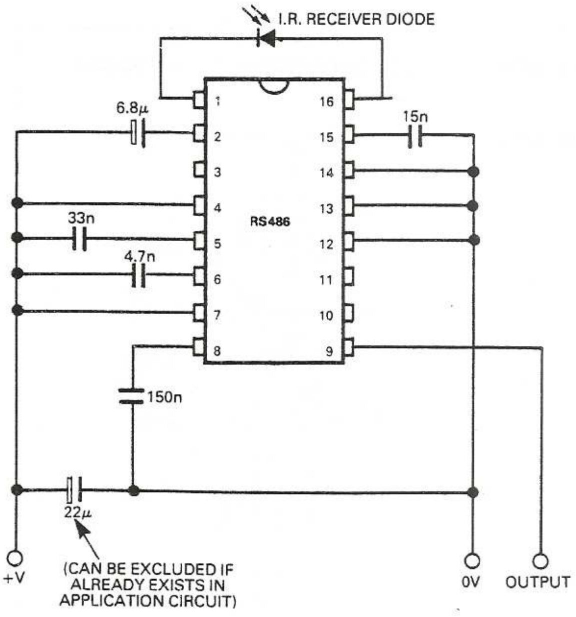


Figure 8 **RS486 application diagram showing all optional circuitry**

Note. Supply decoupling and connections for use of voltage regulator; also pulse stretched output

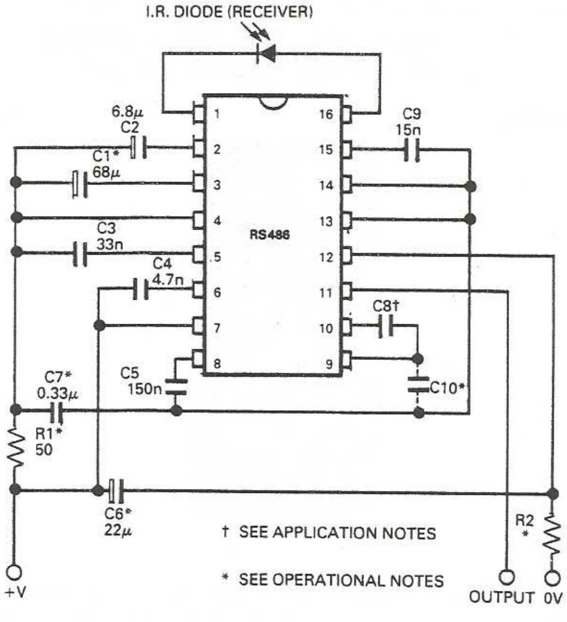


Figure 9 **Application diagram for use with RS920 series remote control receivers, utilising on-chip supply stabilizer**

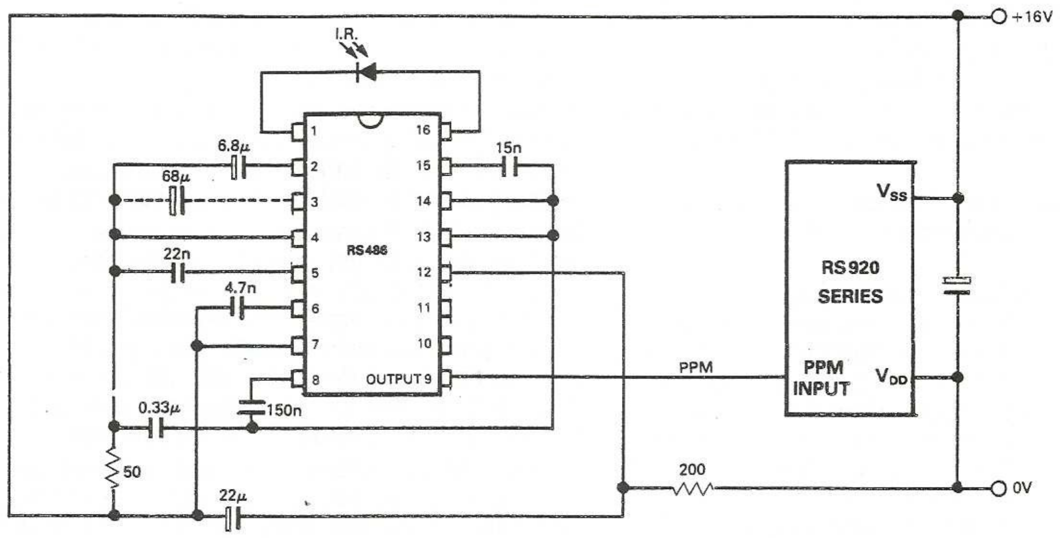


Figure 10 **Circuit diagram of microprocessor interface, utilising on-chip pulse stretching facility**

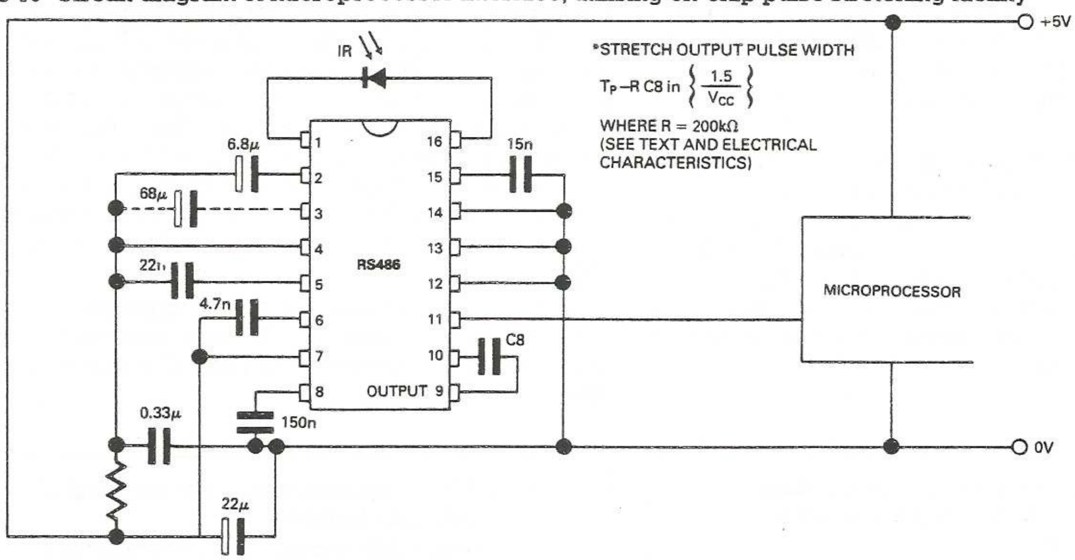
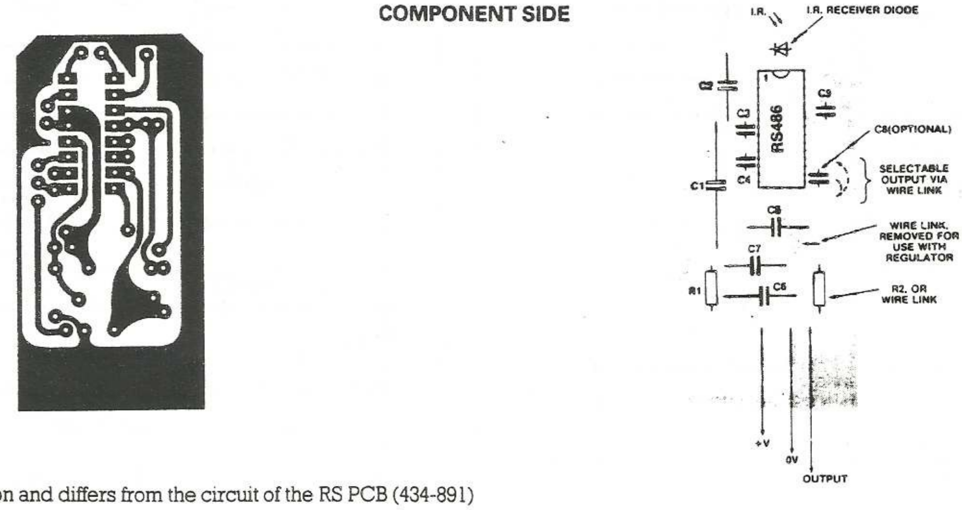


