

Monolithic Servo Controller

GENERAL DESCRIPTION

The XR-2266 is a monolithic servo controller specifically designed for radio controlled model cars. The device is capable of controlling speed in forward or reverse, direction of turn, backup lights, and turn signals with programmable flash rate. Supply voltage may range from 3.5V to 9V.

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FEATURES

- Internal Channel Divider
- Internal Steering Servo with Direct Drive for Servomotor and Turn Signal Indicators
- Directional Signal Time Constant Externally Settable
- Variable Speed Control with Direct Drive for Backup Lights
- Wide Supply Range (3.5 - 8.0 volts)
- Steering and Speed Servos Independently Programmed

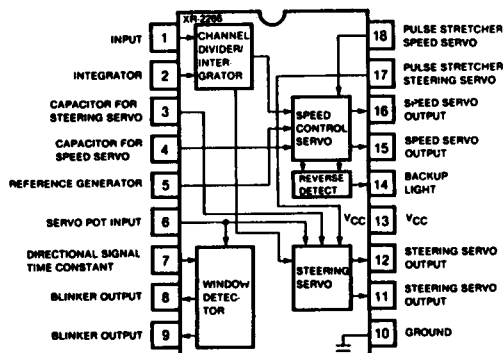
APPLICATIONS

Radio Controlled Cars

ABSOLUTE MAXIMUM RATINGS

| | |
|---------------------------------------|---|
| Supply Voltage | 9V |
| Power Dissipation | 1100 mW |
| Derate above $T_A = 25^\circ\text{C}$ | 6 mW/ $^\circ\text{C}$ |
| Storage Temperature Range | -65 $^\circ\text{C}$ to +150 $^\circ\text{C}$ |

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

| Part Number | Package | Operating Temperature |
|-------------|---------|--|
| XR-2266 | Plastic | 0 $^\circ\text{C}$ to +70 $^\circ\text{C}$ |

SYSTEM DESCRIPTION

The XR-2266 is a monolithic servo controller system specifically designed for radio-controlled model cars. The integrated circuit is a self-contained system made up of two servo controller channels: one controls the direction and speed of travel, the other provides the steering function. The circuit contains an internal channel separator section which automatically steers the incoming control signal to the appropriate servo controller channel.

The entire servo controller system is available in an 18-Pin dual-in-line package, with terminals provided for accessory controls such as turn indicator signals and backup lights. The entire system is fabricated on a monolithic chip, using low-power integrated injection logic (I²L) technology along with precision analog circuitry. It operates with supply voltages in the range of 3.5 volts to 8 volts.

ELECTRICAL CHARACTERISTICS

Test Conditions: $V_{CC} = 6$ Volts $T_A = 25^\circ\text{C}$ unless otherwise specified

| PARAMETERS | LIMITS | | | UNITS | CONDITIONS |
|------------------------------------|--------|----------------------|-----|---------------|---------------------------------------|
| | MIN | TYP | MAX | | |
| Supply Current | | 30 | | mA | Measured at Pin 6 |
| Operating Supply Range | 3.5 | 6.0 | 8.0 | V | |
| Input Threshold | | 0.7 | | V | |
| Reference Generator Output Current | | 100 | | μA | |
| Directional Detector | | | | | |
| Pin 5 Voltage | | 55 | | % | Voltage at Pin 6 (Blinker "off") |
| Pin 5 Voltage | | 61 | | % | Voltage at Pin 6 (Pin 8 Blinker "on") |
| Pin 5 Voltage | | 48 | | % | Voltage at Pin 6 (Pin 9 Blinker "on") |
| Output Current | | | 100 | mA | |
| Steering SERVO | | | | | |
| Output Source Current | | 350 | | mA | Pin 11 or 12 |
| Output Sink Current | | 350 | | mA | Pin 11 or 12 |
| Reverse Detector | | | | | |
| Output Current | | | 100 | mA | Pin 14 |
| Speed Control Servo | | | | | |
| Output HIGH Voltage | | $V_{CC} - 1\text{V}$ | | V | Pin 15 or 16 |
| Output Low Voltage | | 0.2 | | V | Pin 15 or 16 |
| Output Impedance | | 700 | | Ω | Pin 15 or 16 |

