FOR FULL APPRECIATION OF THE FSK-500,
READ THE MANUAL FIRST.

The FSK-500 T.M.

CONTENTS

IRL T.M.

700 Taylor Road
Columbus, Ohio 43230
Call (614) 864-2464

LIMITED WARRANTY

This iRL product is warranted against defects in workmanship or materials for a period of ninety (90) days from the date of purchase. Within this period, iRL will repair defective units without charge for parts or labor. This warranty does not cover transportation or shipping costs; nor does it cover equipment subjected to misuse or accidental damage. In no event, shall iRL be liable for losses incurred by the buyer in connection with the use of this equipment.

SERVICE

If difficulty is experienced with the operation or interconnection of your demodulator, iRL Engineers are available for limited technical consultation by telephone or correspondence, at no extra charge. For repair work performed outside of the iRL limited warranty, iRL charges a fee of Twenty Dollars ($20.00) per hour plus the cost of any parts which may be required. (Most minor repairs to demodulators are accomplished in one hour or less.)

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iRL T.M.
700 Taylor Road
Columbus, Ohio 43230
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I. SPECIFICATIONS

MODE:	Hard limiting, FSK Demodulator/Modulator
SHIFTS:	170, 425, and 850 hertz shift
TONE PAIRS:	"High tones" Mark=2125, Space=2295, 2550, 2975 Optional - "Low tones" Mark=1275, Space=1445, 1700, 2125
AUDIO INPUT:	500 ohm, unbalanced minimum signal, 10mv maximum signal, 17 volts (peak, continous)
OUTPUTS:	LOOP Open collector transistor for high voltage 20 or 60mA loops. I_{max} = 100 mA, V_{CEmax} = 300 v DATA OUT RS-232 compatible, Mark=-7v, Space=+7v or "TTL Logic" levels, M=+5, S=0v
INPUTS:	LOOP Sensing circuit in LOOP for transmission of AFSK from keyboards or "TD's" in high voltage loop SERIAL IN For RS-232 or "TTL Mark High" Levels (same as DATA OUT)
AUTOSTART:	Attack 1 second, Drop-out 10 seconds
POWER:	117 VAC, 50 or 60 Hz. (optional 220vac may be special ordered)
DIMENSIONS:	7 3/4 in. wide x 3 1/4 in. high x 7 3/8 in. deep

II. INTRODUCTION AND BACKGROUND

Amateur radio has experienced tremendous growth in recent years and radioteleprinter (RTTY) communications is one of the fastest growing aspects of the amateur radio service. The overall growth of the amateur ranks has been exciting in that it has been accompanied by significant technological advances which have provided hams with more sophisticated equipment and alternative modes of communication than ever before; however, with this growth has come an ever increasing congestion of powerful signals on the HF bands which makes solid communication over long distances heavily dependent upon highly selective receiving equipment that is capable of rejecting strong adjacent channel interference.

As more computer radio interfaces and "all-in-one" RTTY systems have been introduced, new RTTY hams are beginning to understand that the simplistic demodulators found in these systems are not adequate for coping with the tough QRM found on the HF bands.

Also, since the recent approval of the ASCII codes in the U.S., up-to-date hams want to receive both Baudot and ASCII. The standard ASCII (110 baud) signal requires a much wider tone channel bandwidth than the common 60 wpm Baudot signal (45.45 baud); therefore, only a demodulator that has selectable bandwidths can be optimized for both types of signal (as with different receiver I.F. bandwidths for "phone" or CW).

Many commercial and MARS stations operate 425 or 850 hz. shift so it is important to include three shifts for full shift coverage. The FSK-500 has selectable bandwidths for optimal reception of Baudot and ASCII, as well as the ability to copy the three standard shifts.

Many of the ideas originally developed for the FSK-1000* demodulator have been incorporated into the design of the FSK-500, resulting in a high performance, inexpensive demodulator designed. To meet the stringent demands of todays amateur market.

*Information on the FSK-1000 can be obtained by writing to iRL, 700 Taylor Road, Columbus, Ohio, 43230 or your iRL Dealer.

III. CONTROL AND INPUT/OUTPUT DESCRIPTIONS

FRONT PANEL CONTROLS

ON/OFF: This "push on, push off" switch applies power to the FSK-500, including the AUTOSTART A.C. outlet at the rear of the unit.

SHIFT, 170/850, 170/425: These push buttons are used to select one of the three standard shifts. With both buttons OUT the demodulator is set to receive 170 Hz. shift. To receive 425 Hz. shift, the 425 button should be pushed IN (the 850 button should remain OUT). To tune 850 shift signals, the 850 button should be pushed IN, with the 425 button OUT. (If by accident both buttons are pushed IN, no harm will result, the shift will be 425 Hz.

BANDWIDTH (BW): This push button selects wide or narrow bandwidths, (not wide or narrow shifts) for optimal reception of different baud rates. "Narrow" adjusts the internal active-filter bandpasses for 75 Hz. and a low pass filter roll-off of 28 Hz. This position is best for copying 60 to 100 wpm Baudot code on the HF bands. "Wide" (OUT) produces bandpasses of 145 Hertz and a lowpass roll-off of 60 Hz. This is excellent for 110 baud ASCII or VHF reception of Baudot.

THRESHOLD: This control sets the level for the internal "Mark-Hold" circuitry and the Autostart. It may be thought of as an "RTTY Squelch" control. Maximum sensitivity for receiving RTTY occurs with this control in the full counter-clockwise position. As the control is rotated clockwise (in the absence of a tuned-in RTTY signal), a point is reached where the FSK-500 begins to go into a "Mark-Hold" condition which is indicated by the lighted LED near the THRESHOLD control on the front panel. If, during the course of receiving an RTTY station, the LED blinks periodically, the THRESHOLD control should be rotated counter-clockwise until the light quits blinking. The meter may still be used for tuning while the unit is in the Mark-Hold state.

TUNING METER: The TUNING meter gives indication of a properly tuned-in RTTY signal. A constant Mark tone will deflect the meter to a mid-scale reading and the presence of a shifting Space tone causes the meter to swing to full scale deflection. A good, properly tuned-in RTTY signal of the proper shift will give a fairly constant, full scale reading of the meter; however, a properly tuned constant Space tone will cause the meter to return to zero.

M & S LEDS: These Mark and Space Light emitting diodes show the status of the LOOP and DATA OUT outputs while the unit is receiving and also the state of the inputs to the LOOP or SERIAL IN jacks when transmitting.

REAR PANEL

AUDIO IN: This phono jack receives audio from the receiver. The input impedance is nominally 500 ohms. Although some receivers have special 500 or 600 ohm outputs, the common practice is to simply connect across the receiver's speaker terminals. (If speaker audio appears to be diminished when connected to the FSK-500, simply reverse the leads.)

SERIAL - IN: This phono jack is for connection of a serial computer output, electronic or mechanical keyboard or tape reader. The keyboard may consist of "dry" contacts (such as from a mechanical keyboard without loop current) or RS-232 voltages (Mark=-12, Space=+12). This input may be "strapped" for TTL - Mark=+5v, by moving the internal jumper plugs as shown in figure III-B. THIS JACK DOES NOT ACCEPT HIGH VOLTAGE (greater than 12 volts) LOOP SUPPLIES. This input does, however, drive the LOOP output of the FSK-500 so that local copy can be observed on a mechanical teleprinter. "Dry" contacts should be closed for MARK and open for SPACE. IF THE SERIAL-IN IS NOT USED, THEN A SHORTING TYPE PHONO PLUG IS REQUIRED IN THIS JACK OR, THE SERIAL-IN MUST BE STRAPPED FOR TTL, MARK+HIGH. Otherwise the unit will be in a SPACE mode constantly. See Section III-C.

LOOP: This one-quarter inch, three conductor phone jack is for connection into an external loop circuit (20 to 60mA.). There is an NPN "open-collector" transistor switch and a current sensing circuit for transmitting from the teleprinters keyboard or tape distributor. Since the transistor switch closes to ground, the external loop and the FSK-500 must have a common ground. (See figure III-A) A separate ground wire between the loop supply (-) and the rear panel of the FSK-500 is recommended to reduce the likelihood of electrical shock. The transistor is rated for 300 volts and 100 mA maximum loop current. If the optional FSK-510 internal, or an external loop supply is used, the X1 jumper should be between pins B and C. If a loop supply is not used, X1 must be jumped A to B. See Section III-B.

DATA-OUT: This phono jack provides an RS-232 compatible output (Mark=-7v, Space=+7v). The output information is either the demodulated receiver audio or the information inputted to the SERIAL-IN jack. Thus, this jack outputs the same information as the LOOP jack and may be used simultaneously with the LOOP output. For instance, the DATA-OUT jack may be used to drive a computer or video terminal, while the LOOP drives a "hard copy" terminal. The DATA-OUT jack may be strapped for "TTL", (Mark=+5) by moving the appropriate internal jumper plug as shown in figure III-B.

KEY IN: This phono jack input (high impedance, low voltage) is for connection of a telegraph key, automatic keyer or computer output for the purpose of sending a "Narrow-shift ID". The key should be normally open, of course, or any logic inputs should be normally high. When the KEY IN is pulled low or shorted to ground, the Mark tone shifts from 2125 to 2210 Hz. This input should not be driven below -7 volts.

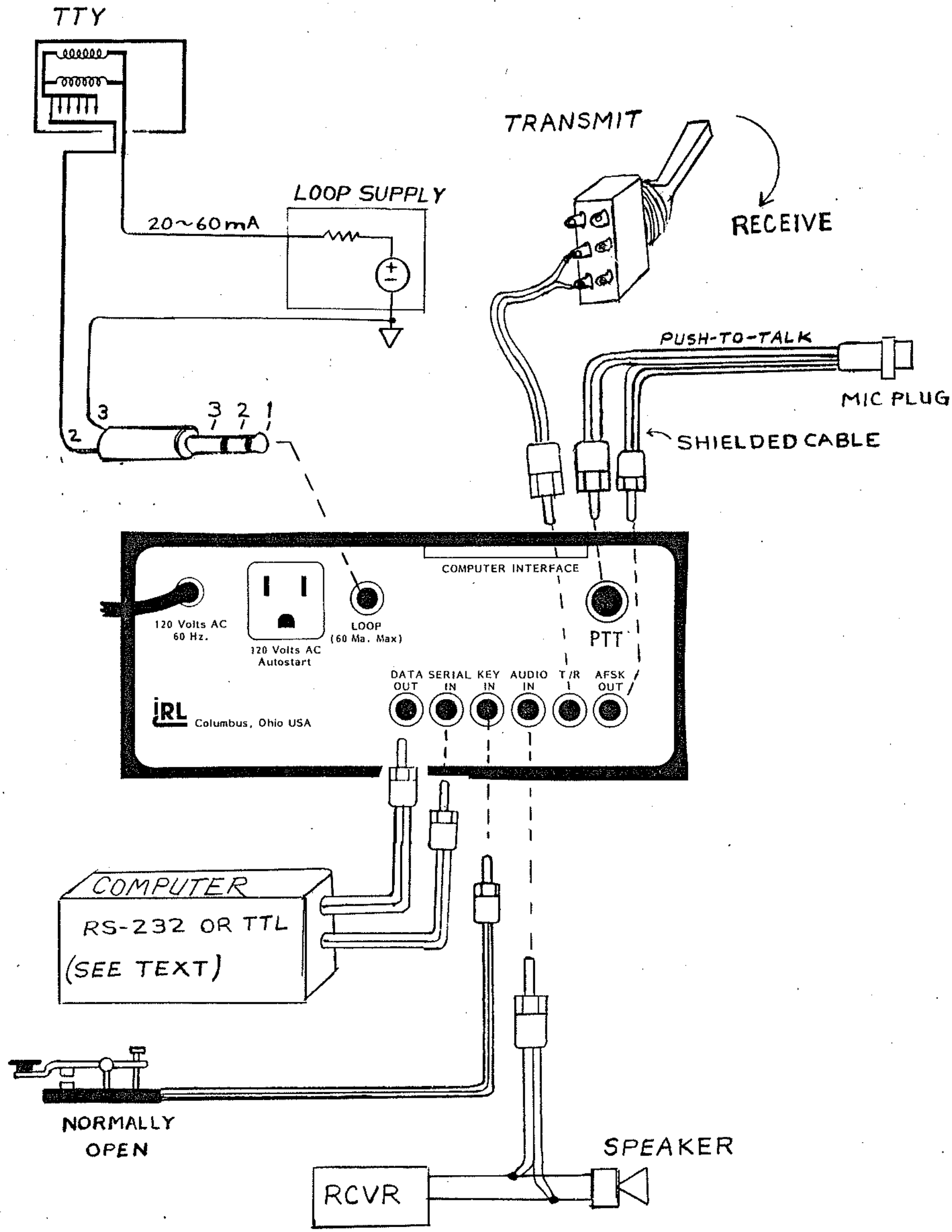
AFSK OUT:	This phono jack outputs the AFSK audio tones for transmitting RTTY signals. The output is a low impedance, coherent, 50mV, FSK audio signal. The transmit shifts are the same as the receive shifts as selected by the front panel SHIFT buttons. This is normally connected directly into the microphone jack of the transmitter as shown in figure III-A.
T/R	This high impedance, low voltage, input is for placing the FSK-500 into the TRANSMIT mode. Grounding this input or a TTL logic "low" puts the FSK-500 in the TRANSMIT MODE. An open jack or logic "high" puts the FSK-500 in the receive mode (see figure III-A).
PTT	The PTT circuit is controlled by an open-collector NPN transistor located at the left rear of the circuit board. The transistor can "pull down" the positive voltage push-to-talk line of most modern transceivers or transmitters. When the FSK-500 is put in the TRANSMIT mode (by way of the T/R switch), this transistor turns on. CAUTION: Some tube-type transmitters have high negative voltage push-to-talk lines and will not work without use of an isolating relay.
SCOPE OUT:	For those who desire an oscilloscope tuning pattern, bandpass outputs from the tone channels are provided (isolated with 100k resistors) at the left rear of the circuit board. These points are labeled M&S. Phono jacks are easily added for those who desire these outputs. (See figure III-C)
AC OUTLET	This outlet is turned on and off by the internal AUTOSTART circuitry. It is for turning on a teleprinter or other device when an incoming signal exceeds the threshold set by the front panel THRESHOLD control. Once the outlet is turned on, it will stay powered up until approximately ten seconds after the signal has fallen below the threshold (as indicated by the threshold LED).

The FSK-500 is not difficult to use or understand, yet it is capable of excellent performance on the hf bands as well as vhf, and with Baudot or 110 baud ASCII.

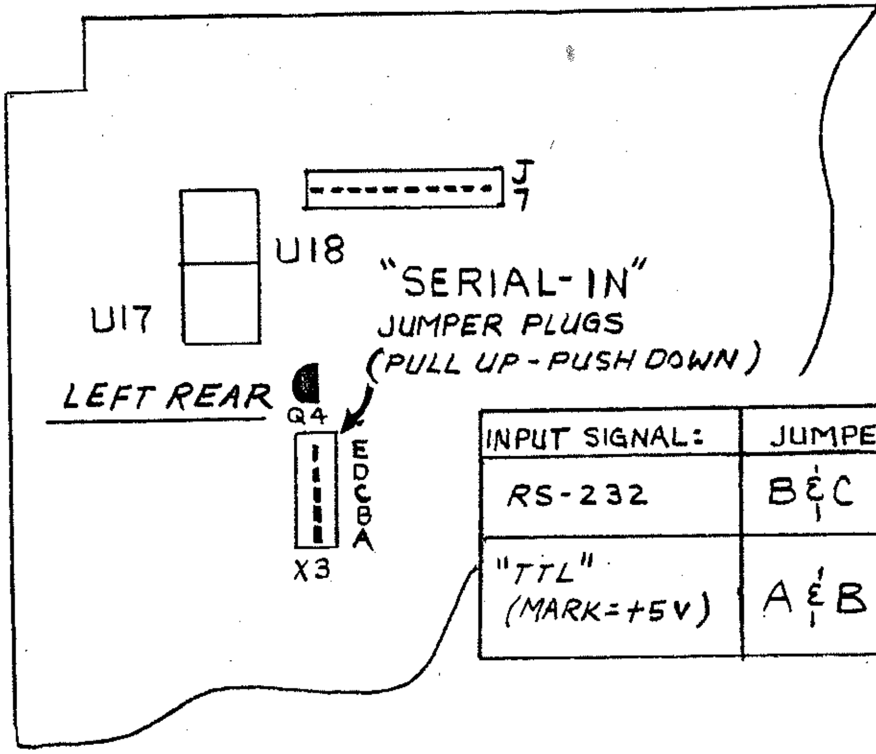
The operator is encouraged to experiment with various combinations of control settings on his receiver and demodulator in order to "get the feel" of what the unit can co. Also the operator should read some of the RTTY literature available from various radio publishing houses, to acquaint himself with the general requirements of an RTTY station. Such things as filter bandwidths, BFO or passband settings, signaling speeds and keying techniques are all dealt with extensively in these handbooks, as well as practical suggestions for station interconnections and explanations of many RTTY terms.

Just as the chain is only as strong as its weakest link, an RTTY station requires a good, stable, properly adjusted receiver and transmitter, a good antenna, a reliable terminal, and most importantly, an operator who is knowledgeable about how the whole system "plays" together.

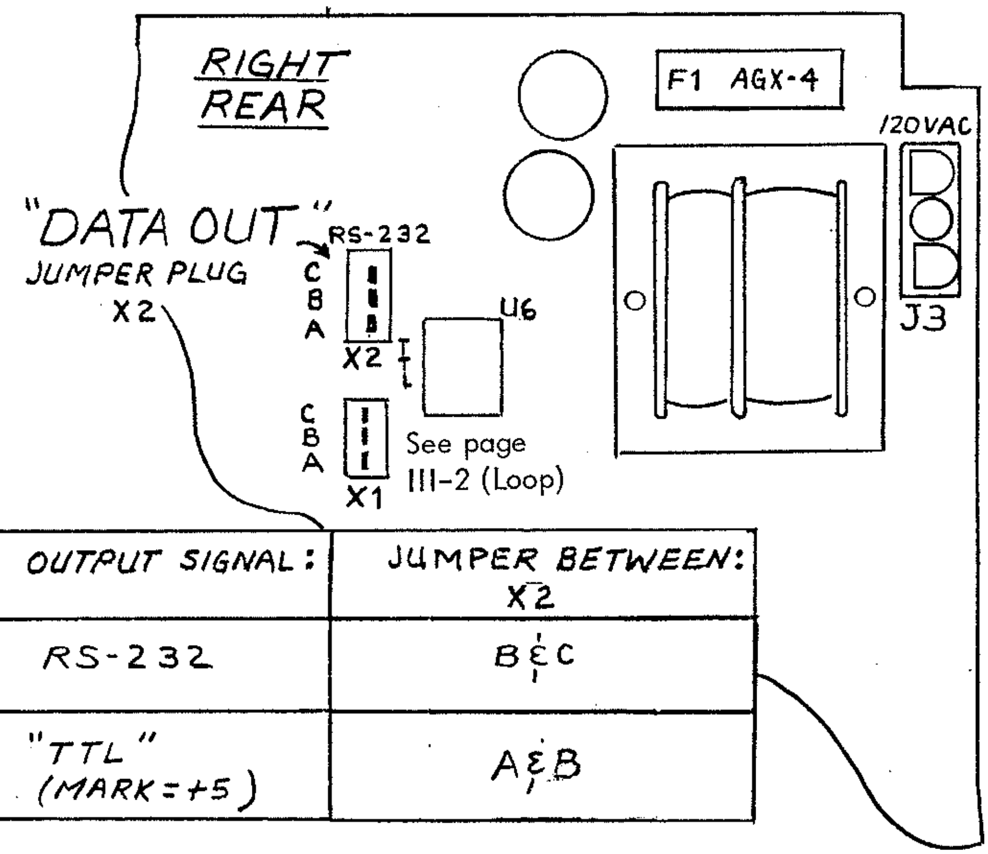
The FSK-1000 demodulator, also made by iRL, includes all of these features and more, but it was recognized that a more affordable unit which also offers selectable bandwidths and full shift coverage should be introduced by iRL. The result is the FSK-500. Many of the sophisticated (and successful) ideas originally developed for the FSK-1000 have been incorporated into the design of the FSK-500 to provide an inexpensive, high performance demodulator designed for the present day operators.


TTY
LOOP SUPPLY
20~60mA
3
2
3 2 1
TRANSMIT
RECEIVE
PUSH-TO-TALK
MIC PLUG
SHIELDED CABLE
COMPUTER INTERFACE
120 Volts AC
60 Hz.
120 Volts AC
Autostart
LOOP
(60 Ma. Max)
PTT
DATA OUT
SERIAL IN
KEY IN
AUDIO IN
T/R
AFSK OUT
IRL Columbus, Ohio USA
COMPUTER
RS-232 OR TTL
(SEE TEXT)
NORMALLY OPEN
SPEAKER
RCVR

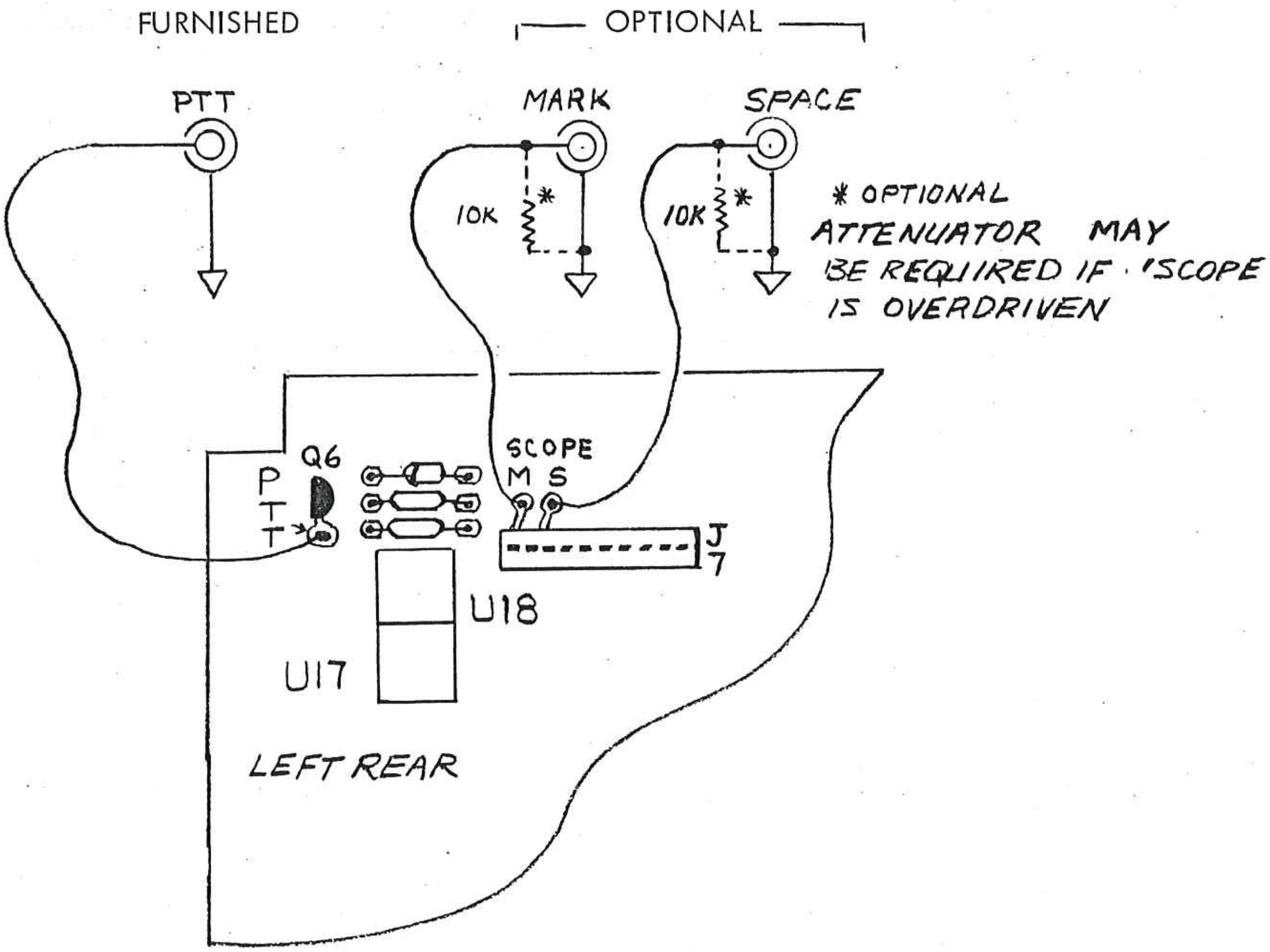
III-A



INPUT SIGNAL:	JUMPER BETWEEN
RS-232	B & C AND D & E
"TTL" (MARK=+5V)	A & B AND C & D



OUTPUT SIGNAL:	JUMPER BETWEEN: X2
RS-232	B & C
"TTL" (MARK=+5)	A & B


FURNISHED
OPTIONAL
PTT
MARK
SPACE
10K
10K
* OPTIONAL
ATTENUATOR MAY
BE REQUIRED IF 'SCOPE
IS OVERDRIVEN
Q6
P
T
T
SCOPE
M S
J
7
U18
U17
LEFT REAR

THE FSK 500 TECHNICAL REFERENCE MANUAL

THE FSK 500
TEHCNICAL REFERENCE MANUAL

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TECHNICAL REFERENCE MANUAL

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APPENDIX

1.0 INTRODUCTION

The FSK 500 Terimnal Unit was designed to give the amateur radio operator a quality H.F. demodulator at an inexpensive price. iRLs' goal was to accomplish this design without sacrificing the major features of the expensive Terminal Units. These features are:

A) Selectable Bandwidth with Dual Filters
B) Self Adjusting Bandpass Preselector
C) Self Adjusting Lowpass
D) Three Standard Shifts (170, 425, 850HZ)
E) Ability to Interface to all computers: (RS 232 or TTL)
F) Printer" Loop" interface with "Autostart"

iRL accomplished its goals and also further enhanced the FSK 500 with improved single meter tuning, helpful troubleshooting indictators, and an inovative AFSK keyer design (which helped keep the cost down). Needless to say the FSK 500 has been received very well by users with all makes of computers.

The purpose of this manual is not to sell an FSK 500. If you bought this manual you probably already have one. It is my express hope that this manual will:

1) Improve you as an operator by promoting a better understanding of the strengths and weaknesses of your Terminal Unit.

2) Improve your ability to "fault isolate" within your system to the "box" level.

3) Allow you to troubleshoot and repair the FSK 500 in the event that it is the " faulty box" and avoid factory service charges.

4) Prevent the most common human inflicted problems, and especially what we will identify in the "Master Technicians Guide" as a "Level One Catastrophy".

5) Provide some basic information about RTTY for the beginner as well as the advanced user.

A few final notes before we begin: Fully 85% of the problems we encounter with the FSK 500 are field servicable and of a simple nature (ie., loose wires, improper hook-up, improper strapping ...etc). If you read only one section ...... let that be the "Master Technicians guide". This section can be found in the Appendix. It will save you a lot of time and can also save you a lot of money! It identifies the most costly as well as the most common problems encountered with the FSK 500.

The writing of this manual allowed us to take a second look at the FSK 500 electronics and ask ourselves the question, "would we do it any differently based on the 4 year track record of the existing FSK 500's?" The answers are in the section on "Improving your FSK 500" in the Appendix.

We encourage you to use this manual, but when all else fails, stop short of laying the unit on the railroad tracks. Troubleshooting can be very frustrating. Sometimes the best fix is a warm bath, a good nights sleep and/or a call to your friendly iRL service people (John, Don or Dave).

2.0 SPECIFICATIONS

Mode: Hard Limiting, FSK Demodulator/Modulator

Shifts: 170, 425, and 850 Hertz Shift

Tone Pairs:

Shift	# 85 Hz	170 Hz	425 Hz	850 Hz
Mark	2125 Hz	2125 Hz	2125 Hz	2125 Hz
Space	2210 Hz	2295 Hz	2550 Hz	2975 Hz

= Narrow Shift I.D.

