

## GENERAL

The ST-20C is a frequency domain Speech Inversion scrambler used to protect the security of two way radio communication systems. The cipher process inverts speech frequencies in reference to one of eight possible inversion carriers. Audio processing filters provide high quality, low distortion recovered audio. The small size and low power requirements make it ideal for portable, mobile, and base station use.

The ST-20C and ST-20B have only one difference. The ST-20C provides a low pass filter in parallel to the normal Receive audio path. This path is use for special applications where CTCSS detection MUST occur after the application point in the host radio.

Application information is available or can be developed for most radio models. Documentation on ALL current products and many of our application notes are available for instant access on our web site [www.selectone.com](http://www.selectone.com) If you would like application details for a specific radio, please call us at (510)887-1950 or request assistance via E-Mail at [techsupport@selectone.com](mailto:techsupport@selectone.com).

## SPECIFICATIONS

SPECIFICATION	DETAIL
<b>Encryption:</b> .....	Frequency Inversion
<b>Operating Voltage:</b> .....	5.2 Vdc to 16.3 Vdc
<b>Operating Current:</b> .....	< 8mAdc
<b>Available Carrier Freq's.:</b> .....	8
<b>Usable Audio Level Rx and Tx:</b> ....	25 mV p-p to 2.0 V p-p
<b>Input to Output Gain:</b> .....	< ± 1 dB
<b>Frequency Response:</b> .....	67 to 250 Hz No cipher 300 to 2600 Hz
<b>Temperature Range:</b> .....	-30° C to +60° C
<b>Interface:</b> .....	18" flying leads terminated in a 13 pin low profile connector
<b>Size:</b> .....	0.90" W x 1.50" L x 0.18" H (22.8mm x 38.1mm x 4.6mm)

**Note:** Operation of radio equipment with encrypted speech capability may be government regulated. The purchaser of this equipment is responsible for compliance with applicable radio regulations regarding operation of this equipment.

**Note:** Installation of secure speech equipment is often time consuming and costly due to the application requirements presented by the radio equipment. We may be able to provide a substantial cost savings for installation. Please contact the SmarTrunk Sales Department for details on factory installation of secure speech equipment.

## OPERATION

Operation is almost transparent to the user. The user may enable or disable the cipher mode with a single toggle or momentary switch. Once enabled all subsequent transmissions and reception will be ciphered using the carrier frequency selected during installation. Clear transmissions will appear as ciphered by a unit in cipher mode.

Each radio model provides different operational challenges. This is generally due to lack of unassigned switches or blank panel space capable of supporting accessory switches. To accommodate these varying situations the ST-20C provides two modes of operation for enabling and disabling cipher operation.

### SWITCHED OPERATION

Clear/Ciphered switching is achieved by a dedicated switch providing a single closure to (-) Supply. User Code Key selection is also selected by a dedicated switch providing a binary input to the two Code Select lines on the ST-20C.

### DOUBLE CLICK OPERATION

Double Click Operation minimizes accessory switch requirements on the radio. The Clear/Ciphered line is connected to any switch (except PTT) capable of providing momentary closures to or away from ground. The switch retains its normal functions; however the user can toggle between Clear/Ciphered by operating the switch two times in rapid succession (Double Clicking). The ST-20C will then provide a tone output to the radio speaker. A high frequency beep indicates subsequent transmissions will be ciphered. A low frequency tone for .5 Sec. indicates subsequent transmissions will be in the Clear (NOT Ciphered).

## INSTALLATION

Installation should be done only by a qualified two-way radio technician. Installation consists of programming, then mounting the unit in the radio set, and making the electrical connections.

SmarTrunk supports this product with application assistance via phone and with APPNOTES (Application Notes). We encourage use of our application service to determine hookup. Most radios do not provide an interface connector for easy installation of voice encryption equipment as is often provided for CTCSS applications. Radios that are not in our application library will receive special consideration and may qualify for sample installation of two units at the SmarTrunk factory for no cost.