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PRINCIPLES OF OPERATION

The theory of operation can be explained with reference to the block diagram of Figure 2 and the timing diagram of Figure 3. The direction and speed information are encoded onto a carrier by either Amplitude Modulation (illustrated Curve A) or Frequency Modulation (not shown). This signal is received and demodulated into Waveform B. The timing of Waveform B is as follows: T_F is the frame time and determines the frequency with which the servos are controlled. T_S is a space pulse used to separate the channel information of T_1 and T_2 . The width of T_1 and T_2 contain the steering and speed information respectively.

Waveform B is applied to the input of the XR-2266. This signal is integrated into Waveform C which is then squared to form D. Waveform D is used as a reset to the channel divider circuit. The channel divider circuit triggers on the leading edge of the input signal and generates two outputs; one for steering and the other for the speed control; Waveforms E and F, respectively.

Waveform E is applied to the input of Servo No. 1 which serves as the positional control for the steering wheel. The servo pot on the linkage forms a closed loop system with the servoamplifier to position the front wheels to the required position. The servo pot is also connected to the directional indicator circuit which determines whether the wheels are turned enough to enable the blinker lights.

Waveform F is the input to the variable speed control servo. This servo determines the error between the input signal and the preset nominal value and applies drive to the motor proportional to this difference. A de-

tection circuit has also been built into the IC to detect when the car is going in reverse and turn on the backup lights.

SYSTEM BLOCKS

The XR-2266 is comprised of three independent systems internally connected as in Figure 4 to perform the complete car function. These blocks are the channel divider, steering servo and a speed control circuit. (While a total understanding of these circuits is not necessary a fundamental knowledge of the operation of each block will be an asset to any servo design.)

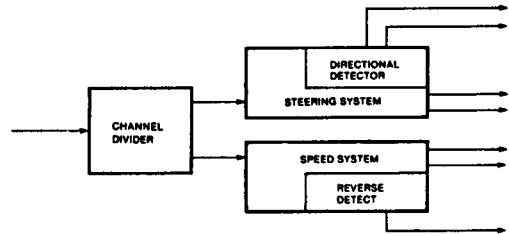


Figure 4. Three Primary Systems of XR-2266

Channel Divider: The function of the channel divider is to decode the channel information from the demodulated input signal and to synchronize the receiver to the transmitter. The synchronization is required to assure that the decoded input is applied to the correct servo. The generation of the synchronization signal is illustrated in Figure 3 and can be explained as follows: The input signal B is integrated by the RC time constant on pin 2 to form waveform C. This integrated signal is then squared to form the synchronization signal D. This signal resets the channel divider when high, guaranteeing that the first input be directed to the channel one servo and the second input be directed to the channel two servo, as illustrated by waveforms E and F, respectively. The width of the input signals is determined by the time interval between two successive positive going edges of waveform B. After the channel two input ends, the integrator charges up to the reset level and enables channel one for the next rising edge of the input signal. The time constant for the integrator is externally set by the RC time constant on pin 2. It is recommended that the time constant be chosen such that the reset occurs midway between the input frame time.