Inputs:

Audio
500 Ohm, unbalanced
Minimum working signal 10 mv
Maximum working signal 17 volts (peak or continuous)

T/R, Key
Active (Tx or Key down) = +2.1 to -8.0 VDC
Absolute Maximum DC voltage = ±8.0 VDC

Serial In
RS-232 Mark = -12.0 to +2.1 VDC
RS-232 Space = + 2.3 to +12.0 VDC
TTL Mark = +2.3 to +12.0 VDC
TTL Space = -12.0 to + 2.1 VDC
Absolute Maximum DC voltage ±12VDC

Loop
Open Collector Transistor
Vnom. = 170 VDC Vmax. = 200 VDC
Inom. = 60/20ma Imax. = 70 ma

Outputs:

Loop
The Loop is both and input and output.
See above specifications.

Data Out
RS-232 Mark = -7 VDC
RS-232 Space = +7 VDC
TTL Mark = +4.5 VDC
TTL Space = -0.7 VDC (not modified)
TTL Space = -0.3 VDC (modified)

AFSK
140 millivolts peak to peak
50 millivolts RMS

Autostart
120 VAC @ 5 AMPS
1 Second Attack, 7 to 10 seconds Drop-out

Dimensions:

Wide 7 3/4 in.
Height 3 1/4 in.
Deep 7 3/8 in.

3.0 TERMINAL UNIT OVERVIEW

Although the actual teletype machine dates back to the first decade of this century, Amateur involvement in "RTTY" did not begin until the 1940's. "In the beginning", "on/off" keying was used which produced a single tone and sounded much like todays high speed CW. With "on/off" keying, a single channel filter followed by a detector and "Loop" driver circuits, could be used to detect and print the RTTY characters. Unfortunately, trying to create reliable quality RTTY communications with a "on/off" keyed transmission/reception system proved difficult, if not impossible, on the low bands. Experimentation with FSK (Frequency Shift Keyed) transmission quickly convinced Amateurs of the superiority of FSK communications over the "on/off" keyed systems.

In order to take advantage of the improved signal to noise ratio of FSK however, receiving devices had to be designed to include two seperate audio filters, one for the "Mark" tone and one for the "Space" tone, or some form of discriminator. These devices are usually refered to as terminal units (T.U.) or demodulators (because they demodulate the incoming FSK to produce the original keyed information). The devices are also sometimes referred to as MODEMS (MOdulator/DEModulator) or "Data Sets" (Bell terminology). The purpose of this section will be to identify the basic requirements of these devices primarily as they apply to low band communications. More importantly we will introduce a block diagram of the FSK 500 to familiarize the reader with how iRL accomplished these requirements.

Most amateur involvement in RTTY communications today occurs in the frequency range below 30 MHZ, "The low bands". This area of the spectrum is very noisy. Besides atmospheric noise, there is an ever increasing amount of adjacent channel interference caused by the growing number of "Hams" taking to the airwaves to exercise their computers. In addition, the fading of each tone ("Mark" and "Space") seperately, or both tones simultaneously can occur. These problems drive the three basic requirements for a T.U. designer.

1) SELECTIVITY....to reject adjacent stations interference
2) COMPENSATION...for faded tones
3) DETECTION......to create "ones and zeros" from the tones

Beyond these three basics, survival in todays RTTY jungle also requires the ability to handle multiple frequency shifts for both transmit (tone generation) and receive, have post data processing circuits to provide easy interface to computers and printers, and more often than not....a good program.

All Terminal Units fall into one of two major classifications.

1) Nonlinear
2) Linear

Under the classification of "Nonlinear Terminal Units" falls the "Limiter" type T.U.. Under the classification of "Linear Terminal Units" you hear words like "A.M." and "Limiterless". Usually an input gain stage will determine how a particular T.U. is classified.

The classification is very important to the T.U. designer because it effects where he places and how he distributes the selectivity in his block diagram of the unit he is designing. A truely "Linear" T.U. does not suffer from the problem of "Capture" (see Section 4) and generally has all of its tone selectivity concentrated in one block. A "Nonlinear" T.U. however, can suffer from "Capture" and the problem must be addressed by the designer. The solution to "Capture" is usually to place a portion of the selectivity in front of the "Nonlinear" stage.

The FSK 500 has a "Hard-Limiter" as a "gain stage", and this fact classifies it as "Nonlinear" T.U.. For this reason, in our block diagram, we placed the "Preselector" filter in front of the gain stage, the "Limiter" (see Fig. 3.0-1). The "Limiter" necessitates the "Preselector and therefore is covered in this manual preceding the "Preselector". For now we will define "Capture" as the control of the "Limiter" by the stronger of the signals present at its input with the consequence that only that stronger signal manifests itself at the output. The weaker signals are lost. The purpose, of the "Preselector" is to weaken the undesired signals and allow "Capture" of the "Limiter" by the desired tones. In other words, reject adjacent channel interference. This is a way to make "Capture" work for you and will be discussed in detail in sections 4 and 5.

The second requirement of a lowband T.U. was "Compensation" for fading. There are two approaches to this: 1) an "Intelligent Threshold", and 2) a "gain stage" with a large amount of "gain" (ie., a "Limiter"). With a "Linear" T.U. an "Intelligent Threshold" is used. For instance, if the "Space" tone fades out, we electronically bias, or create a "Threshold". This causes the "decision maker" to require more energy in the "Mark" channel to output a "Mark" logic level than the amount of energy required in the "Space" channel to output a "Space" logic level. The "decision maker" is that component that ultimately decides whether to output a "Mark" or a "Space" logic level. The bias will cause the "decision maker" to assume, in the absence of a strong signal, to default to a "Space". If this is'nt done, in the absense of the "Mark" tone ("Space" time period), the T.U would have an input of noise only. This would output a logic level which only depended on which channel, "Mark" or "Space", had the highest noise level present. Depending on noise for the correct logic output is a method that doesn't work well. Because this bias has to be able to adjust itself to different levels to compensate for the different degrees of fading, and because it has to be able to compensate for either of the tones fading, and it has to vanish quickly when the strength of a faded tone returns to normal, we call this bias an "Intelligent Threshold." The DLCC used in the FSK 1000 is an "Intelligent Threshold", and most of the higher priced T.U.s use an "Intelligent Threshold" of some form.

The second approach to the requirement of fading "Compensation", as pointed out above, is to use a "gain stage", such as a "Limiter", that will keep the available signal level "pumped up" to something useable. This is the approach taken in the FSK 500. A signal can take a "deep fade" and the "Limiter" will "Blast" it back up to a useable level. Every circuit has it advantages and disadvantages. With a "Limiter", as will be explained in Section 4.0, copying when one tone has completely disappeared is impossible without some further compensation. For reasons of economics and space we did not include this secondary compensation for faded tones in the FSK 500.

After the "Limiter", some means of translating the tones to "ones and zeros" or "DETECTION" must be created. In the FSK 500 we use the "Mark" and "Space" bandpass filters to separate the tones. We then positive full-wave rectify one of the tones, and negative full-wave rectify the other. If we sum and filter the rectified signals (with a result which can be observed at the output of the "Low-Pass") we will have a positive voltage when a "Mark" tone is present and the negative voltage when a "Space" tone is present. The positive portion of the envelope is squared up by the comparator to form the "Mark" logic level and the negative portion of the envelope is squared up to form the "Space" logic level. The squared up logic levels are visable at the output of the "Comparator".

Before the output of the "Low-pass" is squared up by the "Comparator", it is supplied to the "Meter" and the "Mark-Hold" curcuit. The meter indicates that two tones are tuned into the respective "Mark" and "Space" channels by a full scale reading. The "Mark-Hold" curcuit will compare the amount of positive voltage ("Mark" level) present, with a value determined by the setting of the "Threshold" control on the front panel. If the "Mark" tone is below this level for an abnormal amount of time, the "Mark-Hold" circuit will initiate a "Mark-Hold". This will force the "wired 'or'" in the "DATA TX/RCV CONTROL", consisting of diodes D11, D12, and D13 to a constant high, and the "DATA OUT" circuitry to freeze in the "Mark" state. After sufficient signal returns to the "Mark" channel for a sufficient time to allow rejection of false activation by noise spikes, the "Mark-Hold will release.

The The "Mark-Hold" is also supplied to the "Autostart". If it is present for 7 to 10 seconds the "Autostart" will drop out and drop Relay K1. This results in shutting down the printer. When the "Mark-Hold" indicates a sufficient signal has returned for an approximate period of one second the "Autostart" will close K1 and return the printer to operation.

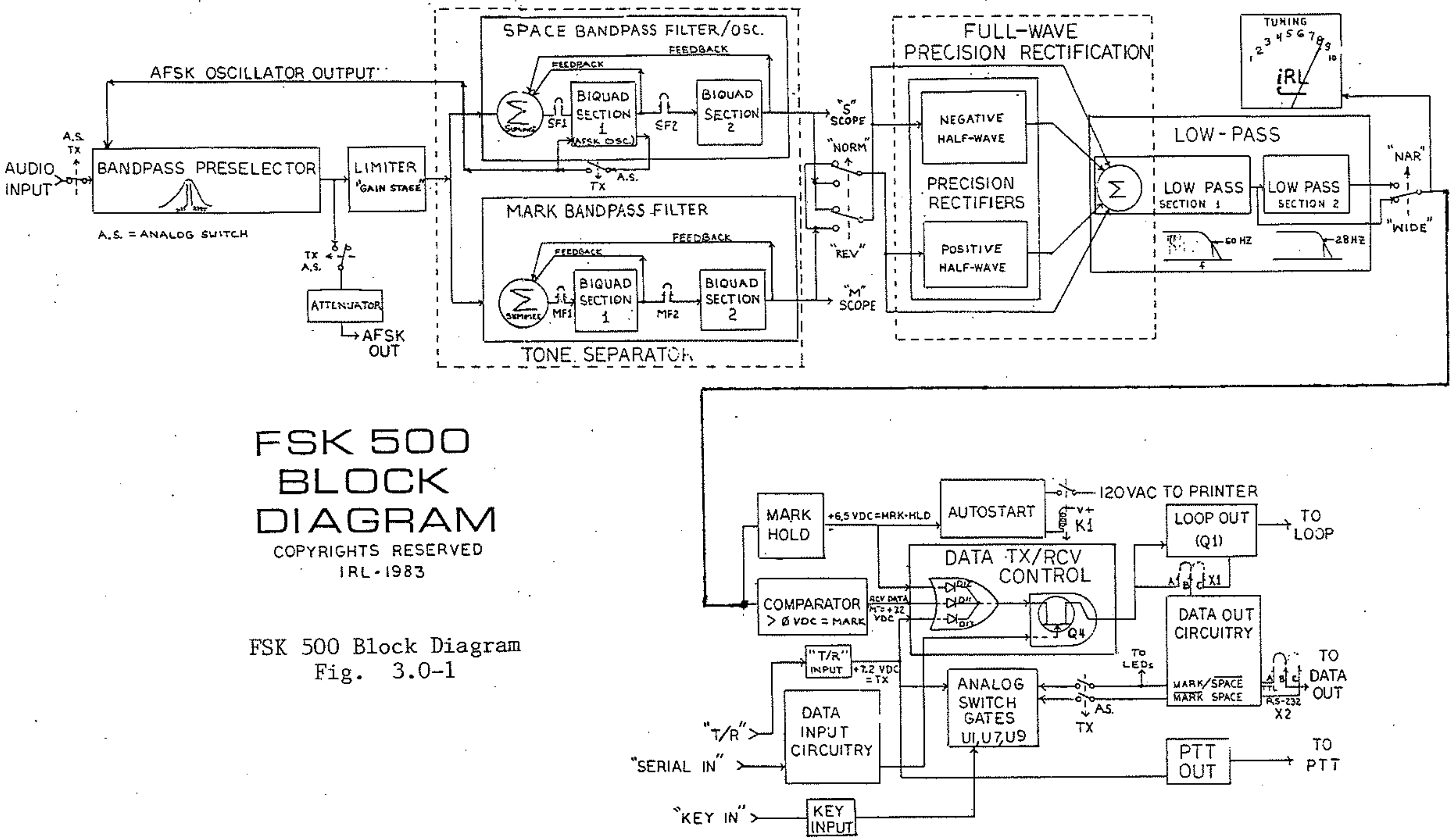
If the "T/R" input is pulled low the "Space Filter/Oscillator" will transfer to the "Oscillator" mode and begin generating the AFSK in coordination with the "Serial In" <u>or</u> "Loop" sense (if "X1" is strapped correctly). The output of the wired "OR" in the "DATA TX/RCV CONTROL" will again be forced to a constant "High" or "Mark" state by forward biased diode D13, and Q4, a J-FET, will turn off to generate a "Space" at the "DATA OUT" or "on" to generate a "Mark". There is a pull down resistor at the output of Q4 (not shown in Block Diagram) which creates the "Space" logic level when Q4 turns "off". If the unit is strapped for a "Loop" the RTTY transmit data is generated by a current sense resistor at the emmiter of the "Loop" switching transistor (not shown in block diagram).

The local generated RTTY data is fed back from the "DATA OUT CIRCUITRY" by way of enabled analog switches, to the gates of other analog switches in the oscillator. In this way they control the generated AFSK tones.

The "KEY INPUT" is buffered and directed to a single analog switch in the "Space Filter/Oscillator" to create the "Narrow Shift" (85 HZ) I.D. tone.

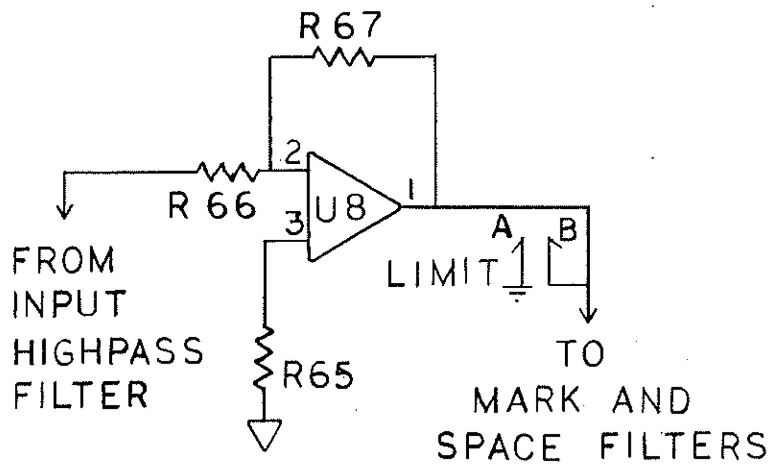
The "PTT" output is simply a transistor biased on by the output of the output of the "T/R INPUT" section.

These blocks will be discussed in much greater detail in the following sections. Refering to the Block Diagram from time to time as you read any of the sections should be helpful.



FSK 500 Block Diagram
Fig. 3.0-1

4.0 THE LIMITER



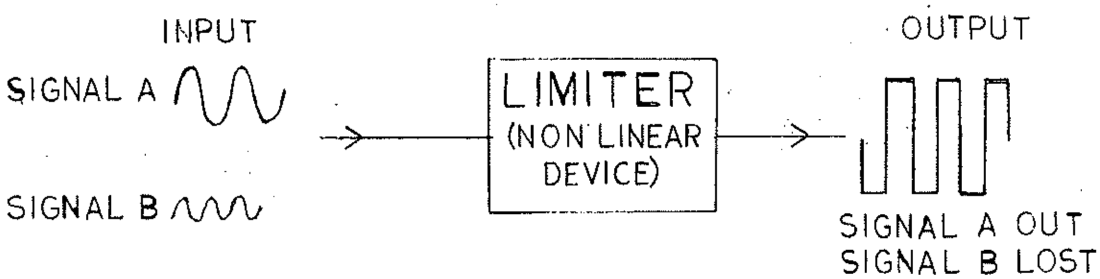
Limiter Schematic
FIG. 4.0-1

4.1.0 Circuit Description

The purpose of the limiter is to "blast" the incoming audio signals up to "the rail" or in other terms supply a large amount of gain. This large gain is responsible for the EXCELLENT SENSITIVITY, which is the main advantage of a limiter. The limiter is a type of nonlinear amplifier and there are "tradeoffs" when they are compared with linear amplifiers. A brief overview of linearity is helpful in understanding these tradeoffs.

If we supply a signal "X" and a signal "Y" to a linear amplifier of gain "A", the output by definition is "AX+AY". Both signals are present at the output with no distortion and amplified by a gain "A". If the gain "A" is then increased to create a hard limiter this "nonlinear" amplifier will react quite differently. A very small input will drive the output to the limit, or "rail", of the operational amplifier. This limit is approximately equal to the positive or negative supply voltages of the Op-Amp. It is the maximum or minimum (negative) drive voltage which the output of the Op-Amp can supply. At this operating point a further increase in voltage at the input causes no change at the output. If signal "X" is present and at a sufficient strength to drive the amplifier output to it rail or "limit", signal "Y" will be lost. This is called "Capture". Signal "X" captures and controls the limiter.

Capture is a very important principal. It can work for you or against you. With amplitude variations removed by the limiting action and capture resulting in only one signal at the output of the limiter, the effect is as you would experience on a two meter repeater or listening to a commercial FM station, "FULL QUIETING". On the other hand if a strong adjacent channel were present and captured the limiter none of the filtering or its' associated selectivity following the limiter will be able to recover the desired station. (See "Improving the FSK 500" in the Technical Reference Manual Appendix.)



"Capture"
Fig. 4.1.0-1

All the various types of gain stages used in constructing a terminal unit have advantages and disadvantages. Capture is the major disadvantage of a limiter amplifier. It is however, not "THE LAST WORD". Most quality terminal units that incorporate a limiter for its fine sensitivity also include a PRESELECTOR filter upstream from the limiter. The purpose of the preselector is to screen out the adjacent channel interference before the audio tones reach the limiter. The theory is simple. If we can attenuate a stronger interfering signal sufficiently, (ie., a 1000 HZ adjacent channel tone) while passing the 2125 Mark and the 2295 "Space" tones of the desired station, we can greatly increase the probability that our desired signal will be the one that captures the limiter. (See the following section, "The Preselector".)

Another consideration of some importance when dealing with gain stages in general (limiter or limiterless) are their action in the absence of any signal. For example, if a CW "QSO" is in progress but at a given instance the transmitting station has their key up (no carrier) or you are receiving RTTY and the "Mark" or "Space" tone fades out completely, a situation exist where the input to and output from the gain stage is noise only. Under this circumstance the demodulated output of the Terminal Unit (dit or dah, "Mark" or "Space") is undefined. Again this is not the last word. The more expensive limiterless rigs like the FSK 1000 employ some type of electronically activated Decision

Level Correction Circuit (DLCC) to create an "intelligent" threshold, which makes it more difficult for noise to effect the output while increasing the probabilty that the terminal unit will default (in the absence of a signal) to the proper output. Manually adjusting the threshold on the FSK 500 will have somewhat the same effect thus allowing copy of CW (see "COPYING CW WITH THE FSK 500), but will not compensate for a signal that has faded completely out.

The author would like to note here that the limiter scheme has worked out well for IRL. This is evidenced by the great many of our users that compliment the FSK 500 on its ability to copy under adverse conditions. In the absence of QRM or if the QRM has been sufficiently attenuated by a preselector, the sensitivity of a limiter can be superior to other schemes when dealing with faded signals. In addition fading will many times effect both tones, and when both tones have faded out "no Terminal Unit will copy reguardless of its gain and detection schemes. For the above reasons we think you will agree that the Limiter with Preselector makes a nice combination!

4.2.0 Technical Talk

The Limiter is not likely to fail. Neither of the two operational amplifiers that comprise U4 I.C. are exposed to the outside world. If U4 is bad you probably have experienced a "Level One" catastrophy (Lighting or Screwdriver) and have many other I.C. failures. Usually if these problems have occured you are aware of the circumstance that caused them. Checking out the Limiter is simple. First supply an audio signal to its input (left side of R66 on schematic). This can be done by applying a one volt peak to peak signal capable of driving 600 ohms to the audio input. If you cannot produce an audio tone at the U10 pin 1, R66 junction then we recommend you first correct the problem in the preselector. (see "The Preselector") This Audio tone should be in the 1400 to 2800 Hertz range and can be supplied by the speaker leads of your receiver. Your best bet is to use the calibrate on your rig to generate the tone and simply "beat it" into that frequency range.

The output of the limiter should be a rail to rail signal as shown in Fig. 4.1.1-2. The frequency will be equal to the frequency of your input but the sine wave you started with will be squared up and any noise which was riding the signal will have been removed by the capturing effect of the limiter. If you have an oscilliscope the .1 milliseconds per division time base works well here. If you increase the time base to ten milliseconds per division the rails will show up as lines of greater intensity at the top and bottom of the displayed signal. You will also notice about .4 volts of supply ripple on both the positive and negative peaks as described in the section on the power supply. This is normal and will not be visable once the signal has passed through the appropriate bandpass filter which lies beyond the limiter.

You should be able to decrease the audio level at pin one of of U10 and watch the limiter output signal drop away from the rails and down until with a 10 millivolt input to the limiter, the output will vanish due to inherent noise and/or operational amplifier offset voltage. If you are using the speaker output to generate your tone, you will stop hearing the tone long before the 10 millivolt threshold is reached. This is why you can turn the volume down on your receiver and continue to get quality copy from the FSK 500. It simply does not require much input signal to do its job!

5.0 THE PRESELECTOR

5.1.0 Circuit Description

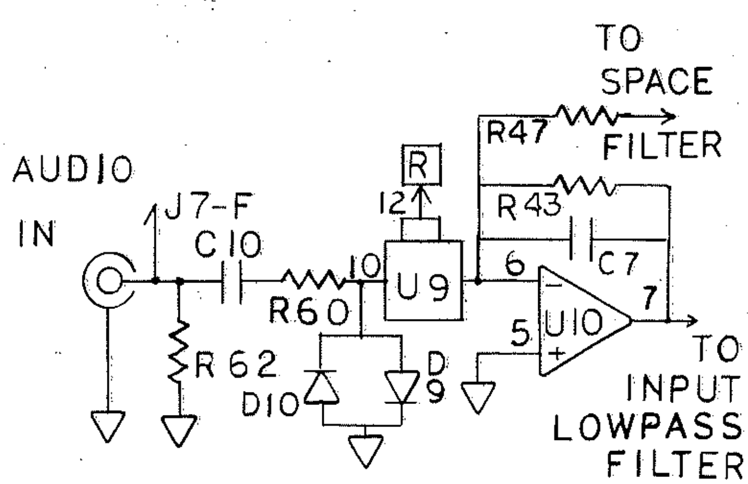
The FSK 500 Preselector performs two distinctly seperate functions in the receive and transmit modes. In the receive mode it helps to prevent capture. As explained in chapter 1, "The Limiter", limiters are subject to capture by the strongest signal. By attenuating signals outside the passband required for the two desired tones, while passing the Mark and Space tones, the possibility of capture by an unwanted tone is greatly diminished. This allows the limiter to produce the well known "full quieting effect" and thus work to clean up the desired tones before presenting them to the Mark and Space band pass filters. In the transmit mode, the Preselector serves to filter out any unwanted harmonic distortion from the generated AFSK tones. This aids in the production of clean audio frequency shift keyed tones (AFSK) for the transmitter.

The three sections which comprise the preselector are;

1.) The Input Scaler,
2.) The Low Pass Filter, and
3.) The High Pass Filter

In the following pages each of these sections and their purpose in the FSK 500 will be discussed. Plots will be supplied for the Scaler, Low-pass and-High pass as if they were isolated circuits, and finally we will treat them as one unit.

5.1.1 The Input Prescaler



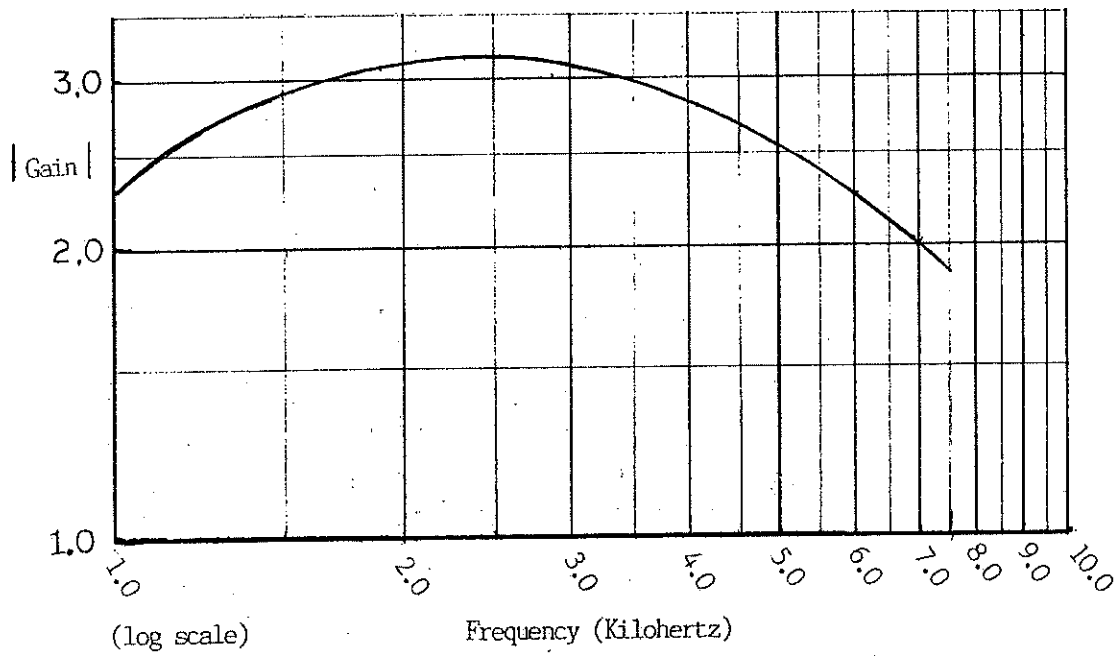
Input Prescaler Schematic
FIG 5.1.1-1

The AFSK tones are generally supplied from the speaker leads of your receiver to the FSK 500 "Audio Input" on the rear panel. This signal is introduced to a 500 ohm input impedance (which R62 is chiefly responsible for), and capacitively coupled to R-60, the input resistor of the scaler. In the receive mode analog switch U9 is turned on by a continuous high (+7.2 VDC) on its gate (pin 12). (This 7.2VDC is supplied by the "T/R" comparator.) The typical "on" channel resistance (pin 10 to pin 11) is 250 ohms and for purposes of circuit analysis U9 can be considered a short when "on". Capacitor C10 provides DC blocking, and thus protects U10 from any DC voltage which may shift it out or to one end of its linear range and thus distort the incoming signal. Diodes D9 and D10 protect the input amplifier and analog switch U9 from any large spikes which might be applied to the "Audio Input" by accident. Under normal circumstances these diodes never turn on due to their close proximity electrically to the Pin 6 of U10. Because the Scaler is a linear amplifier with its' reference input tied to ground, pin 6 is a "virtual ground". By "virtual ground" we mean that even though it is not connected directly to ground, if you could examine the signal and DC voltages present on a virtual ground, without injecting any biases into the circuit from the meter or oscilliscope, you would see what appears to be ground (if the circuit is operating properly).

In the receive mode there are no other inputs (of any significance) to the Input Scaler. Tracing back through R47 we will arrive at another analog switch which is "off" during the receive mode and a branch with a resistor and potentiometer which are connected to pin 2 of U2. This pin is a "virtual ground" in the receive mode and does not contribute any significant inputs to the "Input Scaler" in the receive mode.

Typically the signal being supplied by your speaker leads is approximately .8 volts (peak to peak) at normal listening levels. The "Input Scaler" provides a gain of approximately 3.00 over the 2125 Hz to 2975 Hz range. The purpose of this is to boost the incoming audio tones toward the center of the operating range of the operational amplifiers following the "Input Scaler".