Installation requires a minimum of eight external connections. These connections are Power, Ground, Transmit Audio Input and Output, Receive Audio Input and Output, PTT Input, and the Clear/Ciphered Input. The most critical connections are Transmit Audio Input and Output, and Receive Audio Input and Output. Improper installation of these connections can result in distorted audio, and the loss of either high or low frequency voice components.

## ELECTRICAL INTERFACE

The following paragraphs describe each of the external connections. Numbers shown in brackets [#] refer to the connector pin number.

**[3] POSITIVE (+) SUPPLY (RED):** This wire should be connected directly to a filtered source of continuous positive DC voltage in the range of +5.2Vdc to +16.3Vdc. This connection should be made "downstream" from the power switch and the power supply filter components in the radio set. If a regulated source of DC voltage is available, it should be used. Low level microphone audio is passed through the ST-20C and use of a quiet and stable source of DC voltage inside the radio set will reduce the possibility of picking up power supply noise that may affect audio signals.

**[9] NEGATIVE (-) SUPPLY (BLACK):** This wire should be connected to a location inside the radio that will supply a DC power ground return to the ST-20C. To eliminate ground loops and power supply noise, the ground return should be the same power supply ground used in the transmit and receive audio stages.

**[6] PTT INPUT (YELLOW):** Connect to the PTT circuit of the host radio. The ST-20B expects to see a logic low when the host radio is in transmit condition.

**Note:** Operation of the ST-20C will be erratic if the PTT input is allowed to float. If this point floats when the transmitter is not keyed, a pull-up resistor to Positive (+) Supply must be added.

**[8] AMP ENABLE (BLACK/BROWN):** Many radios power down the receiver audio amplifier when squelched.

**Double Click Mode:** When beep tones are not present this lead is high impedance. During beeping it is switched to ground through a series 10K resistor. If the receiver audio amplifier is turned off while the receiver is squelched, this output may be used to enable the amplifier for speaker beeping.

### [7] MONITOR/CLEAR/CIPHERED (BROWN)

**Switched Operation:** This wire is used to select the transmit cipher mode when pulled to logic low (< 1Vdc). This may be accomplished with an ON/OFF SPST switch. When this lead is at logic high (> 4Vdc) the ST-20C will operate in clear mode, ciphered operation is selected when this lead is low.

**Double Click Operation:** This wire may also be used as an input line for the Double Click signal. It is normally tied to the monitor switch of the radio, however any switch can be used. The connection point in the radio must switch between logic states, high (>4Vdc) and logic low (< 1Vdc). The ST-20C analyzes transition between these levels and is not concerned with the resting state following a double click. Clear/Ciphered power-up follows the conversions of switched operation. This lead is intended to operate in parallel with the existing radio function without effecting radio operation.

**Note:** To enable Double Click operation place a solder jumper across J11.

### [12] TRANSMIT AUDIO INPUT (GREEN)

**[13] TRANSMIT AUDIO OUTPUT (WHITE/GREEN):** These two wires should be connected in series with the transmit microphone audio signal path inside the radio set. The optimum location for connection is directly in series with the microphone. If the microphone requires bias, then the audio path MUST be broken "downstream" of the bias source. In order to provide the best transmit audio quality, be sure that the transmit audio signal path is broken BEFORE the pre-emphasis and transmit modulation limiter circuit. Also, be sure that the transmit audio path is broken next to a "DC blocking" capacitor, or in such a location as not to upset any internal DC bias voltages in the transmit audio stages. If this is not possible, a DC blocking capacitor should be placed in series with this lead.

**[4] SPK BEEP (WHITE/ORANGE): Speaker Beep & Double Click Mode:** Speaker beep is vital to operation in this mode. This lead is the beep output. It may usually be connected directly to the high side of the speaker.

### [11] RECEIVE AUDIO INPUT (BLUE)

**[1] RECEIVE AUDIO OUTPUT (WHITE/BLUE):** These two wires should be connected in series with the receive audio path inside the radio. The optimum location for connection is directly off the receiver detector circuit BEFORE any audio processing circuits (de-emphasis). This connection location will provide high quality audio recovery. Be sure not to break the audio path between the detector and the squelch circuit. Also, be sure that the receive audio path is broken next to a "DC blocking" capacitor, or in such a location as not to upset any internal DC bias voltages in the receiver audio stages. If this is not possible, a DC blocking capacitor should be placed in series with this lead.