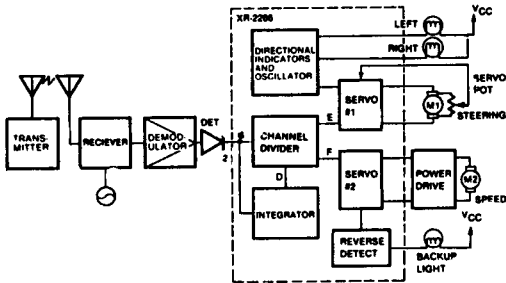


Figure 2. Radio Controlled System Block Diagram

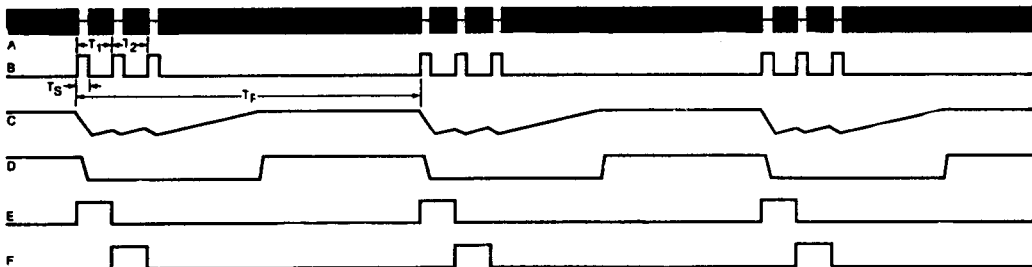


Figure 3. Timing Diagram

Steering Servo: The block diagram of the steering servoamplifier is illustrated in Figure 5. The primary function of this block is to control the position of the front wheels of the car in direct proportion to the input pulse width. The XR-2266 has the additional feature of being able to detect the magnitude and direction of the position of the wheels from their center position and if it is greater than an externally preset amount, to activate a blinker circuit for the appropriate turn-direction. The operation of the steering servoamplifier can be explained with reference to the block diagram of Figure 5 and timing diagram Figure 6. On the leading edge of the input signal an internal one-shot is triggered. The one-shot generates an output pulse whose width is directly proportional to the present position of the shaft of the servomotor. The position information is supplied via the servo pot. The width of these two pulses are then compared and two error signals are generated; one is the directional error which is used to determine the output drive direction and the other is the magnitude error which is applied to the pulse stretcher section which determines whether the error was of sufficient magnitude to enable the output driver stage. If the dead band is exceeded, the error pulse of several microseconds is then stretched to several milliseconds of output drive. The dead band is required to assure that the motor does not oscillate about its center point. The XR-2266 has internal driver transistors that are capable of sinking or sourcing 350 mA. The positional information from the servo pot is also applied to a window comparator and the output of this circuit determines the deviation of the steering wheel from its center position. If this is greater than the preset amount, the blinker signals are activated. The time constant of the blinkers is set by the capacitor on pin 7. The blinker outputs are open collector type capable of sinking 100 mA each.

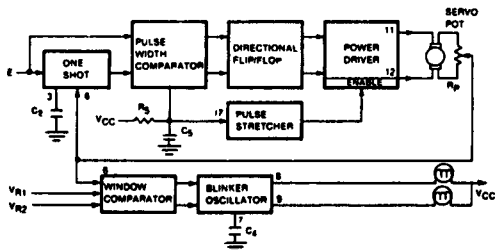


Figure 5. Steering Servo System

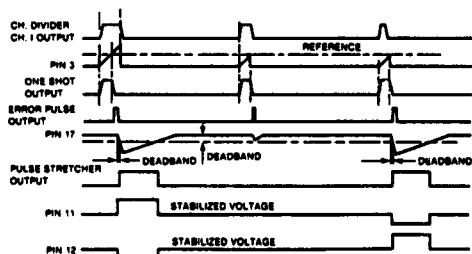


Figure 6. Timing Diagram

Speed Control Circuit: The channel two output Waveform F from the channel divider, as shown in Figure 7, is applied to the input of the speed control servo. This circuit is similar to the steering control servo with the exception that it is operated in an open loop configuration. Thus, the duty cycle of the output drive increases until a maximum drive is reached. The drive characteristics for the speed control are set independently of the steering by an RC time constant on pin 18. Due to the high power motors required for speed control, an external driver transistor must be used. A typical connection for these transistors is illustrated in Figure 7. The speed control amplifier also features an additional output for the backup lights. This output is obtained from the directional logic which determines whether the car is going in the forward or reverse direction. The motor terminals could also be reversed and the output used to drive the front headlights when the car is going forward. The output for the driver lamps is an open collector transistor and is capable of sinking 100 mA. Since this is an open collector output, care should be taken to avoid any possible shorting to the VCC pin, as this will damage the device.