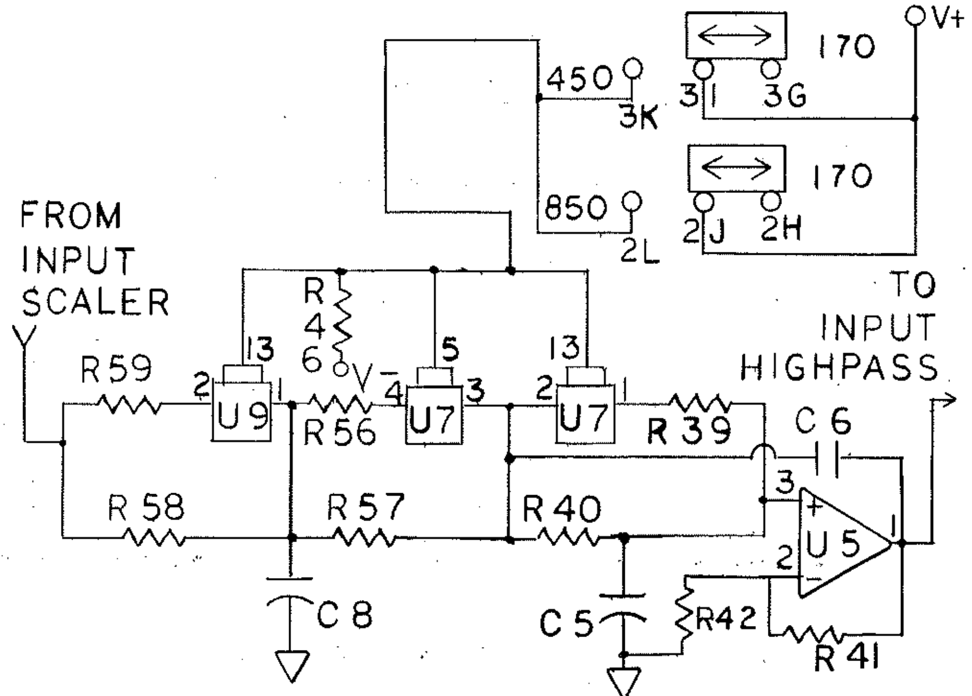
In addition to the scaling function of U10, the value of the DC blocking capacitor "C10" was chosen to create a high pass function, and capacitor "C7" was added to create a low pass function. The combined result of these two capacitors yield a frequency plot as shown in Fig. 5.1.1-2. This is the output you would expect to see at pin 7 of U-10 if you input a 1 volt peak to peak sine wave, sweep the frequency of the sine wave from 500 Hz to 7000 Hz and plot the output voltage every 500 Hz.



Input Prescaler frequency response
Fig. 5.1.1-2

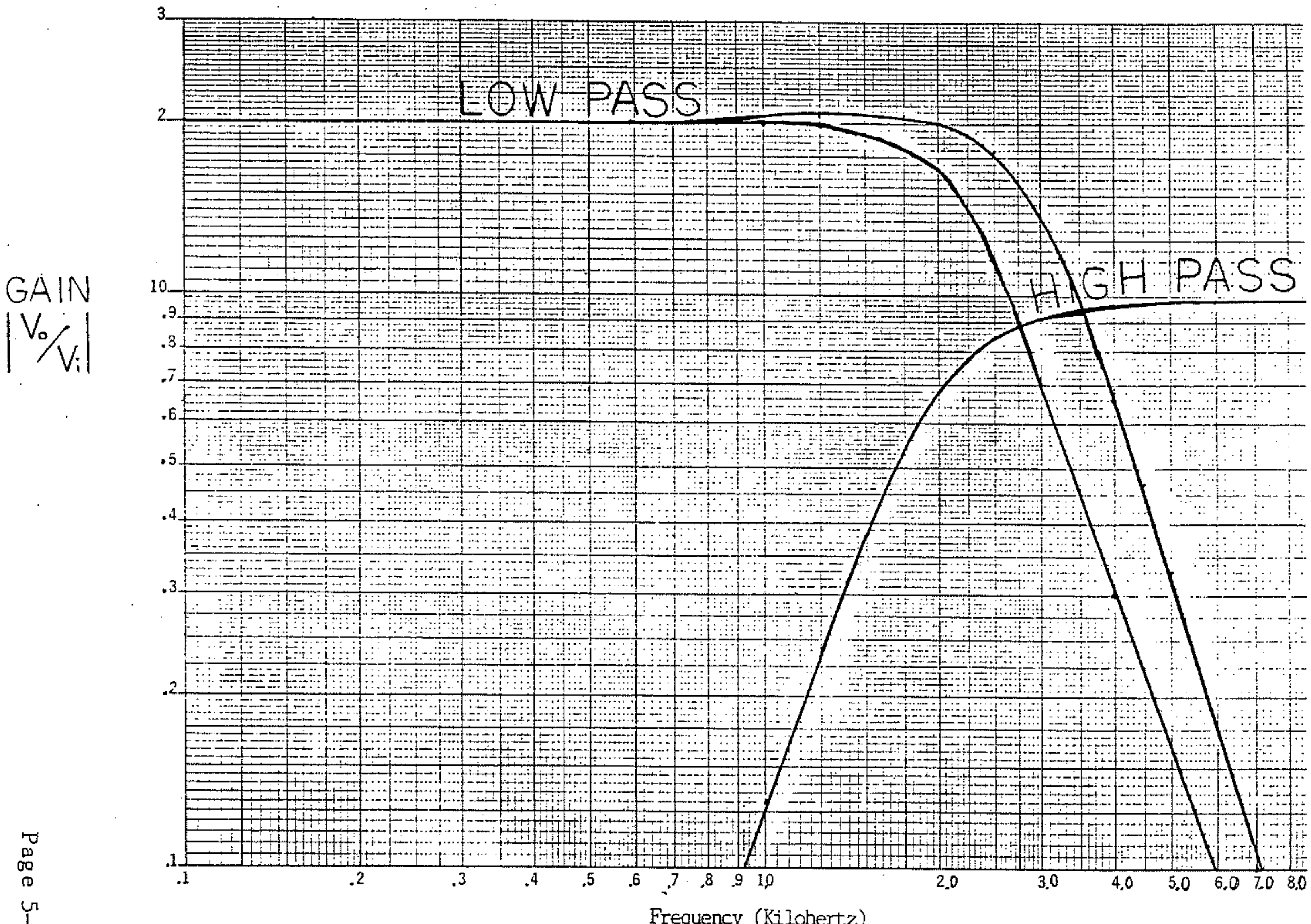
When the "T/R" is externally pulled low to put the FSK 500 in the transmit mode, the analog switch from pin 10 to pin 11 of U9 turns off and essentially disconnects the "Audio Input". At the same instance the analog switch in the Space filter/oscillator (U9 pin 1 to pin 2) turns on allowing the generated AFSK tones to become the input to U10, the scaler. Since the input is now being supplied through a different resistor, R47, the scaler now becomes an attenuator with a gain of approximately minus .08. The input from the filter/oscillator will be a very clean 3.75 plus or minus .25 volts peak to peak sine wave. (Note; This is before it is filtered by the preselector). The output of the prescaler will be a 300 millivolt sine wave (3.75x.08). The output of the scaler is then supplied to the Preslector low pass filter.

5.1.2 The Low-Pass Filter



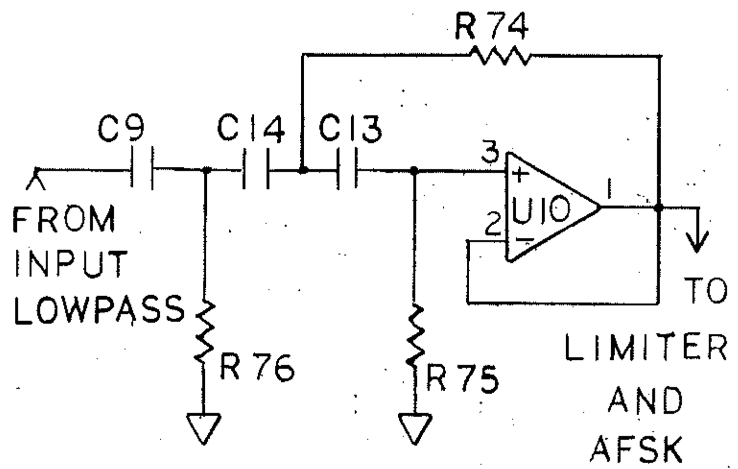
Preselector Low-Pass Filter Schematic
FIG. 5.1.2-1

The Low-Pass section of the preslector is a noninverting third order multiple feedback VCVS filter. The components used in this filter (and all other iRL filters) are 1% metal film resistors and metalized polycarbonate capacitors. This creates a stable precision filter. Its purpose is to attenuate interfering audio tones above the Space channel frequency. Because the Space filter can be set for 2295, 2550 or 2975 Hz depending on which audio frequency shift you have selected (ie 170/425/850), the Low-Pass must also be able to change its bandwidth to compensate for this variability of shift. The designer of the FSK 500 reasoned that most adjacent station interference problems occur on the amateur bands where the 170 Hz shift is being used and not on the commercial bands that are regulated by international treaties. For this reason the Low-Pass section of the FSK 500 Preselector was designed to have a cutoff frequency of 2445 Hz with a 170 Hz shift selection and open up to 3125 Hz for a 425 or 850 Hz selection (See Fig. 5.1.2-2). Analog switches U9 pins 2 to 1, U7 pins 4 to 3, and U7 pins 2 to 1 accomplish this function of opening up the filter. In the 170 Hz shift position the gates of these switches are pulled to V- and the switches remain "off" isolating their respective series resistors (R59, R56, and R39). For the 425/850 shift selection the gates are pulled through push button switch S2 or S3 to V+. This turns the analog switches "on" connecting the respective resistors into the circuit and in so doing shifts the cutoff frequency of the filter up to 3125 Hz. (See Fig. 5.1.2-2)



Preselector Low/High Pass-Frequency Response
Fig. 5.1.2-2

5.1.3 The High-Pass Filter



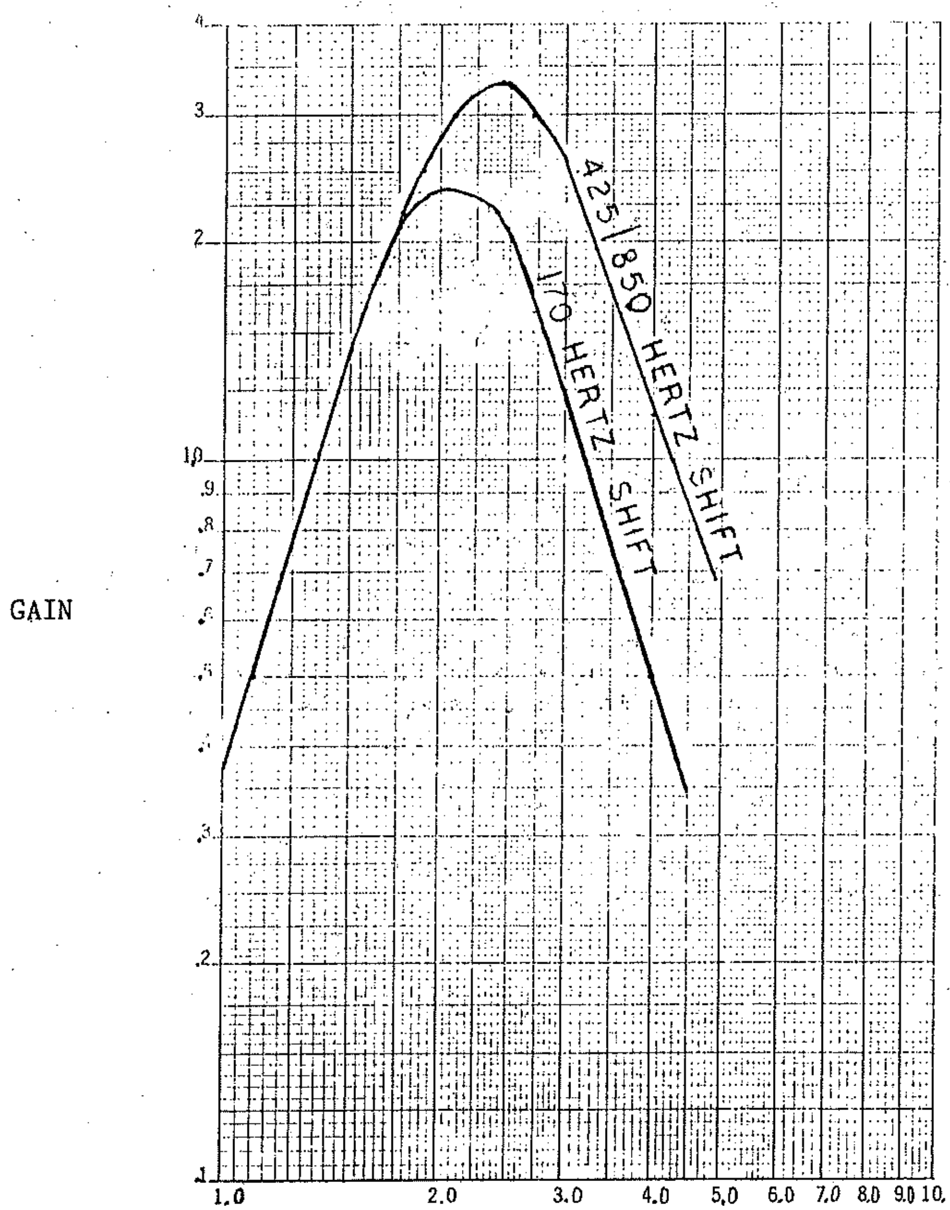
Preselector High-Pass schematic
Fig. 5.1.3-1

The high pass portion of the Preselector is also a third order filter. Because the cutoff frequency of the High Pass section does not change when the Preselector opens up for the 425 and 850 Hertz shift, there are no components to be switched into the circuit as there are in the low pass section. The design cutoff frequency is 2000 Hz and is determined by the 1% resistors and 5% capacitors shown in the schematic above. The High-Pass frequency response plot is shown in Fig. 5.1.2-2.

Inputs to the High-pass section have been amplified by preceeding stages. Further amplification by this stage could cause limiting which may destroy the desired filtering action of the preselector. For this reason the gain of this stage is less than unity for all frequencies.

5.1.4 Preselector Summary

The preselector bandpass filter was included in the design of the FSK 500 to provide attenuation of adjacent channel interference. Its main purpose is to cause capture of limiter by the desired mark and space tones while rejecting the undesired adjacent channel audio noise. The overall preselector bandpass filter plot which is created by the Input Scaler, Low Pass, and High Pass sections is shown in Fig. 5.1.4-1.



(log scales) Frequency (Kilohertz)

Overall Bandpass Preselector Frequency Response

Fig. 5.1.4-1

5.2.0 Technical Talk

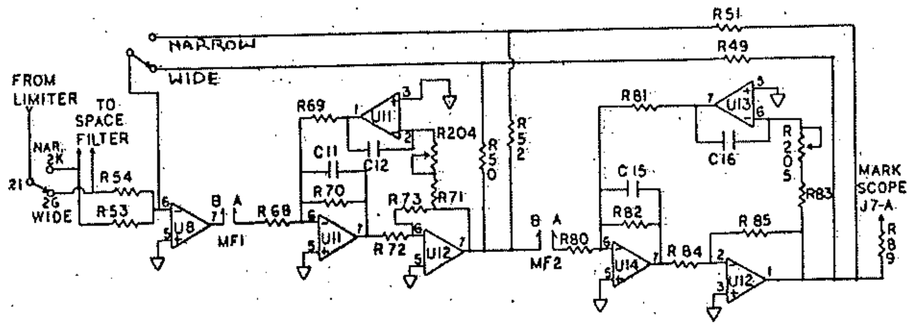
The Preselector usually does not cause problems. The most likely component to fail here is the analog switch U9. Because of the diode protection at the front end, the cause of failure is rarely supplied through the "Audio Input". More than likely it is due to lightning, a screw driver, or in general a large voltage (120VAC/LOOP) misdirected into the FSK 500. If this is the case the other two analog switches (U1 and U7) are probably also be bad. Occasionally, we at iRL do see an operational amplifier go bad. This failure mode is rare in units which have more than 10 hours of operating time.

The best advice I can give you when troubleshooting the Preselector is do not waste time ploting filters. First, insure that you are in the Receive mode. If your "T/R" has not been modified for the H89 computer this amounts to disconnecting any input to the "T/R". Second, put your receiver in SSB, and calibrate modes and inject a audio signal from your receiver to the "Audio Input. Sweep through a calibrate marker frequency (ie. 14.000 MHz) while monitoring the High Pass output, U10 pin 1. A meter set to AC volts range or an oscilliscope will work nicely. If you see an output of 2 to 8 volts (anywhere in that range) which increases and then decreases as you sweep from about 1000 Hz to 3000 Hz, your preselector is probably working fine and you can look elsewhere for your "gremlin".

The bottom line is if the Scaler, Low Pass, or High Pass, fail, the probability is great that they will not merely shift their bandpass, but instead will cause no signal to be seen at the preselector output, U10 pin 1. If no signal is present repeat the above sweep while monitoring the Scaler output. Logically a signal here would mean trouble in the Low or High Pass. If so, the chief suspect is the analog switches U7 and U9 followed by op-amp U5 and lastly U10.

If there is no signal at the output of the Scaler check the R60-C10 junction. Remember at this point the signal has not been amplified and may be only of the order of .8 volts for a normal listening level. If the signal here is low (less than 100 millivolts) you may be trying to drive the FSK 500 audio input from a high impedance source. The source impedance of your audio generator should be 700 ohms or less. If there is no signal here check your audio input cable first, replace the analog switch (U9) second, and the operational amplifier (U10) third.

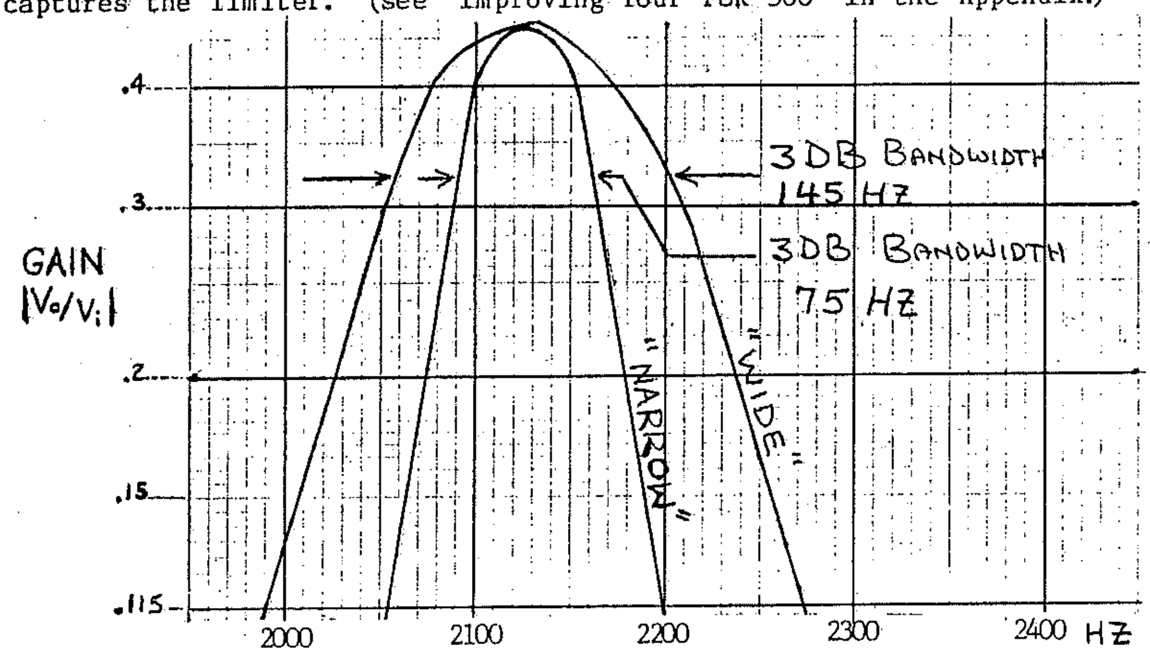
6.0 THE MARK BANDPASS FILTER



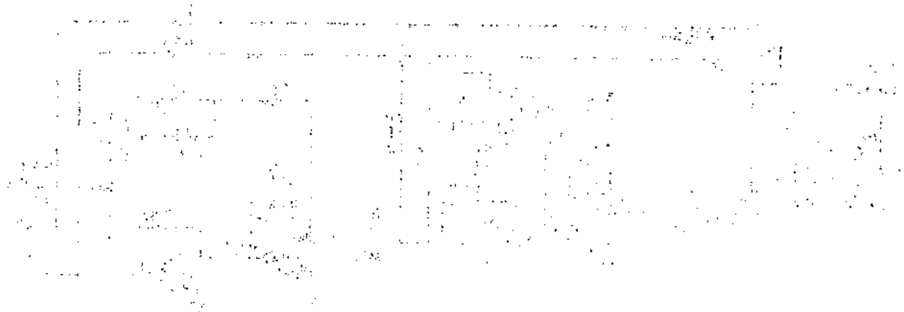
Mark Bandpass Filter Schematic
Fig. 6.0-1

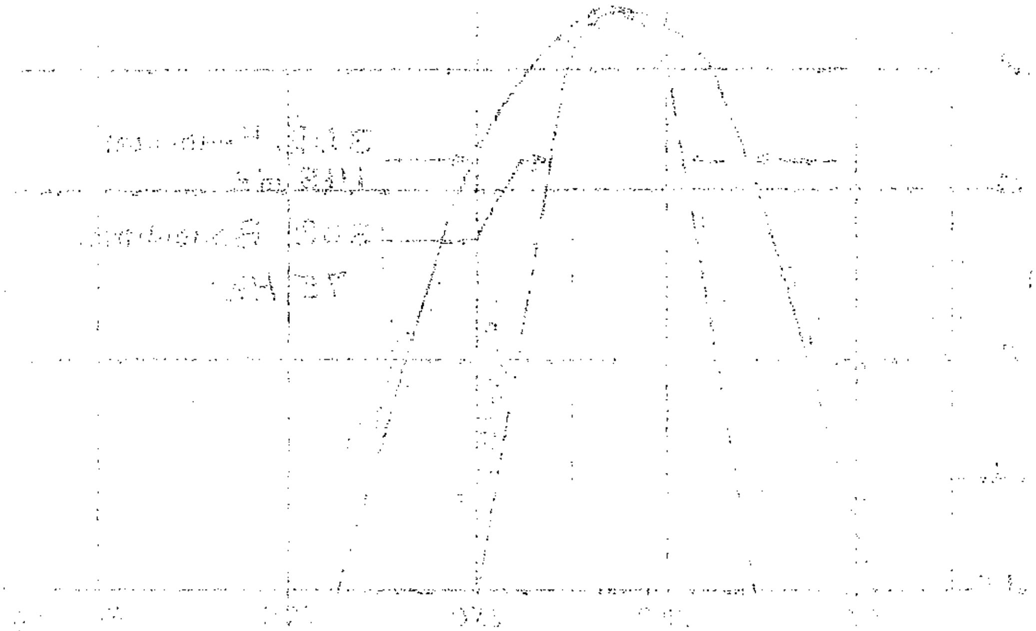
6.1.0 Circuit Description

The FSK 500 Mark filter is a dual bandwidth bandpass filter. The filters were designed to have selectable bandwidth to satisfy the requirements of a greater bandwidth at 110 baud while not sacrificing the selectivity required at 45 baud. A plot of a typical FSK 500 Mark Filter bandwidths is shown in Figure 6.1.1-1. With the "WIDE/NARROW" button in the "Narrow" position, resistors R51 and R52 set the Mark filter bandwidth to 75 Hz. In the "Wide" position, the filter bandwidth is set by R49 and R50 to 145 Hz. The importance of this is stopping the effect of noise spikes or other short term noise which temporarily captures the limiter. (see "Improving Your FSK 500" in the Appendix.)



Mark Bandpass Filter Frequency Response
Fig. 6.1.0-1

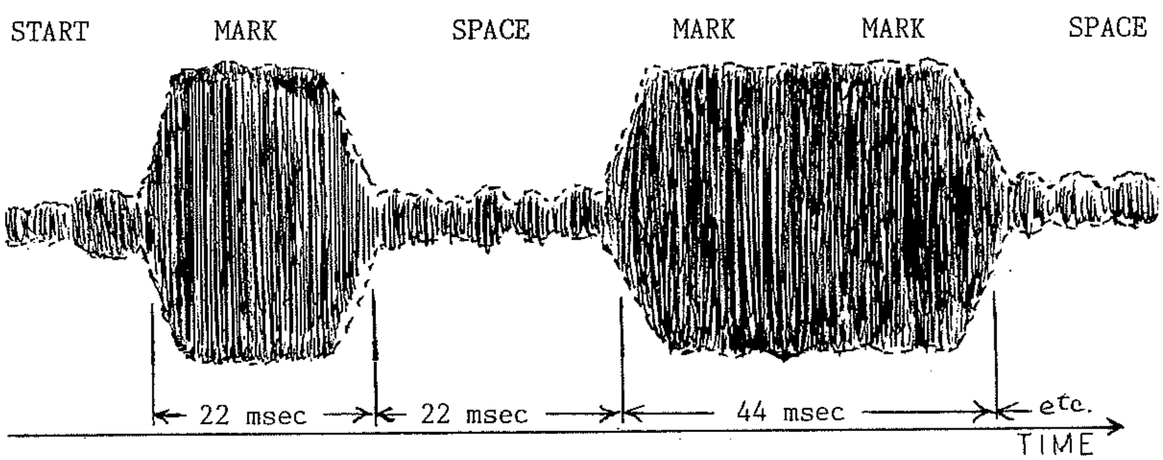




6.3.0 Technical Talk

The most common failures in the Mark filter are caused by a nearby lightning strike, a human trying to adjust the trim pots to compensate for a low meter reading (usually caused by something unrelated to the Mark filter), or ("shamefully") a premium iRL op-amp integrated circuit that has died; in that order. Usually the op-amp will depart within the first 10 hours of use if it is going to die. If it is nearby lighting, and knocked out one op-amp there are likely many more "down for the count".

The best way to approach a possible problem in the mark filter is to first supply a one volt peak to peak audio signal at 2125 to the "Audio Input". Remember that your receiver in the calibrate mode is capable of generating a stable audio tone. Check the output of the limiter for a strong signal (approximately 14.4 V P-P). Alternatively you may derive this signal from the AFSK oscillator (if you have a working Space filter/oscillator) by putting your FSK 500 in transmit (pull "T/R" low) and insuring the "Serial Input" is set up to generate a "Mark". If there is a 2125 Hertz tone at 14.4 V P-P going into the Mark filter (as would be supplied by the limiter), there should be a 2125 Hertz tone at 6.6+1 V P-P at the output of the Mark filter. The Normal/Reverse switch pin "C" and "D" is a handy place to hang a scope probe when you desire to view the output of either the Mark or Space channel. If you look close on the circuit board you will see where we have screen printed an "M" (output of Mark channel) and a "S" (output of Space channel) on the circuit board next to the appropriate pins of the switch. If the signal is there at the right amplitude, look to the preselector, low pass or Space filter for your problem. It is probalbly worth while to mention here that the signal present at MF1 and MF2 will not look like the signal at the output of the Mark filter when RTTY is being received. Below in Fig. 6.3.0-1 is an example of 45 baud Mark filter output.



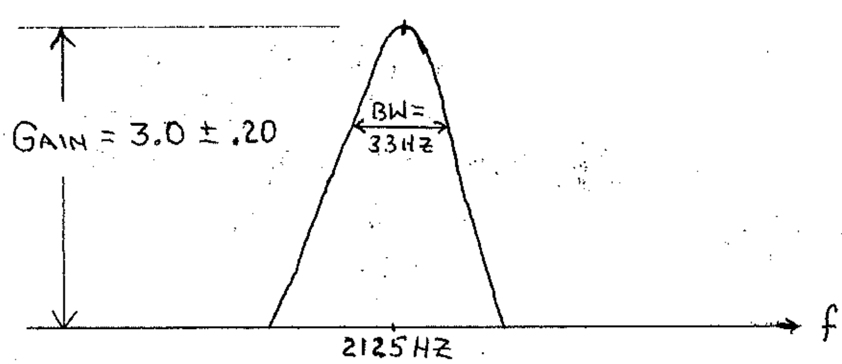
Typical Mark Filter Output (Copying 45 Baud)
Fig 6.3.0-1

If the 2125 signal was not present or not of the right amplitude iRL recommends you follow the tuning procedure. If a section will not tune at all you can attempt to single out the one of the three Op-Amps that is causing the problem or just replace all three. Any time you replace an Op-Amp you should retune any Mark or Space bandpass filters that received a new integrated circuit. Remember that each of the 8 pin integrated circuits have two operational amplifiers inside and they are not usually found in the same filter section.