**Note:** If the receive audio path can be broken after the CTCSS decoder, the ST-20B may be used instead of the ST-20C.

### [2] CODE SELECT 1 INPUT (VIOLET)

### [5] CODE SELECT 2 INPUT (BLACK/ORANGE)

**[10] CODE SELECT 3 INPUT (BLACK/YELLOW):** Code Select 1,2,3 inputs are used for selecting one of eight inversion carrier frequencies on the ST-20C. These inputs have pullups to +5Vdc internal to the uP, and may be left unconnected if only the Primary User Code Key is to be used. Table 1 indicates the Code Select requirements to select Inversion Carrier Frequencies.

(Logic High = Open, Logic Low = Grounded).

TABLE 1

Carrier Freq.	Code Select 1	Code Select 2	Code Select 3
3023 Hz	Open Circuit	Open Circuit	Open Circuit
3729 Hz	(-) Supply	Open Circuit	Open Circuit
2718 Hz	Open Circuit	(-) Supply	Open Circuit
3339 Hz	(-) Supply	(-) Supply	Open Circuit
3495 Hz	Open Circuit	Open Circuit	(-) Supply
3196Hz	(-) Supply	Open Circuit	(-) Supply
2868 Hz	Open Circuit	(-) Supply	(-) Supply
2632 Hz	(-) Supply	(-) Supply	(-) Supply

## ADJUSTMENTS

### GAIN SETTINGS

As shipped from the factory, the ST-20C is fully functional for many applications. However experience indicates the ST-20C functions best when audio signals internal to the ST-20C are at or near pre-determined levels. To optimize operation, receive and transmit levels must be evaluated independently and the proper gain setting resistors must be installed. Use the following procedures to determine the input level for the receive and transmit audio paths. The measured levels are for evaluation with TABLE 2. Use TABLE 2 to select resistors values for optimum operation. Measurements may be made with an oscilloscope or an AC level meter. For convenience TABLE 2 presents input levels in mV peak to peak and mVrms.

**TABLE 2**

Input Level				Gain Resistor			
MVpp		mVrms		TX	R35	TX	R28
From	To	From	To	RX	R21	RX	R4
10	65	4	23		1.1K		1.1K
65	125	23	45		2.2K		2.2K
125	250	45	89		4.7K		4.7K
250	500	89	179		11K		11K
500	1000	179	357		33K		33K
1000	2000	357	714		None		None

**Receive:** Measure the level on the [11] RECEIVE AUDIO INPUT (BLUE) lead while receiving a full quieting signal modulated at full system deviation. Use this level to select R21 and R4 from TABLE 2.

**Transmit:** The RF generated by the transmitter often makes it difficult to make accurate measurements for the microphone circuit. Two methods of measurement are presented, the first does not always produce accurate results. If method 1 does not appear effective, use method 2.

**METHOD 1**

Key the transmitter and, while speaking loudly into the microphone, measure the Peak to Peak level on the [12] TRANSMIT AUDIO INPUT (GREEN) lead. Use this level to select R35 and R28 from TABLE 2.

**METHOD 2**

Disconnect the [12] TRANSMIT AUDIO INPUT (GREEN) from its connection in the radio. Use an audio signal generator to inject a 1KHz tone into this lead. Key the transmitter and adjust the output level from the signal generator to produce 2/3 system deviation as measured on a service monitor. Un-key the transmitter and measure the output level from the signal generator. Use this reading multiplied times 4 to select R35 and R28 from TABLE 2.