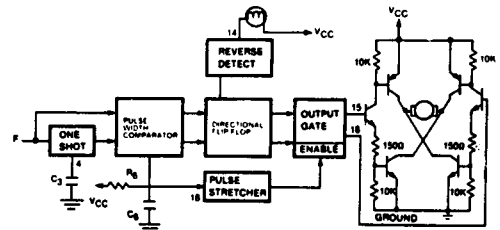


Figure 7. Speed Control Servo System with Connection for External Driver Transistors

DESCRIPTION OF CONTROLS

Input (Pin 1): The demodulated output from the receiver is applied to this pin. The threshold for the input is approximately 0.7V. It is recommended that a 0.0022 μ F capacitor be connected from this point to ground to eliminate any RF signal at the input.

Reset Integrator (Pin 2): The function of this pin is to synchronize the servo control to the transmitter. This assures that the steering and speed control signals are not interchanged. The time constant used for this circuit is dependent upon the frame time of the input signal. For a 15 millisecond frame, the value for R₁ is 510K and for C₁, 0.1 μ F. Other frame rates may be used, in which case the RC time constant may be determined by the following equation:

$$R_1 C_1 = [T_F - X(T_N)] / 2 \ln [V_{CC} / (V_{CC} - .66)]$$

where

- T_F = Frame Time
- X = Number of Servos
- T_N = Nominal Pulse Width for Servos
- V_{CC} = Nominal Supply Voltage

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Timing Cap for Steering Servo (Pin 3): The capacitor on this pin is used to determine the nominal one-shot time constant for the steering control. The capacitor value is chosen by the following equation:

$$C_2 = T_N / (R_2 + R_P / 2)$$

where R_2 is a 1K potentiometer and R_P is the servo pot, nominally 5K. This yields $0.47 \mu\text{F}$ for C_2 . R_F is a damping resistor that provides a momentum feedback to prevent the servo from overshooting. The recommended values for R_F are 100K to 700K, depending on the required loop damping.

Timing Cap for Speed Control (Pin 4): This capacitor determines the nominal one-shot time constant for the speed control servo. The capacitor value is determined by:

$$C_3 = 1.3 T_N / (R_P + R_2)$$

Reference Generator (Pin 5): Pin 5 is used to generate the reference level for the speed and steering servos and also control the degree of turning before the directional indicators are activated. This pin is directly connected to one end of the servo pot with the other connected to a 1K pot or fixed resistor to ground. This 1K pot is used to adjust the dead time for the directional indicators. In noisy environments, pin 5 should be bypassed to ground via a $0.001 \mu\text{F}$ capacitor.

Steering Positional Input (Pin 6): The wiper of the servo pot is connected to this pin to supply the positional information to the one-shot of the steering servo. In noisy environments this pin should be bypassed to ground via a $0.002 \mu\text{F}$ capacitor.

Directional Signal Time Constant (Pin 7): The capacitor connected to this pin determines the time constant for the directional indicators. The ratio of 'ON' to 'OFF' is approximately 2:1 and the frequency is determined by:

$$F(\text{Hz}) = 81 / C_4 (\mu\text{F})$$

Outputs for Directional Indicators (Pin 8 & 9): These pins are used to drive the directional signal indicators. These are open collector outputs that can sink a maximum current of 100 mA.

Steering Motor Drive (Pin 11 & 12): These outputs connect directly to the steering servomotor and are capable of sinking or sourcing 350 mA.

Output for Backup Lights (Pin 14): This terminal is activated when the car is driving in the reverse direction. This is an open collector output with a maximum current of 100 mA.

Note: by reversing the motor leads, this terminal could be used to control front headlights when the car is moving forward.

