

TONE OPERATED BISTABLE & MONOSTABLE SWITCHES

Obsolete Product - For Information Only -

GENERAL DESCRIPTION

The FX-501/FX-601 Series are high performance selective switching devices, constructed in monolithic microcircuitry form using MOS technology. They are designed for use as tone receivers in Remote Control, Instrumentation, Automation, Communications and Telemetry systems, where specific tone frequencies are used to control remote switching functions.

The FX-501 and FX-501R are tone triggered BISTABLE switches, where the integral output switch is turned ON by an input tone of correct frequency and can be turned OFF at any required time by repeating the tone command. A variable period lock-out timer is incorporated which inhibits further operation of the switch for a defined minimum interval, following each switching action. The output switch can also be reset to OFF at any time by grounding a Direct Reset control pin. The tone frequency 'accept' bandwidth of the FX-501 is internally pre-set at a value suitable for general purpose use; the bandwidth of the FX-501R is externally adjustable to suit specific user requirement. With both versions, the nominal tone channel frequency can be set to almost any required value and is determined simply by the values of one external resistor and one capacitor.

The bistable action of these switches is ideal for controlling remote ON/OFF switch functions; the switch maintaining the selected condition for an unlimited time between successive

trigger tones, thus freeing the signal line for other traffic. A number of devices can be connected to a common line and switched on a selective basis by transmitting tones of appropriate frequency.

The FX-601/FX-601R are tone triggered MONOSTABLE TIMERS, where the integral output switch is turned ON for an accurately defined time following receipt of an inband trigger tone. This timed period is externally adjustable from a few milliseconds through one hour, at duty cycles up to 90%. The trigger tone frequency and monostable period are externally set using simple RC networks. The FX-601 has a preset tone channel bandwidth; the FX-601R differs only in that the channel bandwidth is externally adjustable.

These Monostable switches are particularly suitable for remotely controlled switching of relays, contactors, stepping mechanisms and timing functions, where a precise 'one-shot' on-time is called for.

Input signal amplifiers are incorporated in all devices allowing operation with low-level or high-level sine or square-wave tones. The devices operate from a single low current supply of -8V to -15V D.C. and are rated for use at extended temperatures. A printed circuit card, to assist in experimental work, is available for the FX-501/FX-601 preset bandwidth devices.

TONE OPERATED BISTABLE SWITCHES

TONE OPERATED MONOSTABLE TIMERS

FX-501/501R

FX-601/601R

FIG.1 SIMPLIFIED BLOCK DIAGRAM FX-501/501R

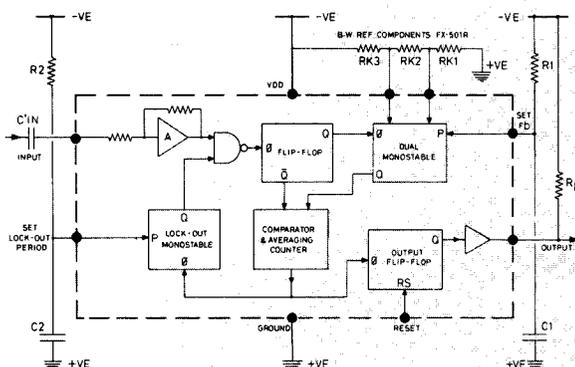
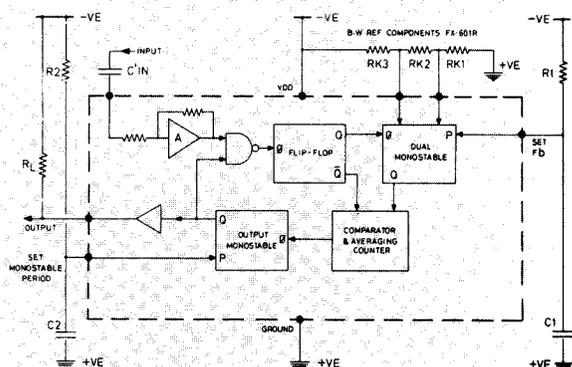


FIG.2 SIMPLIFIED BLOCK DIAGRAM FX-601/601R



GENERAL CIRCUIT OPERATION

The tone recognition system employed by the FX-501/601 series is based on a period sampling technique. Input signals are amplified and shaped to provide clock signals to the bistable flip-flop, the output of which is a square wave having a period equal to the interval between successive input waveform 'zero-crossings'.

