SDR-Kits – PA0KLT Si570 VFO Synthesizer Kit for FIRST ISSUE PCB

IMPORTANT - This Manual is for Kits supplied before May 31st 2010 with PCB marking V238031



1. Introduction:

The "standalone" PAOKLT VFO Synthesizer kit uses the Silicon Labs Si570 XO Low noise Synthesizer chip controlled by a Atmel Mega 8 or Atmel Mega 88 Controller with connections to an external 16 or 20 character x 2 lines LCD Display and a 96 step rotary encoder for tuning.

Frequency coverage is from 3.5 MHz up to 945 MHz, depending on the type of Si570 device fitted. The minimum tuning step is selectable from 1 Hz, 10Hz, 100 Hz, 1kHz upwards.

The design offers a Smooth Tuning like in a high quality Analogue VFO – There is no interference when the frequency of the Si570 is tuned within +/- 3500 ppm from last Coarse Frequency command executed. Tuning speed is 96 steps for each turn of the tuning control knob.

Up to **32** frequencies may be stored in Memory in two banks (Memory A and Memory B)

This kit is the latest version of the "Universal Si570 project" by Ton PA0KLT, which was first published in Dutch in "Nieuwsbrief" the club journal of BQC, the Belgium and Dutch QP in 2008 and 2009 (http://home.wanadoo.nl/bqc/)

2. Brief Specification:

- Standalone Low Noise VFO Synthesizer suitable as Signal Generator, Local Oscillator or VFO etc with good frequency stability for many (Amateur) Radio Projects.
- Si570 "Smooth Tuning" Algorithm No interuption of rf output when Si570 is tuned within +/- 3500 ppm of last Coarse Frequency command. 96 steps/rotation by firmware.
- 32 Frequencies may be stored in Memory in two Memory Banks
- Frequency coverage options depending on Si570 type fitted:
 - Si570CAC CMOS: 3.5MHz 160 MHz at 3V pkpk Square wave CMOS Output (215 MHz possible but not guaranteed)
 - Si570BBC LVDS: 3.5 MHz 280 MHz at 0.7V pkpk LVDS level
 - Si570BBB LVDS: **3.5 MHz 810 MHz** at 0.7V pkpk LVDS level (Max 945 MHz possible but not guaranteed)
- Mode Offset applied: AM = 0 kHz, USB/LSB = +/-1.5 kHz and CWU/CWL = +/-750 Hz
- Power Supply voltage: 8-12V or from single +5V supply with modification
- Current consumption 125mA (20mA drawn by LCB backlight)
- Provision of RF output transformer options on PCB
 - Homebrew BN43-2402 4:1 transformer up to 200 MHz (BN61-2402 core to 300 Mhz)
 - Minicircuits T-622 4:1 up to 200 MHz
 - Coilcraft WBC4-1WLB up to 800 MHz (fits on PCB)

A Minicircuits ADT4-1WT 4:1 transformer 2 - 775 MHz may also be used by cutting tracks on the PCB.

- Support industry standard LCD display 2 x16 to 2x20 characters
- LCD module supplied has built-in backlight size 73mm x 36mm
- PCB size: 70mm x 34mm Tin plated screen box available.
- Firmware written in Assembler and supports following features:
 - Programmable IF Offset, minimum and maximum frequency and SI570 I2C address
 - Si570 Frequency calibration
 - Programmable multiplier x1. x2 x4 or x8
- If an IF-Offset is of <100 kHz is specified then the IF-offset will be removed with a delay of 5mS if the Lock (PTT) is activated by grounding this line to earth.
- If an IF-Offset is specified <1000 Hz then the 5 mS delay will not be applied (FSK)
- Kit suitable for constructors with some previous kit assembly experience. Some components like capacitors (0805mm) and Si570 are Surface Mount Devices. Ability to understand circuit diagrams is required if the kit is to fit your specific requirements.

The following parts are supplied in the basic kit.	
Parts marked in blue are options as ordered by you.	