Output for Speed Control (Pin 15 & 16): These pins are used to drive an external power bridge to control the speed of the car. A typical connection is illustrated in Figure 7.

Pulse Stretcher (Pin 17 & 18): The RC time constant on pin 17 and pin 18 is used to set the dead band and the maximum drive pulse to the steering servo and speed control servo, respectively. The dead band time is determined by:

$$T_{dB} = (51.4)(C)$$

The maximum drive time is determined by:

$$T_{MD} = RC1n [(V_{CC} - .73e^{-(1 \times 10^{-6}/C)})(V_{CC} - .66)]$$

Power Supply (Pin 13 & 10): The battery should be connected from pin 13 (V_{CC}) to pin 10 (ground). The operating power supply range is 3.5 to 9 volts. A $100 \mu\text{F}$ capacitor is recommended across the power supply terminals.

APPLICATION EXAMPLE

The method for determining the component values for any servo application can be obtained by the following design rules. These equations will yield values suitable for proper operation and can later be adjusted to suit particular applications. For the example chosen, the frame time is 15 ms and the pulse width is nominally 1.4 ms with a deviation of $500 \mu\text{s}$. Dead band is chosen to be $30 \mu\text{s}$ and $80 \mu\text{s}$ for the steering and speed control sections, respectively. The servo pot is a 5K pot and the operating supply voltage is 6 volts.

Procedure:

1. To determine the time constant of the integrator on pin 2, use the following formula with R_1 assumed to be between 100K and 1M. In this example we set $C_1 = 0.1 \mu\text{F}$ and calculate R_1 .

$$R_1 = [T_F - X(T_N)] / 2C_1 1n[V_{CC} / (V_{CC} - .66)]$$

This yields $R_1 \approx 510\text{K}$

2. C_3 and R_2 setting (using a 1K pot) is determined by the following: First approximate R_2 to be one half of its value and solve for C_3 .

$$C_3 = 1.3 T_N / (R_P + R_2 / 2)$$

$$C_3 \approx .33 \mu\text{F}$$

$$C_3 = 0.25 \mu\text{F}$$

Select nearest standard value for C_3 and calculate R_2 value

$$R_2 = (1.3 T_N / C_3) - R_P$$

$$R_2 \approx 515\Omega$$

3. C_2 is determined by the following: Use value for R_2 as calculated above.

$$C_2 = T_N / (R_2 + R_P / 2)$$

$$C_2 \approx .47 \mu\text{F}$$

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4. C_4 determines the blinker frequency, for a frequency of 2 times per second.

$$C_4(\text{Hz}) = 81/F$$

$$C_4 \approx 47.0 \mu\text{F}$$

5. C_5 determines the dead band time for the steering servo for most car applications. This is chosen to be approximately 30 μs . Solving for C_5 yields:

$$C_5 = T_{\text{dB}}/51.4$$

$$C_5 \approx .47 \mu\text{F}$$

6. R_5 is selected via the formula

$$R_5 = T_{\text{MD}}/[C_1 n(V_{\text{CC}} - .73e^{-(1 \times 10^{-6}/4C)})/V_{\text{CC}} - .66]$$

$$R_5 = 910\text{K}$$

7. C_6 is chosen with the same formula as C_5 except dead band is set to approximately 80 μs . This gives the system better speed control.

$$C_6 = T_{\text{dB}}/51.4 = 1 \mu\text{F}$$

8. R_6 is chosen via the same equation as R_5 .

$$R_6 = T_{\text{MD}}/[C_1 n(V_{\text{CC}} - .73e^{-(1 \times 10^{-6}/C)})/V_{\text{CC}} - .66]$$

$$R_6 = 430\text{K}$$

9. Set $R_f = 510\text{K}$. To adjust value see Table I.

The complete circuit with the calculated values is illustrated in Figure 8. The circuit layout is illustrated in Figure 9.