Figure 11 **Typical application board layout; suitable for use with a screened can. This board accommodates all circuit options of Figure 8 (except C10)**

COPPER SIDE

COMPONENT SIDE



This is a typical application and differs from the circuit of the RS PCB (434-891)

Remote control receiver RS922 (308-089)

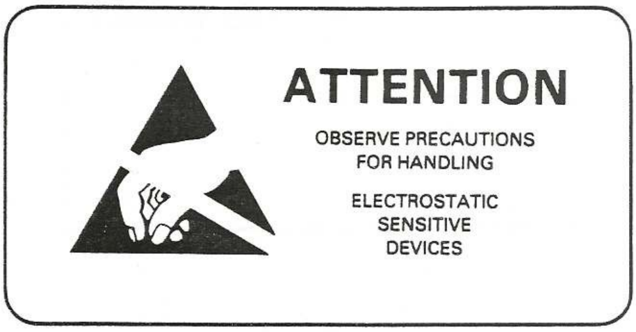
A range of monolithic integrated circuits which give a wide variety of remote control facilities. As well as ultrasonic or infra-red transmission, cable, radio or telephone links may be utilised. Pulse position modulation (PPM) is used with or without carrier and automatic error detection is also incorporated. Although initially designed with TV remote control in mind the devices may equally easily be applied for use in radios, tuners, tape and record decks, lamps and lighting, toys and models, industrial control and monitoring.

The RS922 decodes the PPM signal received from the RS490 transmitter. After error checking the received code may condition a 10 programme memory or one of three D/A converters.

The receiver timing may be set by adjusting the oscillator time constant to give 40 periods at pin 6 equal to a 0 interval on the received PPM input.

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

Supply voltage V_{DD} .... +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

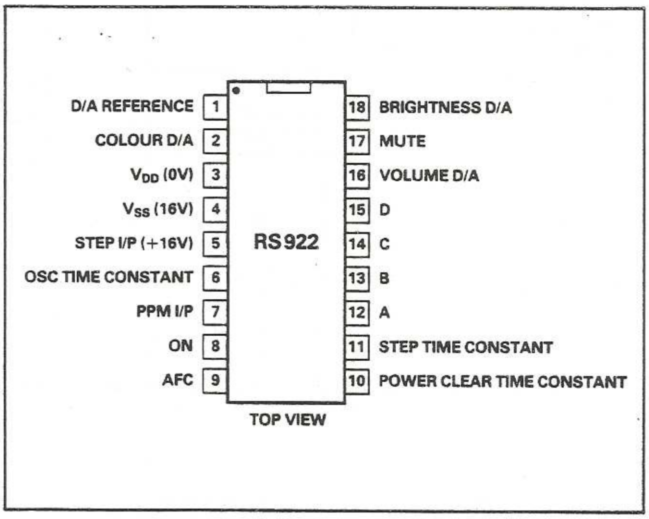


Features

- Accepts 5 bit PPM
- All timing from on-chip oscillator
- Incorporates error protection
- Easily used with ultrasonic or infra-red system
- Up to 10 programmes with latched binary output
- 3 D/A outputs with normalise level at ⅜ of maximum
- Automatic power-on reset and normalise
- Many other facilities, AFC, mute, etc.

Quick reference data

- Power supply: 16V 14mA
- Demodulation: pulse position with time window checking by on-chip oscillator
- Decoder: 5 bit with successive codeword comparison
- Programme: latched 4 bit binary, 10 programmes
- Other outputs: on, AFC, mute
- Local inputs: programme step



Electrical characteristics Test conditions (unless otherwise stated) V_{SS} = 0V, V_{DD} = –16V, T_{amb} = +25°C

Characteristic	Pin	Conditions	Value			Unit
			Min.	Typ.	Max.	
Supply voltage	3		–14		–18	V
Supply current	3			8	14	mA
Input logic level high low	5		–1 V_{DD}		0 V_{DD} + 3.5	V V
Output logic level high low	8, 9, 12-15, 17	50k to V_{DD} 50k to V_{DD}	–1 V_{DD}		0 V_{DD} + 0.5	V V
Analogue output current range	2, 16, 18	3.9 to V_{DD}	0		$\frac{31}{8}$	I_{ref}
Analogue step size	2, 16, 18	$V_{out} < V_{DD}$ +5V	0	⅛	¼	I_{ref}
D/A reference, I_{REF}	1	33k to V_{DD}	–250	–345	–455	μA
Oscillator timing	6	C = 22n, R = 100k see note 1		3		kHz
Power clear time constant	10	C = 4.7μ R = 100k		400		ms
Step time constant	11	C = 470n R = 3.3M		2		s
PPM input level high	7		–1		0	V
PPM input level low	7		V_{DD}		–6	V
PPM input pulse width	7		1		$22T_{OSC}$	μs

Note 1. R_{OSC} (pin 6) is 56k-156kΩ. $f_{osc} \simeq \frac{1}{0.15CR^1} \pm 20\%$