The flip-flop output triggers a dual monostable, which generates reference periods corresponding to $\frac{1}{f_a}$ and $\frac{1}{f_b}$, where f_a and f_b represent the

tone-accept channel. These periods are determined by R1, C1 and the d.c. reference levels applied to the monostables. Internal references are used for FX-501/601, externally applied levels for the 'R' versions.

The reference periods are compared against the signal input period in a comparator, the output of which controls a special counter/storage system. This counting system discriminates against random spurious information and delivers an output only when a true inband tone signal is received. The output of the counter triggers a bistable output switch (FX-501) or a monostable switch (FX-601). Gating circuits are incorporated which prevent false operation when harmonics of the tone frequency are applied.

This unique and patented tone recognition system yields extremely sharp tone channel definition, coupled with a fast response time and total immunity to false turn-on due to outband noise, regardless of the noise frequency and amplitude. The period sampling system requires, however, a 'regular' input waveform for correct operation. Input noise can, if mixed with the required inband tone, prevent the circuit from recognising that the tone is present. This effect is produced because the noise 'jitters' the interval between successive signal zero-crossings and the comparator/counter system rejects the information as not being consistent with an input signal having a frequency actively within the tone channel limits.

If the noise is *random* in nature, e.g. spurious noise spikes or short term interference (short in relation to the device recognition time, or inband tone duration) it will have little or no effect other than possibly to increase the overall tone recognition time by a few cycles. If the noise is *continuous*, e.g. parallel inband and outband tones on the signal line simultaneously, the device will not recognise the inband tone. If the noise is *semi-continuous*, e.g. speech signals, increasing the inband tone duration will allow the tone to be recognised during a momentary 'noise' pause.

The devices are therefore ideal for use when inband tones are transmitted individually, or sequentially, but operation in parallel-tone signalling schemes is not recommended.

FX-501 OPERATION

Fig. 3 illustrates the bistable switching function of the FX-501 and FX-501R. When an inband tone is recognised by the frequency decoder section, the output flip-flop is triggered and changes state (from OFF to ON or vice-versa). Simultaneously, the lockout monostable is triggered and inhibits a signal input gate, so that no further input signals are recognised until this lockout period (TL) has expired. This ensures that only one output switching action is performed for each inband tone burst received, and prevents ON/OFF chatter of the output switch in the event that the inband tone is interrupted by noise. For correct lockout operation, the lockout period should be equal to, or greater than, the duration of the inband tone. If a continuous inband tone is applied, the output switch will change state at regular intervals, the switching rate being governed by the lockout period selected. The output flip-flop can be directly reset to OFF by applying a momentary 'O' level to the Reset pin. A permanent 'O' at this pin will hold the output at OFF, regardless of input tone signals or the state of the lockout timer.

FX-601 OPERATION

The monostable switching action of the FX-601 and FX-601R is also shown in fig. 3. When the inband tone is recognised the output monostable is triggered and the output switch turned ON. The input signals are simultaneously inhibited by a gate circuit, preventing further re-triggering of the output monostable. At the expiry of the monostable time period the output switch turns OFF, and the circuit is ready to receive a further trigger tone. The monostable period is accurately defined for duty cycles up to 90%, at higher duty cycles the period will be reduced by approximately 10% relative to the calculated value. The applied inband tone burst should be shorter than the monostable period for normal applications.

SUPPLY NOTES

References to ground, 'O' and 'I' in this data sheet are based on the use of a grounded positive supply, i.e. HT (VDD) is negative. A 'I' level is therefore near VDD (-ve) and a 'O' level near ground (+ve). There is however, no objection to operation with the -ve supply grounded, but reference to logic potentials should then be inverted. Note also that the case is internally connected to the +ve pin and will therefore be above ground potential. It is also very important to ensure that no pin receives a potential which is positive with respect to the +ve supply pin; failure to observe this rule may result in damage to the device. The specified operating range is -8V to -15V, with a maximum applied D.C. rating of -20V.

SIGNAL INPUT NOTES

All the devices incorporate a signal input amplifier offering a high input impedance. The amplifier is designed using negative feedback principles and therefore the input is D.C. self-biased. Signals to the input pin should normally be A.C. coupled to avoid disturbing this bias point. High level pulse signals (-6V) may be directly coupled. The actual shape of the signal waveform is not important and may be sine, square or pulse in form.

