Numerical Display Glitch Counter

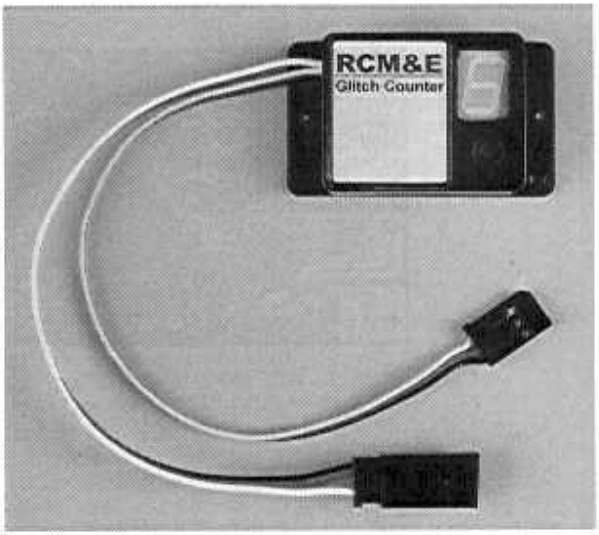
Introduction

This Project Article describes a small, lightweight diagnostic unit designed to monitor the servo control signal supplied by a radio control receiver. It is intended that, in the event of erratic model behaviour, the unit be installed in the model and connected to the servo channel suspected of giving trouble.

During a flight, or sail, the unit continuously monitors the servo control signal measuring the four important waveform parameters and logs any failures detected.
The number of failures, up to 99 for each parameter, are sequentially displayed in a timed sequence on a 7 segment LED display on a continuous 'round robin' basis.
The display process will continue even in the absence of an input signal due to the action of the internal software timer.

When 'armed' the unit performs an initial validation of the incoming servo control signal and then executes an automatic self-calibration based on the various control signal parameters. Once calibrated the unit enters its normal operating mode continuously checking for, and recording, the four parameters listed in the box below.
It thus provides a more comprehensive range of operational and monitoring facilities than any of the similar commercial devices known to the author. It also has the unique advantage of being able to monitor the signal of an R/C channel that is actually in use... something that other units cannot do and is referred to as 'In-Line' mode.

Consisting, as it does, of a single IC, an LED display and a handful of other components it is both easy to build and, requiring no manual calibration, easy to use.



Features

- Logs and Displays 4 Parameters
- Numerical Display of Logged Errors
- Small Size
- Low Power Consumption
- Simple to Build and Install
- Works with Input Signal Removed

Recorded Parameters

- Servo Control Pulse too Narrow
- Servo Control Pulse too Wide
- Erratic Frame Rate
- Missing Frames

Description

At the heart of the circuit is a small microprocessor from the popular PIC range; the PIC16C52. It is programmed to continuously measure the servo control signal parameters listed in the box on page 1 and increments an internal 'Parameter Error Counter' for each occasion that a failure is detected. Each of the four Parameter Error Counters can accumulate up to 255 error events but, in order to simplify interpretation, the on-board display is limited to 99 error events with any more than this displayed as an 'over-range'.

The current value of each of the counters is displayed in a timed sequence as shown in Table 1.

An R/C system consists of one or more channels each with its own variable width servo control pulse. The transmitter repeatedly sends the control pulses, from each of the channels in succession, to form a 'Multi Channel Frame' or MCF. After the last channel has been sent a 'dead zone' is entered during which no useful information is sent.

The start of the next MCF is signified by the rising edge of the servo control pulse corresponding to the first channel. The receiver separates the MCF into a number of single channel frames, or SCF, for driving the servos.

Displayed Parameter	Duration
Servo Pulse too Narrow Count (Tens)	0.5 second
Servo Pulse too Narrow Count (Units)	0.5 second
Display Blank (Short)	1.0 second
Servo Pulse too Wide Count (Tens)	0.5 second
Servo Pulse too Wide Count (Units)	0.5 second
Display Blank (Short)	1.0 second
Erratic Frame Rate Count (Tens)	0.5 second
Erratic Frame Rate Count (Units)	0.5 second
Display Blank (Short)	1.0 second
Missing Frame Count (Tens)	0.5 second
Missing Frame Count (Units)	0.5 second
Display Blank (Long)	3.0 seconds

Table 1: On-Board Display Sequence Details
(Timing values are for an R/C system with a 20ms PRF)

The unit looks for four types of SCF and/or servo control pulse error as described in Table 2 below.

Typical causes of all the failures described in Table 2 are:-

1. Interference caused by other R/C transmitters operating on the same (or nearby) channels.
2. Any other non-R/C transmitter causing interference in the radio control bands.
3. The model going out of range, particularly in the case of a Type 4 failure.