Table I lists the recommended values for the servo application outlined above and describes the result if improper values are used.

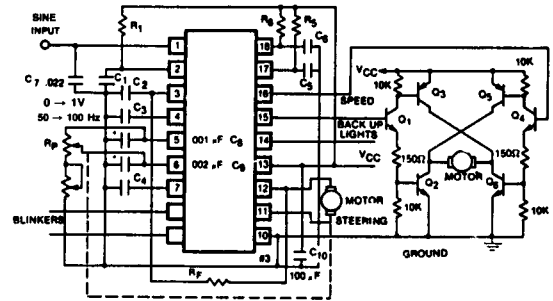


Figure 8. Typical Application Schematic

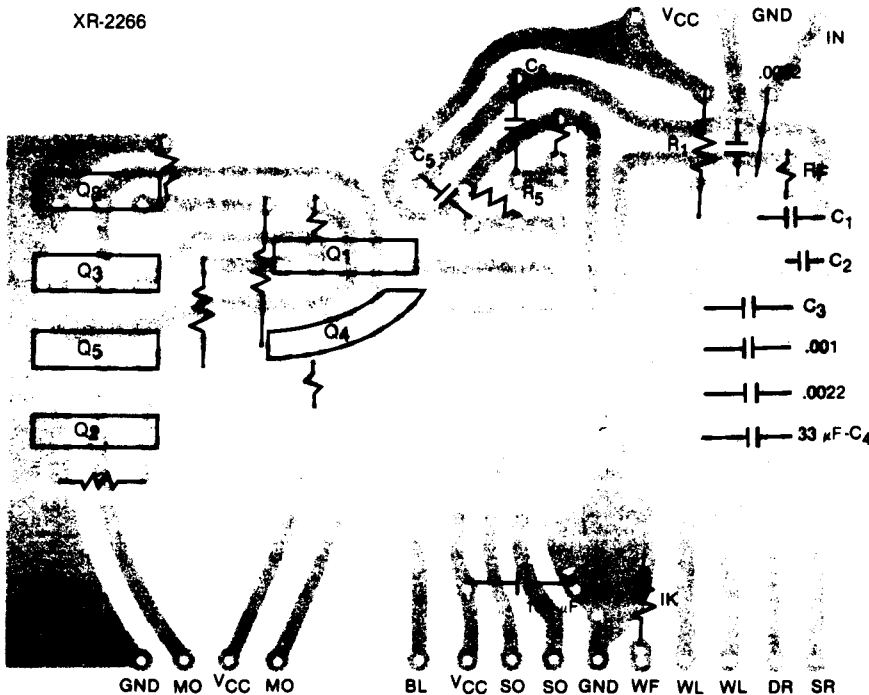


Figure 9. Printed Circuit Board Layout (4x)

TABLE I

| COMPONENT NUMBER | VALUES | EFFECTS |
|--------------------------|-------------|---|
| R ₁ 510K | Small | The integrator rise time becomes too fast and the fall time becomes too slow. Therefore, the integrator may reset too soon. |
| | Large | The integrator rise time becomes too slow and the integrator may not reset before the next input. |
| | Recommended | 200K — 700 K carbon film R25 series. |
| R _F 510K | Small | Too much negative feedback occurs, causing the response of the servo to be too slow. |
| | Large | Almost no negative feedback occurs and a large positional overshoot results. |
| | Recommended | 100K — 800K should be selected by the actual test results (dependent upon motor gears and linkage used). Carbon film R25 series. |
| R ₅ 910K | Small | The pulse stretcher gain becomes too small and this reduces output drive time causing wheels to turn slowly. |
| | Large | The pulse stretcher gain becomes too large and the motor tends to oscillate (hunt) about its position. |
| | Recommended | 500K — 1M, largely dependant upon the value of C ₅ , frame time and maximum deviation of the input pulse width. The equation for determining the nominal value is given in the "Description of Controls" section for pins 17 and 18. |
| R ₆ 430K | Small | The pulse stretcher gain becomes too small and the maximum speed of the car is reduced. |
| | Large | The pulse stretcher gain becomes too large and the car speed becomes hard to control. It is either 'ON' full, or 'OFF'. |
| | Recommended | 400K — 700K, depending on the value of the capacitor; since this is for the speed, the dead band width is set larger and pulse stretcher gain is set high. Carbon film R25 series. |
| R _p 5K | Recommended | This is the servo pot connected to the steering linkage, a B type volume potentiometer is recommended. |
| R ₂ 1K | Recommended | This potentiometer is used to set both the neutral position for the speed control and the range of operation for the directional indicators. A temperature stable carbon type is recommended. |
| C ₁ 0.1 μF | Small | The charging time tends to be short and the discharging time constant tends to be long, therefore, the integrator may reset too soon. |
| | Large | The charging time tends to become long and the integrator may not reset before the next input. |
| | Recommended | If R ₁ = 510K, C ₁ should be between 0.047 μF to 0.22 μF. Mylar recommended. |