Fig. 4 shows the production spread of input sensitivity VS supply voltage. If overvoltages and transients can occur on the signal line, a protective diode clamp should be used to limit input voltages to a safe level.

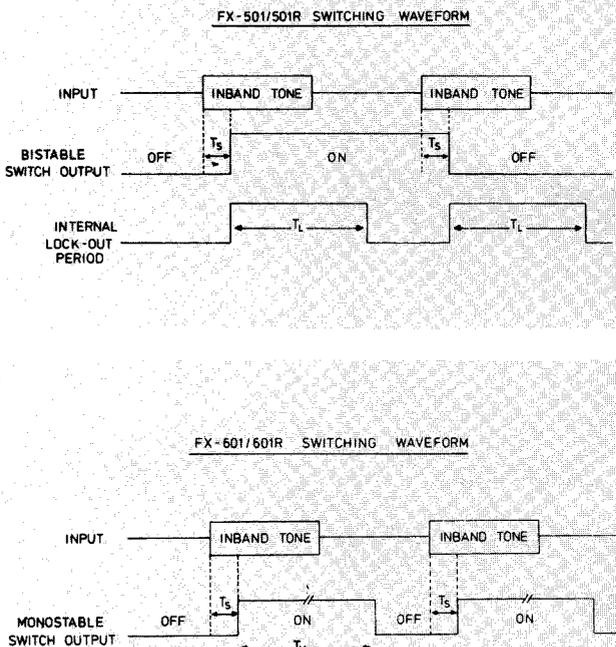
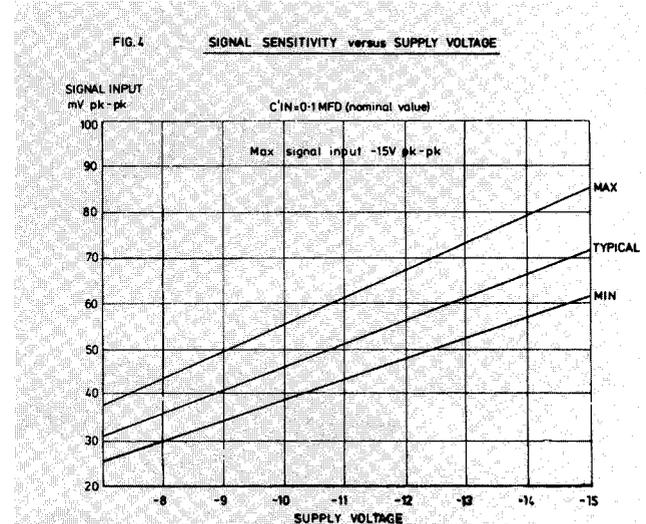


FIG.3



OUTPUT SWITCH CHARACTERISTICS

The standard output switch used in all devices is a MOS driver transistor connected between the output pin and the ground pin (+ve). No internal load is provided, therefore the only potentials present at the output pins are those provided by the external load. Low current loads may be directly connected between the output pin and -ve supply, high current loads should be operated through a buffer transistor, (see example in Fig. 9).

When the switch is turned ON, it becomes a low resistance path (value = R'_{on}) connecting the output pin to ground, (see Fig. 5). When the switch is turned OFF, it exhibits a high resistance ($10M\Omega$ minimum), effectively open-circuiting the output pin. The switch has a 'jitter-free' snap action; typical OFF-ON transition times are in the order of 2 micro-seconds.

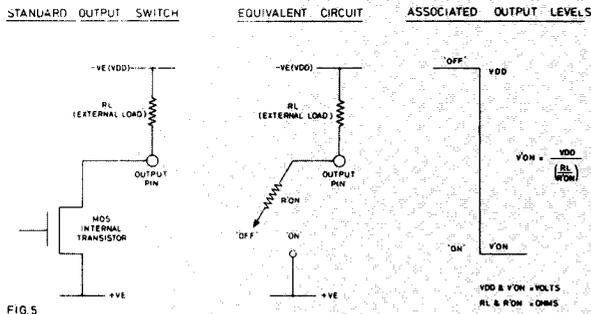


FIG 5

TRIGGER TONE FREQUENCY

Fig. 6 illustrates a typical tone channel. A frequency lying between the channel edges ($f'a$, $f'b$) is recognised as an inband trigger tone. The lower channel edge $f'b$ is determined by $R1$ and $C1$ (see Figs. 1 & 2). $R1$ can conveniently be made up of a variable resistor in series with a fixed value, this allows the user to adjust the overall resistance value "R1" when non-standard values are required to obtain a specific channel frequency. $R1$ and $C1$ should be good quality components to ensure stable channel frequencies.