Theory of Operation

Pressing the ARM button resets all four of the internal Parameter Error Counters to zero and initiates the self-calibration sequence. During calibration, which may last up to 8 seconds if an input signal is not detected, the letter 'C' is displayed.

The procedure starts by assessing the incoming servo control signal and measuring its PRF. Should the calibration sequence fail a descriptive character replaces the displayed 'C' with any one of the following

Type 1 Error	Type 2 Error	Type 3 Error	Type 4 Error
The positive going servo control pulse is too narrow. To be considered valid the control pulse must be at least 740us wide and any pulse , or glitch, wider than 6us is guaranteed to be detected	The positive going servo control pulse is too wide. To be considered valid the control pulse must meet the minimum width criterion and also be less than 2250us wide.	The measured Pulse Repetition Frequency, or PRF, of two successive frames differs by more than an acceptable amount. To be accepted an SCF must start within 1ms of its expected time based on the recent past history of the incoming waveform.	A missing frame was detected. The servo control pulse did not occur before an internal timeout expired. The unit re-synchoronises itself to the incoming waveform as soon as servo control pulses are detected.

Table 2: Description of Error Types

four reasons being classed as a failure:-

1. There is no signal present and the input line is 'stuck' at a logic 0. This type of failure is denoted by the display of the character 'L'.
2. The input line is either stuck at a logic 1 or is high for an unacceptably long time. This type of failure is denoted by the display of the character 'H'.
3. The input signal is pulsing but the PRF is too fast, i.e. less than 8ms. This type of failure is denoted by the display of the character 'F'.
4. The input signal is pulsing but the PRF is too slow, i.e. more than 32ms. This type of failure is denoted by the display of the character 'S'.

If the incoming waveform is basically satisfactory the unit measures the PRF of a number of cycles and calculates a mean value for the PRF. It then uses this mean PRF value as a reference to compare with the PRF of a further number of incoming cycles. If the PRF of any of these tested cycles differs from the calculated reference by more than 1ms an error is deemed to have occurred and the letter 'E' is displayed. Pressing the ARM button again will restart the calibration sequence.

After a satisfactory self-calibration the unit begins to display the values stored in the internal Parameter Error Counters with each of the values being displayed as a two-digit sequence with the 'tens' being presented first followed by the 'units' as described in Table 1. Thus an error count of 12 would be shown as a '1' followed by a '2'. A short duration 'blank' separates each of the 4 displayed values and each complete sequence is separated from the next by a long duration 'blank'.

The largest error count that can be displayed using a two digit sequence is 99 and any Parameter Error Counter holding a value greater than this displays as an 'o' followed by an 'r' denoting an over-range.

Most R/C control systems operate on the principle of a constant PRF with a variable pulse width, usually between about 1ms and 2ms, containing the information regarding the desired servo position. However there are systems in which the 'dead-time' (the time in the cycle where no servo position information is present) is constant and so, as the sticks are moved and hence the pulse widths change, the PRF changes.

The unit handles this type of R/C system by continually assessing the PRF of the incoming signal and adjusting its calculated reference PRF value as necessary and so can, in this way, always predict when to expect the start of the next servo control pulse. The permitted time difference between the expected arrival of the incoming pulse and its actual arrival is 1ms, which is enough to cope with all normal multi-stick movements. However, and only on this latter type of system, should two or more switched channels be operated simultaneously, a very unlikely occurrence, with each lengthening (or shortening) their respective pulses it is possible that the PRF will change by more than 1ms on two successive cycles. This will be detected, and recorded, as an occurrence of a 'Type 3' error.

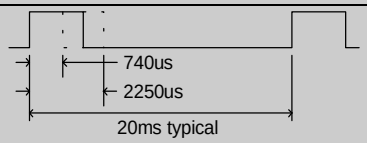
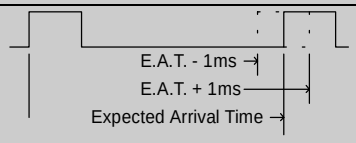
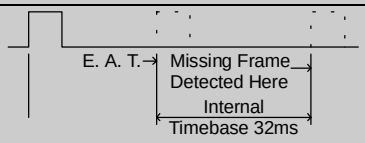
Error Types 1 and 2	Error Type 3	Error Type 4
The figure below shows the range of acceptable servo control pulse widths. Should a pulse be detected that is less than 740us the 'Short Pulse' error counter will increment or if more than 2250us wide the 'Long Pulse' error counter will be incremented.	The figure below shows the Expected Arrival Time (E.A.T.) based on calculations performed on the PRF of recently received frames. The two lines, at ±1ms, denote the limits window. Any pulse arriving outside the limits will be detected and increment the 'Erratic Frame' counter.	The following figure shows how a Missing Frame is detected. The servo control pulse does not arrive at the expected time which starts an internal timer. If no pulse arrives before the timer expiry it is considered that a frame was missing and the 'Missing Frame' counter is incremented. Should a pulse arrive before the internal timers expiry the error is classified as a Type 3.
		