Figure 12 **RS922 remote control receiver block diagram**

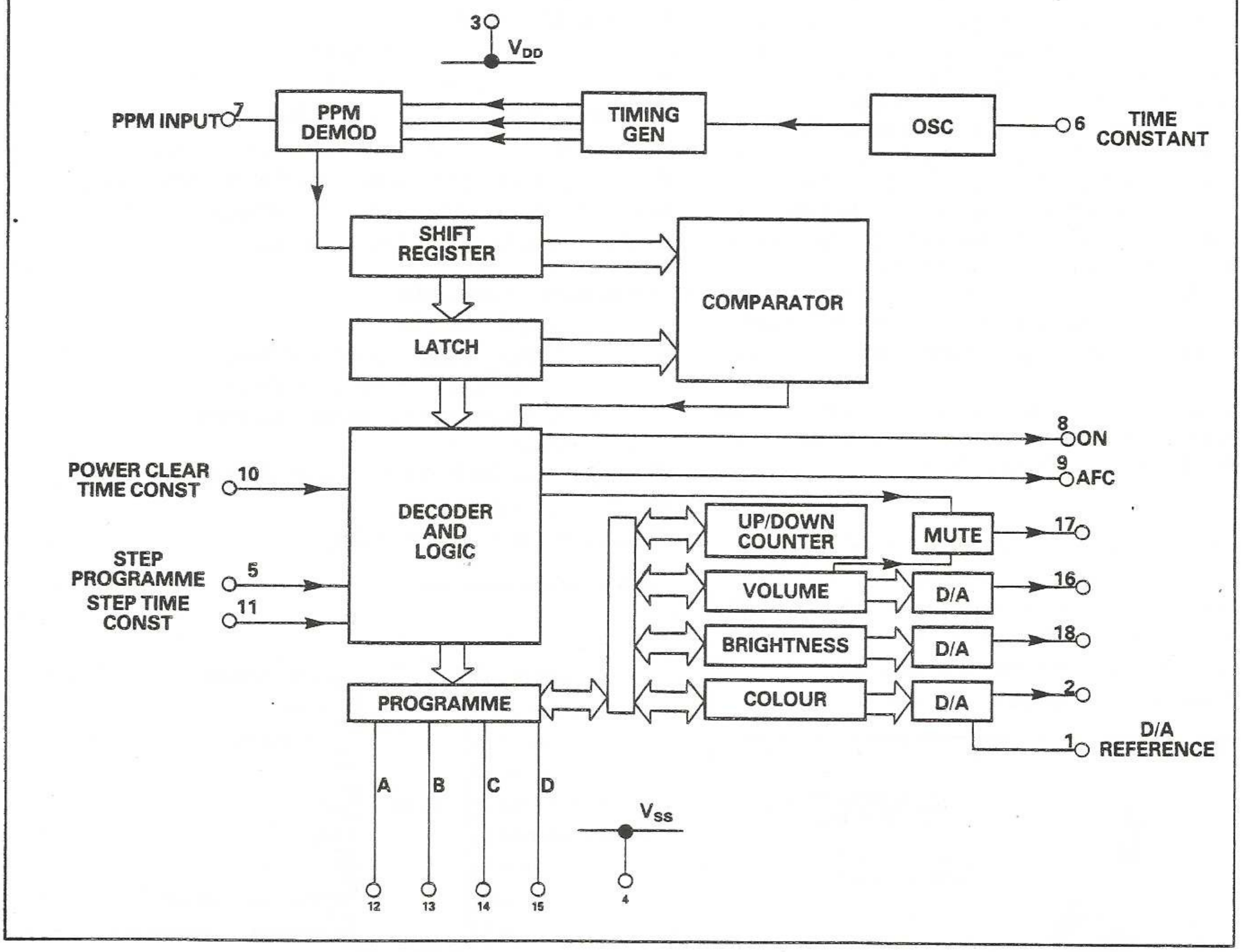


Table 1 **Basic 21 command set for RS922 receiver**

Transmitter code	Function	Programme O/Ps 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	Colour D/A+	
10101	Programme Step+	
10110	Volume D/A+	X = Don't care digit
10111	Brightness D/A+	
11000	Standby	
11001	Mute (Volumne D/A)	ie. 00110 and 00111 both produce programme 4
11011	Normalise	
11100	Colour D/A–	
11101	Programme Step–	
11110	Volume D/A–	
11111	Brightness D/A–	

NB. Logic Convention RS922
Logic '0' – output transistor ON – pulls output to V_{SS}

Logic '1' – output transitor OFF
ie.: Negative logic

Figure 13 **RS922 receiver unit**

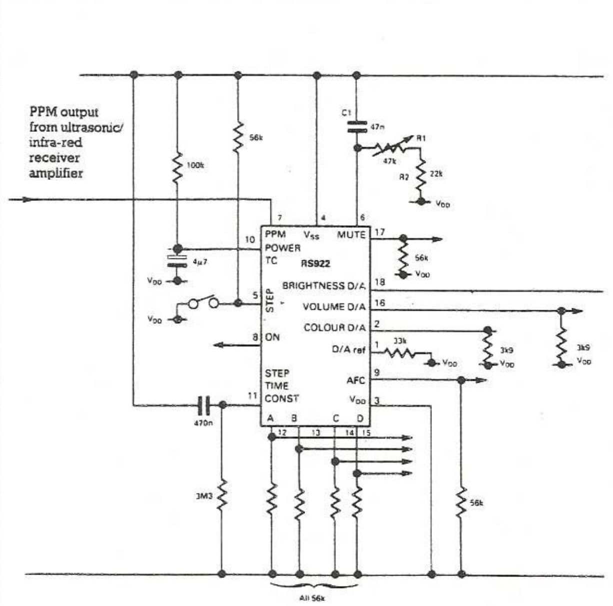


Table 2 **Pin functions of RS922**

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/Ps to $I_{ref}/8$.
2, 16, 18	Colour D/A Volume D/A Brightness D/A	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 (+16V)	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 PPM pulses from the RS490 transmitter.
7	PPM I/P	The output of the receiver amplifier provides positive PPM pulses which supply the data input to this pin. With no signal this I/P is held low.
8	On	An open drain O/P with an initial condition of logic 0. This input 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. Subsequent reception of a programme or step signal causes the analogue outputs to be normalised and the standby pin goes to logic 1. Whilst in standby all other controls continue to function normally.
9	AFC	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 13.
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/Ps	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 the logic 0 corresponding to programme 1.
17	Mute	This pin has an 'initial' condition of logic 1 and only changes to logic 0 when Brightness D/A 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 Brightness D/A O/P is not at the zero level.