Adjusting the frequency of $f'b$ has no effect on the bandwidth of the tone channel; as $f'b$ is moved, $f'a$ tracks by the same constant percentage. The overall result of adjustment is to move the channel either up or down within the overall operating frequency spectrum.

Formula for $f'b$:

$$f'b = \frac{1}{0.7 R1 C1} \text{ (Hz)}$$

Where 0.7 is a design constant 'K' and subject to production tolerances of $\pm 5\%$, R = Meg-Ohms and C = MFD. Recommended component limits are $R1 = 100K \text{ min.}$, $C1 = 470\text{pf min.}$, no maximum values are specified.

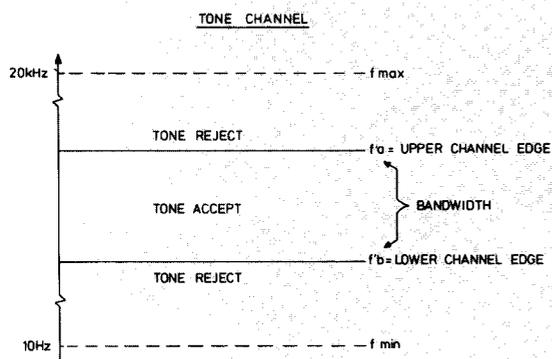


FIG. 6

BANDWIDTH

The bandwidth of the tone channel is the difference in channel edge frequencies, expressed as a percentage of $f'b$. Bandwidth is independent of operating frequencies and is determined simply by a resistor ratio chain applying reference levels to the dual monostable. In the FX-501 and FX-601, this resistor ratio chain is incorporated on the chip and forms an integral part of the circuit; it sets the bandwidth to a fixed percentage value, subject only to production tolerances.

The bandwidth of the FX-501R and FX-601R is determined by three externally connected resistors ($RK1$, $RK2$, $RK3$ of Fig. 7) which form a potential divider applying reference levels (constant fractions of the supply voltage) to pins 9 and 10. Bandwidth is then determined simply by the ratio of $RK2$ to $RK1$. The voltage level at Ref. HI (pin 10), expressed as a fraction of the supply, controls the value of the K factor used in the frequency calculations. When Ref. HI = 50% of supply, $K = 0.7$ ($\pm 5\%$ production tolerances). $RK3$ should therefore normally equal the sum $RK1 + RK2$. $RK3$ may be used to adjust the K factors, thus calibrating the frequency of $f'b$ and offsetting any tolerances in the frequency components $R1$, $C1$, but any adjustment should be limited to $RK3 = RK1 + RK2 \pm 20\%$. Resistors $RK1$, $RK2$, $RK3$ should be high stability types and the value of RV just sufficient to provide the required adjustment range. Convenient values for $RK3 = 8.2K\Omega$ (fixed resistor) plus a variable resistor of $4.7K\Omega$. $Rk1$ should be $10K\Omega$ and $RK2$ calculated for the required bandwidth (Fig. 7).

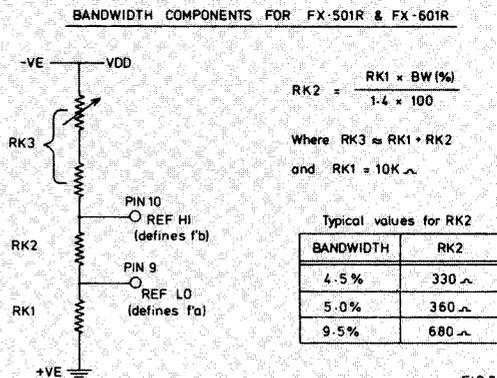


FIG. 7

CALCULATIONS FOR T_L & T_M

$R2$ and $C2$, connected to pin 2 on all devices, determines the period of the Lock-out generator (T_L) for the FX-501 and FX-501R and the monostable output period (T_M) of the FX-601 and FX-601R.

$$T_L \text{ or } T_M = 0.7 R2 C2$$

Where 0.7 is a design constant subject to production tolerances of $\pm 5\%$, R = Meg-Ohms, C = MFD and T = seconds. Recommended component limits are $R2 = 100K \text{ Min.}$, $C2 = 470\text{pf Min.}$, no maximum values are specified.