Table 3: Graphical Display of Error Types

Assembly

Assembling the parts onto the PCB is straightforward. However some of the components must be inserted in the correct orientation and the notes below should help:-

U1 This component is a CMOS device and should be treated accordingly. It has a semi-circular 'notch' in the end that marks pin 1. The IC should be inserted such that pin 1 connects with the square pad.

U2 With the PCB orientated such that this component fits in the top-right hand corner fit U2 such that the decimal point is in the bottom-right corner of the display.

RNx All three resistor networks must be fitted with the correct orientation and a 'dot' marked on their bodies denotes pin 1. Fit RN1/RN2 such that pin 1 connects with the square pad. RN3 should be fitted such that pin 1 is toward J2 and J3.

X1 This 3-leaded device is not orientation sensitive and may be fitted either way round.

SW1 This component should be recessed below the front panel of the enclosure to prevent accidental operation. NOTE: the circuit diagram shows only two connections to the switch but all four leads must be soldered, both for mechanical strength and, more importantly, because the unused switch terminals are used as part of the circuit continuity.

J2/3 These 'connectors' are not fitted. Connection to only one of these is required if 'In-Line' mode operation is not envisaged. For use in In-Line mode a suitable servo extension lead may be cut in two and the free ends of each half stripped and tinned prior to soldering through the PCB. Both these leads are termed the 'Signal Input' leads.

LK The link may be made from a short length of wire cut from a resistor or similar component.

J1 This 'connector' is also not fitted but wired as for J2/3 above if required...see the section headed **Download Capability** below.

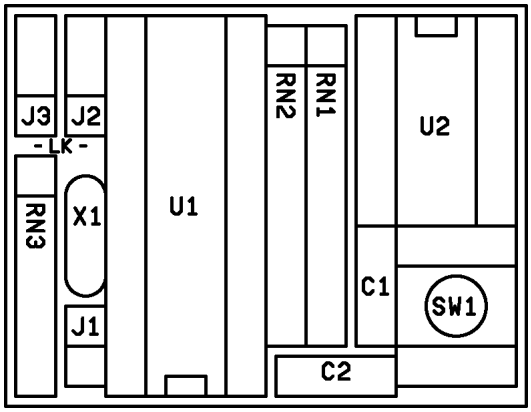


Fig. 1: Component Placement Drawing (Top Side View)

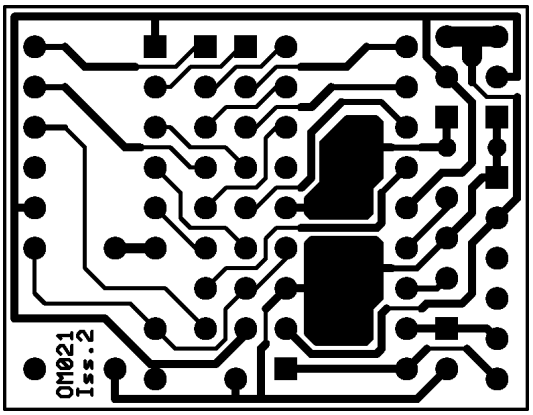


Fig. 2: PCB Copper Trace Detail (Underside View)