Remote control receivers RS 926 and 927 (309-981 and 303-836)

The RS926 and RS927 are MOS LSI monolithic circuits for use as receivers of remote control signals for television control and many other applications. They are general purpose devices each receiving sixteen of the thirty-two codes transmitted by the RS490 circuit as pulse position modulation (PPM).

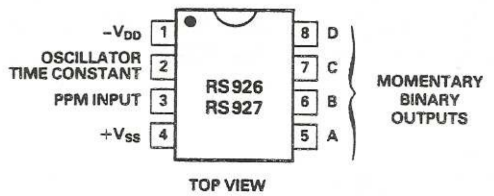
Absolute maximum ratings

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

Features

- Minimum packing size – 8-lead minidip
- Four outputs indicate in binary the code currently being received, and are switched off (low) when no valid code is detected
- On-chip oscillator
- High power, free drain, output buffers.

Pin connections



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

Characteristic	Pin	Conditions	Value Min.	Value Typ.	Value Max.	Units
Supply voltage	1		−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	$T = \frac{1}{f_{OSC}}$	1		$22T_{OSC}$	µsec
Oscillator time constant see Note 1						
Oscillator frequency	2		15		150k	Hz
		Typical TC: 22nF to V_{SS} 100k to V_{DD}		3k		Hz
Variation wrt V_{DD}				1		%/V
Output voltage high	5-8	$R_L = 3.0k$ to V_{DD}	−1.5		0	V
Output device leakage (Output OFF)	5-8				1	µA

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

Operating notes

The receiver operates on a timescale fixed by an internal oscillator and its external timing components. The oscillator may be adjusted to any value between 15Hz and 150kHz (allowing different receivers to respond to different transmission rates within the same area).

Checks are made to ensure 6 pulses, or 5 bits, are received for a word to be valid, and only after two consecutive and identical words is the receiver allowed to respond to the incoming code.

The RS926 responds only to codes 00001 to 01111 from the RS490 transmitter whereas the RS927 responds to codes 10001 to 11111.

Pin functions

Positive logic '1' = V_{SS}, '0' = V_{DD}

1. V_{DD}
−12V to −18V power supply.

2. Oscillator time constant
An RC time constant of a capacitor and resistor at this pin defines the internal clock frequency. The clock frequency may be varied from 15Hz to 150kHz.

3. PPM input
The output of the 'front end' amplifier is connected to this pin; the signal must consist of a normal 'low' level with pulses to high level corresponding to the PPM pulses from the transmitter.

4. V_{SS}
0V (ground).

5-8. A,B,C,D
Four open drain high power transistors give a binary coded output of the valid code being received.

Figure 14 **Block diagram**

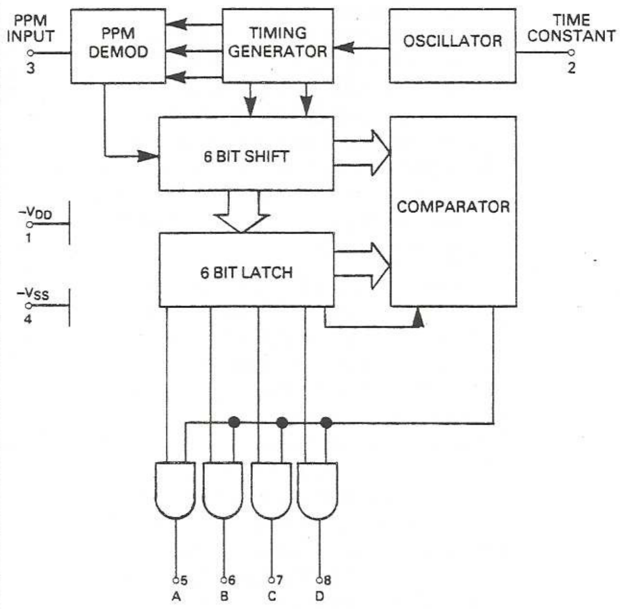


Figure 15 **Test circuit**

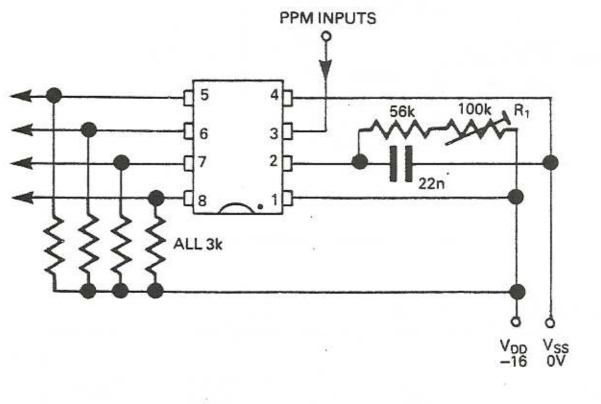


Table 3 **Response to RS490 codes**

Transmitter Code	Momentary binary outputs	
	RS926	RS927
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
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	
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	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 0 1 1 1		0 1 1 1
1 1 0 0 0		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

RS926 and RS927 (momentary outputs)
Logic '0' – output transistor OFF
Logic '1' – output transistor ON
– pulls output to V_{SS}
ie: **POSITIVE LOGIC**

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

The RS928 and RS929 are general purpose remote control receivers, each receiving and latching 16 of the 32 codes transmitted by the RS490 circuit in the PPM (Pulse Position Modulation) mode. The RS928 responds to codes 00000 to 01111 only, and the RS929 to codes 10000 to 11111. Both devices are packaged in 8-lead minidip to minimise board area. The on-chip oscillator may be adjusted from 15Hz to 150kHz, allowing different transmission rates. They have a high degree of immunity to incorrect codes; there must be two consecutive correct codes received before the outputs can change.

Absolute maximum ratings

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

Features

- Accepts 5 bit PPM
- On-chip oscillator, 15Hz to 150kHz range
- Easily used with ultrasonic, infra-red or other transmission media
- Four high drive outputs
- 16 latched states
- Minimum sized package.

Quick reference data

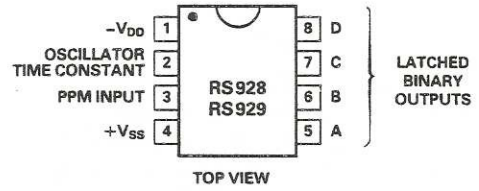
- Power supply: 12V to 18V. Typical 4mA at 16V
- Demodulation: pulse position with time window checking by on-chip oscillator
- Decoder: 5 bit with successive codeword comparison
- Outputs: maximum 15mA sourced from open drain drive
- Logic convention: Logic 0 – output transistor ON, pulls output to V_{SS}
  Logic 1 – output transistor OFF.