Occasionally when you attempt to retune you will find a pot with an irratic adjustment. This is usually caused by the chemical used to secure the pot getting under the wiper. If this is the case and you cannot retune you may have to replace the trim-pot. Do not confuse this condition with an improperly operating Op-Amp. Whatever the problem, once you have corrected the it, do not forget to reinstall the jumpers.

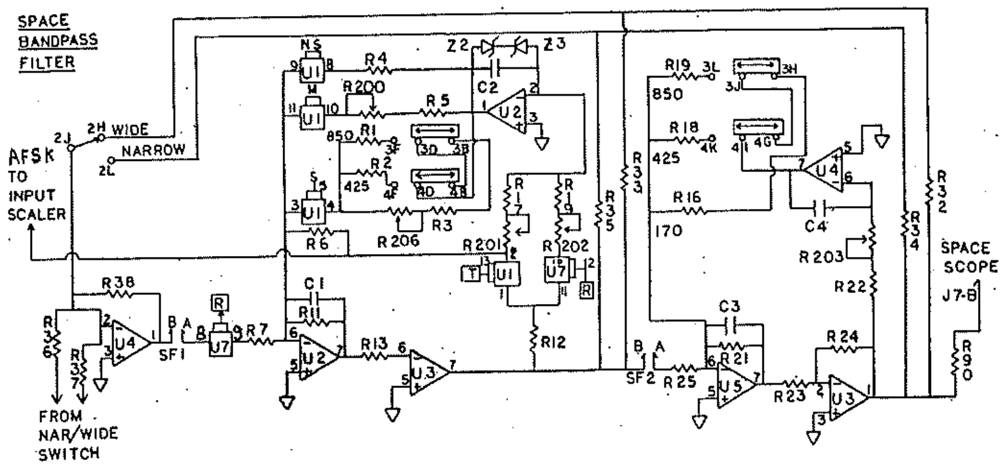
If both biquad sections tune up normally, the only other suspect left is the input/feedback summer U8. If replacing this amplifier does not correct the problem then it is probally time to call us or just box it up and ship it back to iRL for repair.

In closing this section we would like to point out that the plot you would obtain if you sweep a working isolated biquad section of the Mark filter from 2000 to 2250 Hz is not the same as the overall plot shown in Fig. 6.6.1-1. The gain (Vin/Vout) for an isolated biquad section will be between 2.8 and 3.2, and the bandwidth will be 33 + 3 Hz regardless of the setting of the "Wide/Narrow" switch. If you preform this sweep be sure to maintain the input at 1 V P-P for each plotted point of the filter output. Use the same input and monitor points as described in the tuning procedure. If the sweep looks like Fig. 6.3.0-1, that section of the filter is in pretty good shape. I personally do not remember any operational amplifier failure ever causing a biquad section to change to a marginally unacceptable point. Look for them to work right or fail completely.



Sketch of Isolated Biquad Section Frequency Response
Fig 6.3.0-2

7.0 THE SPACE BANDPASS FILTER/AFSK OSCILLATOR



Space Bandpass Filter/AFSK Oscillator Schematic
Fig. 7.0-1

7.1.0 Circuit Description

The Space filter differs from the Mark filter in two respects:

1.) The requirement to shift its bandpass to one of three different center frequencies.

2.) The requirement to preform the function of an AFSK Oscillator in the transmit mode.

To simplify the discription of this circuit we will first discuss the operation of the Space filter in the Receive mode and second in the Transmit mode.

7.1.1 The Filter

In the Receive mode U7 pin 8 to 9 and 3 to 4 can be considered a short, and U1 pin 1 to 2, 8 to 9, and 10 to 11 an open. Resistors R201, R17, R67, R6 and R47 (Input Scaler), R200, R4, and R5 can be considered disconnected from the circuit and therefore have no function in the Receive mode. Zeners Z2 and Z3 are never in a conducting state and can also be considered not present in the Receive mode. All but one of these components are found in the first biquad section of the Space filter. This is also the section that doubles as an oscillator in the transmit mode.

As explained in Section 6.0, the topology of the multiple feedback biquad filter allows us to easily shift the center frequency of the bandpass without changing the filter shape by shifting the resonant frequency of the two biquad sections within the filter. In the receive (and transmit) mode of the filter (oscillator) we use push button switches S3 and S4, located within the biquad sections to switch in various 1% resistors which determine the filter bandpass resonant frequency. When both buttons are "out" the resonant frequency of the first biquad section is 2295 Hz. The frequency determining resistor of the first biquad section is R206 (not in FSK 500 versions below serial # 50500) and R3. In the second, section the 2295 Hz frequency is determined by R16. If the 425 Hz button or both the 425 and 850 Hz shift buttons are pushed "in", the space bandpass and biquad resonant frequency is 2550 Hz as determined by R2 in the first section and by R18 in the second section. With the 850 Hz shift button "in" and the 425 Hz shift button "out" the resonant frequency of sections 1 and 2 is set for 2975 Hz by resistors R1 and R19(850) respectively thus allowing for an 850 Hz shift reception. Note: R19 has been screen printed on the P.C. board twice by mistake. For this reason we will always refer to the 850 Hz shift frequency determining resistor of the second section of the Space filter as "R19(850)" and the R19 connected to U2 pin 2 and R202 as simply "R19".

Trimmer Pots R202 and R203 are used to compensate for initial departures of the individual biquad sections from design resonant frequencies due chiefly to the two 5% tolerance capacitors in each section. Capacitors used in these circuits (both Mark and Space) are of the metalized polycarbonate family and have a reputation for <u>low temperature drift and high Q</u>. Precicion 1% metal film resistors were chosen for their superior temperature characteristics relative to the less expensive carbon and carbon film resistors. The resistor values also were chosen to minimize the drift characteristics of the series analog switches, allow standard values which put us as close to the design frequency as possible before adjusting any trimmer poteniometers, and yield an acceptably small adjustment range. In some cases original design trim pots were actually obsoleted by a "home grown" filter optimization program. The MC4558 operational amplifiers used in the filters (both mark and space) were chosen based on a gain bandwidth specification which was superior to the older 741 an 1458 series and would therefore support the mathematical foundations of the filters. The net result of the above is a very stable and precise filter and oscillator with a the same filter shape bandwidths and gain as the "Mark" filter (Fig 6.1.1-1). The only difference from Fig. 6.1.1-1 is the filter shape is shifted up to the currently selected "Space" frequency (ie., 2295, 2550, or 2975) and the new "3 DB down frequencies will be approximately equal to the "Space" frequency plus or minus the selected bandwith (ie., 75 or 145) divided by two.

7.1.2 The AFSK Oscillator

The first step in switching the FSK 500 to the transmit mode is to activate the "T/R" input (see "T/R" input). The output of the T/R input operational amplifier will cause analog switch U7 pin 8 to 9 (located at first biquad section input) to turn off and effectively isolate that section. This first section becomes the AFSK oscillator. The same T/R comparator output is used to turn off U7 pin 10 to 11 and in its inverted form used to turn on U1 pin 1 to 2 on. The latter switch turning on brings a feedback resistor R6 into the circuit. Since the phase shift from the input to output of the biquad is 360 degrees and the gain is greater than one, the insertion of the feedback resistor from input to output creates an oscillator which will oscillate at approximately the resonant frequency of the biquad. The the oscillitory frequency is very close but not exactly the same as the receive mode resonant frequency. For this reason we use a different trimmer poteniometer (R201) to shift it back to the desired oscillitoryt frequencies. The two zeners Z2 and Z3 are used to insure that U2 does not reach its natural limit (the rail) which would cause the generated AFSK tones to be amplitude modulated by the supply ripple.

Once oscillations are present and R201 has put the frequencies "in the ball park" we need only switch in the appropriate frequency determining resistors to generate the appropriate frequency. This is accomplished by using the state of the "Serial In" or the sensed current in the printer loop to control three analog switches (U1 pins 8 to 9, 10 to 11, and 3 to 4), which in turn control which frequency determining resistors are in the circuit. The states required of each of these analog switches and the positions required of the push button switches to generate the various tones is shown in Table 1.1.2-1 These generated tones are tapped out of the Space Filter/Oscillator at the junction of U1 pin 2 and potentiometer R202 and presented to the preselector by way of R47.

	U1 PINS 9-8	U1 PINS 11-10	U1 PINS 3-4	SW 3 3F-3D	SW 3 4F-4D	FREQUENCY HZ	DETERMINING RESISTORS
MARK	OFF	ON	OFF	X	X	2125 HZ	R200, R5
NARROW SHIFT	ON	ON	OFF	X	X	2210 HZ	R4
SPACE 170 HZ	OFF	OFF	ON	OPEN	OPEN	2295 HZ	R206, R3
SPACE 850 HZ	OFF	OFF	ON	OPEN	SHORT	2975 HZ	R2
SPACE 425 HZ	OFF	OFF	ON	SHORT	OPEN	2550 HZ	R1

Analog and Push Button Switch States v.s. AFSK Tones
Table 1.1.2-1

7.2.0 Tuning The Space Filter/Oscillator

Tuning the Space Oscillator requires the same equipment listed in Section 6.2.0 for tuning the Mark filter. The Space filter tuning procedure is sequencially dependent and should be followed in the step by step manner of presentation for best results.

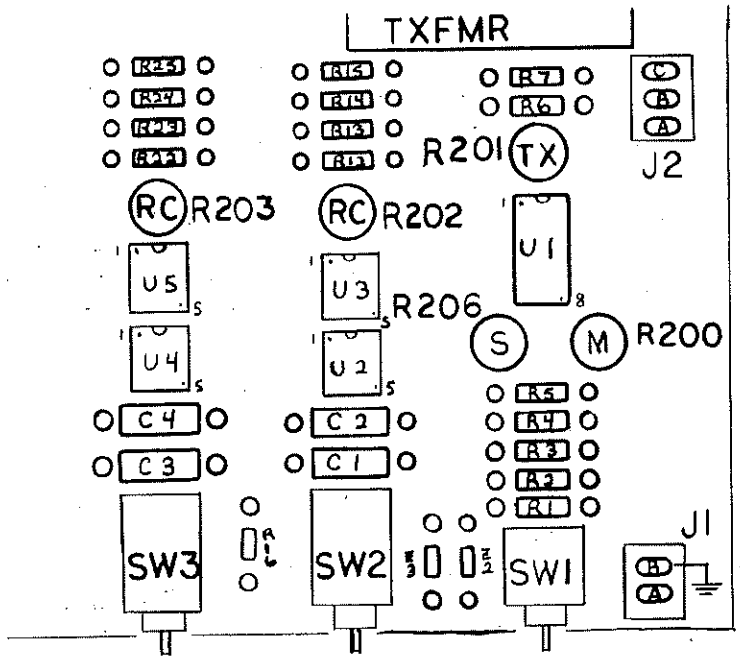
7.2.1 Step By Step Tuning Procedure

Step 1.) Move "X1" jumper to pins "A" and "B", if it is not already in that position. "X1" is located 1 inch to the left of the power transformer.

Step 2.) Put the FSK 500 in the transmit mode. This can be accomplished by putting a shorted RCA plug into the "T/R" input. If you have the H89 computer modification you will have to supply this input from your computer.

Step 3.) Input to the "Serial Input" a logic level which is equivalent to a "Space" for the FSK 500. This is "no input" or plus 2.2 to 12 volts DC if the FSK 500 is strapped for RS-232 levels and 0 to -12 volts DC if it is strapped for TTL (Mark=High) If the correct logic state is present, the "S" (SPACE) light emitting diode on the front panel will be "on".

Step 4.) Remove the jumper from "SF2" (the second biquad section input) and connect the frequency counter to SF2 Pin B. Select the "850 Shift" and adjust R201 for 2975 Hz. All trimmer poteniometer adjustments required for the Space filter/ oscillator are located on the right side of the printed circuit board in front of the transformer (see Fig. 7.2.1-1) Select "425 Shift" and check for a frequency of 2550 plus or minus 5 Hz. There is no adjustment for the 2550 but it is possible for example, to compensate for a lower than normal 425 shift tone by tuning the 850 shift a little high or visa versa. This will in effect "split the difference". Ordinarily if you use one of these shifts it will be the 850 shift and your best alternative is setting it on the money and allowing the 425 (used most often for shortwave listening) to be "off".



Space Filter Trimmer Pot. Locations
Fig. 7.2.1-1

Step 5.) Select the "170 Shift" and adjust R206 for a frequency of 2295 Hz. In some older FSK 500's with serial numbers below 50500 there is no R206 adjustment. For these units we recommend the following; If the 170 shift is the primary shift as in most stations, readjust R201 for 2295 Hz. If on the other hand you are active on the 850 Hz shift, you may want to alternately adjust the 850 shift and the 170 shift to split any differences that exist between the two shifts.

STEP 6.) Invert the Logic state of the "Serial Input" to produce a "Mark" tone. The "Mark" light emmiting diode on the front panel should be "on". Adjust R200 for 2125 Hz.

Step 7.) While maintaining the "Serial Input" in the "Mark" logic state key the CW "Key Input" (short to ground) and check for nonadjustable frequency of 2210 Hz. This frequency is usually within 3 Hz of the nominal 2210Hz.

STEP 8.) The oscillator alignment is complete. Return the FSK 500 to the "Receive" mode by removing the activating input from the "T/R". Return the "Serial Input" to a "Mark" input condition. The "Mark" light emmiting diode on the front panel should be "on".

Step 9.) Connect an oscilliscope or volt meter (on five volt range) to pin B of SF2 and an audio frequency generator to pin A of SF1. Set the audio generator to a 2975 Hz frequency with a peak to peak frequency voltage of 1 V. Set the shift button to select a 850Hz Shift. Adjust R202 for a peak reading on the oscilliscope/meter. If you are using a meter be sure it is set to the A.C. range and will function at 2125 Hz. The output at Pin B of SF2 will be a sine wave between 2.8V and 3.2 V peak to peak. Be sure your oscilliscope vertical gain is in the calibrate position. No further adjustment of the filter/oscillator is required.

7.3.0 Technical Talk

Because the "Space" and "Mark" Channel are electronicly similar they have similar problems. Read section 6.3.0. Figure 6.3.0-1 is a good likeness of the output of a working Space channel when copying a 45 baud station which has been tuned properly. The only difference is that wherever ever in Fig. 6.3.0-1 you see "Mark" mentally write "Space" and where ever you see "Space" mentally write "Mark". In order to see this signal the scope probe must be connected to the "Normal/Reverse" switch pin "D". The scope should be set to a time base of approximately 10 milliseconds/division and the amplitude at about 2 Volts/division. When comparing the output of the Mark and Space channels notice that if a station pauses (sending "Mark" only) the output of the Mark channel becomes a constant amplitude (the greater of the two amplitudes shown in Fig. 6.3.0-1). The "Space" channel amplitude becomes the lesser of the two shown in Fig. 6.3.0-1 and remains there until the transmitting station returns to shifting out "Spaces". You might also notice that when you select the "Narrow" channel bandwidth the lesser of the two amplitudes will decrease indicating that the increased selectivity of the filter is choking off a little more of an audio frequency which is not the design resonant frequency of that channel.

All of the above assumes that the "Space" filter is working. However, the number "1" complaint with reguards to the "Space" channel is caused by an improper input to the either the "T/R", "Key In", or "Serial In". These inputs control the analog switches in the "Space Filter/Oscillator" and can cause "no reception", "meter stuck at half scale", "odd shift" ("they are copying my mark but not the Space") or any combination of the above. A rule of thumb is always make sure these inputs are correct and the shift you desire has been selected before trying to troubleshoot the "Space" channel.

The best way to approach troubleshooting the "Space" channel is to "divide and conquer". First disconnect evrything that is not necessary for the test you are performing, If you are checking the Space channel in the receive mode and you have an FSK 500 which has <u>not</u> been modified for the H89 computer you will have nothing in the "T/R", or "Key In".

The "Serial In" will have no input if you are strapped for TTL (Mark = High) or must have a low input (insert shorted RCA plug) if your unit is strapped for RS-232. Input a signal from your tranceiver to the "Audio In". Put your receiver in the calibrate mode and sweep through a marker frequency. You should be able to get a AC voltage peak at the output of the Space channel if it is working. This will be best viewed by an oscilliscope but an AC meter will work. Like the Mark filter, a failure will rarely cause a marginal condition. The peak will either be there and strong or not there at all. If the "odd ball" weak response does occur it is likely caused by a maltuned Space filter.

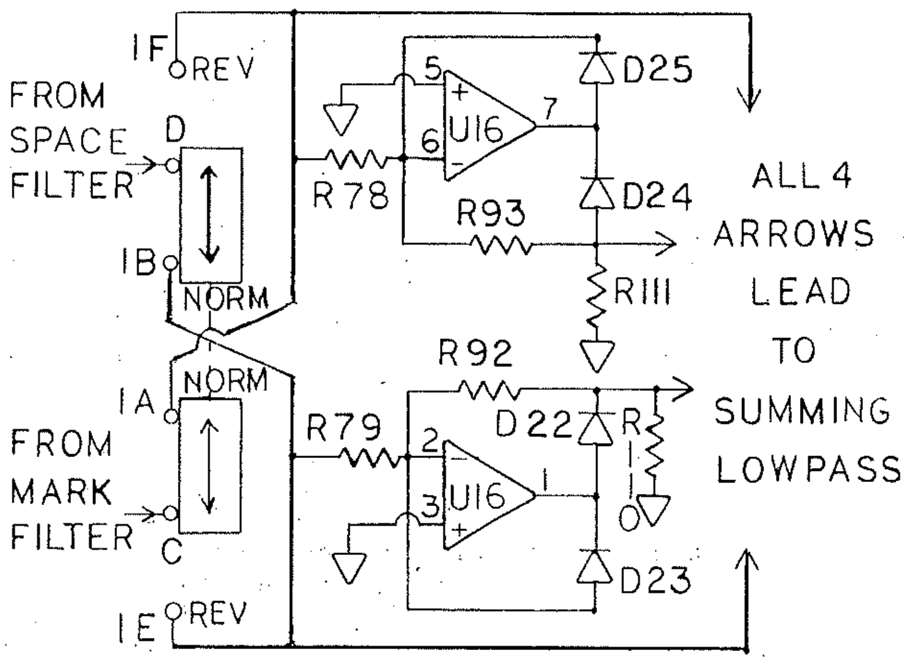
A good indication that your Space channel has died is a meter that will only read half scale when you tune a station, but zero or very low at all other times. This also may be caused by selection of an 850 Hz shift with a receiver that will not pass the 2975 Hz audio tone or selection of a shift that no one is transmitting.

To select the transmit mode put a shorted RCA plug in the "T/R" input. The Mark LED on the front panel should be "on" and if the oscillator is operating properly the meter will read half scale. Use the "Serial In", and "Key" to select the audio tone you desire and check them with a frequency counter. If there is not enough signal level to drive your frequency counter at the AFSK output on the rear panel then try the output of the limiter or SF2 jumper.

If you find you cannot receive or generate AFSK tones, and the Space Filter/Oscillator will not tune up, the most likely failure is one of the analog switches. They are located in sockets and are easily replaced. Be sure to check your AFSK tone frequencies if you have replaced any of these chips. You may have to retune the Oscillator.

Remember that in the transmit mode the "Space" filter is non existant and therefore the Scope outputs do not reflect the quality of the tones or the shift of the AFSK tones.

8.0 THE PRECISION RECTIFIER



Precision Rectifier Schematic
Fig. 8.0-1

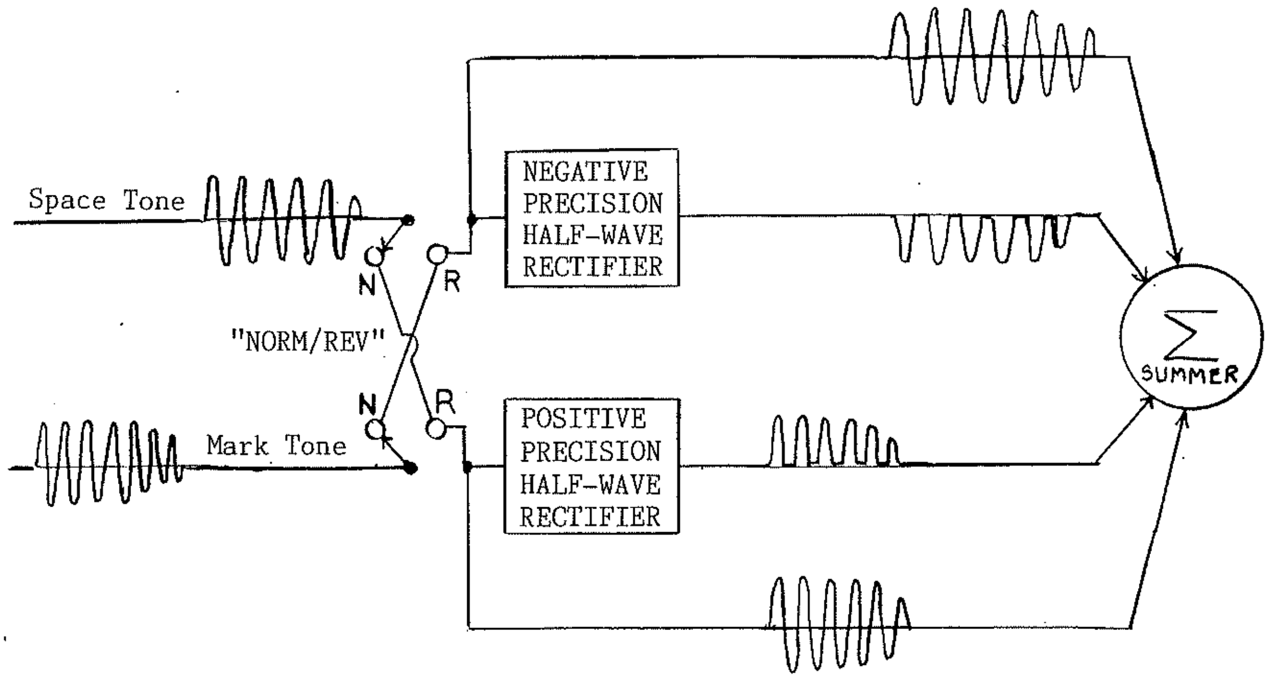
8.1.0 Circuit Description

The iRL FSK-500 schematic label "Precision Rectifier" should actually be "Precision Rectifier<u>s</u>". There are two separate precision rectifiers. The word precision is used to set them apart from a simple rectifier. A simple rectifier requires a approximately .7VDC (for silicon diode) forward bias before it turns on. This can create an artificial threshold or "wall" for a weak incoming audio tone to climb. The precision rectifier takes advantage of the large gain of the operational amplifier to overcome this obstacle, and therefore will facilitate copy of weak or faded signals.

The "Precision Rectifier" can be difficult to understand if you do not first understand its overall purpose in the terminal unit. The desired goal is to create a "rounded" version of the logic "ones and zeroes" we will later square up with the comparator stage before supplying them to your computer or printer. In order to accomplish this task, we negatively <u>full-wave</u> <u>rectify</u> the Mark tone, positively <u>full-wave</u> <u>rectify</u> the Space tone, and low-pass the combined (summed) result.

The Low-Pass will remove the higher frequency components of the rectified signals yielding an envelope that approximates the amplitudes of the tones being rectified. This envelope is a the rounded version we desired. Now for the difficult part ....."the Precision Rectifiers are in reality half wave rectifiers." It is the way the half-wave rectified signals are summed into the Summing Low-Pass that allows us to preform the same function as a full-wave rectifier. With an oscilliscope you can view the half-wave rectified tones (see in Fig. 8.1.1-1). If we had designed a separate summer followed by a low-pass section, you would have been able to see the full-wave rectified signal at the output of the summer. Since, in this circuit they are combined you we can only observe the signals being fed to the Summing Low-Pass.

Components U16, D24, D25, R78, R93, and R111 make up the negative half-wave rectifier. When operating the terminal unit with the "Norm/Rev" switch in the "Normal" position and a "Mark" tone is present, the output of the negative "Precision Rectifier" is a negative half-wave Precision rectified "Mark" tone. Components U16, D22, D33, R79, R92, and R110 make up the positive half-wave rectifier. When operating the terminal unit as described above and a "Space" tone is present, the output of the positive half-wave rectifier will be a positive half-wave rectified "Space" tone (see Fig. 8.1.1-1). Notice that outputs of the Precision Rectifiers are taken from the anode of D24 and the cathode of D22 and <u>not</u> pins 1 and 7 of the Op-Amps, as you would normally expect. Also notice that there is always some signal present at the outputs even when no tone is being rectified. This is because, as pointed out earlier there is no "wall". No filter is perfect and any signal which gets through the filters will be rectified due to the ability of the "Precision Rectifiers" to work with much less signal than a simple rectifier. As described in the section "The Limiter", any signal or noise (in the absence of signal) is blasted to the rail and some portion is bound to get through the filters....which brings us to the importance of the Low pass which we will discuss in the next section.



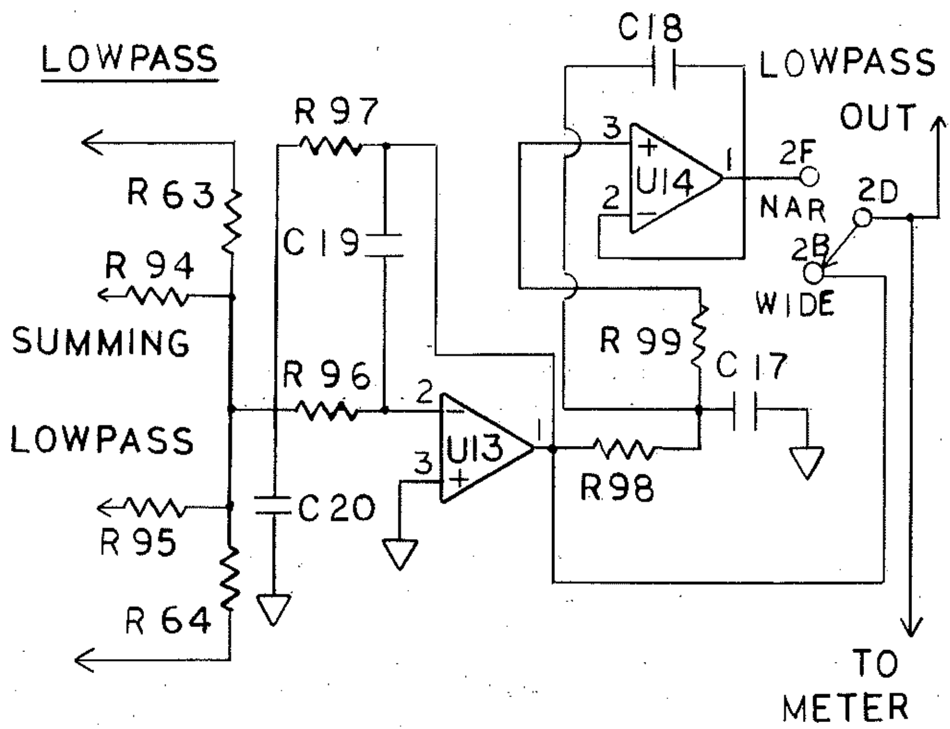
Precision Rectifier Input/Output
Fig. 8.1.0-1

8.2.0 Technical Talk

A portion of the unrectified "Mark" and "Space" bypasses the "Precision Rectifiers" and is fed directly to the "Summing Low-pass". This can be confusing. That is especially true when taking into consideration that iRL made a schematic error. On most schematics that iRL has supplied with their units there is a short line (less than 1/4 inch) that connects the cathode of D25 with a line representing a wire between switch 1 pin A and R63. This is incorrect! More will be said about the portion of the unrectified "Mark" and "Space" signals that bypass the "Precision Rectifiers" in the section on the "Summing Low-Pass". For now, be sure to correct your schematic before proceding, to look like Fig. 6.01.