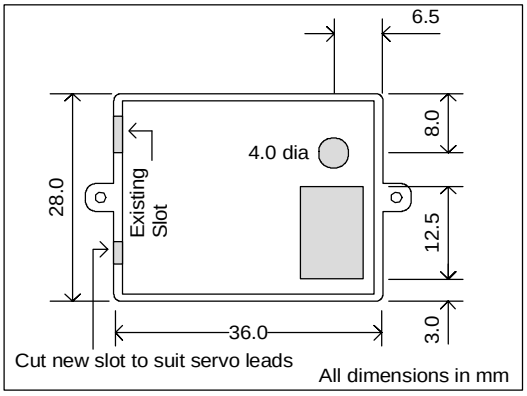
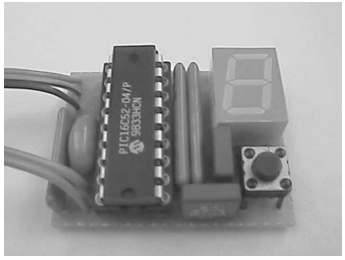
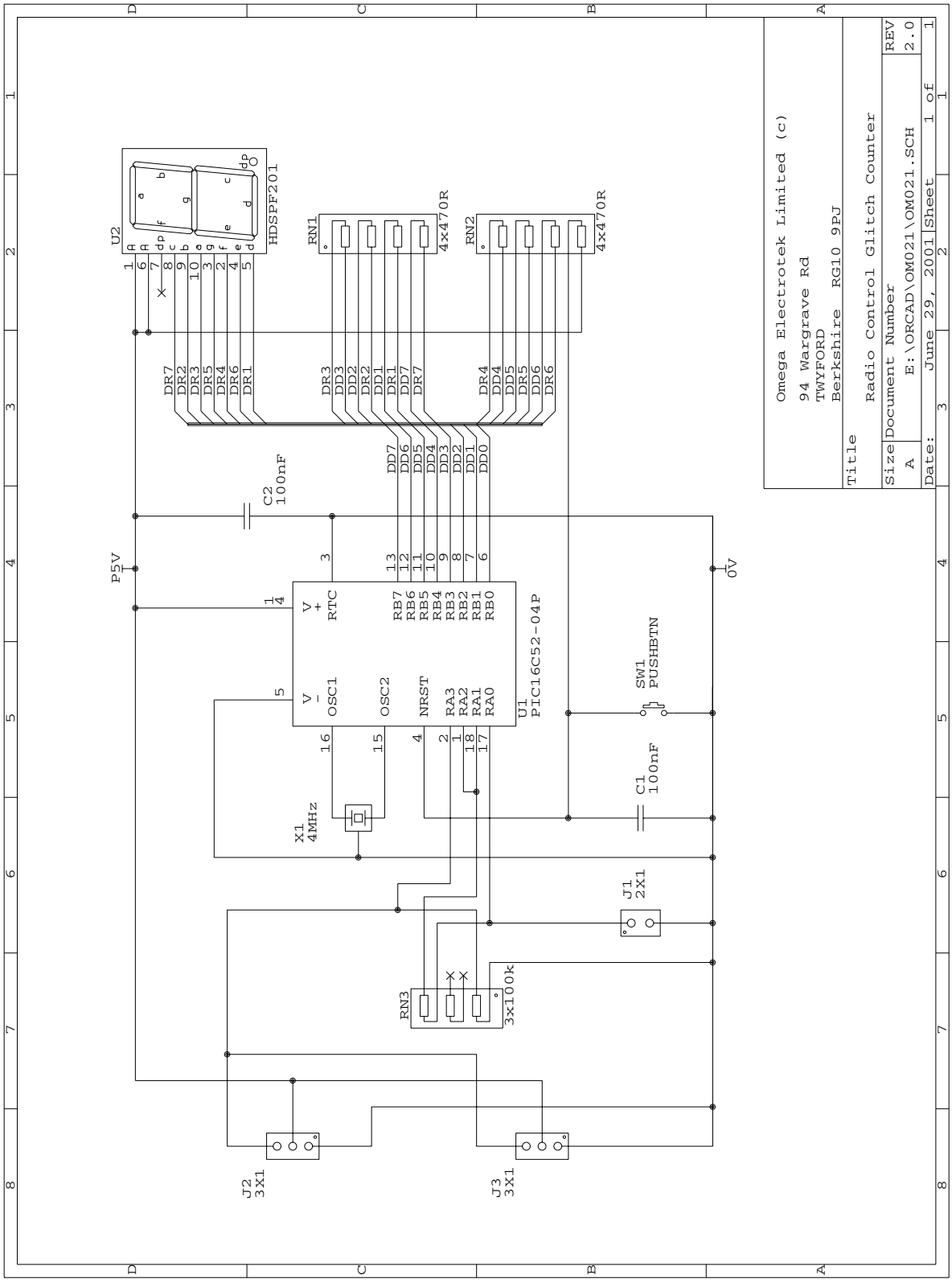


Fig. 3: JX56L Rework Drawing (Underside View)

Fig. 4: Assembled PCB



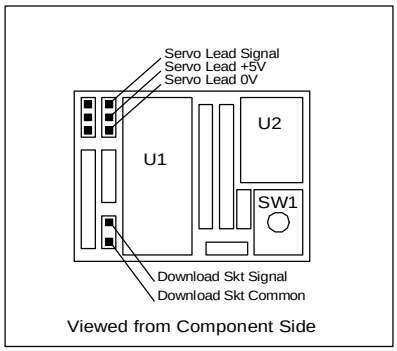
Schematic Diagram



Initial Checking and Power-up

Having carefully checked that all the components are correctly located, orientated and soldered, and in particular the flying leads, the assembled unit may be tested.