ATTENTION

OBSERVE PRECAUTIONS FOR HANDLING

ELECTROSTATIC SENSITIVE DEVICES

Pin connections



Electrical characteristics Test conditions (unless otherwise stated) V_{SS} = 0V, V_{DD} = –16V, T_{amb} = +25°C

Characteristic	Pin	Conditions	Value			Units
			Min.	Typ.	Max.	
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		$T_{OSC} = \frac{1}{f_{OSC}}$	1		$22T_{OSC}$	μs
Oscillator timing	2					
Frequency			15		150k	Hz
		Typical TC: 22nF to V_{SS}, 100kΩ to V_{DD}		3k		Hz
Variation wrt V_{DD}				1		%/V
Latched binary output Logic '0' output voltage	5, 6, 7, 8	R_L = 3.0k to V_{DD}	–1.5		0V	V
Output leakage in logic '1' state					1	μA

Note 1. R_{OSC} (pin 2) is 56k-156kΩ. $f_{OSC} \approx \frac{1}{0.15CR}$ ±20%

Figure 16 **RS928 and RS929 remote control receivers block diagram**

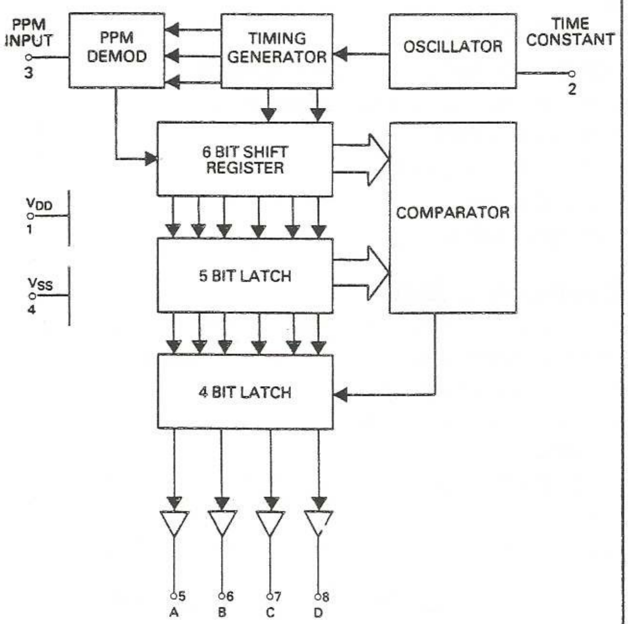


Figure 17 **Test circuit**

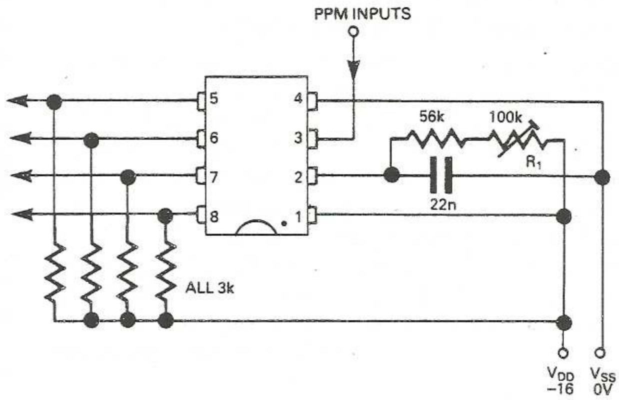


Table 4 **Response to RS490 codes**

Transmitter Code	Momentary binary outputs	
	RS928	RS929
E D C B A	D C B A	D C B A
0 0 0 0 0	0 0 0 0	No change
0 0 0 0 1	0 0 0 1	No change
0 0 0 1 0	0 0 1 0	No change
0 0 0 1 1	0 0 1 1	No change
0 0 1 0 0	0 1 0 0	No change
0 0 1 0 1	0 1 0 1	No change
0 0 1 1 0	0 1 1 0	No change
0 0 1 1 1	0 1 1 1	No change
0 1 0 0 0	1 0 0 0	No change
0 1 0 0 1	1 0 0 1	No change
0 1 0 1 0	1 0 1 0	No change
0 1 0 1 1	1 0 1 1	No change
0 1 1 0 0	1 1 0 0	No change
0 1 1 0 1	1 1 0 1	No change
0 1 1 1 0	1 1 1 0	No change
0 1 1 1 1	1 1 1 1	No change
1 0 0 0 0	No change	0 0 0 0
1 0 0 0 1	No change	0 0 0 1
1 0 0 1 0	No change	0 0 1 0
1 0 0 1 1	No change	0 0 1 1
1 0 1 0 0	No change	0 1 0 0
1 0 1 0 1	No change	0 1 0 1
1 0 1 1 0	No change	0 1 1 0
1 0 1 1 1	No change	0 1 1 1
1 1 0 0 0	No change	1 0 0 0
1 1 0 0 1	No change	1 0 0 1
1 1 0 1 0	No change	1 0 1 0
1 1 0 1 1	No change	1 0 1 1
1 1 1 0 0	No change	1 1 0 0
1 1 1 0 1	No change	1 1 0 1
1 1 1 1 0	No change	1 1 1 0
1 1 1 1 1	No change	1 1 1 1

RS928 and RS929 (Latching output)
Logic '0' – output transistor ON
– pulls output to V_{SS}
Logic '1' – output transistor OFF
ie: **NEGATIVE LOGIC**

Pin functions

Negative logic '0' = V_{SS}, '1' = V_{DD}

1. V_{DD}
–12V to –18V power supply.

2. Oscillator time constant
An R-C time constant at this pin defines the internal clock frequency. The clock frequency may be varied from 15Hz to 150kHz and should be set so that there are 40 periods in one 't_o' transmitter pulse interval.

3. PPM input
The output of the 'front end' amplifier is connected to this pin; the signal must consist of a normal 'low' level with pulses to high level corresponding to the PPM pulses from the transmitter.

4. V_{SS}
0V (ground).

5-8. A,B,C,D
Four open drain high power transistors give a binary coded latched output of the last valid code received.