**NOTE:** In some cases, the output level from the signal generator may be too low for accurate readings, or the level may be difficult to adjust. In these cases build a resistive divider with the supplied 11K and 1.1K resistors from the resistor packs. Don't damage the resistors as they may be required as gain resistors. Connect the 11K to the output of the signal generator, connect the 1.1K to (-) Supply for the ST-20C, and connect the junction between the resistors to [12] TRANSMIT AUDIO INPUT (GREEN). Key the transmitter and adjust the output level from the signal generator to produce 2/3 system deviation as measured on a service monitor. The output level from the signal generator divided by 10 produces 2/3 system deviation. Use this reading times 2 to select R35 and R28 from TABLE 2.

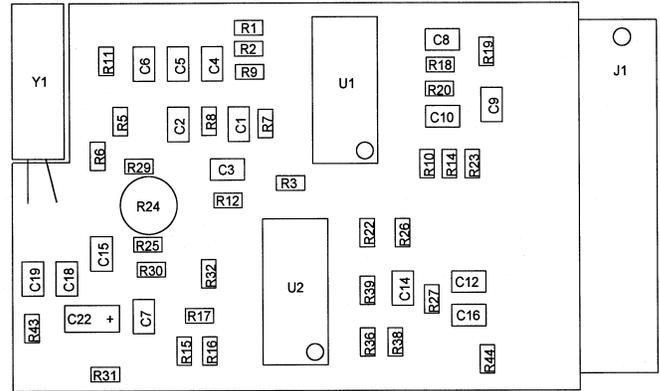
Don't forget to reconnect the [12] TRANSMIT AUDIO INPUT (GREEN) lead in the radio.

**MOUNTING**

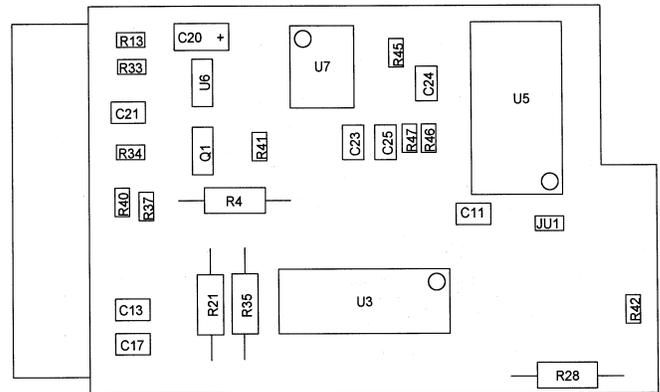
Use of a double-sided adhesive pad or an insulating shrink tube eliminates hardware requirements. When using the adhesive pad, mount the ST-20C on a clean dry surface, oriented to allow easy routing of the wiring to the radio and to allow future adjustments should they be necessary. Press firmly after mounting to ensure good adhesive contact. Do not touch the adhesive surface or attempt to re-position after mounting.

**ST-20C COMPONENT LOCATOR**

The ST-20C uses a multi-layer printed circuit board. Field repair is not recommended.



**TOP SIDE**



**BOTTOM SIDE**

**WARRANTY POLICY**

All Selectone products are guaranteed to meet or exceed published performance specifications and are warranted against defects in material and workmanship for a period of two (2) years from date of purchase. Third party equipment such as radios, power supplies, antennas, etc., carry the factory warranty of their respective manufacturers.

All warranty repairs must be performed at the SmarTrunk factory in Hayward, California, or other factory authorized repair depot. Any unauthorized repair attempted by the customer, alteration or modification of the equipment, damage by external sources, or removal or alteration of the serial number label or date code, will void the warranty. Specifically excluded from this warranty are batteries, fuses, lamps, and damage caused by lightning, power surges, or mechanical abuse.