Pcs/kit	Part	Value	Remarks	
1	C1	10uF Electrolytic	Radial	
5	C2, C3, C4, C5	1uF Ceramic	0805 SMD Blue stripe	
	C6, C7, C8, C9,			
8	C10. C11	100nF Ceramic	0805 SMD - No marking	
2	C12	1nF Ceramic	0805 SMD - Black Stripe	
3	R1, R3	4k7 0.25W	vellow violet black black brown	
1	RV1	4k7	adjustable	
1	R4	47 ohm 0.6W	For LCD backlight	
1	D1	1N4001		
1	U3	LF33ABV	3.3V LDO Regulator TO220	
1	U4	7805	5V Regulator TO220	
1	U1	ATMega8-16 or Mega88-20PU	PAOKLT Firmware marked	
1	IC Socket	28 pin DIL for U1	28 pin	
1	P1	2 pin header plug (+8 - +12V)	0.1" male	
1	P2	3 pin header plug (HF Out)	0.1" male	
1	P3	LCD Header	14 pin IDC Male	
1	P4	Aux Conn Header	20 pin IDC Male	
1	J1	LCD Connector	14 pin IDC female	
1	J2	Aux Connector	20 pin IDC female	
1	PCB	PA0KLT	SDR-Kits - marked V238031 on trackside	
2		mini push switch	Red (Mem and ESC)	
2		mini push switch	Black (< and >)	
0.3	Ribbon cable	16 way		
1	Encoder	Encoder	24 step	
1		LCD Display with backlight	16 character by 2 lines	
1	U2 option 1	Si570CAC000141DG	3.5-160 MHz - max 210 MHz - CMOS output	
1	U2 Option 2	Si570BBC000141DG	3.5-280 MHz - LVDS output	
		0.570000000000000		
1	U2 Option 3	SI570BBB000141DG	3.5-810 MHZ - MAX 940 MHZ - LVDS output	
1	T1 Option 1	43 BN 2402 kit	with 32AW/G = 0.23mm enamelled wire	
1	T1 Option 2	Colleraft ADTA 1V/T 4.1	wound transformer	
	l			

Caution - This Manual is applicable to Kits supplied up to May 31st 2010 with PCB marking V238031

If the PCB supplied has V238031 printed on the track side then this manual is applicable. If another number is printed on the PCB then do NOT use this manual but download and use the PAOKLT Assembly and Operations MANUAL for SECOND ISSUE PCB.

4. PCB Assembly instructions

Assembly of the PCB should be quite straight forward. Observe antistatic precautions especially when handling Semiconductors - Si570 and the programmed AVR. The Kit assembly sequency is as follows:

- Assemble the PCB and check voltages on regulators
- Wire up LCD Display unit and Aux Connections to 4 push buttons
- Install AVR in socket
- Apply Power and check AVR and LCD functionality
- Solder in Si570 XO Synthesizer chip and test RF output

Use a 15-40W Solder station or a 15W - 25W soldering iron and 0.5mm solder. SMD soldering is not difficult - Apply a little tin to one of the pads, place the SMD capacitor over the pads and apply heat to make the bo.d. Once the SMD part has been soldered to one of the pads continue by soldering the second pad and finish off by reflowing the tin on the first pad, applying a little more tin if necessary. Use a magnifying glass to inspect any joints.

Caution: Do NOT solder U2 = Si570 until instructed to do so.

- () Start by fitting the 1uf Ceramic 0805 capacitors C2, C3, C4 and C5 (blue stripe) as shown in fig 2. (there is no polarity indication as capacitors are bipolar)
- () Solder 100nF 0805 capacitors (no markings) C6, C7, C8, C9, C10 and C11
- () Solder C12 = 1nF black stripe
- () Solder R1, R2 and R3 = 4k7 resistors (yellow violet black black)
- () Fit and solder RV1 4k7 Preset
- () Fit diode D1 1N4001 observe white band and solder
- () Fit 28 pin DIL socket Observe notch and align as shown on PCB. Ensure that the socket is mounted flush to the board solder pin one and pin 28 then check for a snug fit to the board. If it is not apply a slight pressure to the DIL socket and re-solder the pins. Once it is flush solder the rest of the pins
- () Fit connectors P1 (location 8-12V) and P2 (location HF Out) making sure that the short pins are the ones you solder to the board.

() Refer to fig. and fit connectors P3 (14 pin LCD header) and P4 (20 pin AUX Connector).
Caution - ensure that the notch in the connector is on same side as the marking of Pin 1.
Use the same procedure as you did with the 28 pin DIL socket to ensure that the connectors are flush with the board.