Figure 19 **Direct drive of LED**

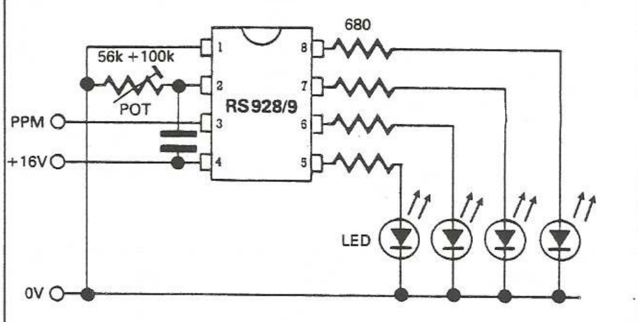
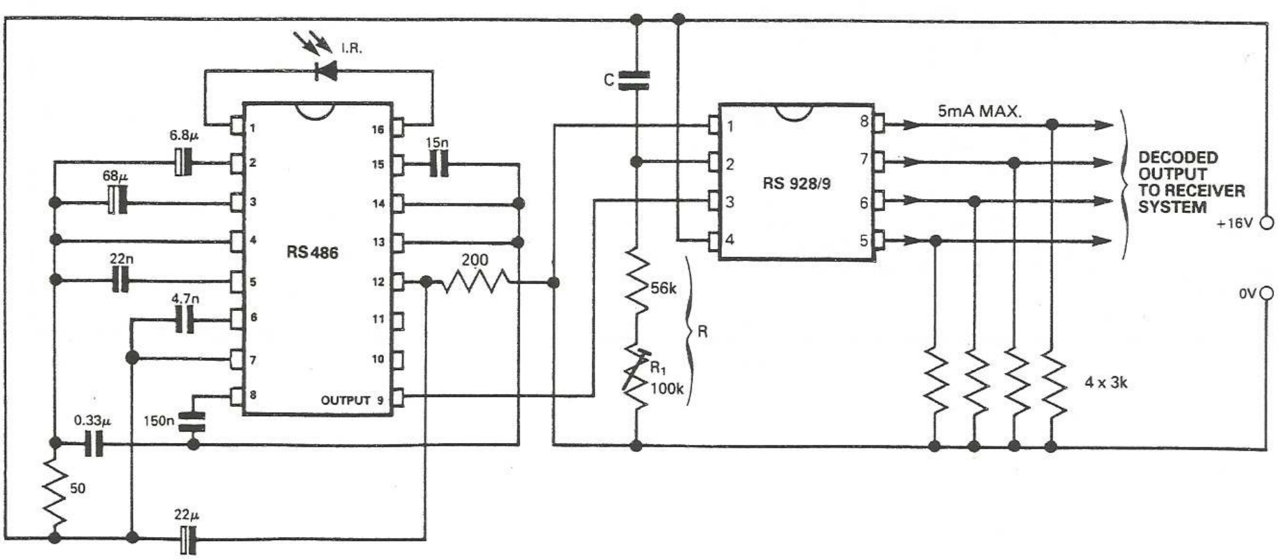


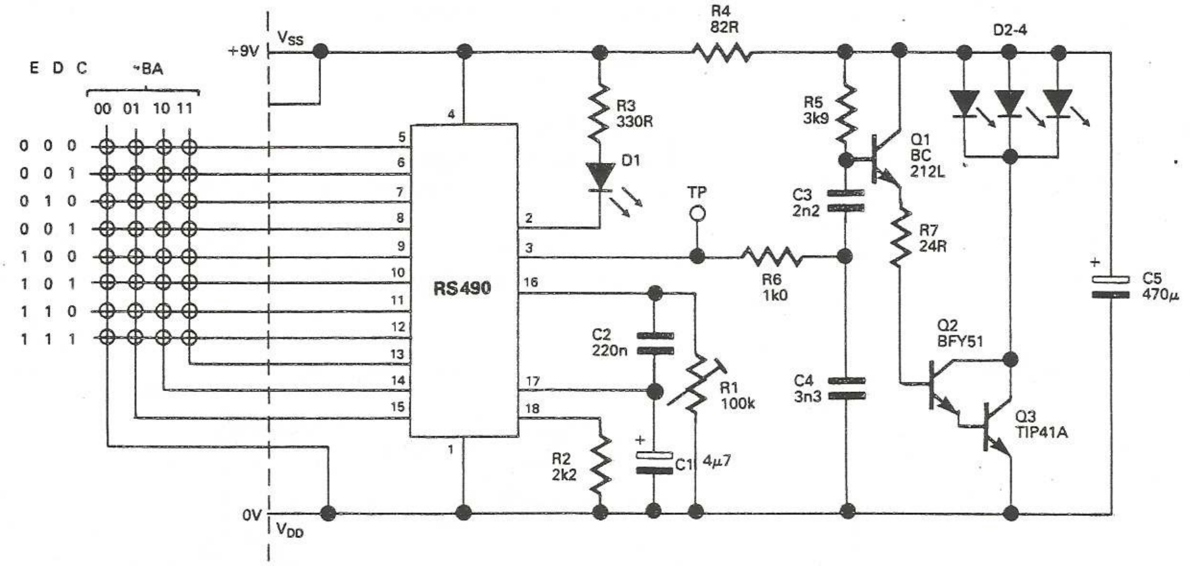
Figure 18 **Typical application circuit**



Applications information for RS printed circuit boards

A range of four printed circuit boards to suit an infra-red link is available (stock numbers 434-807, 434-813, 434-835 and 434-891). In some cases the design of the circuits for these pcb's is different from the examples given earlier in this data sheet. The following gives circuit diagrams and component listings for the pcb's with linking requirements where applicable.

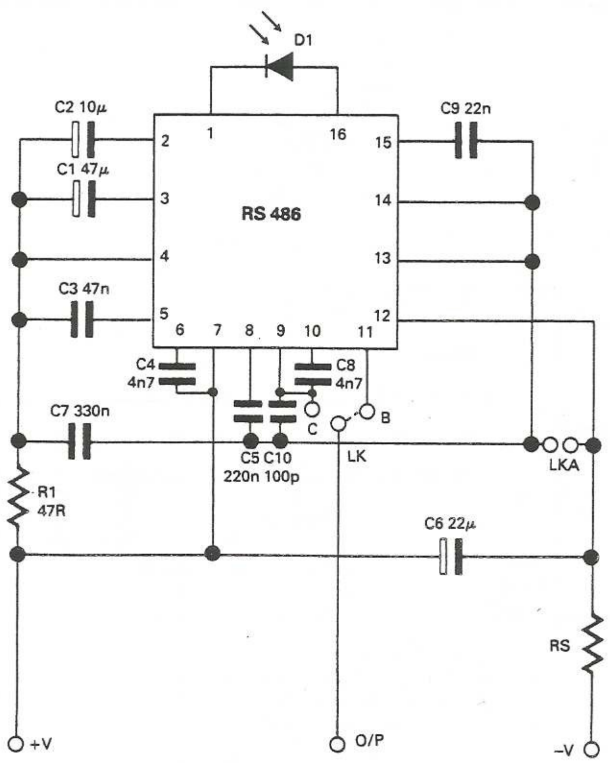
Figure 20 **Infra-red transmitter RS490**



Component	Stock No.	Pitch
pcb	434-807	—
D1	586-475	0.1 in
D2-4	635-296	0.1 in
R1	186-558	—
R2	132-573	0.5 in
R3	132-371	0.5 in
R4	132-236	0.5 in
R5	132-630	0.5 in
R6	132-494	0.5 in
R7	148-102	0.5 in
C1	104-528	0.1 in
C2	114-418	0.3 in
C3	113-342	0.5 in
C4	113-358	0.5 in
C5	104-893	0.8 in
Q1	294-299	—
Q2	293-640	—
Q3	294-362	—
490 transmitter	308-073	—

Suitable key matrix (not mounted on 434-807) 32 x SPST switches eg 334-921.