| COMPONENT NUMBER | VALUES | EFFECTS |
|--------------------------------|-------------|---|
| C ₂ 0.47 μ F | Small | The width of the one-shot for the steering servo becomes too small and the front wheels may turn fully in one direction. |
| | Large | The width of the one-shot for the steering servo becomes too large and the front wheels may turn fully in one direction. |
| | Recommended | If the nominal input width is 1.4 ms, 0.47 μ F is recommended. For operation with other conditions, see "Description of Controls" section for pin 3. Tantalum type is recommended. |
| C ₃ 0.33 μ F | Small | The width of the one-shot for the speed control servo becomes too small and drive occurs in only one direction. |
| | Large | The width of the one-shot for the speed control servo becomes too large and drive occurs only in one direction. |
| | Recommended | If the nominal input width is 1.4 ms, 0.33 μ F is recommended. For operation with other conditions, see "Description of Controls" section for pin 4. Tantalum type is recommended. |
| C ₄ 33 μ F | Recommended | This capacitor determines the direction signal time constant. The capacitor value is determined by the equation in the "Description of Controls" section for pin 7. |
| C ₅ 0.47 μ F | Small | Dependent upon the value of R ₅ . Generally the pulse stretcher gain becomes smaller, thus, slowing down the general speed and making acute turns slower. This also decreases dead band causing hunting about its position. |
| | Large | Depending on the value of R ₅ , the pulse stretcher gain becomes extremely large and although turning speed improves, the hunting condition becomes worse. This also increased dead band causing the motor to jump position. |
| | Recommended | In case of R ₅ = 910K, 0.1 μ F to 0.68 μ F is suitable. Tantalum type is recommended. |
| C ₆ 1 μ F | Small | Depending on the value of R ₆ , the pulse stretcher gain becomes smaller and you cannot achieve 100% drive; also, the dead band is reduced and the neutral position on the stick may be eliminated. |
| | Large | The pulse stretch gain increases causing rapid increase in speed, once the dead band is exceeded; also, the dead band increases causing a long amount of neutral position in the control stick. |
| | Recommended | In case of R ₂ = 430K, 0.68 to 2.2 μ F is suitable. Tantalum type is recommended. |
| C ₇ 2200 pF | Recommended | As mentioned in the "Description of Controls" section for pin 2, this value should be between 0.001 and 0.01 μ F. Ceramic or mylar is the best choice. |
| C ₈ 1000 pF | Recommended | As mentioned in the "Description of Controls" section for pin 5, this value should be between 0.01 and 0.001 μ F. Ceramic or mylar are recommended. |
| C ₉ | Recommended | Same as above. |
| C ₁₀ 100 μ F | Recommended | As mentioned in the "Description of Controls" section for pin 10 and 13, this capacitor helps to stabilize the power supply when the car is running. If operation becomes intermittent, this value should be increased. Recommended 10 to 470 μ F tantalum. |