- () Fit TO220 Regulators U3 (LF33) and U4 (7805) and check position against PCB before soldering
- () Fit C1 = 10uF Electrolytic. Note: there are no holes provided for C1 on the current PCB version. C1 is (sometimes) required to prevent oscillation on the +3.3V Line. Caution observe polarity Mount C1 by soldering the negative wire to P1 -12V pin and the positive wire to "OUT pin of the LF33 3.3V wire as shown in fig 1.

Fig 1. - fitting of C1



Inital PCB testing

At this stage all components except the AVR and SI570 are fitted on the PCB.

- () Connect +8V 12V DC Power to P1 on the PCB observe polarity. Current consumption should be no more than 20mA at this stage. Switch of and investigate if current is too high or if any components are getting hot or any of the voltages are not within +/- 5% of the expected valued.
- () Use a DC voltmeter to check whether +5V is present on the "IN" of U3 LF33. and +3.3V is present on the output pin of U3 - LF33 regulator before proceeding.
- () Switch off Power and remove leads from P1.

Final Assembly

CAUTION: In the following step ensure the 14 Way cable is connected correctly so pin 1 of LCD is connected to GND and Pin 2 to +5V otherwise the LCD display will be destroyed.

- () LCD Connector J1: In this step the wiring to the LCD display. Refer to Fig 4. Before cutting to length you will wish to consider how long the cable needs to be to fit in the enclosure you are going to use. Cut a length of 16 way ribbon cable required to connect between PCB and LCD module. Peel off two of the cores at the opposite end to the red cores to reduce the cable to 14 wires. Fit the cable at right angle into the IDC connector so the red coloured wire connects to P3 Pin 1 (See fig 2). Clamp into a small vice. Turn the vice until the ribbon cable is solidly pressed into the connector. Caution: Over-tightening may damage the connector.
- () Remove a 2mm insulation from the end of each of the wires. Refer to Fig 6. and Solder the 14 wires to the LCD module. Observe connections as shown in fig 5. (J1 pin 1 connects to LCD pin 1, J2 pin 2 to LCD pin 2 etc)

- () **LCD Backlight connections J1:** Caution the following instructions are only valid for LCD modules supplied by SDR-Kits: Use the two wires removed previously and solder one wire from LCD Pin 1 to LCD Pin 16. Solder one end of the 47 Ohm resistor to LCD module pin 15 and the other end of the resistor to Pin 2 of the LCD module. (This is shown in fig 6.)
- () AUX Connector J2: Fit the required length of 16 way ribbon cable on the 20 Way connector J2 similarly to how you prepared the cable for the LCD module. Caution the red coloured wire should connect to pin 1 of P4, Note: the correct orientation of the pins for J2 is shown in Fig 2 and Fig 4. Pin 17-Pin 20 are reserved for future use.

The table below shows the essential connections required to support the four pushbuttons (<> ESC and MEM) and the Rotary Encoder for Tuning.

Wiring Aux Connector – J2 (mates with P4)				
Description	Remark			
Band Select Output A	Optional use			
Band Select Output B	Optional use			
Band Select Output C	Optional use			
Band Select Output D	Optional use			
< cursor pushbutton	essential connection			
> cursor pushbutton	essential connection			
Rotary Control "A"	essential connection			
Rotary Control "B"	essential connection			
AM Mode Select input	Optional use			
+5V output	Optional use			
GND	essential connection			
ESC pushbutton	essential connection			
MEM pushbutton	essential connection			
SSB/CW Select input	Optional use			
LSB/USB Select input	Optional use			
LOCK input	Optional use			
PB2 – D4	Future Use			
PB3 – D5	Future Use			
PB4 – D6	Future Use			
PB5 – D7	Future Use			
	Aux Connector – J Description Band Select Output A Band Select Output B Band Select Output C Band Select Output D < cursor pushbutton			

Table 1: Aux Connector J2

- () **Rotary Encoder:** The 24 step encoder (enhance to 96 steps due software) comes standard with a "click mechanism" which can be easily disabled. This is preferred by most users. Please see Appendix 1 for modification instructions.
- Viewed from the back of the encoder and with the pins facing down, solder wire from pin 11 (GND) to Left pin of the encoder.
 The wire from Pin 7 (Rotary control A) is soldered to the Right lug.and the wire from Pin 8 (Rotary Control "B") to the middle lug. See Appendix 1. fig 2.