Typically, the "Precision Rectifier" does not cause any problems for the operator. If it works in the normal position , then it will work in the reversed position, unless the "Normal-Reverse" switch fails (which is not likely). Because the negative and positive Precision Rectifiers are isolated from the normal inputs and outputs the most likely failure here is an operational amplifier, and the most likely cause is an unsolicited input from a operator shorting 125 AC or 170 VDC loop voltage into the Op-Amp supply or ground. Ocassionally the natural elements conspire to wreck havoc (lightning) or an Op-Amp just drops dead.

9.0 THE SUMMER/LOW-PASS



Summer/Low-Pass Schematic
Fig. 9.0-1

9.1.0 Circuit Description

There are two sections which comprise "The Summer/Low-Pass". Section one has the purpose of summing the inputs from the precision rectifiers and the "Mark" and "Space" filters. In addition it preforms the function of a two pole "Low-Pass" filter to detect the envelope of the received tones by removing the higher frequency audio components while allowing the lower frequency switching components (ie., 45 baud = 22 Hz) to pass. Section two is an extra two pole Low-Pass section which can be switched out of the circuit by the "WIDE/NAR" switch on the front panel.

In order to simplify the explanation of the first section low pass we will consider the operation of this section when a "Mark" tone (2125Hz) is being received. There are four inputs to the first section. From the "Space" filter there will be no input other than noise that is passing through the "Space" channel. The positive half-wave rectifier will reflect the energy present in the "Space" channel and have no input other than a little rectified noise. The "Mark" channel will have a full sine-wave at approximately 2125 Hz (depending on how well you tuned) and the negative half wave rectifier will output the negative rectified version of the "Mark" tone. Now, for the magic! In the "Summer/Low-Pass" we sum the negative half-wave rectified input with twice the gain that we give the "Mark" sine-wave input (which has bypassed the "Precision Rectifier" stage). Because the negative half-wave rectifier is an inverter, when the "Mark" sine-wave is positive we invert and sum a value "-2" times the positive value with that positive value. If the positive value at some instant in time is "X" volts we have:

"Positive Peaks" X + (-2*X) = -X * = "multiplied by"

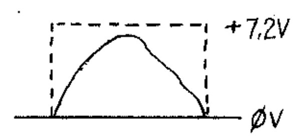
What started as "X" volts positive is now equal "-X" volts. Clearly we have simply inverted the positive peak. Now when the negative peak is present the output of the negative rectifier is zero volts, which inverted and mutiplied by 2 is still zero. Summing this with X we have:

"Negative Peaks" X + (-2*0) = X

The result is that we have inverted the positive peaks and passed unchanged the negative peaks. Because our summer is itself an inverter, <u>if</u> we could see this before it was low-passed we would see a positive full-wave precision rectified signal as in Fig. 9.1.0-1 a). However, at the output of the "Summer/Low-Pass" we can only see the filtered version, Fig. 9.1.0-1 b). The audio component has been stripped out leaving the envelope. The dashed line is a "look ahead" and illistrates what this rectified and filtered signal will look like after it passes through the comparator to form the Mark logic output.

The Space Filter output will be positively half-wave rectified and summed with inversion to produce the same full-wave rectification. The peaks would be negative and the filtered version when squared by the comparator would produce the "Space" logic level.

a)
Full-Wave Positive Rectified Mark



b)
Summer Low-Pass Output

Fig. 9.1.0-1

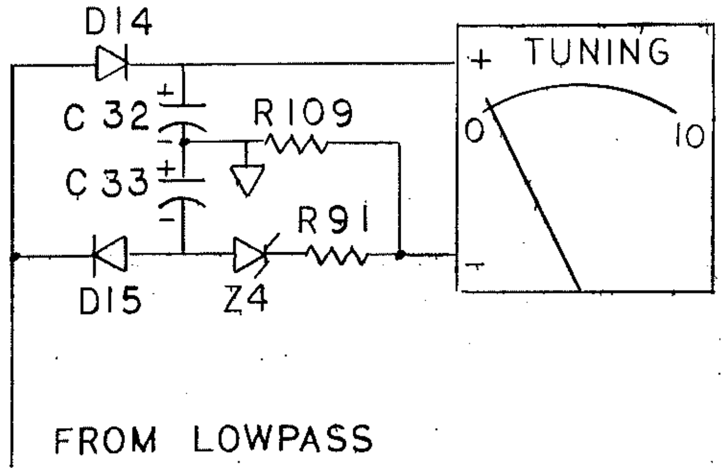
Fig. 9.1.1-1

The "Low-Pass", both sections one and two, not only remove the higher audio component of the envelope, but also attenuate higher frequency noise which penetrate the bandpass filters. We know for example, that 45 baud represents a switching rate of approximately 22 Hz. It would be nice to restrict anything from getting through the filters that was above 22 Hz. Unfortunately to pass higher baud rates such as 110 baud ASCII a 22 Hz bandwidth would be much to restrictive. The awnser to this dilemma is a two section "Low-Pass" which will allow one section to be removed. The first section which is always present has a design bandwidth of 60 Hz (0 to 60 Hz) and the second section has a design bandwidth of 28 Hz. Most of the interference problems on the band occur at 45 baud. For this reason, with the "WIDE/NAR" switch in the Narrow position, we assume you have selected the more selective bandwidth because you are trying to copy 45 baud. The "Mark" and "Space" filters are 75 Hz wide and the "Low-Pass" filter is rolling off at 28 Hz. With the "WIDE/NAR" switch in the Wide position we assume you are trying to tackle something greater than 50 baud and the "Mark" and "Space" filter are opened up to 145 Hz while the "Low-Pass" is opened up to 60 Hz by removing the second section.

9.2.0 Technical Talk

Because of its position in the circuit relative to the "Low-Pass", the meter circuit is an excellent troubleshooting tool for problems in the "Low-Pass" filters. Remembering that a signal in the "Space" channel with nothing in the "Mark" channel will result in a very low reading on the meter, you can use the calibrate mode on your receiver to generate a "Mark" tone or just pull the "T/R" low and generate a "Mark" AFSK tone. The meter should read about 4 to 6 units on the meter. If this is not the case, first check with a scope or meter the output of each precision rectifier. If the "Norm/Rev" switch is in the Normal position you will have a negative half-wave DC voltage at the anode of D24. This voltage should be about -4.6 volts peak. The voltage at the cathode of D22 will depend on the amount of interfering noise that is in your "Space" channel. Normally with no signal in the "Space" channel, the voltage at D22 cathode will be a half-wave positive voltage less than +400 millivolts peak. If the rectified signal is not there, you have a problem preceding the "Low-Pass" which should be fixed before tackling the Low-Pass. If the voltages are there, but no signal is present at the output of the "Low-Pass" and a visual inspection of the "Low-Pass" turns up nothing, try replacing the Op-Amps U14 and U15. Remember you can switch U14 out with by putting the "Wide/Nar" in Wide position. If it suddenly starts working don't bother replacing U15! In the "Low-Pass" you may use an MC1458, or a MC4558. Whichever is available at your local Radio Shack.

10.0 THE SINGLE METER TUNING CIRCUIT



Single Meter Tuning Schematic
Fig. 10.0-1

10.1.0 Circuit Description

The unique feature of the FSK 500's single meter tuning circuit over conventional type circuits, is that it requires a signal in both the "Mark" and "Space" channels to yield a full scale reading. This eliminates two "false-out" conditions which greatly simplifies the tuning process.

The tuning circuit operates as follows; When a solid "Mark" tone is present, D14 diode will be forward biased and allows C32 to charge up to the peak "Mark signal" voltage, which in turn presents a half-scale reading on the meter. D15 will stay reversed biased until the detection of a "Space" tone. D15 then becomes forward biased and C33 is charged. The use of Z4 becomes quite significant to this unique design for the following reason; Z4's rated zener voltage is higher than the maximum voltage that will occur across C33 which is generated by the "Space" tone. Without the presence of both the "Mark" and "Space" tones and the combined voltage from C32 and C33, Z4 will stay reversed biased. This cuts off R91 current preventing the meter from a reading greater than half scale.

The only "false-out" which cannot be detected by the meter circuit is when the "Mark" and "Space" tones are reversed. If this is the case, you should see a lot of garble on the screen or printer. This is cured by simply pressing the normal-reverse switch into the reverse position. If this does not cure the garble, you are probably trying to copy at the wrong baud rate.

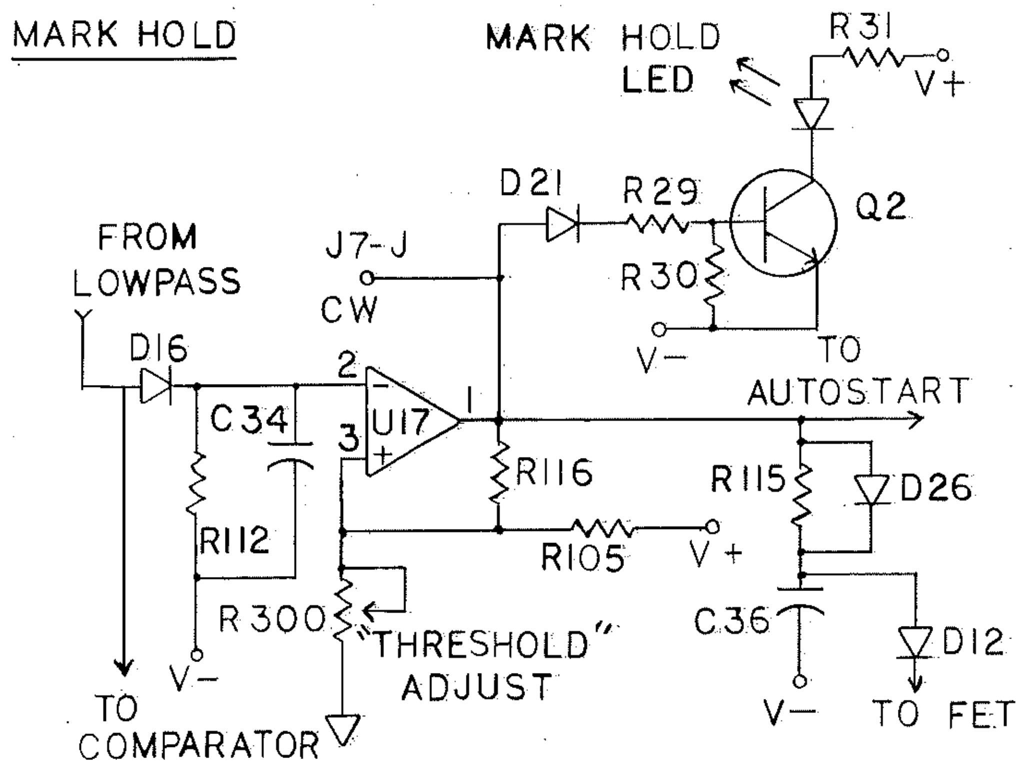
10.2.0 Technical Talk

When iRL designed this circuit we felt there should be a clear difference between a Mark only tone and a tone in both channels. For this reason we purposely allowed the meter to swing from mid-scale to full scale with enough momentum to tap the needle stop on the right side of the scale. To the best of my knowledge we have never lost a meter from this design practice. However, on more than one occasion we have been called by someone who was bothered by this practice and perhaps even thought they might have a defective rig. With this in mind we would like to tell you how to adjust the meter in the event that this bothers you.

The best way to adjust the meter is to add a 100 K potentiometer with the center tap shorted to on end, in series wyth R91. Also add a one Meg potentiometer with one of its ends shorted the center tap in parrallel with R109. Adjust the 100K pot. to zero ohms and the one Meg pot. to it maximum resistance. Next tune in a station that is transmitting at a quick pace (ie,. W1AW or someone sending a picture). The meter should be tapping against the full scale position as it normally does. Now, adjust the 100 K until the meter begans to just touch the stop. Follow this by using the calibrate to generate a tone which peaks the meter. Be sure there is no interference in the "Space" channel. Adjust the one Meg pot. until the meter is back to half scale. Alternately repeat the 100K and one Meg adjustments explained above until the meter reads half scale on a "Mark" only tone and just reads full scale with no further adjustment.

There is one other way to make this adjustment which you may prefer.....especially if you don't have the potentiometers around. Replace R91 with a with a resistance of about 80.6 K. This should take some of the energy out of the needle but is not as accurate as the potentiometers for setting up the meter.

11.0 THE MARK-HOLD CIRCUIT



Mark-Hold Schematic
Fig. 11.0-1

11.1.0 Circuit Description

The purpose of the FSK-500's "Mark Hold" circuit is to put the "Data Out" to your computer and "Loop" output to your printer in a stand-by state if the mark tone drops below a user adjusted level. This adjustment is the "Threshold" control located on the front panel.

In order to create the "Mark Hold" process, we first create an adjustable biased hysteresis which is formed at U-17 by using R-116, R-300 ("Threshold" control) and R105. Hysteresis is an intimidating word if your not used to it. Basically it is a way of dealing with a common problem. When an operational amplifier is used as a comparator, to determine the value (greater than or less than) of one input relative to another (usually refered to as the reference) and the input value being compared undergoes slow changes (ie., a discharging capacitor like "C34") this problem develops. As the compared signal gets near the reference value, the sum of noise riding the compared value and that value will cause rapid transitions back and forth across the reference level. The output of the comparator will, in turn, switch back and forth ("rail to rail") wildly with the noise until the compared value is far enough away from the reference that its sum with the noise will not drive it across the reference level. However, lets say we have our reference set at +2.00 volts, and the compared value is slowly decreasing from +5.00. Further suppose, when the compared value hits +2.10 volts, its sum with a -.11 volt noise causes it to momentarily cross the 2.00 volt reference. The output will momentarily switch to a new rail (ie., -7.2 VDC to +7.2VDC). Now, if we were able to "feedback" some of that new positive rail in such a way as to modify the reference level to a new level of 3.00 volts. The result is no more wild switching of the output. As the input compared value continues to move in the negative direction we are moving further away from the new reference and "no more noise problems". This feedback modification of the reference level is called hysteresis and is very effective.

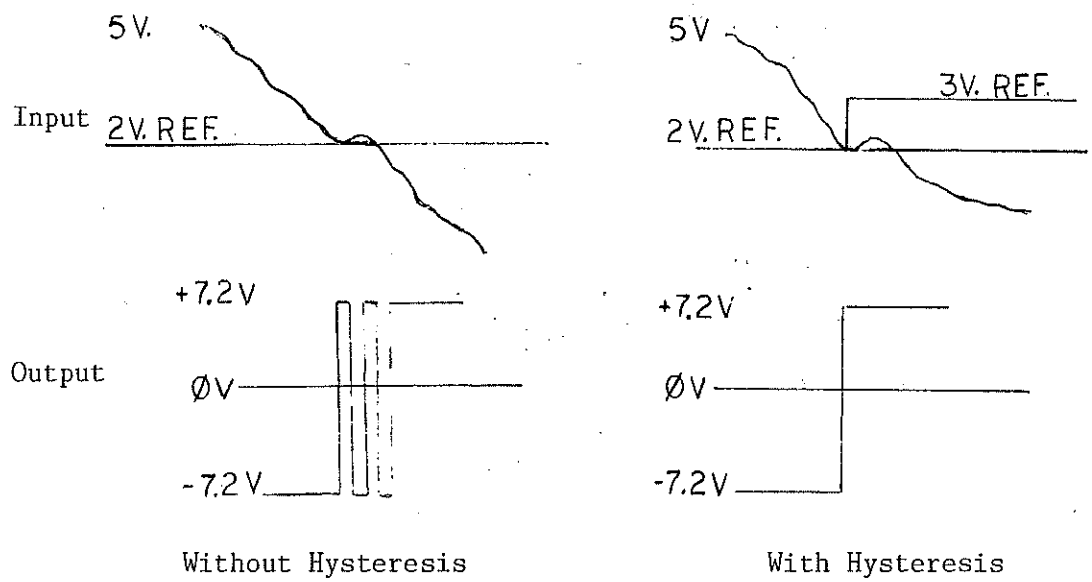


Fig. 11.1.0-1

Hysteresis stabalizes the output of U-17 so that there will not be any chatter or oscillation present which would lead to a disturbance to the "DATA OUT" and the "Autostart" circuits. Because the threshold circuit is dependent on the presence of a "Mark" tone, R-112 and C-34 serve to prevent the initiation of the "Mark-hold" process during the reception of the "Space" tones of a character. The "Mark" tone will charge the capacitor immediately, but a "Space" tone will cause the capacitor to slowly discharge thru R-112. The time constant that is formed by R-112 and C34, must be greater than the sum of the total periods of continguous "Space" tones present in any one received character. A faster time constant would allow C-34 to discharge below the value adjusted by the "Threshold" control, and thus erroneously activating the "Mark-Hold". If the detected "Mark" tone, present at pin 2 of U-17, drops below the desired level adjusted by the "Threshold" control, U-17 would switch from its normal low voltage, (approximately -7.2v), to a positive voltage, (approximately +7.2v). This positive voltage permits D-21 to become forward biased allowing Q2 to turn on and light the "Mark-Hold" LED indicating that the "Mark-Hold" is activated. At this point, D-26 also becomes forward biased when the "Mark-Hold" is present supplying a path to rapidly charge C-36 which in turn supplies a "Mark-Hold" to the "Data Out" and "Loop" circuits.

If there is noise of sufficient amplitude to momentarily rise above the reference level set by the "Threshold" control, this noise may cause the "Mark-Hold" to momentarily "release" (U-17 pin 1 makes the transition to low, -7.2v). R-115 will prevent C-36 from immediately discharging and thus inhibit further noise from propagating to the "Data Out" and "Loop" circuits.

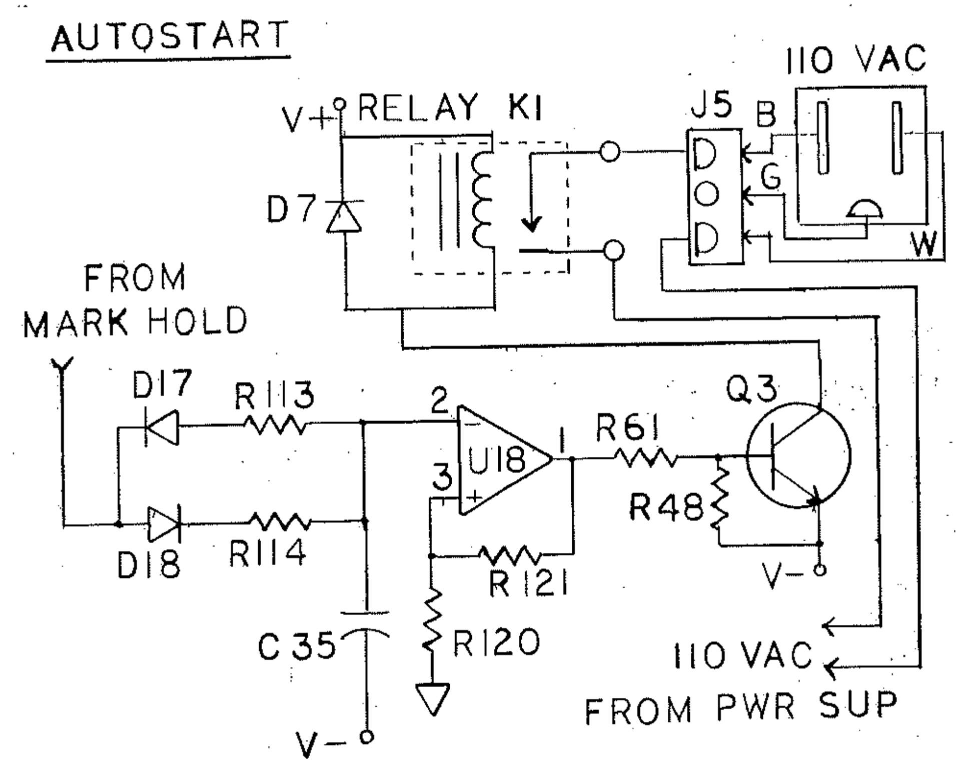
When a"Mark" tone above the adjusted level is tuned in, U-17 switches back to a low voltage (-7.2VDC). This low allows two basic functions to occur; First, it permits C-36 to discharge thru R-115 removing the Mark-Hold. Second, it removes the bias from Q2 allowing the Mark Hold LED to shut off and thus indicate to the user that the signal is above the adjusted "Threshold".

11.2.0 Technical Talk

The "Mark-Hold" Circuit is another one of those that cause few problems due to its relative isolation from the outside world. In addition the "Mark-Hold" LED is an excellent indicator of the status of this circuit. To check it out, tune a tone into the "Mark" channel. The calibrate tone from your receiver or a signal generator will work best. With the "Threshold" fully counter clockwise the "Mark-Hold" LED should be "off". Now turn the "Threshold" fully clockwise and the LED should come on (even with the tone present). This indicates the Op-Amp, and threshold circuit are working properly, but it is still possible that electrolytic capacitor C34 is defective. If C34 was shorted it would cause the "Mark-Hold" LED to come on and stay on. If C34 was disconnected (cold solder joint by factory or faulty field maintainence) it would cause the "Mark-Hold" LED to blink on and off even when there was a strong incoming signal and it was adjusted properly.

One other point worth mentioning is in some of the first FSK 500's that were shipped, we used a different time constant than the current values of C34 and R112 establish. If your serial number is below 50150 you may want to check to see that you have a 10 uF installed at the C34 location and a 105K installed at the R112 location. If you do not have these values, you may want change to a 10 uF Capacitor and a 105K resistor. This is optional as you may not even notice any significant improvement in the "Mark-Hold" operation from these new components. We felt it would add a little stablization to the "Mark-Hold" circuit at the sacrifice of the ability to copy slow CW (less than 20 Words/Minute) at J-7 pin J. The levels available there were not computer compatible and besides we now have a far superior method of handling the CW (see "Copying CW with the FSK 500).

12.0 THE AUTOSTART CIRCUIT



Autostart Schematic
Fig. 12.0-1

12.1.0 Circuit Description

The "Autostart" circuit operates in conjunction with the "Mark hold" to allow the printer to drop out approximately 5 seconds after a signal is lost and to quickly re-engaged it if another signal is detected.

The slow drop out is caused by the RC time constant established by resistor R-114 and capacitor C35. It allows the printer to stay on for an approximate time of 5 seconds after the signal is lost. This helps prevent the printer motor from cycling on and off when a station fades out or momentarily drops his carrier. On the other hand, R113 and C35 have the ability to discharge quickly enabling the printer to turn on at a quickly if another station is tuned in.

A low or high present at the output of U17 in the Mark-Hold circuit actually operates the Autostart circuit. For instance, when U17 switches to +7.2 volts (indicating the station being received has droped his carrier), D18 becomes forward biased enabling C35 to charge thru

R114 slowly to about +4 volts causing U18 pin 1 to switch from +7.2 to -7.2 volts. This removes the bias from Q3, de-energizing K1, and causing the printer to drop out. When a new station is tuned in, the Mark-Hold output of U17 switches back to -7.2 volts, D17 becomes forward biased allowing C35 to quickly discharge thru R113 causing U18 pin 1 to switch back to +7.2 volts, thus biasing Q3 on and restoring the printer. R120 and R121 form a hystersis circuit similar to the one described in the section on the "Mark-Hold" circuit. The hysteresis prevents the relay K1 from chattering as the voltage on C35 slowly charges toward the value of the reference voltage on pin 3 of U-18.

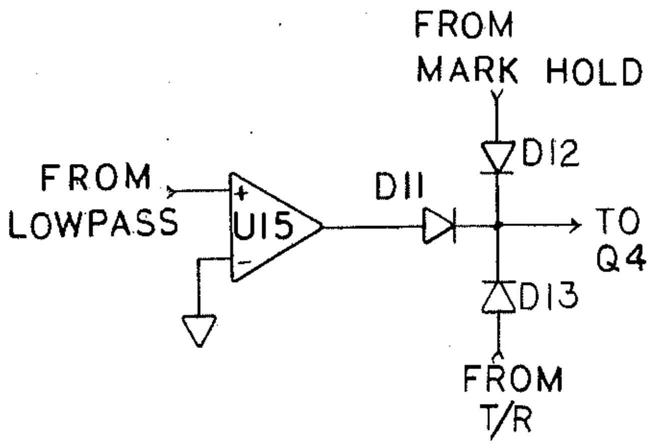
Resistors R61 and R48 form a voltage devider that insure U18 will be able to turn Q3 off when it drives low. U18 cannot output a voltage lower than approximately -7.2 VDC. The emitter of the transistor is tied to the negative supply. This is approximately -8.2 VDC. The difference of 1.0 VDC would be enough to keep Q3 biased on if R61 and R48 were not present. R44 is an alternate bias path to allow a Low at the "T/R" to turn on the printer and the optional Loop supply which works out of J5 connector.

12.2.0 Technical Talk

The best way to troubleshoot this circuit is to plug a lamp into the outlet on the back panel. Turn the "Threshold" fully clockwise. Wait 15 seconds. Tune in a station. Wait 15 seconds to insure the "Autostart" does not activate prematurely and then turn the "Threshold" fully counterclockwise. The light should come on in approximately 1.5 seconds. Now rotate the "Threshold" control back fully clockwise and the light should go out after approximinately 5 to 7 seconds.

If the "Autostart" circuit fails this test, check first to see that it is getting the right signals from the "Mark-Hold" circuit. Second check pin 1 of U18 to see that the proper drive signals are being supplied to Q3. If the drive signal is there the defective component has equal odds of being Q3 or K1.

13.0 THE COMPARATOR

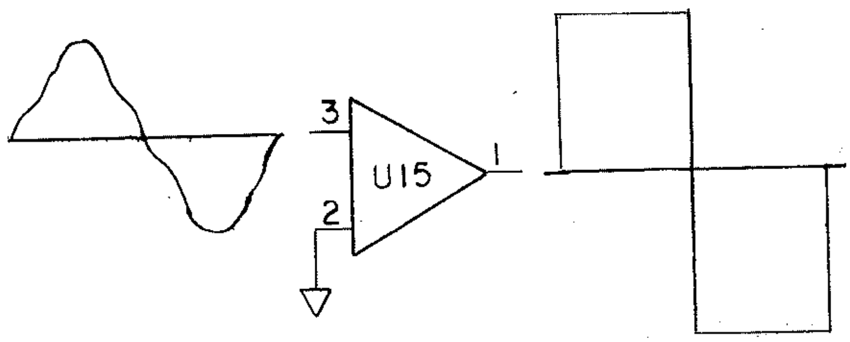


Comparator Schematic
Fig. 13.0-1

13.1.0 Circuit Description

A "Basic Differential-Input Comparator" circuit is one that provides a diagnosis of the comparative state of two possible inputs. If one input is used as a reference voltage and the other as an unknown, the comparator output will signify whether the unknown signal is above or below the reference signal.