Note.

$R2$ and $C2$ must always be fitted to the FX-501 and FX-501R to ensure correct operation of the device.

DIRECT RESET CONTROL

The Direct Reset pin on the FX-501 and FX-501R is a logic controlled input. A logic '0' (ground or +ve) turns the switch OFF immediately, over-riding the lockout generator and any inband tone that may be present at the input. As long as a '0' is maintained at the Reset pin, the switch is held in the OFF condition. Resetting operation in systems may be derived from a momentary ground (via push-button) or any logic circuit that provides a 1-0 edge. (TTL, DTL, MOS). An internal 200K pull-up resistor maintains a '1' (-ve) at the pin when it is open circuit, thus allowing correct operation of the switch.

Being a Bistable switch, when power is first applied the switch may be in either the ON or OFF condition. If a guaranteed start-up OFF state is necessary, a small capacitor may be connected between the reset pin and ground.

FUNCTIONAL CIRCUIT ARRANGEMENTS

The three diagrams opposite give circuit details and typical component values for some common application examples: In Fig. 8, a FX-501 is used to operate a L.E.D. indicator, in response to ON/OFF tone instructions from a remote point. To ensure that the L.E.D. adopts the OFF state at power-up, a small capacitor (1000pf) is connected between the Direct Reset input pin and ground (+ve). The L.E.D. is switched ON and OFF alternately on receipt of each successive command tone.

The arrangement shown in Fig. 9 allows different tone frequencies to be used for turn-ON and turn-OFF which eliminates any possibility of *de-synchronisation* between the calling and the called stations. The minimum tone duration specified is related to the lowest tone frequency used. With this circuit, no malfunction will occur if tone duration exceeds the nominal lockout period used, e.g. the output will only change state once for each command tone, regardless of duration, but the maximum repetitive signalling rate is still determined by the lockout period adopted.

Note:

This P.C.B. is for use with FX-501 or FX-601, but is not suitable for FX-501R or FX-601R.

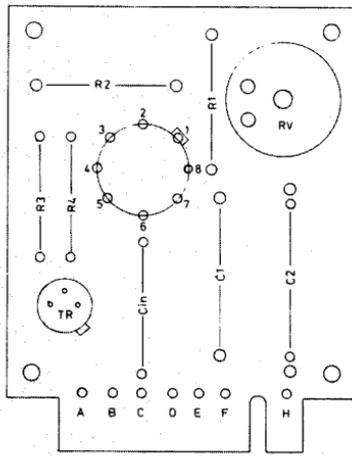


FIG.11

The C-015 printed circuit card has been designed to assist in laboratory and system development work using the FX-501 or FX-601. Provision has been made for all frequency components, A.C. signal coupling, timing components and a choice of output loads to be fitted. All component mounting positions are clearly marked on one side.

Manufactured from E-60 grade S.R.B.P. with tinned copper conductors and ready drilled for components (not supplied), the card is supplied with a set of press-in terminal posts; these may be used for mounting those components most likely to be changed during evaluation, thus minimising possible damage to the metal tracks. Connections to the cards may be made by direct wiring or suitable edge connector. The device is normally soldered directly to the card but an 8 pin TO-99 mounting socket may be used if required.

The P.C.B. measures 2.5" (64mm) x 1.95" (50mm) x 1/16" (1.5mm) and has edge connectors arranged for a 0.15" pitch 8 way socket.

CIRCUIT DESCRIPTION

The supply voltage to the device is connected to terminals A (-ve supply) and H (+ve supply). A separate negative supply may be connected to terminal D to supply the output load current, otherwise terminals A and D should be linked. When switching loads in excess of 10mA, the transistor and resistors R3 and R4 should be fitted and the load connected between terminals B and H. Terminal E is directly connected to the output pin; and R4 may be fitted as a low current load resistor, with terminals A and D linked.