() AVR Chip installation

Caution observe ESD precautions by grounding yourself with a ESD strap or frequently touching the stations EARTH connection.

() Install the programmed AVR (AT Mega8 or AT Mega88) into the 28pin socket. It may be necessary to gently bend all the pins slightly first before the AVR will fit into the IC socket. Check that the notch of the AVR points towards the location where the Si570 will be mounted later. (See photo on page 1).

Initial Functionality test

At this stage the kit is fully assembled with exception of the SI570.

- () Adjust Preset Resistor RV1 to full Anti clockwise position
- () Connect +8V 12V DC Power to P1 on the PCB observe polarity. Current consumption should be no more than 30mA at this stage.
- () The LCD Screen should display the Welcome Message as shown in Fig 6. after Power up and the Frequency should change when turning the Tuning Control.
- () Adjust Preset Resistor RV1 for "best contrast" on the LCD Screen.
- () Switch off Power and remove leads from P1.

Si570 Installation

In this final step the Si570 chips will be installed. **Caution** observe ESD precautions by grounding yourself with a ESD strap or frequently touching GND connection.

() Refer to fig 2. and coat PCB pads marked 1 and 4 for the Si570 with a small amount of solder. Locate Si570 pin 1 indicated by a dot on the case and align with pad 1 shown in fig 2 below. Place Si570 over the pads and solder pin 1 to the pads secure the chip to the PCB. Check alignment. Next solder all remaining pads to the PCB. Make sure there is a small bow of solder connecting the side pad of the Si570 to the PCB pad. Check all connections, especially if pad 7 and 8 are properly soldered to the PCB pads. (Common reason why AVR does not talk with the Si570 chip)

Final Functionality test

() Connect +8V - 12V DC Power to P1 on the PCB - observe polarity. Current consumption should be no more than 100-150mA depending on Si570 type. The LCD Screen should display the Welcome Message after Power up and the

Frequency should change when turning the Tuning Control.

() Connect a RF Counter, Oscilloscope to the Si570 output to check RF output is obtained. Alternatively hold the antenna lead of a communications receiver near the Si570 output terminal and check whether the Si570 RF signal is audible.



fig 2: Top Component placement view PA0KLT PCB - Note location Pin 1 of P3 and P4



Fig 3: Bottom Component Placement view PA0KLT PCB



Fig 4: Circuit Diagram of PA0KLT Synthesizer





Notes:

- LCD Display supplied by SDR-Kits backlight connections: Connect pin 16 to pin 1 (GND) and Pin 15 via a 47 Ohm resistor to pin 2 (+5V)
- 2. C1 10uF electrolytic is fitted over the output of the LF33 regulator to stop oscillation on 3.3V supply.
- 3. Rotary encoder: Viewed from rear with pins facing down: GND = Left, B = Middle and A = Right
- 4. Capacitor colour coding: 1 uF 0805 = blue, 1 nF 0805 = black, 100 nF 0805 = no colour/no stripe

PAOKLT	Firmware 4.16	3.45 MHz – 945 MHz	
Required Mode	Connection	Offset	Remarks
AM	9 to GND	0 Hz	
LSB	No connections	Displayed Freq – 1.5 kHz	Default
USB	9 and 15 to GND	Displayed Freq + 1.5 kHz	
CWL	9 and 14 to GND	Displayed Freq – 0.75 kHz	
CWU	14 and 15 GND	Displayed Freq + 0.75 kHz	
		If IF offset = set to any frequency less than 100 kHz then both IF	
		offsset and Mode offset are removed regardless what mode is	
LOCK	16 to GND	selected	
		If IF offset = set to any frequency more than 100 kHz then only Mode	
		Offset is removed	

Table 2: Mode Offset information

Note: Calibration should always performed with in AM Mode (0 Hz Offset)