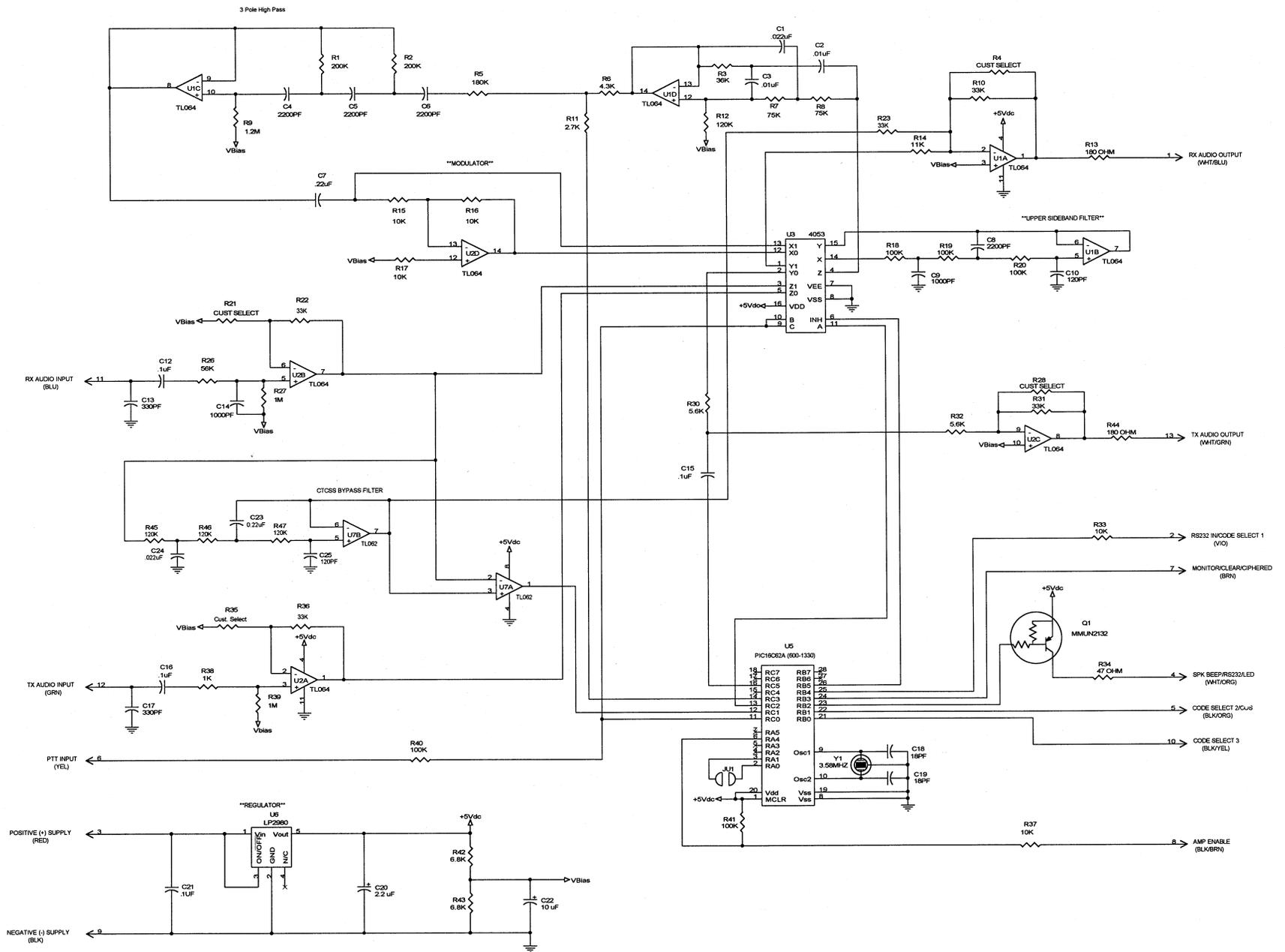
Equipment for repair may be returned to the factory without prior written authorization; however, a note must be sent with the packing list briefly describing the nature of the defect. Repairs must be shipped freight prepaid and will be returned freight prepaid. Shipments should be directed to:

SmarTrunk Systems, Inc.  
Attn: Repair Department  
23278 Bernhardt Street  
Hayward CA 94545, U.S.A.

E-mail: salesinfo@smartfunk.com • Web Address: http://www.smartfunk.com

23278 Bernhardt Street • Hayward, CA 94545-1621 USA  
Phone: +1-510-887-1950 - Fax: +1-510-887-4011

SmartFunk Systems, Inc.



ST-20C SCHEMATIC