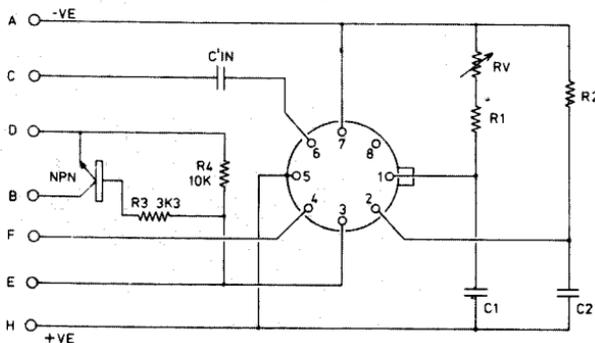
Input Signals are applied to the device via terminal C, the signal input ground connected to terminal H. Terminal F is the Direct Reset input to the FX-501; the FX-601 has no connection to terminal F. If the potentiometer (RV) is not used then a shorting link to connect R1 to the -ve supply is required.

Component Notes.

- TR1: BFY51 or similar NPN type.
- RV: Plessey WMP or similar type.
- R3: 3K3 nominal Rating 0.5 watt.
- R4: 10K nominal Rating 0.5 watt.
- C'in: Nominal 0.1MFD, Rating 60V D.C.

CIRCUIT DIAGRAM C-015

FIG.12



Many electro-mechanical steppers, counters and impulse relays require a defined width operating pulse Fig. 10 shows how a FX-601R is used to provide this in tone operated remote control systems. The duration of the transmitted tone burst is not critical and may vary over a 10-1 range with the values shown; the current pulse into the load coil is a constant width and determined simply by $R2/C2$. The shunt diode should always be fitted with inductive loads to protect the transistor and MOS device against excess potentials.

STONE SWITCHED INDICATOR

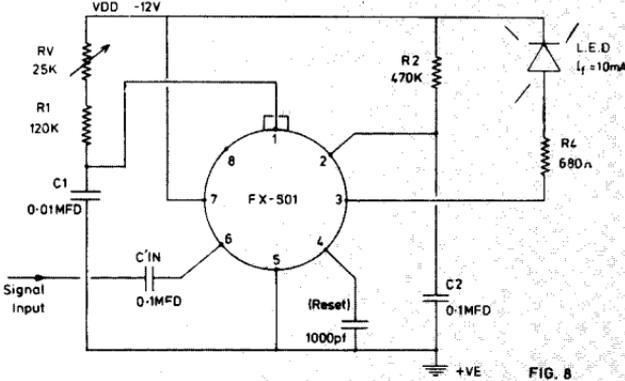


FIG. 8

Tone frequency 1kHz \pm 3.5%, minimum tone duration 10mS. Lock-out time ($R2/C2$) 33mS.

TWO-TONE ON/OFF RELAY SWITCHING

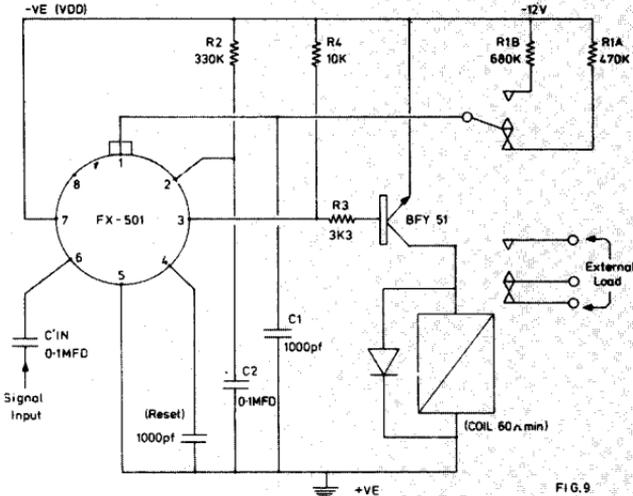


FIG. 9

Relay turn-ON to 3kHz \pm 3.5%, turn-OFF tone 2.1kHz \pm 3.5%. Minimum tone duration 5mS. lockout period 23mS.

STONE TRIGGERED RELAY PULSING

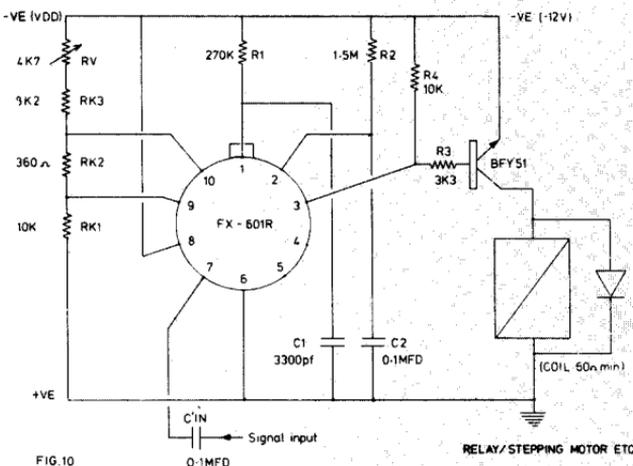


FIG. 10

Tone frequency 1.6kHz \pm 2.5%, tone duration 6.5mS to 90mS. Solenoid operating pulse 105mS duration, max. operating current 200mA.