Band Select Output				
	Band Output	Frequency MHz		
0	0000	0.1357 – 0.1378		
1	0001	1.8 – 2.0		
2	0010	3.5 – 4.0		
3	0011	7.0 – 7.3		
4	0100	10.1 – 10.15		
5	0101	14.0 – 14.35		
6	0110	18.068 – 18.168		
7	0111	21.0 – 21.45		
8	1000	24.89 – 24.99		
9	1001	28.0 – 29.7		
10	1010	50.0 - 54.0		
11	1011	144.0 – 148.0		
12	1100	430.0 - 440.0		
13	1101	0-30.0 *		
14	1110	30.001 – 180.0 *		
15	1111	180.001 - 800.0 *		
* = Frequency selected outside Amateurband				

Table 3: Band Select Output on AUX Connector J2 pin 1, 2, 3 and 4 (A, B, C, D)



Fig 6: LCD Connections and 47 Ohm Resistor soldered to pin 15 with link to pin 2 (+5V). Pin 16 is linked to pin 1 (GND)

5. Kit Configuration Options:

A number of options are available depending on the type of Si570 chip ordered and application are illustrated in fig 7. Reasons for using a transformer are:

- Matching the Si570 CMOS device which has approx 200 Ohm output impedance to a 50 Ohm load by using a 4:1 transformer. Up to +12dBm output over 50 Ohms may be obtained this way. Please note the Si570 CMOS only has one output
- Si570 LVDS devices have two (push-pull) complimentary outputs. Using a 4:1 transformer with a centre tap on the primary allows combining the two outputs and matching into 100 Ohms. An external MMIC amplifier (MAV11 or equivalent) will provide 12dB gain...
- The secondary of the transformer may be grounded at one end to obtain single ended output.

The following transformers have been used:

- homebrew transformer. This consists 5 turns 0.2mm wound trifiliar on a BN43-2402 core up to 200 MHz. alternatively use a BN61-2402 core with 6 turns 0.2mm trifiliar for up to 300 Mhz.
- You can also use a Minicircuits T-622 4:1 up to 200 MHz This drops into the PCB.
- Another option is the Coilcraft ADT4-1WT 4:1 up to 800 MHz this is a SMD transformer No pads are provided on First issue PCBs.



Fig 7: RF Output configuration options

6. Operating instructions PA0KLT - Si570 VFO v4.0 firmware

Four push Buttons and the Rotary Tuning control are used to operate the VFO: These are: Cursor "<", Cursor ">", Escape ESC, Memory MEM and TUNING (Rotary tuning Control)

6.1) There are four modes of Operation: These are:

- VFO A (VFO A frequency Manual tuning Frequency Recal and Store)
- VFO B (VFO B frequency Manual tuning Frequency Recal and Store)
- Memory A (16 Memory Locations 1 16 to Recall or Store Frequencies)
- Memory B (16 Memory Locations 1 16 to Recall or Store Frequencies)

A Short push on "MEM" button switches between these four modes

6.2 VFO Mode A or VFO Mode B

- The Tuning speed Frequency step is adjusted with < and > CURSOR keys. The mininimum frequency step can be set from 1 Hz, 10 Hz, 100 Hz, 1 kHz etc up to 100 Mhz
- Press ESC sets all the digits right of the curser to zero
- To store the current frequency the MEM key is pressed for 2 seconds until the LCD displays STORED
- When selecting VFO A or VFO B mode (using short push on MEM button) the stored frequency is recalled and displayed on the LCD display. Changing the frequency is done with the TUNING KNOB.

6.3 Memory Mode

- Select Memory A or Memory B using a short push on the MEM button and use < > cursor buttons to select the required memory location (1 16). The previously stored frequency in the selected memory location is now displayed.
- Pressing ESC button **or** TUNING KNOB changes the display to MANUAL TUNING and a new frequency may now be selected.
- To store the current frequency the MEM key is pressed for 2 seconds until the LCD displays "STORED"
- Press ESC sets all the digits right of the curser to zero

6.4 Synthesizer Configuration Mode

The desired frequency and mode is configured as follows Press CURSOR < and > keys together for about 2 seconds until the configuration menu appears.

Release and use CURSOR buttons < or > to select Configuration Options 1 to 8 as described below. Store your selection by pressing the MEM key

1. Intermediate Frequency (IF) Offset Mode:

Press MEM and select the desired (MF Offset =IF Offset). The offset can only be a positive frequeny (Local Osc is higher than IF Signal Frequency). Press MEM to store the offset. Press ESC to cancel.