Figure 21 **RS486 infra-red pre-amp**



Component	Stock No.	Pitch	Notes
pcb	434-891	—	—
D1	635-296	0.1in	
R1	148-174	0.4in	
RS	—	0.4in	1
C1	104-461	0.1in	
C2	104-613	0.1in	
C3	125-799	0.1in	
C4	125-761	0.1in	
C5	126-045	0.2in	
C6	104-944	0.5in	
C7	114-907	0.3in	
C8	125-761	0.1in	2
C9	125-783	0.1in	
C10	125-840	0.1in	2
RS486 pre-amp	301-527		

Options

For on chip regulation (supply voltage 9.0 to 18V), fit resistor RS. Omit link A.

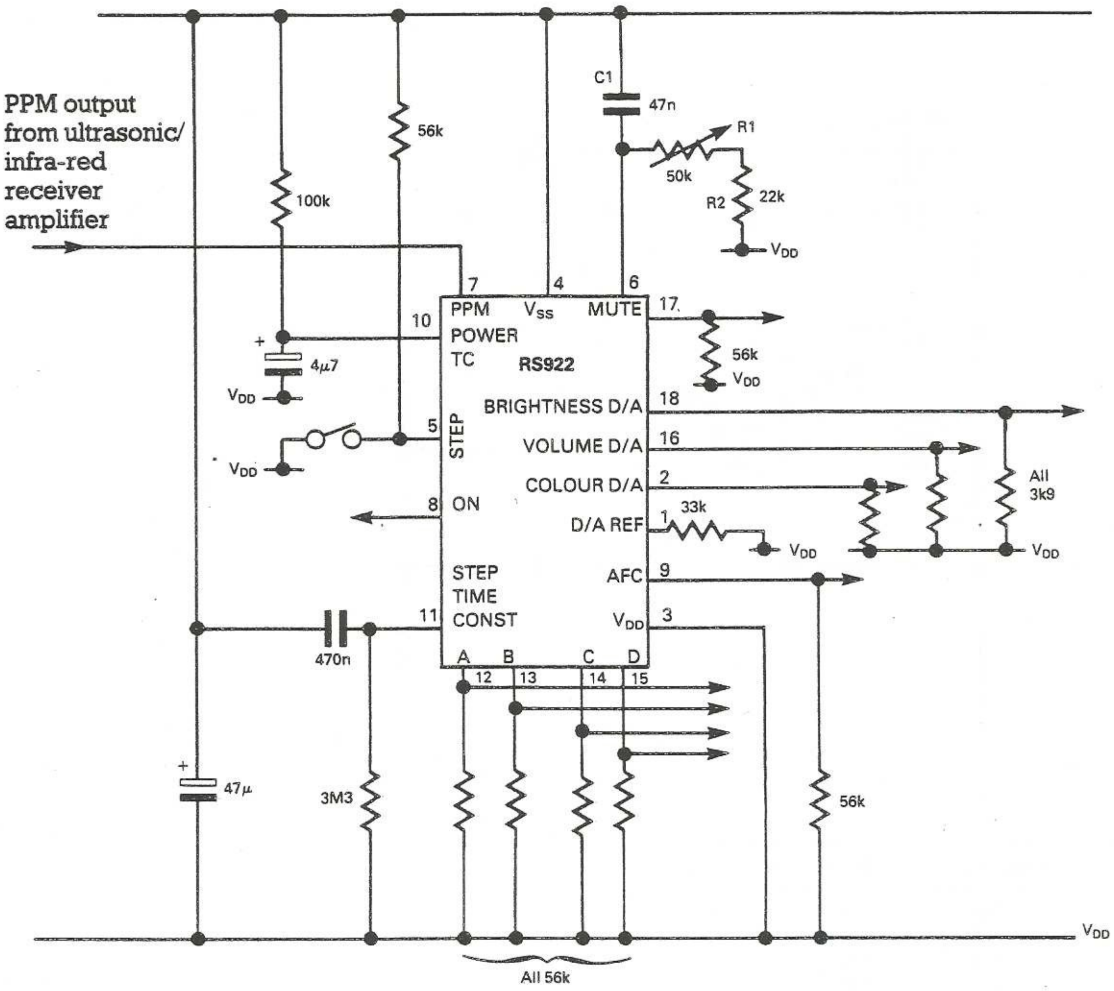
For operation with supplies between 4.5 and 9V, short out RS. Fit link A.

For normal output, omit link B. Fit link C.

For stretched output, fit link B. Omit link C.

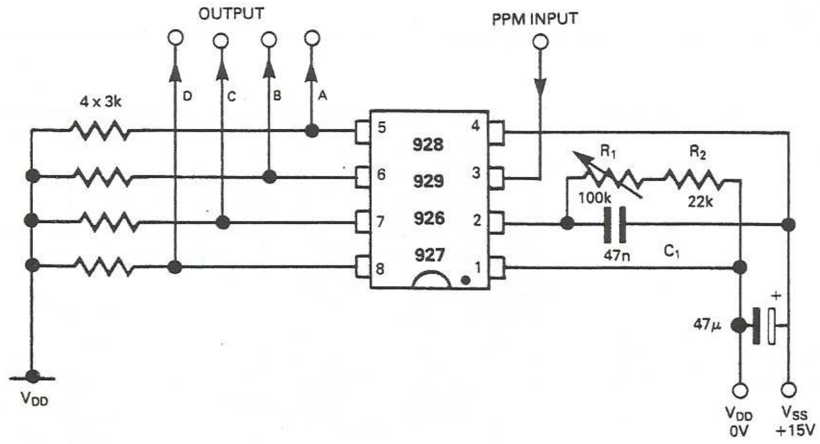
Notes 1. Value depends on supply voltage, see 'Operational notes – decoupling' on page 7.
2. Only required if stretched output is required.