SPECIFICATION

MAXIMUM RATINGS*

Applicable to all devices unless stated

Max. voltage between any pin and +ve supply pin.	-20v & +0.3v
Max. output switch load current	-10mA
Max. device dissipation @ 25°C T'amb	400mw
Operating temperature range	-30°C to +85°C
Storage temperature range	-55°C to +125°C



CHARACTERISTICS

(T'amb = 20°C, VDD = -12V ±2V, operating frequencies 10Hz to 3kHz unless specified)

Symb.	Parameter	Conditions & Notes	Min	Typ.	Max	Units
VDD	SUPPLY VOLTAGE	Operating Range	-8	-12	-15	V
IDD	SUPPLY CURRENT	Total, excluding switch load current		-3.5		mA
V'in	SIGNAL AMPLITUDE RANGE	Sine or square inputs, A.C. coupled, Input impedance typically 100KΩ		50		mV pk-pk
f'in	OPERATING TONE FREQUENCIES	Permitted frequency limits	.01		20	kHz
BW	CHANNEL BANDWIDTH	FX-501/FX-601 Fixed Bandwidth.	5.5	7.0	8.5	%
		FX-501R/FX-601R Adjustable Bandwidth	2.0		10.0	
Δ f	CHANNEL STABILITY	versus VDD (%f or %T vs VDD)		.04	.07	%/%
Δ T	MONOSTABLE STABILITY	versus T'amb.		.01	.02	%/°C
TL/TM	MONOSTABLE PERIOD	Duty Cycle. Period adjustable from 0.5mS to 1 hr.			90	%
Ts	SWITCH RESPONSE TIME	Overall switching time following receipt of inband tone (Approx. 10 cycles of inband tone)		10 3.3		mS
R'on	SWITCH 'ON' RESISTANCE	Internal resistance between output pin and +ve pin, switch ON. (Switch OFF resistance > 10MΩ)		.3	1.0	KΩ
'0'	LOGIC LEVELS	Recommended input levels for operating Direct Input. (FX-501/501R). Pin O/C = logic '1'	'0'	0	-1.5	V
			'1'	-6	-15	V

PIN DATA

FX-501 (To-99) FX-501R (To-100)

- | | |
|------------------------|------------------------|
| 1. Set f'b | 1. Set f'b |
| 2. Set Lock-out Period | 2. Set Lock-out period |
| 3. Bistable Output | 3. No connection |
| 4. Direct Reset Input | 4. Bistable Output |
| 5. +ve Supply (Ground) | 5. Direct Reset Input |
| 6. Signal Input | 6. +ve Supply (Ground) |
| 7. -ve Supply (VDD) | 7. Signal Input |
| 8. No connection | 8. -ve Supply (VDD) |
| | 9. Ref. LO |
| | 10. Ref. HI |

TYPICAL TIMING & FREQUENCY COMPONENTS

R1 + Rv	C1	f.b FREQUENCY (Hz)
143K Ω	0.01μ f	1000
270K Ω	3300pf	1600
470K Ω	1000pf	3000

R2	C2	PERIOD
680K Ω	0.01μ f	5mS
470K Ω	0.1μ f	33mS
1.5M Ω	0.1μ f	105mS

PIN DATA

FX-601 (To-99) FX-601R (To-100)

- | | |
|--------------------------|--------------------------|
| 1. Set f'b | 1. Set f'b |
| 2. Set Monostable Period | 2. Set Monostable Period |
| 3. Monostable Output | 3. Monostable Output |
| 4. No connection | 4. No connection |
| 5. +ve Supply (Ground) | 5. No connection |
| 6. Signal Input | 6. +ve Supply (Ground) |
| 7. -ve Supply (VDD) | 7. Signal Input |
| 8. No connection | 8. -ve Supply (VDD) |
| | 9. Ref. LO |
| | 10. Ref. HI |