The output of the Low-Pass is input to pin 3, the noninverting input of the Comparator. This output is a voltage greater than zero when a "Mark" tone is being detected and a voltage less than zero for a detected "Space" tone. Any positive voltage (Mark) applied to Pin 3 of the Comparator instantly drives the Comparator output to its positive saturation limit of +7.2 volts. Any negative voltage (Space) applied to pin 3 causes the Comparator output to instantly drive to its negative saturation limit of -7.2 VDC. The result of this is a "squaring up" of the signal appearing at the input (see Fig 13.1-1)



Input Output

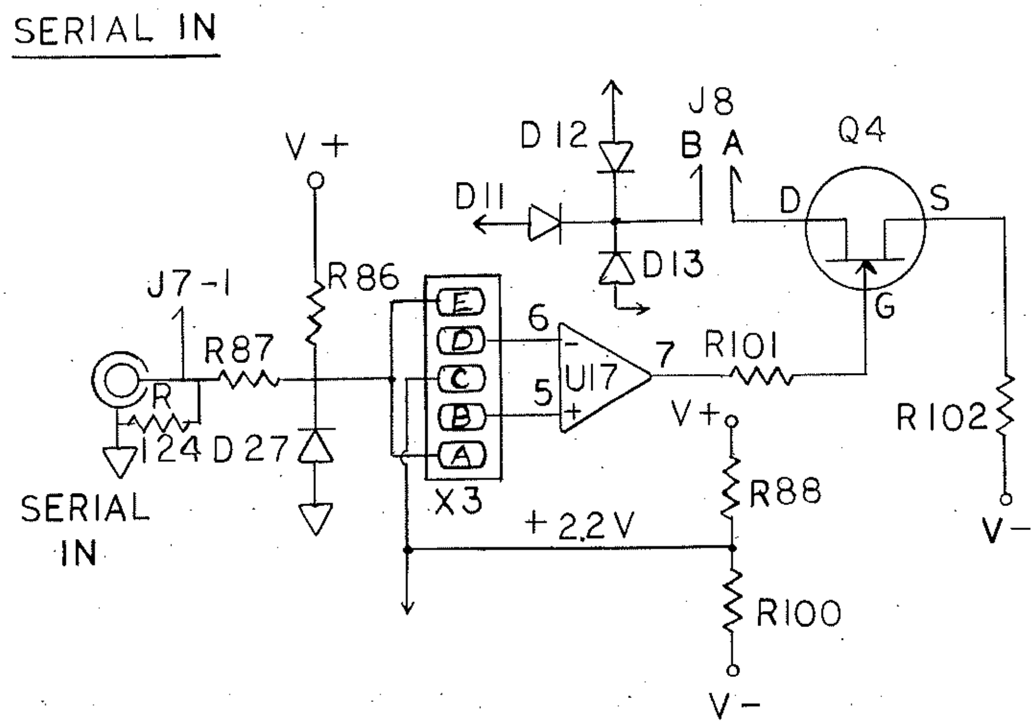
Comparator Input/Output
Fig. 13.1.0-1

13.2.0 Technical Talk

The Comparator is definitely not a troublemaker! Tune in a RTTY station and monitor the output of the Comparator at U15 pin 1. If it is squaring up the input it is alive and well. If everything preceding this stage is doing its job and you have tuned in a station properly you will see a very squared up signal as in Fig. 13.1-1.

Usually if your FSK 500 is working up to this point but you still have "Zilch" at the "Data Out" either a constant high is being driven through D12 or D13 due a problem in the "Threshold" or "T/R", respectively, or the "Serial In" is forcing Q4 to its off state. U15 does not have the ability to force the three diode junction low or if Q4 is "off", express a high (Mark) at the "Data Output". The "Mark" and "Space" LEDs can tell you quickly if Q4 is off or the three diode junction is permanantly driven high. Q4 off will always reflect as a "Space" LED on constantly. See Section 14 on "The Serial Input" for more on Q4 and the three diodes (D11, D12, D13).

14.0 THE SERIAL INPUT



Serial Input Schematic
Fig. 14.0-1

14.1.0 Circuit Description

The FSK-500 input/output ports are structured to operate in RS-232 compatible or TTL mode (Mark = high). RS-232 "compatible" does not mean that the FSK-500 has the full 25 D pin RS-232 arrangement. RS-232 was in fact created to standardize the connections between a Modem ("Data Set" in "Bell" talk) and a printer/keyboard ("Remote Terminal"). All but three of the 23 assigned pins are unnecessary for our application. The three required Pins are;

1) Pin 2 "Transmit Data" to iRL "Serial Input"
2) Pin 3 "Receive Data" to iRL "Data Out"
3) Pin 7 "Signal Ground" to iRL Ground (on RCA Jack)

NOTE: The connections above and below are general connections which may not reflect the connections of your particular system. The final authority on connections must be your computer manual.

The rest of the RS-232 signals must either be left open or used to "hand-shake"themselves". For instance the "request toSend" must be returned to the "Clear to Send" at the computer connector. The "Data Terminal Ready" must be returned to the "Data Set Ready" also at the computer. The one exception is the DCD ("Data Carrier Detected") also called "Received Signal Line Detector") which must be wired high (+12VDC) in some systems. In sumarry;

1) Pin 4 (RTS) connected to Pin 5 (CTS)
2) Pin 6 (DSR) connected to Pin 20 (DTR)
3) Pin 8 wired to system High, usually +12 VDC.

In some cases (ie., the H89 modification) the PTT transistor has been commandeered and used to provide an inverted input to the "T/R". Where this is the case you will find the RTS is being used to put the FSK 500 into the transmit mode.

Refering to the circuit schematic, Op-Amp U17 is used as nothing more than a comparator. We establish a reference voltage of +2.2 VDC with resistors R86 and R100. This reference can be directed to either the inverting or non inverting input of the Op-Amp by way of the plug-in jumpers on X3. The logic level being input to the "Serial Input" can also be directed via X3 to which ever input (inverting or non inverting) the reference is not on.

For example an FSK 500 strapped for RS-232 would have X3 pins B jumpered to pin C and Pin D jumpered to Pin E. This would in turn direct the reference to the noninverting or "+" input and the logic level being input to the "Serial Input" to the inverting input (pin 5). The result is when the user inputs any voltage between +2.2 VDC and -12 VDC and the FSK 500 is strapped for RS-232 it will be consider a "Mark". The output of U17 will be multiplying the large very large gain of the Op-Amp times the input difference and as long as the "+" input is just a little (10 millivolts) more positive than the "-" input, U17 output will be glued to the positive rail of approximately +7.2 VDC. Notice that if you are strapped for RS 232 and you have nothing pluged into the "Serial Input", if your computer is not on, or the program has "bombed" and there is no active circuit pulling the input to less than +2.2 VDC, R86 preforms the function of a "pull-up" resistor. The "-" input of the Op-Amp will be positive with respect to the "+" input and the Op-Amp output will be glued to the -7.2 VDC rail. This is iRL's most often heard complaint, "it's locked in Space" and is characterized by the "Space" LED being on. It will stay on forever unless you correct the input or unplug the unit.

You may be wondering why we chose 2.2 volts as a reference or used a pull-up instead of a pull-down. The 2.2 VDC with a pull-up lends itself well to a TTL open collector or dry contact interfaces. Also most actively driven TTL outputs circuits typically have more noise immunity on the high side (especially when they have a pull-up helping) than the low side. For this reason we favored a reference that is actually a little higher than would be used in most standard TTL circuits.

When strapped for TTL (Mark = High), X3 will have Pin A jumpered to Pin B and Pin C jumpered to Pin D. The approximately +3.4 VDC Mark input is then directed to the noninverting "+" input and the reference is directed to the inverting "-" input. With the noninverting input more positive than the inverting input, the U17 Op-Amp output will be as is was for an RS-232 Mark input, +7.2 VDC. If we change the "Serial In" input to a "Space" (less than 2.2 VDC) the Op-Amp output will go to a -7.2 VDC.

J-FET Q4 is used in the FSK 500 as a switch. The output of Op-Amp U17 is supplied through gate current limiting resistor R101 to the gate of Q4 and thus determines whether Q4 is on or off. In the receive mode there should always be a "Mark" input to the "Serial In" and the output of U17 will always be at the positive rail. This +7.2 volts biases Q4 on. As long as the Drain of Q4 is not driven to a constant high (Mark) by an input from the Mark-Hold through diode D12 or an input from the "T/R" Op-Amp U18 via diode D13, the received data highs will be supplied from the comparator through diode D11 and in there absence R102 will pull the Source of Q4 to a Space logic level. In the transmit mode the drain of Q4 is forced high by the "T/R" input Op-Amp U18 via diode D13. The logic level at the source of Q4 is the logic level that will be sent to the printer loop keying transistor and the "Data out". In addition it will eventually determine which AFSK tones are being keyed. As long as the Drain of Q4 is high and Q4 is on we will have a Mark to the output circuits and a AFSK Mark tone output. If a Space is input to the "Serial In", the output of U17 will go low and Q4 will turn off. The logic level (Space) of the Source side of Q4 will now be determined by the pull down resistor R102.

The only components not mentioned yet are D27 and R124. D27 is a protection diode. The inputs to U17 (pins 5 and 6) are never supposed to be taken lower in voltage than the negative supply (-8.9 VDC) of the Op-Amp. An RS-232 can be as low as -12 VDC. D27 insures that the junction of R86, R87, and D27 will never be more than one diode drop below ground. R124 forms a voltage divider with R86 and R87 to drop the voltage at the "Serial In" down from +8.9 VDC to +4.0 VDC, a level more compatable with TTL.

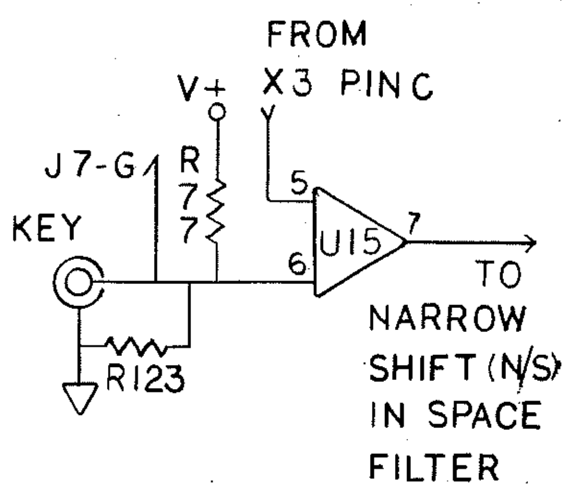
14.2.0 Technical Talk

As mentioned above, the "Serial In" is the cause of most of iRLs' telephone calls from amateurs with troubled systems. Ninety percent of the time it is due to X3 being strapped wrong. Ocassionally we get an older unit (Serial number less than 50150) that does not have R124. This resistor was added to the FSK 500 as a modification and can not be seen on the top of the board. A voltmeter on the center conductor of the "Serial In" that reads greater than +5 VDC means the modification is not there and should be added for a more compatible TTL interface.

The best way to check out the "Serial In" is to remove all inputs and outputs from the Terminal Unit. Turn the "Threshold" control on the front panel fully clockwise. Put a blank RCA plug into the "Serial In" and alternately short and open the center conductor to ground of the plug. If the "Mark" and "Space" LED alternately turn on and off you know the "Serial In", Q4, half of U6 and Q5 are working. Remember to turn the "Threshold" control back fully counterclockwise when your test of the "Serial In" are complete. The threshold was just used in this test to force the Drain of Q4 high. We could have just as easily used a shorted RCA plug in the "T/R" input to drive the Drain high. That is a better method if you have the RCA plugs around.

If the LEDS did not alternately flash check the connection of the wires on the jumper to make sure they have not come loose. Put a Meter on the output of U17 and repeat the shorting procedure above. If the Op-Amp output is switching from rail to rail and the LEDs are not flashing you probably either have a bad Q4 or the method used to force the Drain of Q4 high for some reason is not working. It is also possible that the Jumper on X1 is set up for a "Loop" current sense (between pins B and C) and you have very low or no "Loop" current.

15.0 THE KEY INPUT



Key Input Circuit Schematic
Fig. 15.0-1

15.1.0 Circuit Description

The "Key Input" is an input to operational amplifier U17, operated as a comparator (see Section 13, "The Comparator", first paragraph). It was originally designed to interface to an Amateur Key and later modified to allow the TTL levels of a computer. The 2.2 volt reference used here is the same as we use for the "Serial In" and the "T/R". Whenever the voltage at the "Key In" RCA jack is pulled below 2.2 Volts, the output of U17 will go to +7.2 VDC. This voltage is used to key U1, the analog switch in the "Space Filter/Oscillator" "on". The effect is to place resistor R4 in parallel with the "Mark" AFSK frequency determining resistance. This changes frequency determining resistance of the Oscillator and causes the frequency to pull 85 Hertz off of the 2125 Hz "Mark" frequency to 2210 Hz.

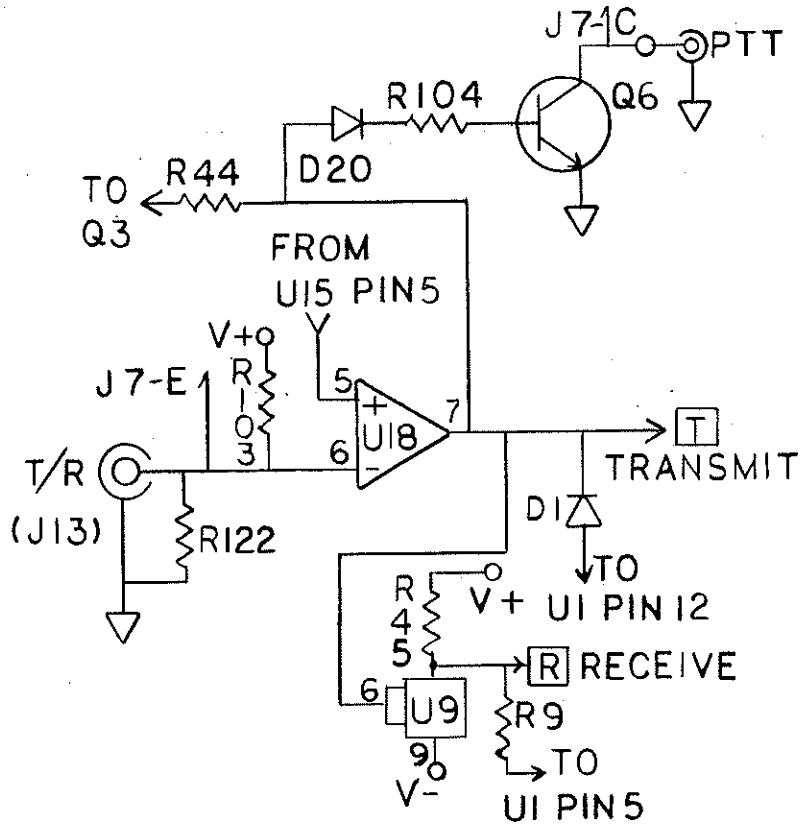
15.2.0 Technical Talk

The "Key Input" is exposed to the outside world and therefore is susceptible to outside wiring problems, incorrect logic and sometimes inputs which are lethal to U17. The most common problem is a computer putting the wrong logic level into the "Key Input". The complaint we hear is, "The transmit shift is reported to be off by other stations and it will not tune to greater than a half scale reading on receive". The test for this is simple. Remove all connections to the rear of the FSK 500 except the "Audio In", and "Data Out". If you are strapped for RS-232 <u>at the "Serial Input"</u> you should short an RCA plug and insert it into the "Serial Input". If you do not have a spare RCA plug you can supply this signal from your computer. Make sure the RS-232 signal you use is correct in the "Mark" state (less than -3 VDC). If the FSK 500 is strapped for "TTL" just leave the "Serial In" with no input. Now check to see that it receives normally. If it does receive normally, troubleshoot the electronics that is supplying the "T/R" input. If it will not receive correctly, check the output of the "Key Input" Op-Amp U17. It should be approximately -6.2 $\pm$.8 VDC. If the voltage is correct, the problem is not at the "Key Input". One final check is to plug a shorted RCA plug into the "Key Input". The output pin 7 of U17 will go to +7.2 $\pm$.8 VDC if the Op-Amp is working correctly.

The "Key Input" is not rated for RS-232. A -12 VDC at this input may destroy the Op-Amp.

On most schematics, the resistor we add as a modification to create a more universal "TTL" compatability, has been left off by mistake. In some of the earlier units that left iRL the resistors were not used. If you are using this input to interface to "TTL" levels and you are having problems, we recommend you unplug any input to the "Key Input", turn the power on and measure the voltage on the center conductor. If the measured voltage is greater than +5 VDC the modification has not been done to your unit. If your serial number is greater than 50500, your unit probably was modified. Be sure to add it to your schematic. (For further details see Appendix B-9.)

16.0 THE T/R INPUT - PTT OUTPUT



"T/R" Input - PTT output Schematic
Fig. 17.0-1

16.1.0 Circuit Description

The "T/R" input is used to switch the FSK 500 between the "Receive" mode the "Transmit" mode. The input Op-Amp (U18) is functionally identical to the "Key In" input Op-Amp up to and including the reference voltage of +2.2 VDC. The only difference between the two is the functions controlled by the Op-Amp output (pin 7, U16). When the "T/R" is pulled low the Op-Amp output goes to +7.2 $\pm$.8 VDC. This positive voltage forces the triple diode junction consisting of D11, D12, and D13 to a high or "Mark" state. Because the Comparator does not have the ability to drive the triple diode junction low, this junction will remain at a positive, or "Mark" level regardless of any interference that might be getting through the Comparator. As long as Q4 is on, and <u>if</u> you are strapped for "Loop" current sense at X1, there is a 60 ma "Loop" current present. The outputs should be at a "Mark" logic level and the "Mark" LED should be "on". For explanation of J-FET Q4 read Section 14, "The Serial Input".

A positive voltage at the output pin 7 of U16 will also cause analog switches U1 (pins 1 to 2), U9 (pins 3 to 4) and U9 (pins 8 to 9) to turn "on". The section of U1 is located in the "Space Filter/Oscillator". It is used to switch in a feedback resistor to start oscillations and the potentiometer R201, which is the master frequency adjust for the AFSK oscillator. The analog switch U9 (pin 3 to 4) connects the AFSK output to the "AFSK OUT" RCA jack on the rear panel. This section is located between the "Preselector" and the "Limiter".

The second section of U9, activated in the above paragraph (pin 8 to 9), is used as nothing more than an inverter. Its output (pin 8) will go to the negative rail (approximately -8.5 volts) when the output of the "T/R" Op-Amp makes a positive transition ("T/R" is pulled "Low"). This negative voltage is used to shut "off" analog switch U9 (pins 4 to 10) located between the "Audio In" and its input Op-Amp U10 pin 6. It also turns analog switch U9 (pin 8 to 9) located at the input to the "Space Filter/Oscillator" "off". This isolates this filter/oscillator section from any undesired feedback not desired in the oscillator mode.

When the "T/R" input is open or being driven to an active high, the corresponding negative voltage at pin 7 of U18 expresses itself on pin 12 of U1. This analog switch is shown on the schematic below the "T/R" input Op-Amp. It is also shown in the "Space Filter/Oscillator" where its function is to connect or disconnect the resistance (R5/R200) which determines the AFSK "Mark" tone frequency. As long as pin 7 of U18 remains negative, this will overdrive (through D1) any of the "DATA OUT" keying voltages present on the schematic right side of R10 and prevent analog switch U1 (pins 10 to 11) from being falsely keyed "on". The inverted output at U9 (pin 8) will, by way of R9, turn "on" the analog switch between U1 pin 3 to pin 4. Its corresponding switch (pins 3 to 4) will effectively be a short. This connects the proper frequency determining resistor in the "Space Filter/Oscillator" to set the filter to the selected "Space" tone frequency. Any keying voltages present on the schematic right side of D2 can only reinforce the positive voltage at pin 5 of U1. For this reason, during the receive mode, it will remain "on" continually.

When the "T/R" input is pulled to any voltage between +2.2 and -8.9 VDC, the output of U18 (pin 7) goes to its positive state. D1 becomes reverse biased, and now any voltage present at the schematic right side of R10 will control analog switch U1 (pins 10 to 11) by expressing itself on the gate (pin 12). This voltage will be positive for a "Mark" and negative for a "Space". As long as the "T/R" is "low", it will reflect either the keying voltage at the "Serial In" (via Q4) or the "Loop" current (if you are strapped for "Loop" current).

The same positive that reversed biased D1 and enabled the "Mark" tone frequency determining resistor is inverted by U9, and expressed on gate pin 5 of U1. This negative voltage will turn U1 (pins 3 to 4) "off", but it can easily be overridden by a positive voltage on the schematic right side of D2 and U1 would be turned back to the "on" state. A positive voltage at D2 always occurs simultaneously with a negative voltage at the schematic right side of R10. If we alternate the voltage at R10 and D2, we alternate the resistors which determine the AFSK oscillator tone frequency. In this way we can shift between the "Mark" and the "Space" frequencies creating the two "AFSK" tones required to modulate the carrier.

When the output of the "T/R" is high ("transmit" mode) this high is used to bias the "PTT" transistor (Q6) "on" through diode D20 and resistor R104. For this reason your transmitter can be a helpfull indicator of the state of the output of the "T/R" input Op-Amp. However it can also be misleading. The "PTT" transistor is for positive keying voltages up to 30 VDC and currents up to 30 ma.

The same positive voltage used to key the "PTT" transistor is used to bias Q3 on by way of R44. This insures that if you are using a printer and our internal "Loop" supply, which is dependent on the autostart relay for AC power, you will not lose the "Loop" voltage.

16.2.0 Technical Talk

The "T/R" is exposed to the outside world and therefore can be a trouble source. The trouble call we get most often that involves the "T/R" is caused by an inverted logic level from a computer. The complaint usually is, "It is locked in 'Transmit'."

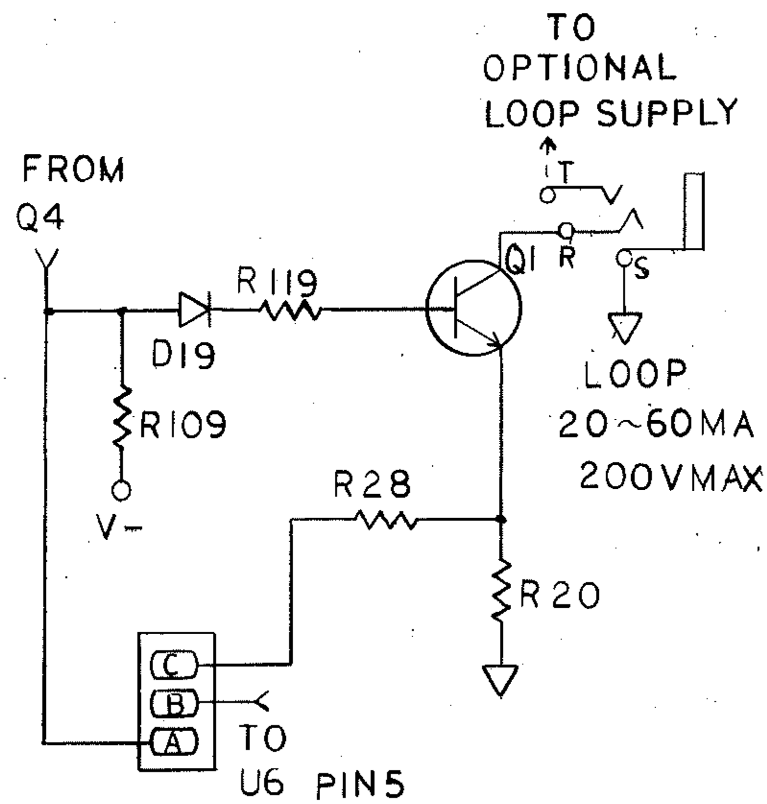
If the FSK 500 is generating an AFSK tone and the "PTT" is pulled to ground "locking" your <u>transmitter</u> in the "Transmit" mode when you should be in the "Receive" mode, the chances are about 100% that the output of the "T/R" input Op-Amp, U18 pin 7 is high. The question that must be awnsered is why is it high. To further check your system out unplug any input to the "T/R" jack (for units with H-89 computer modification, plug in shorted RCA plug) and if the tone stops, troubleshoot the box that is supplying that faulty logic level to the "T/R" input. If the tone stops and you still cannot receive, also check the logic of the "Serial In" and "Key In". If there is no change, measure the output at U18 pin 7 to insure that it is high (+7.2 VDC). If it is and you have followed the above instructions, the odds are "Good" the Op-Amp is "Bad". If the voltage is -7.2 volts, try replacing the analog switches.

Occasionally we do get the "locked in transmit" comment from a customer with a "T/R" on his transmitter that requires "negative grid keying" and there has been no negative grid keying modification made (see appendix B, Fig. B.1.2-2). This causes the "locked in transmit" but there should be "NO" tone accompanying this problem. The "PTT" transistor will probably fail and have to be replace if you make this mistake.

Most computers have an output which keys the "T/R" but ocassionally the have been wired by someone in the field to a field installed switch. If you are just setting up and the "stuck in transmit bug" hits check the unit out for any extra switches that may be holding the "T/R" input to the FSK 500 in the "Transmit" mode.

If your unit has been modified for the H-89, failure to input a signal to the "T/R" input will cause a default "Transmit" mode. If your unit "T/R" input has not been modified for RS-232 (most are not), these levels could damage the "T/R" input Op-Amp.

17.0 THE PRINTER LOOP KEYER



Loop Keyer Schematic
Fig. 17.0-1

17.1.0 Circuit Description

The purpose of the "Loop Keyer" circuit is to translate the logic levels present at the "Source" of Q4 J-Fet, to a 60 ma "Loop" current interface output. By definition, a 60 ma current in the Loop is equlivent to a "Mark", and no current is a "Space". As discussed in previous sections (ie., "The Serial In", "The T/R Input") a positive voltage (between +5 VDC and +6.7 for a healthy FSK 500) at the "Source" of Q4 is a "Mark". This is true regardless of whether it is being generated from the "Mark-Hold" circuit, the "T/R" circuit, or received data from the "Comparator" circuit. This positive voltage biases transistor Q1, the Loop keying transistor, "on". The level of bias is established by resistor R119. If no positive voltage is driven through one of the diodes of the triple diode junction, D11, D12, and D13, or if Q4 is "off", resistor R109 will pull the anode of D19 to -8.9 VDC. This will reverse biases the diode and turns the "Loop" keying transistor "off" and in doing so generates a "Space" (no current) to the "Loop".

The "Loop Keying" transistor is a motorola TIP 47 and has a rated collector to emitter breakdown voltage of 250 VDC. It is not protected from the inductive "kick" of the "Loop" magnets, and should not be. It is necessary for the energy stored in the printer "Loop" to be dissipated quickly. A diode clamp, which is standard in most transistor keyed inductive circuits, would slow this process and therefore was ommited from the design.

Resistor R20 is the "Loop" current sense resistor. It is a quarter Watt 60.4 Ohm resistor. With 60 ma current in the "Loop", the voltage across it will be 3.6 VDC. DO NOT ATTEMPT TO MEASURE THIS WITH A METER OR OSCILLISCOPE! Read section 17.2.0 to understand this warning. This voltage sensed by R20 is passed on to U6 (pin 5) a non inverting buffer that processes the sensed voltage (see section 18, "The DATA OUTPUT") and passes it on to be used to "Key" the AFSK keyer or the "DATA OUT".

In the event that the "Loop" is not being used, X1 is used to avert a falsely sensed "Space" in the "Loop" that would result from the lack of current through R20. For this case X1 will have contacts "A" and "B" jumpered.

Resistor R28 has a value of 100 K Ohms and is present only to limit the destructive current which the Loop voltage can generate in the event that R20 opens up leaving up to 200 volts at R28.

17.2.0 Technical Talk

The most common problem with the "Loop" circuit is caused by an accidental application of "Loop" voltage without any current limiting resistor. The result is usually R20 "burned open", Q1 "shorted", U6 "blown" or any combination of the above. As pointed out in the "Master Technicians Guide" one of the most costly mistakes made with the FSK 500 is caused by a probe or other metal object in the right rear corner of the FSK 500 with the power "ON". Even with the power "off" there is still 120 VAC on the fuse holder. Don't even think about putting a probe in this right corner. <u>The best place to measure the "Loop" current sense voltage is X1.</u> If it ever measures outside of the range from 0 VDC to +4.0 VDC turn the power off immediately and troubleshoot. If the voltage is greater than 4 VDC, you either have to much "Loop" current or X1 is strapped for no Loop (pins A and B shorted). A negative voltage of approximately 8.9 VDC also indicates it is strapped wrong.

If the (M)ark and (S)pace LEDS are flashing with the received data but your printer is "Humming" as though the magnets are pulled in and staying "in", you probally have a short from the wire that connected to the ring of your phone plug to FSK 500 ground. Usually this ground is the shielded cable ground. Also a shorted Q1 will cause this symptom. Our experience is that if it is bad it will be shorted 19 out of 20 times.