Note 1. If an IF-Offset of less than <100 kHz is specified then the IF-offset will be removed with a delay of 5mS if the Lock (PTT) is activated by grounding this line to earth.

Note 2. If an IF-Offset of less than <1 kHz is specified then the 5 mS delay will not be applied (as is the case for FSK)

2. Calibration mode:

Note: Calibration should always performed with in AM Mode (0 Hz Offset)

Press MEM momentarily. The Si570 Crystal frequency is now displayed and may be changed so the SI570 output frequency measured on a counter is exactly as displayed on the LCD display. Once the corrected Crystal frequency has been selected press the MEM for 2 seconds to store the new value.

3. Multiplier (Si570 output frequency = (Displayed Frequency * Multiplier)

Presss MEM momentarily and select the required multiplier factor: 2^0 for Multiplier 1, 2^1 for Multiplier 2, 2^2 for Multiplier = 4 and 2^3 for Multiplier = 8. Press MEM for 2 seconds to store.

4. Default Configuration

If the configuration is corrupted for whatever reason the default configuration may be loaded in EEPROM. Press MEM momentarily. Press MEM for 2 seconds to confirm or ESC to cancel

5. Set Maximum Frequency for Si570

The maximum frequency which is supported by the Si570 depends on the installed Si570 chip as well as the IF Offset and the Multiplier value selected. For example: Si570BBB max frequency is 945 MHz. If a IF Offset of 40MHz and Multiplier of 4 is selected then the maximum frequency will be (940-40)/4 = 225 MHz. Press MEM briefly and set maximum frequency using rotary control and > buttons. Press MEM for 2 seconds to store or press ESC to cancel. (Max Freq = 945 MHz is supported on V4.15 firmware)

6. Minimum frequency for Si570

The minimum frequency which is supported by the Si570 and the firmware is 3.50 MHz but IF Offset and Multiplier need to be taken into account. For Example if IF Offset = 40 MHz and multiplier of 4 is selected then the minimum frequency should be set to: (3.5+40)/4

7. Configuring I2C adres Si570

In V4.13 firmware: This option allows you to select the correct I2C address for AVR to communicate with the Si570 chip. Si570 chips supplied by SDR-Kits from England or by Tom Hoflich KM5H have address HEX 55. Si570 supplied by others may use other addresses (for example on German Supplier uses HEX 50). For V4.15 firmware: you may specify any I2C address between Hex 50 and Hex 5F. The default is Hex 55.

8. END Configuration

Selection of of this option exits the configuration mode and returns to normal tuning mode with the new saved configuration selected.

6.5 Complete Power-up Reset.

On **rare** occassions the EEPROM data may become corrupted which could prevent the VFO from initializing properly. Erasing EEPROM and applying the default Configuration is not possible and a Power-up Reset may be necessary as follows:

Press ESC and MEM buttons at same time and apply DC Power until the LCD Screen shows the normal start-up screen. Release ESC and Mem buttons. Any configuration information previously applied have been lost and need to be re-applied.

Success & 73s

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PCB Design and Firmware development

APPENDIX 1 - Removing clickstop from Rotary encoder

Note: The rotary encoder supplied has 24 clickstops, which is enhanced to 96 steps per resolution through firmware by detecting additional steps between each clickstop. Removing of the clickstop is essential for the enhancement to resolution of 96 steps per resolution.

() Gently bend open the four lugs from (two at each side) of the encoder and remove the rear plate as shown in the picture below.



Appendix 1 - Fig 1 - Adjusting Click Stop Spring

() Remove the contact assembly as shown in the photo below and locate the contact spring.

Gently bend the sliding contract spring away to the back so the pressure on the rotary disc is reduced.

Ideally you want to maintain a little pressure - You can test by placing the contract assembly back and trying out until you feel it is right for you.

CAUTION: Do not touch or try to adjust the three sliding contacts below as it may damage the encoder and cause erratic operation.

() After adjustment fit the rear plate and secure by bending the lugs back in original positon



Appendix 1 - Fig 2 - Adjusting Click Stop Spring

End of Appendix 1.