The diagram below shows the three 'connectors' and their pin functions.



NOTE: There is no reversed polarity protection provided and connecting the unit with the wrong polarity will probably destroy it.

The testing procedure is very simple, as no manual calibration is required. The following procedure will check that the unit is functioning correctly:-

1. Connect the unit to a receiver using the input lead and power up the receiver.
2. With the transmitter switched OFF press the ARM button. The letter 'C' should appear on the display and remain there for 8 seconds followed by the letter 'L'. This occurs because, with the transmitter switched off, the receiver does not output any servo control pulses. Note however that receivers fitted with Fail-Safes do output a servo control pulse in the absence of a transmitter. In this case you will need to power the unit without connecting the servo signal lead (often the white one). Reconnect the servo signal lead once this test has been performed.
3. Switch the transmitter ON and press the ARM button again. Once again the letter 'C' will be displayed and, provided the calibration succeeds, it will be followed by a series of '0's displaying the contents of the 4 Parameter Error Counters.
4. Watch the display for a while and check that the display sequence repeats every 10 seconds or so.
5. Switch off the transmitter for a very brief period and then on again. For those without Fail-Safes the 'Missing Frame' error counter should now display a number above zero. The actual count will depend on how quick you were with the on/off switch. Note that you may see error counts greater than zero displayed for the other parameters. This is because as the transmitter powers down and up again its output may be undefined...this is quite normal and not a problem with the unit.
6. Take a note of the error count values and then move all the sticks to each of their extremes and check that none of the error values change.
7. With the transmitter on press the ARM button again. Check the calibration sequence is performed as normal. Leave the system like this for a while, say 10 minutes, and check that after this time all error count values are zero. If they are not you may need to investigate a possible Tx/Rx problem!

This completes the testing procedure and, in order to secure the Input Lead connections, a blob of Araldite may be applied around the wires on the component side of the PCB to increase the mechanical strength.

Wiring into the Model

The simplest connection of the Glitch Counter to the models receiver/servo system is to connect the appropriate Signal Input lead to an otherwise unused receiver output. The other Signal Input lead, if fitted, is left with no connection but should be placed so as to prevent a possible short circuit if it has protruding male connections.

As stated in the introduction the unit may be used in In-Line mode to monitor a servo channel that is actually in use. To use the unit in this way disconnect the servo lead from the receiver and connect it to the appropriate Glitch Counter input lead and connect the other input lead to the appropriate receiver output.

Download Capability

This project, along with other projects available from the Model Electronics Company, is part of a series having a 'data download' capability built into their software. As described above the Glitch Counter software maintains four Parameter Error Counters, whose values are displayed locally using the 7 segment LED display, but these values may also be extracted from the unit using a simple cable connected to J1.

To make use of this download facility it is intended that J1 be connected to a small jack socket, or similar, mounted in a convenient location on the model.

Another project is available that allows the values to be downloaded to an IBM, or compatible, PC using a simple interface that plugs into the parallel port. The PC, fitted with the interface and running the custom software, may be used to download and display the contents of the four Parameter Error Counters. Using the software the information may then be stored in a disk file and, optionally, printed.

Downloading the stored data does not change the values stored in the Parameter Error Counters or upset the monitoring process, which continues as normal after the download is complete.

Components

Complete kits of the components required to build this project are available from the Model Electronics Company. Alternatively just the PCB and pre-programmed microprocessor may be purchased and the remaining parts obtained from other sources using the Parts List table as a guide.

For those people not wishing to undertake the assembly of the PCB this is available pre-assembled and tested. Please see the price list for details.

Item	Manufacturer	Specification or Part Number
C1,2	N/A	100nF 63V 10%
RN1,2	Bourns	470R 0.2W 5%
RN3	Bourns	100k 0.2W 5%
U1	Pre-Programmed	PIC16C52-04P
U2	Agilent Technologies (HP)	HDSP-F201
SW1	Bourns	7906H-001-000
X1	Murata	CST4.00MGW

Table 4: Parts List

Note that where manufacturers part numbers are given their continued accuracy cannot be guaranteed.

Notes

This Project Article is issued by :-

The Model Electronics Company
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TWYFORD
Berkshire RG10 9PJ

For information on placing an order for this project please see our price list which gives details of prices and payment methods. The price list may be obtained from the address above or from our web-site.

http://www.omegaco.demon.co.uk/mechome.htm