Be sure that if you replace Q1 you get a transistor with a like power rating and pin-out. It should have be at least a V of 250 VDC, be able to handle 1 Amp continous collector current, and have a minimum H of 30.

In the operators manual there is a hook-up diagram for an external Loop supply. This must be followed to the letter. If the FSK 500 is not connected this way, damage may result to your equipment. It requires a polarized "Loop" and depends on an external current limiting resistor. The ground connection is very important.

18.0 THE DATA OUTPUT

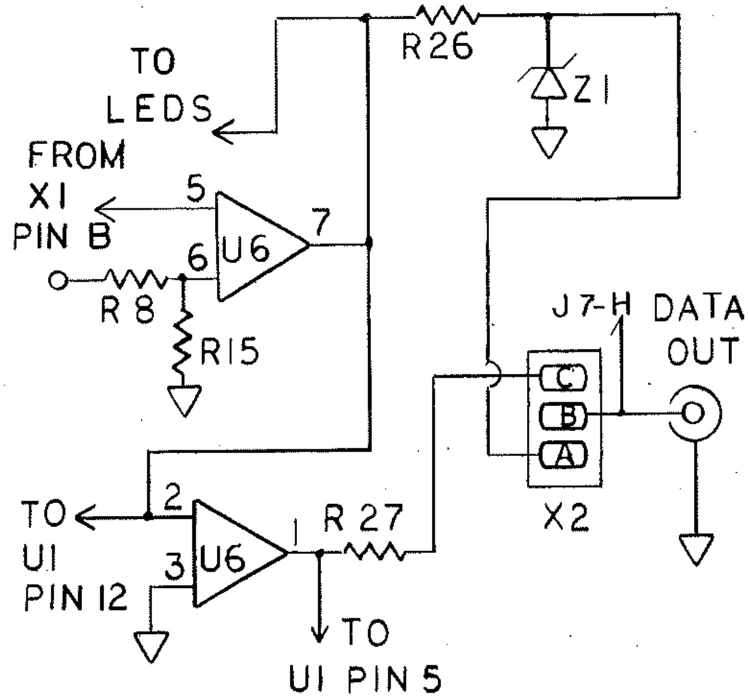


Fig. 18.0-1
Data Output Circuit Schematic

18.1.0 Circuit Description

The "Data Out Circuitry" consists of two Op-Amps, 4 resistors, one zener and an optional (now standard) Schottky diode. Its purpose is to supply TTL ("Mark" = High) or RS-232 compatible signals to the "DATA OUT" RCA jack on the rear panel, and in the transmit mode, to drive the gates of the analog switches in the "Space Filter/Oscillator" that determine the AFSK generated tone.

Op-Amp U6 is used as a "Comparator". Any voltage at Pin 5 above +.8 VDC, the reference voltage at pin 6, will cause an output of +7.2 VDC at Pin 7 of U6. This voltage, which corresponds to a "Mark", is passed through the current limiting resistor R26 and clamped by zener Z1 at approximately 4.7 VDC. When the input to U6 pin 5 drops below 0.8 VDC, a "Space", the output drops to -6.6 VDC. The output available at Pin A of "X2" is clamped at one diode drop below zero volts. If the Schottky diode is installed as described below, the diode drop will be less than 0.3 volts. If the circuit relies on the forward drop of the zener to clamp the cathode to ground the result will be approximately a negative 0.7 VDC. One other option is shown in Appendix B, Fig. B.4.1-1 b). This option using two 1N4148 diodes will yield a "Mark" voltage of about 4.0 volts and a "Space" voltage of approximately zero volts.

The other Op-Amp of U6 integrated circuit (pins 1,2, and 3) is used as an inverter to supply the RS-232 compatible signal levels. Pin 1 will output a -6.6 volt logic level for the "Mark" and a +7.2 volt logic level for the "Space".

Both of the outputs of U6 integrated circuit (pins 1 and 7) are also used to key the analog switched frequency determining resistors in the "Space Filter/Oscillator" as mentioned above, and described in detail in Section 16.

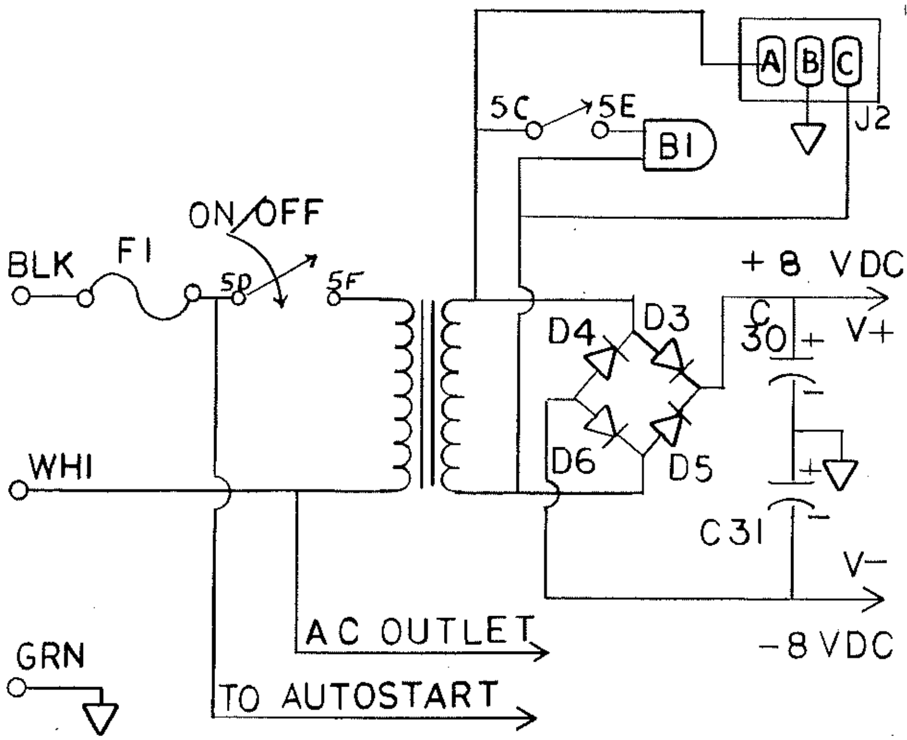
18.2.0 Tecnical Talk

The "Data Output Circuit" has caused few problems since we began shipping the FSK 500. There is one exception. The 6522 integrated circuit used in the VIC 20 computer usually can handle the the unmodified "DATA OUT" negative "Space" voltage of -.7 VDC, but ocassionally just locks-up or is erratic in operation. For VIC owners we recommend they add the modification which is discussed in detail in the "Technical Talk" section of Appendix B. This modification is now a standard part in FSK 500s. If your serial number is over 501000 you already have the modification installed.

The most likely component to fail in this circuit is U6, and the cause is associated with a printer in the "Loop". See Section 17.2.0 for more details. If you are not using the "Loop", problems that show up at the "DATA OUT" are usually caused by something "upstream" and not a component in this circuit.

The (M)ark and (S)pace LEDs are excellent troubleshooting indicators for the entire unit and especially the "Data Out Circuits". If you put a volt meter on pin A of "X2" you should be able to measure the positive +4.7VDC when the (M)ark LED is "on" and 0 to -.75 when the (S)pace LED is "on". The output pin 1 of U6 is available at pin C of "X2". This is the RS-232 compatible levels as described above. If they both check out good, make sure the jumper at "X2" is relaying your chosen logic levels to the rear panel RCA jack labeled "DATA OUT".

19.0 THE POWER SUPPLY



Power Supply Schematic
Fig. 19.0-1

19.1.0 Circuit Description

The FSK 500 power supply uses a full-wave bridge constructed out of 1N4001 diodes to create an unregulated symetrical supply of plus and minus 8 to 9 volts. iRL choose to use an unregulated supply to take advantage of the large ripple rejection ratio or lack of response to power supply ripple that modern Op-Amps incorporate when used in the linear mode. The bridge outputs are filtered by C30 and C31, and under normal power supply load should have a ripple of less than 500 millivolts peak to peak riding either the positive or negative DC voltages.

The transformer not only supplys the symetrical DC voltages, but also supplys current to drive the Westinghouse wedge based W194 light bulb (approximately 270 ma), and anything connected to auxillary connector J2. Now, for those of you who noticed the light bulb does not require switch contacts 5C and 5E to turn "on" an "off", and always wondered why we did that...... It was a circuit board layout simplification, and from an electronic point of view is a perfect definition of the word "Superfluous". Two other contacts of the power

"On/Off" switch, contacts 5D and 5F, are used to remove the power from the transformer, and functionally make the connection of contacts 5C and 5E in the circuit useless.

The transformer is manufactured by "Signal" of Inwood, Ny. The "Signal" part number is "ST-4-12". It is a 120 VAC primary, 12.6 VAC secondary rated at 500 ma. If you ever require one you may purchase it from us or direct from "Signal".

19.2.0 Technical Talk

Notice that the 120 VAC "HOT" side is connected to the fuse before it proceeds to the "On/Off" switch. We just want to take this opportunity to say it again. The power always goes to the fuse first in a circuit. Turning the power off from the front panel does not remove the 120 AC from the fuse. If you use a metal object (ie., screwdriver or pliers) to remove the fuse with the plug still connected to the wall you will probally destroy most of the Op-Amps on your circuit board. Unplug your unit first. The fuse is located at the back right of the circuit board. The fuse which is factory installed has a value which will handle most printers. It is a 5 AGX or 5 Amp, 125 V "Normal-Blo" fuse. We said most printers above because we have found some model 28s will overload them. If you have a model 28 and you want to use the Autostart you may have to use a littlefuse part # 362 006. This is a 6 Amp 125 VAC fuse. If this does not suceed, make sure your printer is not binding up. This fuse will usually work. However, the model 28 should really have a 6 Amp slow blow fuse. It may be necessary in some cases to change to an in line fuse holder that will hold a 1 1/4 in. fuse and use a 6 Amp "Slo-Blo". "Slo-Blos" are not available in this size fuse.

The best way to get the fuse out is to remove the 4 screws holding the circuit board in, slide the back panel up, and put a screw driver under the fuse. A small allen wrench can be used to pull it up without removing the screws. Whatever method you choose "<u>UNPLUG THE UNIT FIRST</u>". As for the tight location, we tried to isolate the power circuity as much as possible from the signal circuitry. The back right hand corner was a natural location for the fuse.

APPENDIX

A.0 THE MASTER TECHNICIANS GUIDE

A.1.0 Typical Problems, Complaints, and Causes

The first item of importance in this section is to help prevent you from making a costly mistake. The most costly service jobs we do at iRL on defective units are caused by one of three things; in the following order of priority, and two out of three of these are preventable:

1) A metal screw driver, alligator clip or probe pushed down into the right rear corner. This mistake, a "Level One Catastrophy", usually involves an attempt to pry the fuse out of its socket while the FSK 500 is still "PLUGED INTO THE WALL OUTLET." Occasionally it is the result of a technicians probe around the "Loop" sense resistor, "Loop" transistor, or relay K1.

2) Another common "Level One Catastrophy", is 120VAC from another piece of equipment in your station getting shorted to the FSK 500 ground on either the RCA jacks or the "LOOP" jack. This 120 VAC almost always is produced by a wiring problem in an old printer or a "Rats Nest" of wires piled behind the T.U..

3) Lastly, the "Lightning Strike" can be devastating.

When the worst happens it usually takes out enough of the integrated circuits and electrolytic capacitors that it pays to just replace all integrated circuits and electrolytics, and begin retuning.

We mentioned the fuse above. That was "a moment you have all been waiting for". iRL apologizes for never mentioning anywhere that there is a fuse on the back right hand corner of the FSK 500 printed circuit board; somehow that has slipped our notice since we began shipping the FSK 500 in 1980. It is a "Buss" AGX 5, 5 Amp 120 V fuse. The symptom that indicates that the fuse needs replacing is no light from the lamp and LEDs. The best way to remove the fuse is to first remove the four screws securing the circuit board (located on the left and right edges of the printed circuit card). Second, lift the rear panel up and out of its grove. The three heavy gauge wires connecting the rear panel outlet to the printed circuit board may be disconnected or left alone at your discretion. Now you are free to examine the fuse and, "if the unit is unplugged", to pry the fuse out of the socket with a small screw driver.

Most problems that occur in the FSK 500 are of a simple nature and involve the interface levels present at the "Serial In", "T/R", "Key In", and/or "Loop" interfaces on the rear panel. In a random fashion lets look at some of the complaints we hear most often and the possible causes. We will follow this with some tips on troubleshooting the FSK 500 and a "Flow Chart" to aid in an organized search for most of the common problems we see in the field.

Complaints:

"The unit is locked in Space".
"The 'Space' LED stays on continually."

Possible Causes:

1) "Serial In" is strapped for wrong interface levels or whatever is connected to the "Serial In" is producing the wrong logic level (ie., computer program has "bombed", has not loaded correctly, or the computer is not "on").
2) "X1" is strapped for "Loop" current and there is no "Loop" current flowing through R20, the "Loop" sense resistor.
   a) "Loop" current is being shorted to ground in the cable If the current is getting to the magnets, the printer will be "Humming" and if the short is prior to the magnets it will be noisely running open.
   b) External supply is not generating current.
   c) Internal "Loop" power supply is not generating the current. (It must be receiving the audio tones or have T/R" input at "Low" logic state or it will shut "off". We also occasionally see an open "Loop" power resistor.)

Complaint:

"The meter is reading full scale but the "Mark" LED is staying on."

Possible Causes:

1) The "Threshold" control is fully clockwise.
2) The "T/R" is at the wrong logic level.
   a) Computer program has bombed or the computer is off.
   b) Older FSK 500 with "T/R" that is not modified for "TTL" levels. (see APPENDIX B, page B-9)

Complaint:

"The transmitter is locking in the °Transmit° mode."

Possible Causes:

1) Your transmitter requires negative grid keying and the FSK 500 has not been modified for negative grid keying. (See APPENDIX B, page B-4, Fig B.1.2-2)

2) The "T/R" is pulled low for one of the above reasons. (See "2" above)

Complaint:

"I get reports of an odd shift or no 'Space' tone on transmit."
"The FSK 500 will not tune to a full scale reading and prints garbage on a relatively clear signal."

Possible Causes:

1) The "KEY" input logic level is reversed and is being held at a constant low state.
   a) The computer program has "bombed" or has not loaded properly.
   b) The "KEY" input cable is shorted or the Key is being held "closed".

The best tools to have around for troubleshooting most FSK 500 problems are three RCA phono plugs which have been purposely shorted. Throughout this manual, in the troubleshooting sections labeled "Technical Talk", we will make reference to their use. The best procedure to follow in troublshooting the FSK 500 is to:

1) Isolate the problem to the FSK 500.
2) Isolate the problem to "before" the "Low-Pass" output or "after" the "Low-Pass" output.
3) Isolate to the faulty section.
4) Read the manual section that involves that FSK 500 faulty section.
5) Troubleshoot the faulty section.

A.2.0 Using The "Flow Chart"

If you are sure your problem involves a given section of the FSK 500, you may skip the "Flow Chart" and procede directly to the section of the manual that involves the section of the FSK 500 you are having problems with. The "Flow Chart" will give you a logical path for identifying and in some cases, isolating the problem.

Unplug all "inputs" and "outputs" from the back of the FSK 500. Turn the "Threshold" control on the front panel fully counterclockwise. If your FSK 500 uses an external "Loop" supply you will have to leave the "Loop" phone jack pluged in and the external "Loop" supply "on". Insure that The "Norm/Rev" button is in the "Normal" (out) position. If you have installed the "CW Survival Kit" or the "300 Baud modification", you must put both of these switches in the "off" (down) position.

Follow the "Flow Chart" using the shorting plugs as prescribed. In the event that you do not have any RCA phono plugs, you may use your stations normal input to a given FSK 500 rear panel input, as specified by the "Flow Chart". Be sure to connect "inputs" and "outputs" in the sequence that the "Flow Chart" requires.

For users of the FSK 500 which have been modified for the H-89 computer, a +3 to +12 volt signal must be supplied to the "T/R" input when the "Flow Chart" asks for a "Shorted Phono Plug".

There is a test in the middle of the "Flow Chart" that requires you to measure the 2125 Hz "Mark" frequency. If you have an internal "Loop" supply board installed, we recommend you skip this step. The "Loop" supply board has +170 VDC present at this point of the test and "SF2" lies underneath this board approximately 1/4 inch from the front left corner of the FSK 500 power supply transformer. You can read the same frequency at the "AFSK OUT" jack if the the "Preselector" is also functioning properly. If the "Preselector", "Mark Filter", "Precision Rectifiers", "Low Pass" and "Single Meter Tuning" circuits are working, the meter should read 1/2 scale (4 to 6) when the "Mark" tone is represent. If you inject a logic level in the "Serial In" that causes a "Space" tone, the meter will momentarily kick up to full scale, and then because no "Mark" tone is present, drop back to less than "one". If you try the test at the "Serial In", be sure to return it to the logic input level it was at before you conducted the test and then continue with the "Flow Chart".

For users with FSK 500s which have been modified for the H-89 computer, when the "Flow Chart" requires a shorting plug at the "T/R", you will have to supply a high (+3 to +12 VDC) from your H-89 to the "T/R" input.

If you get all the way through the "Flow Chart", you have checked out everything but the "Key In" circuit and the actual" transmit" and" receive" (resonant) tones. A suspected tone problem here can be found by following the tuning procedure in "The Mark Filter" and "Space Filter/Oscillator" sections.

If you find yourself progressing through the "Flow Chart" to one of the circles with a "letter," this indicates something is not preforming correctly. Find the same "letter" below and it will give you some possible causes of your problem.

If you proceed completely through the "Flow Chart" using the shorting plugs and find yourself being referred back to "Using the Flow Chart", your FSK 500 is probably working fine and the problem you have been experiencing is being caused by some outside device. Try removing all "inputs" and "outputs", returning the "Threshold" to the full clockwise position, and begin the "Flow Chart" a second time. This time when the "Flow Chart" requires a "Shorted phono plug", use instead whatever is normally plugged into that respective input at your station. In order to duplicate the effect of the shorted jack in the "T/R" input, you will have to put your computer, switch, or any other device supplying the "T/R" input, into the "transmit" mode. When asked to "REMOVE THE SHORTING PLUG FROM 'T/R'" input, simply return the device producing the "T/R" input to the receive mode.

If you find yourself vectored out to a circle with a "letter" on this second pass of the "Flow Chart", read the possible causes identified by the respective" letter" below and examine the last input that you supplied from the outside world.

We have also added into this section an assembly drawing of the FSK 500. The "parts list" is on the schematic inside the front cover pocket. If you need any further assistance please give us a call.

(A) "Space" LED is on continuously.

1) The "Loop" sense resistor R20 has no current through it.
   a) "Loop" power resistor on optional "Loop" supply board is open.
   b) Fuse on "Loop" supply is open.
   c) "X1" is erroneously "strapped" for the presence of a "Loop" supply and there is none.
2) U6 is defective.

(B) The "Mark" LED is on continuously.

1) Loop" sense resistor R20 has a constant uninterrupted current.
   a) "X1" is "strapped" to sense "Loop" current. Q1 is shorted and current is continuous.
   b) The "Serial In" is unable to control the "Loop" transistor. The "Serial In" input Op-Amp U17 or Q4 is not functioning properly.
2) U6 is defective.

(C) The "Space Filter/Oscillator" is not generating 2125 Hz.

1) The analog switches are defective.
2) U18, the "T/R" input Op-Ampis defective.

D The meter is is reading less than half scale.

1) The meter is defective ("not often") or there is a defective Op-Amp/s prior to the output of the "Low-Pass".
2) A defective Op-Amp in the "Preselector", "Mark Filter", "Precision Rectifiers", or "Low-Pass Filter" could cause a meter reading of zero.
3) A maladjusted "Mark" filter could cause a "peak" meter reading of less than half scale.

E Meter peaks to half scale (4 to 6) but will not go higher.

1) A defective Op-Amp in the "Space Filter/Oscillator", "Biquad" sections 1 or 2 (see section 7) will cause this symtom.
2) A defective analog switch or maladjusted "Space Filter/Oscillator will cause this symptom.

F LEDs do not alternately flash.

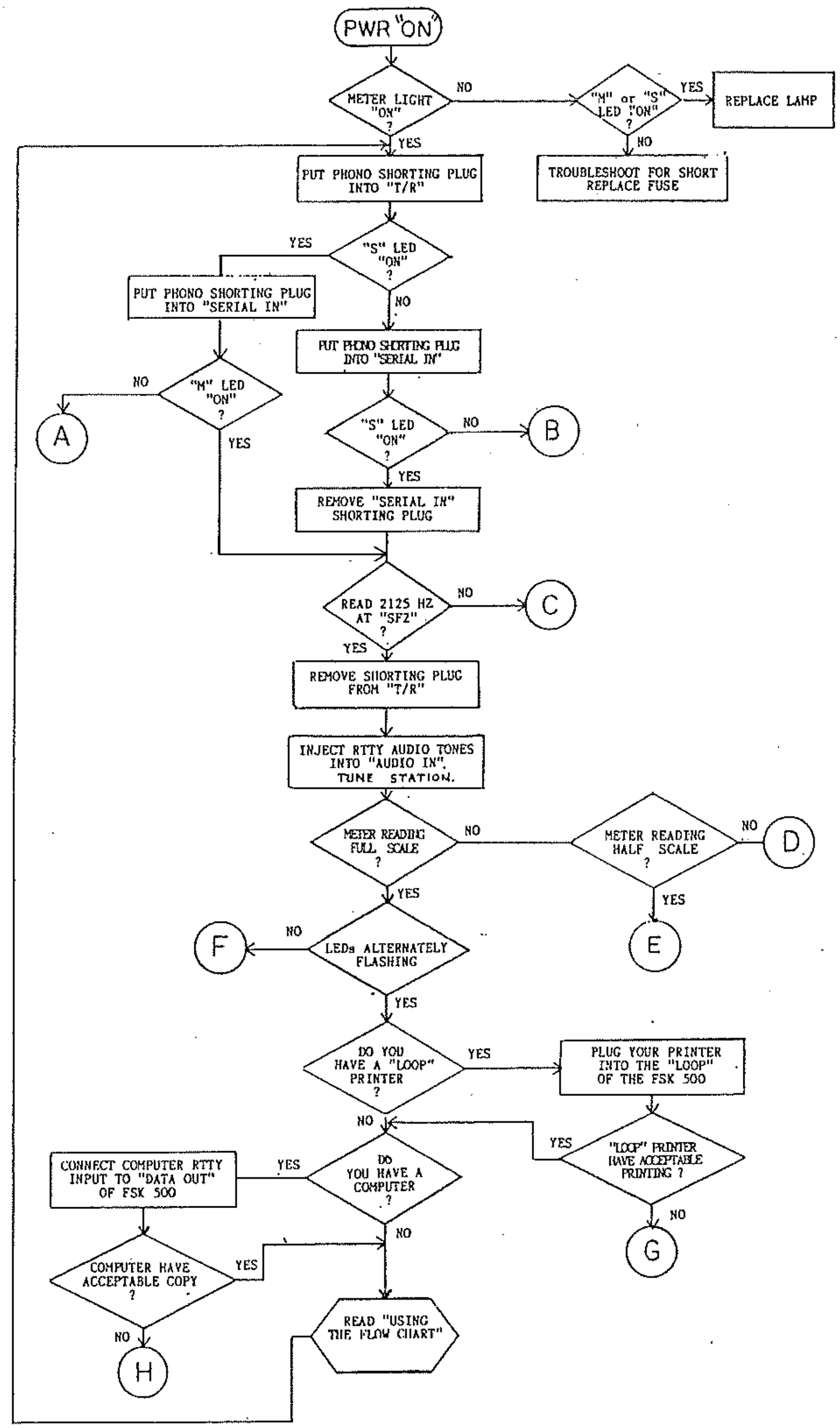
1) "Threshold" control is set to high or is defective and causes a continuous "Mark-Hold".
2) Defective "T/R" input Op-Amp.
3) Defective "Comparator", U17.

G "Loop" Printer printing garbage.

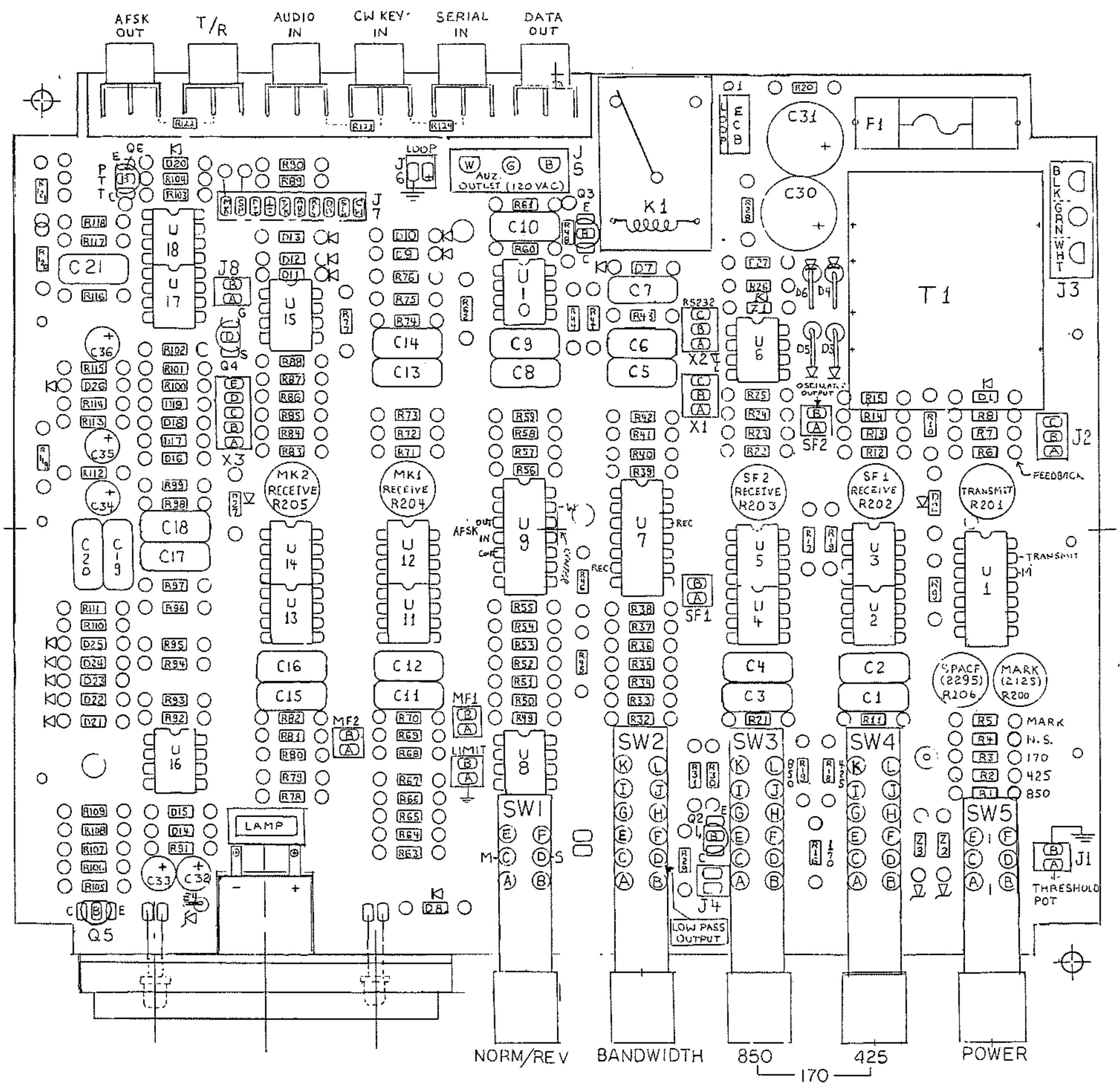
1) Printer "bias" is maladjusted.
2) Defective "Threshold" circuit.

H Computer "Locked Up" or printing garbage.

1) VIC 20 users ...."TTL" and "Data Out" modifications not made.
2) "Data Out" is "strapped" for wrong logic levels (ie., RS-232 where "TTL" is required).
3) "Threshold" circuit is defective.