Figure 22 **RS922 receiver circuit**



Component	Stock No.	Pitch
pcb	434-813	—
R1	186-542	—
R2	148-095	0.5in
3k9	131-328	0.5in
33k	131-435	0.5in
56k	131-463	0.5in
100k	131-491	0.5in
3M3	133-273	0.5in
C1	114-395	0.3in
470n	114-424	0.3in
4u7	104-528	0.1in
47μ	104-950	0.7in
RS922	308-089	—

Figure 23 **RS928/9 and RS926/7 circuit**



Component	Stock No.	Pitch
pcb	434-835	—
C1	114-395	0.3in
47μ	104-950	0.7in
R1	186-558	—
R2	148-095	0.5in
3k0	148-613	0.5in
RS926	309-981	—
RS927	303-826	—
RS928	309-997	—
RS929	305-248	—

Application hints

It can be difficult to trigger an oscilloscope from the output of the transmitter ic due to the nature of the pulse position modulation employed. An alternative method of setting up the transmitter and receivers is described below. This method measures the time constant period of the oscillators in the transmitter and receivers thus enabling oscilloscope triggering.

Note. Always use an X10 oscilloscope probe to avoid overloading the ic oscillators.

Infra-red control system

Setting-up procedure

Transmitter

The potentiometer R_1 shown in Figure 20 should be adjusted for the required PPM rate. Avoid PPM rates which correspond to the 50/60Hz mains frequency or multiples thereof.

Activate the transmitter to produce codeword 11111 continuously and monitor the oscillator waveform of the transmitter ic appearing at pin 16. The period of the observed ramp waveform is the **ON period t_1** of the transmitter, adjust R_1 to set the required PPM rate (Note $t_o = 1.5t_1$:).

Receiver

Monitor the waveform on the oscillator time constant pin of the receiver ic. The period of the observed ramp waveform is the **OFF period t_o** of the receiver, adjust R_1 on the receiver circuit so that the period of the waveform is 3/80th of the period of the transmitter waveform.

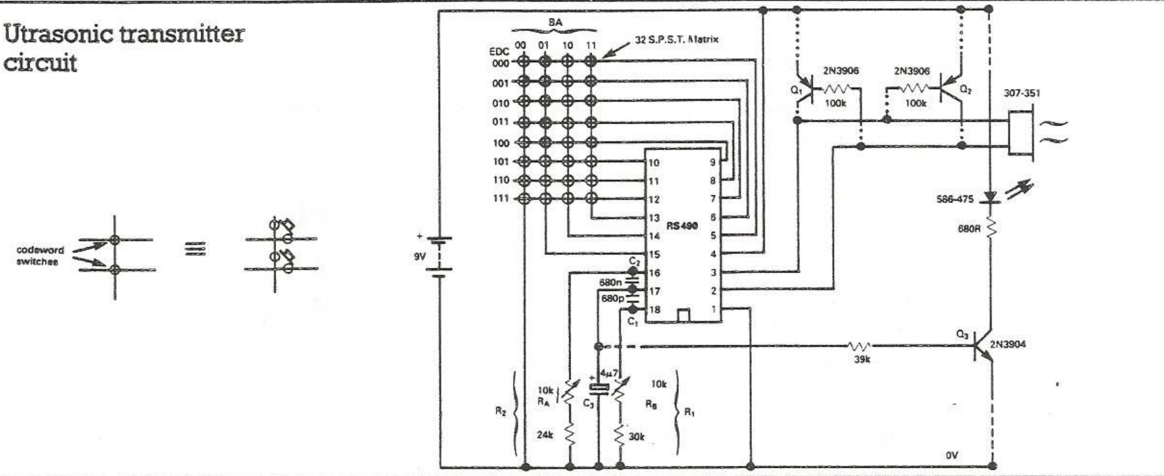
Ultrasonic control system

Transmitter

The potentiometers R_A and R_B in the transmitter circuit shown in Figure 24 require adjustment to define the carrier frequency and PPM rate required. Activate the transmitter to produce the codeword 0000X and monitor the output waveform of the transmitter ic 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. Set up the required PPM rate as detailed in the infra-red setting up procedure.

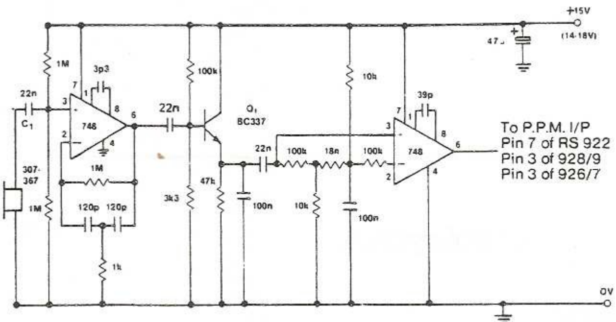
RS Data Library

Figure 24 **Ultrasonic transmitter circuit**



Receiver

Figure 25 **Ultrasonic receiver amplifier**



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.

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

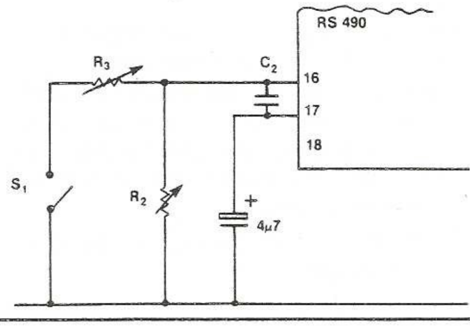
A. Position the transmitter and receiver transducers 3m apart. Activate the transmitter to produce the codeword 0000X continuously and monitor the PPM input pin on the receiver ic.

B. Readjust RB, controlling the carrier frequency of the transmitter circuit, to provide a maximum signal at the PPM input of the receiver ic. Finally adjust the period of the oscillator time constant as per the infra-red setting up procedure.

Transmitter control for 2 receivers

Figure 26 illustrates a method of employing one RS490 transmitter to control two independent receivers. The PPM rate for one receiver is selected by the potentiometer R_2. The second receiver should be adjusted to receive the PPM rate defined by the parallel combination of R_2 and R_3. The two different PPM 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 PPM rates should be within the limitations of the transducer, only one receiver amplifier being required to directly feed the PPM inputs on the two receivers.

Figure 26 **Transmitter modification for controlling two receivers**



TTL interface

Figure 27 shows a simple interface between logic level outputs of the remote control receiver ic's, to standard TTL inputs. This circuit also inverts the logic levels, a logic 1 from the receiver producing logic 0 TTL output.

Figure 27 **TTL interface**