Troubleshooters Flow Chart
Fig. A.2.0-1



FSK 500 Assembly Drawing
Fig. A.2.0-2

B.0 CW AND THE FSK 500

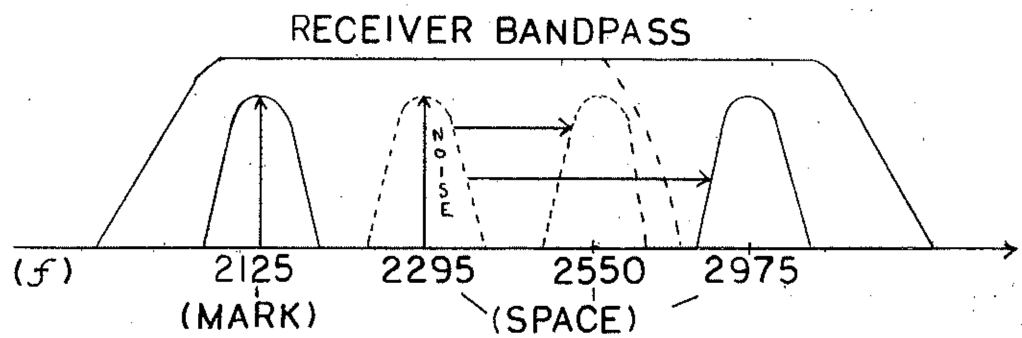
B.1.0 Receiving and Transmitting CW with the FSK 500

B.1.1 Receiving CW With The FSK 500

Although the FSK 500 was designed to copy RTTY, it can be utilized as a CW filter with a few simple modifications. Receiving CW requires the installation of a DPDT switch, some wire and A 10 uF capacitor. These parts can be purchased from your local Radio Shack or from iRL direct. We call this the "CW Survival Kit" and you may install it yourself or ship your unit to us for installation.

In theory, to electronically detect the information content of "On-Off keyed" CW beyond your speaker, you require a device with sufficient selectivity to single out the tone you are trying to detect, and a means of converting that tone to useful information. The conversion of tones to intelligent print in todays amateur station is more often than not accomplished by a computer. This adds the additional requirements of circuitry to change the tone to "Ones and Zeroes" at voltage levels which are compatible to the computer, and software. The FSK 500 possesses both the filters necessary for reliable tone selection and the additional circuitry required to convert the received tone to a digital signal at the levels required by the computer. Once the CW survival kit has been installed only the software is necessary to allow your computer to make the conversion to print.

When tuning CW, most amateurs adjust their main tuning dial to produce an audio tone of about 800 Hz. Many modern stations have transceivers which actually shift the carrier up 800 Hz on transmit so that both stations can "zero beat" the same frequency and still hear an 800 Hz offset tone from the transmitting stations carrier. In order to select out the CW tone we must shift that tone up to 2125 Hz. To prevent spectral walking you should first tune as you normally do for a tone of approximately 800 Hz and then adjust your receiver incremental tuning, "RIT" to produce the 2125 tone required for the FSK 500. If you find the tone "drops out" before you get it up to 2125 Hz, you will have to adjust your passband tuning to allow this higher frequency tone to pass. If your station has a separate transmitter and receiver, adjust the receiver to produce the desired 2125 HZ tone. The FSK 500 meter will peak up to only a 5 or 6 reading as is normal for a single tone present in the mark channel only. If it reads higher than 6, you may be receiving QRM through the space channel. Try selecting a 425HZ shift to move the space channel away from the interfering noise (see Fig. B.1.1-1). If the problem persists, select an 850Hz shift and adjust the Pass Band Tuning on your receiver, to reject or in other words, put the 2975 space channel outside of the pass band of your receiver. iRL does not recommend this unless you have QRM interfering through the Space channel. When the transmitting station has the key up, it can actually be helpful to have the average amount of noise in the space channel equal to the average noise in the mark channel. Natural noise sources (atmospheric noise) will be present in both channels at approximately the same levels if the space channel has not been shifted out of the band pass of the receiver. Under these conditions the mark and space channel have a tendency to cancel each other which is beneficial downstream from the filters. See Fig. B.1.1-1.



Moving The Bandpass Aaway From The QRM
Fig. B.1.1-1

Once the CW tone has been selected out, a method must be found to differentiate between a true "key down" received signal and noise which is amplified by the Limiter in the "key up" situation when no signal exists (see Section 1, "The Limiter"). Two facts are known about the incoming signal and QRN (atmospheric noise): (1.) When the key is down we will have a strong tone present at the output of the Mark filter (if tuned properly) which will be filtered by the lowpass to produce a strong positive voltage at the input to the threshold and comparator circuits. (2.) When the key is up most of the QRN we hear at the speaker is severely attenuated by the mark channel allowing only a weak voltage at the input to the threshold and comparator circuits. By adjusting the "Threshold" control so that the threshold comparator (U17) reference switch level (voltage on pin 3 of U17) is greater than the voltage produced by noise, but less than the stronger positive voltage produced by the signal tone, we create an output at the "Threshold Comparator" which changes state from +7.2 VDC to -7.2 VDC when the transmitting station presses the key down.

Well....this is almost true. We also have to decrease the RC time constant at the input to the threshold circuit so that it does not interfere with copy at higher CW speeds. The easiest way was to parallel a resistor large enough to not load the driving Op-Amps but small enough to allow copying CW at speeds up to 70 words per minute. This explains the 5K resistor supplied with some of the earlier modifications we did for customers. The resistor is switched in to reduce the time constant. There is a better way to to accomplish this modification but it is a little more difficult to install. If you use the switch to insert or remove the capacitor C34, to enable RTTY or CW copying respectively, you will (in the CW position) have completely removed the time constant allowing speeds up to 100 words per minute and easier adjustment of the "Threshold".

It should be noted that beyond 70 words per minute CW, with the FSK 500 bandwidth select button in the "Narrow" position, the Low Pass filter (28 Hz bandwidth) and the Mark filter (75 Hz bandwidth) is too selective to insure optimal performance. With the bandwidth button in the "wide" position, the Low Pass will be 60 Hz wide and the Mark filter will be 145 Hz wide. The Wide position allows adequate channel bandwidth to pass up to about 130 words per minute, well beyond any practical communications requirements. The FSK 500 may copy speeds greater than 130 words per minute, but the filters will not be functioning in a manner that facilitates the copy of CW at these speeds.

Now that we have at the output of the Threshold Comparator a -7.2 to +7.2 digital output that is representative of the incoming CW, all that remains is to translate it to the levels our computer requires. Since the circuitry to preform this function is present in the FSK 500, we simply extract and switch the output of the the threshold circuit by using our newly installed switch to the output processing circuits at "X1" pin B. The result will be your choice (dependent on strapping of "X2") TTL, key down = low or RS-232 compatible, key down = +7.2 volts.

B.1.2 Transmitting CW

In the transmit mode things are a little more dependent on your individual station. Although the Terminal Unit in general has nothing to do with keying the "Key" input on the transmitter, todays modern amateur sometimes uses the T.U. as a buffer to compensate for the occasional inability of the computer to interface to the various keying voltages present at the key jack on their rigs. The FSK 500 will key any positive voltage up to 30 VDC and sink at least 30 milliamps by connecting the keying line from your computer into the T/R input on the rear panel and connecting the collector of the PTT transistor (Q6) to the Key input on the transmitter (see Fig. B.1.2-1) This set up will yield the equivalent of a key down if you pull the T/R low. If you use this method be sure to return your connections PTT and T/R to their normal state before returning to the "RTTY" mode.

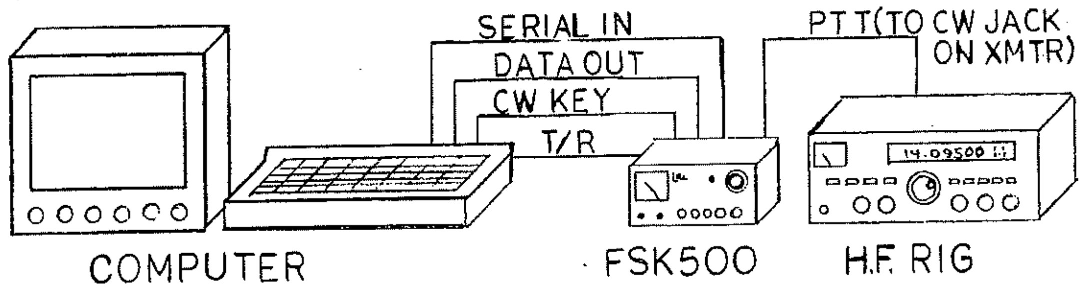


Fig. B.1.2-1

In the event that your transmitter requires negative grid keying, a special problem exists. Depending on the make and vintage of your rig, the voltage at the Key input can be -75 to -400 VDC. We recommened the use of a DIP relay to isolate the solid state circuits of the terminal unit and computer from the transmitter keying voltages and let the FSK 500 key the relay (See Fig. B.1.2-2). Some FSK 500's in the field already have this modification to allow the "PTT" output to work with negative grids. At iRL we physically glue the DIP relay to the back panel and tap the positive drive voltage out of the supply. As metioned earlier, the computer now can key the "T/R" on the FSK 500 and the "PTT" output will key your transmitter "Key Input". (Note; Although all FSK 500's have a "PTT" drive transistor (Q6), on some units the collector may not be brought out to the back panel and may be accessible only as a solder pad at the rear left of the PC board, next to the transistor.)

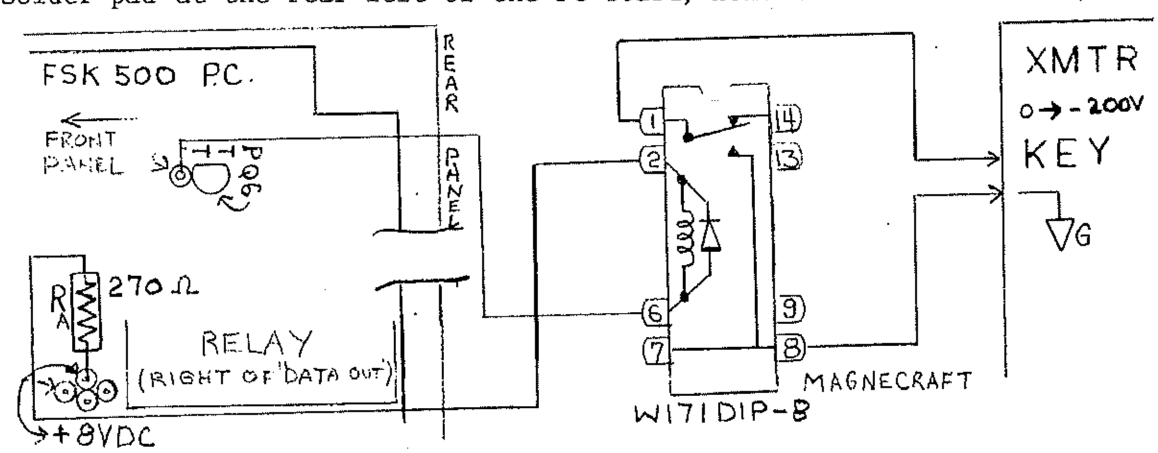


Fig. B.1.2-2

B.2.0 Installation of CW Modification

B.2.1 Procedure

Note; If you bought the survival kit from iRL skip steps 1 thru 5.

Step 1. Cut 3 pieces of color coded wire 4 inches long for back pannel mount, and 8 inches long for front panel mount of switch. One wire should be blue, one violet, and one orange. If you do not have these colors use any 20 to 26 gauge wire in your scrap box.

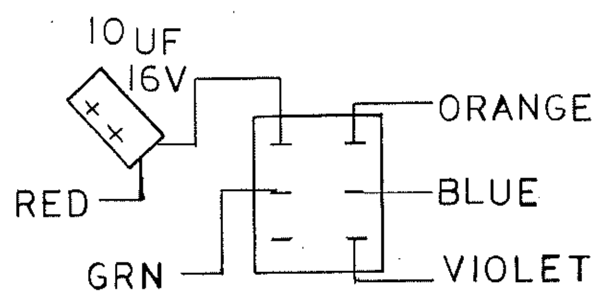


Fig. B.2.1-1

Step 2. Solder the blue wire to the center of the right side (the pole) of the switch. Solder the orange wire to the top of the same switch and the violet to the bottom. (Fig. B.2.1-1)

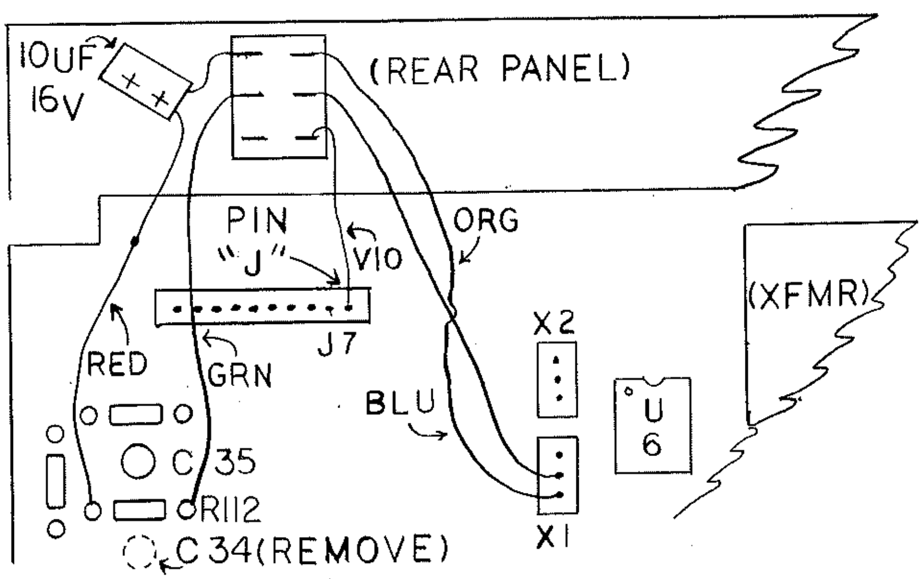
Step 3. Cut a length of green wire 4 inches long for rear mounted switch and 7 inches for front. Connect this wire to the center (pole) of the left side of the switch. (Fig. B.2.1-1)

Step 4. Cut a Red piece equal to the length of green you cut in step 3. Solder this to the positive lead of a 10 uF capacitor. Solder the negative lead to the top left of rear of switch. The switch should now appear as in Fig. B.2.1-1.

Step 5. Select the spot that you wish to mount the switch. Sometimes a small piece of masking tape (.5 X 1 in.) placed over this spot will help prevent the drill bit from scrolling off and scarring the panel. Remove the four screws from the bottom, remove the top of enclosure and convince yourself that the spot you have chosen to mount the switch will not create a mechanical interference problem with any other components inside the FSK 500. Using a punch or sharp nail, make a small "ding" in the panel (through the tape) to help guide the drill bit. Turn the unit upside down to prevent metal filings from dropping into the rig, and drill the hole required to mount your switch. Most miniature switches require a 1/4 inch diameter hole. The survival kit contains a miniature. Deburr hole if necessary and mount switch.

Step 6. If you bought the Survival Kit, plug in the connectors such that the same connections are made as described below. Note which pins of "X1" are connected by the blue two pin jumper. (Fig. B.2.1-2) Remove the jumper and solder the blue wire to the center pin and the orange wire to the pin that was being jumpered to that center pin. (If you do not have a loop supply or are not using a keyboard in your 60 ma loop you will have connected the wires to pins A and B, the center pin and pin closest to the front panel.) Solder the violet wire to pin J of J-7, the 10 pin conector at the rear left of your board.

ERRATUM:
REVERSE P.C. BOARD ENDS OF RED & GREEN WIRES SO RED IS CONNECTED TO RIGHT SIDE OF R-112 & GREEN TO LEFT SIDE OF R-112. THIS WILL AGREE WITH STEP 7 ON PAGE B-7.



CW Modification
Fig. B.2.1-2

Step 7. Solder the end of the red wire to the right side of R112 and the end of the green wire to the left side of R112. Double check to make sure that the positive side of the capacitor is connected to the right side of R112.

STEP 8. Using your thumb push the capacitor C34 over on its side and remove with a pair of wire cutters.

This completes the modification. Turn unit upside down and shake out any loose wire ends. Check wiring before replacing chassis top. You are ready for the "Smoke Test".

B.3.0 Operation

Operation of the FSK 500 in the CW mode falls into two categories; 1.) receive only and 2.) receive and transmit. For the second category the receiver/tranceiver RIT control must be capable of tuning over a plus or minus 1400 Hz range (most due).

For Receive only;

1. Throw installed switch to CW mode (up).

2. Adjust your rig for the Single Side Band mode as you normally do. Tune for a 2125 Hz tone (which will cause the meter to peak). This peak will be less than 6 units on the meter barring any interference in the space channel.

3. Adjust "Threshold" clockwise to a point at which Threshold LED turns off each time the transmitting station tone is present and stays off when it is absent. If the LED appears to stay on, as it will for faster CW, rotate the threshold control until the LED just lights and then continue rotating clockwise until best copy is obtained. This will occur at about 10 to 40 degrees beyond the point at which the LED turned on. By experimentation you will find an optimal position for the threshold which will produce copy 90% of the time without further adjustment.

For Transmit and Receive;

1. Set the transceiver to the CW mode (up).

2. Turn any CW filters internal to your receiver off.

3. Set receiver incremental tuning (RIT) and passband tuning (PBT) to zero.

4. Tune in the station you want to copy to produce the normal 800 Hz tone you are used to.

5. Alternately adjust the passband tuning and RIT controls until the tone you are trying to copy is causing a deflection of the FSK 500 meter. This will occur when you have shifted the tone up to 2125 Hz. The meter will "peak" at less than 6 (barring QRM).

6. Follow step 3 above in "For Receive Only" section.

7. Transmit as is normal for your station.

B.4.0 Technical Talk

This modification usually goes smoothly due to its simplicity. If it completely fails to copy or copy is 100% garbled, check that the blue wire from the installed switch is connected to the center pin (B) of X1. Also try pushing the Normal reverse button. It may be that your computer requires a key down = high at the "DATA OUT". If you are copying but still taking a lot of hits, first check to see that you are tuned properly and second that the "Threshold" is adjusted properly. Also, if you are trying to pass more than 70 words/minute, insure that bandwidth select is in the "WIDE" (out) position.

If you have chosen the VIC 20 for your computer, the 6522 VIA inside the VIC ocassionally cannot accept the -.7 voltage that the FSK 500 "DATA OUT" supplies in the TTL strapped space condition. In some cases it will work trouble free and in other cases it will occasionally lock up the computer in various states. At iRL we parallel the output zener diode Z1 with a Schottky diode connected cathode to cathode and rely on its lower forward voltage drop to hold the negative drop to less than .3 VDC (Fig B.4.0-1a). If you do not have a Schottky diode handy there is another way to eliminate this problem. Place two parallel 1N4148 or 1N914 diodes in series with the the "DATA OUT". These diodes can be soldered directly to connector X2 in place of the Jumper. These parts are all available at your local Radio Shack (See Fig. B.4.0-1b).

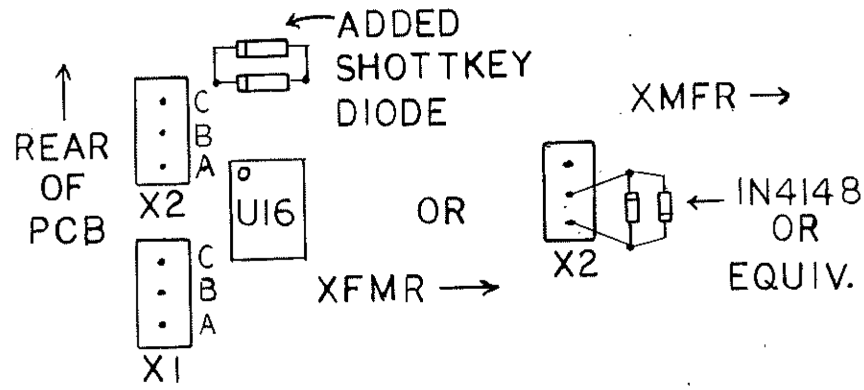


Fig. B.4.0-1

One final word, the first FSK 500's shipped out by iRL had "T/R" and "KEY IN" jacks which were designed to interface to a switch and an amateur key. We have since begun modifying both of these jacks and the "Serial In" to produce levels more compatible to TTL. If you have just connected your computer and you find you are continually locked up in transmit, or the Space LED stays on, or your shift in transmit is continually reported to be off, disconnect the inputs and check the voltages on the center pins of the T/R, KEY IN, and SERIAL IN. If the measured voltage is above 5 VDC, your T.U. has not been modified. This modification amounts to connecting a 10 K 1/4 watt resistor from the center conductor of the RCA jack to ground on the Serial In and Key In. On the T/R, use a 100 K 1/4 watt resistor to ground. Add these resistors to your schematic as shown in Fig B.4.1-2. Do not assume that the absence of these parts on your schematic indicates that we have not installed them. There are a few isolated cases ("ALL") where we failed to add these parts. "SORRY!" At the factory we put these resistors on the jacks on the bottom of the board, but they can be tacked with a little solder on top of the board at the jack (from center conductor to ground).

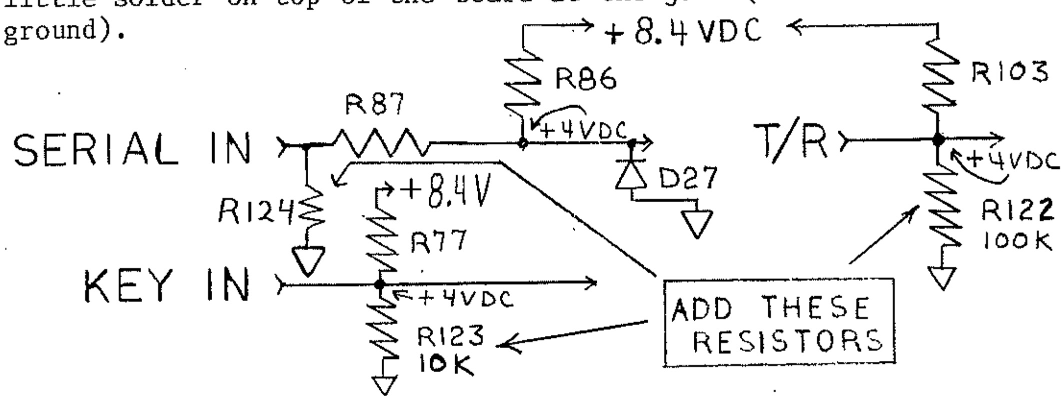


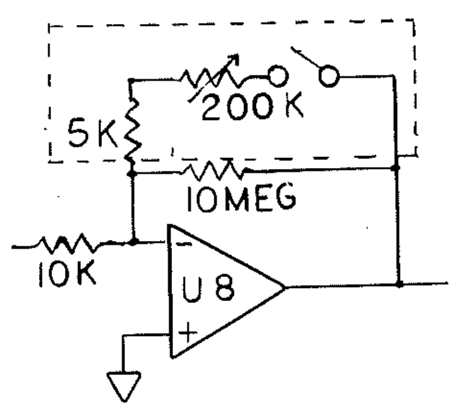
Fig B.4.0-2

If you have tried all of the above and still have problems, give us a call or drop your unit in the mail with a note.

C.0 IMPROVING THE FSK 500

It is impossible to procuce a product and over time find not something that you might do differently if you were redesigning that product. I think if we produce an FSK 500B it would have a gain adjust on the front panel which allowed the user to adjust the unit back into the "Linear" mode if he was getting pounded by QRM. As explained in the the section on the "The Limiter", if an affending station is close enough to your desired tone to get through the preselector, and is stronger than the desired station, it will "Capture" the "Limiter". The four poles in each channel beyond the "Limiter" are wasted. Nothing gets beyond the "Limiter" except that "affending" station. However, it is possible to pick that 4 poles per channel back up. This would add back into the circuit a sharply selective section of filter and help CW as well as RTTY copy. If a 200 K potentiometer were installed on the front panel, the gain could be turned down until the meter reached a point that produced "Limiterless" operation. The potentiometer would be soldered across R 67 (see Fig. C.0-1). The best way to adjust your FSK 500 is to take the top off the unit the first time it is used with the modification and put a scope at the output of the "Limiter". Tune in a station and adjust the gain down until the clipping or "flat-topping" at the top of the signal stops. Note the reading on your front panel meter. This is the meter reading which is optimal for your FSK 500.

Remember that the "Limiter" is an aid during conditions of fading. For normal operation keep the gain all the way up. The best gain control actually would have an accompanying switch (as shown) connected in series with the potentiometer. This would allow you to remove the potentiometer from the circuit by opening the switch. Without the switch, it will not be possible to return the FSK 500 to the "Hard-Limiter" mode for conditions of fading signals. Occasionally you can find a potetiometer with the switch included.



Gain Adjust For The FSK 500
Fig. C.0-1

NOTES DE KA8HCG

NOTE ON FUSES: 9 JULY 1982

DAVE GRISSOM SAYS THAT RELAY WILL HANDLE STARTING CURRENT FOR MODEL 28ASR TELETYPE MACHINE, AND THE AGX-4 FUSE WILL HAVE TO BE INCREASED TO POSSIBLY A 5 AMP OR 6 AMP FUSE. MY 28ASR BLOWS THE 4 AMP FUSE 50 PCT OF THE TIME ON STARTING UP. ALSO, IF THE AUX. PERFORATOR (LPR-63) IS TURNED ON AND STARTS AT THE SAME TIME, THE FUSE WILL BLOW EVERY TIME.

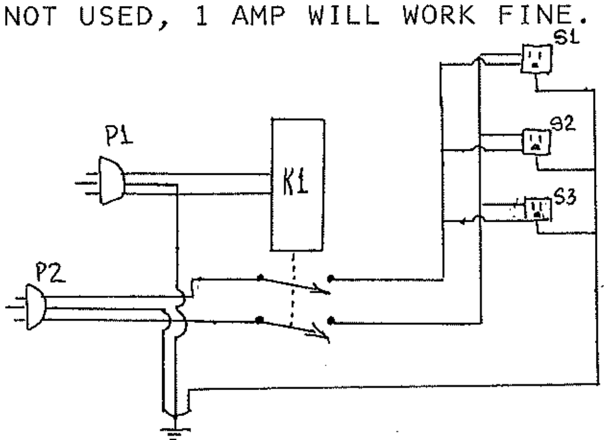
CHANGED TO A SIX-AMPERE FUSE (AGX-6) AND NOW THE 28ASR IS OKAY BY ITSELF, BUT IF THE PERFO LPR-63 IS ON, IT'S STILL 50/50 ON BLOWING THE FUSE.

COMPLETE SOLUTION

BUILD A BOX CONTAINING A LARGE RELAY (D.P.D.T., N.O. CONTACTS) WITH TWO POWER CORDS. THE MAIN POWER CORD IS PLUGGED INTO THE WALL SOCKET AND CURRENT IS FED TO THE TTY MACHINE PLUGS ON THE BOX THROUGH THE RELAY CONTACTS. THE SECOND POWER CORD GOES DIRECT TO THE RELAY COIL, AND IS PLUGGED INTO THE AUTOSTART SOCKET ON BACK OF THE FSK-500. THIS ALLOWS PLENTY OF EXTRA CURRENT-HANDLING CAPABILITY TO RUN COOLING FANS AND AS MANY MOTORS AS DESIRED.

MAKE SURE, WHEN CONSTRUCTING BOX, THAT 3-WIRE GROUNDING IS OBSERVED THROUGHOUT; OTHERWISE CASE OF 28ASR MAY BE AT 55 VAC POTENTIAL!

THEN USE A 2 OR 3 AMP FUSE INSIDE THE FSK-500. IF THE A/S OUTLET IS NOT USED, 1 AMP WILL WORK FINE.



K1: LARGE RELAY DPDT,NO

P1: CONTROL LINE 110VAC TO FSK-500 AUTOSTART

P2: POWER INPUT, SWITCHED TO WALL SOCKET

S1-S3: SQUARE APPLIANCE TYPE POWER SOCKETS

HOUSING: 3X5X8" ALUMINUM BUD-BOX