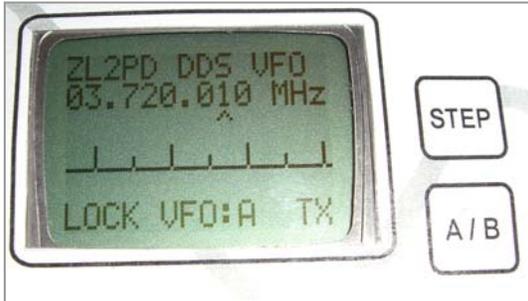


## ZL2PD DDS VFO Modifications



- Using different receiver IF Frequencies, and
- Changing the DDS VFO for use with a common Tx/Rx offset frequency

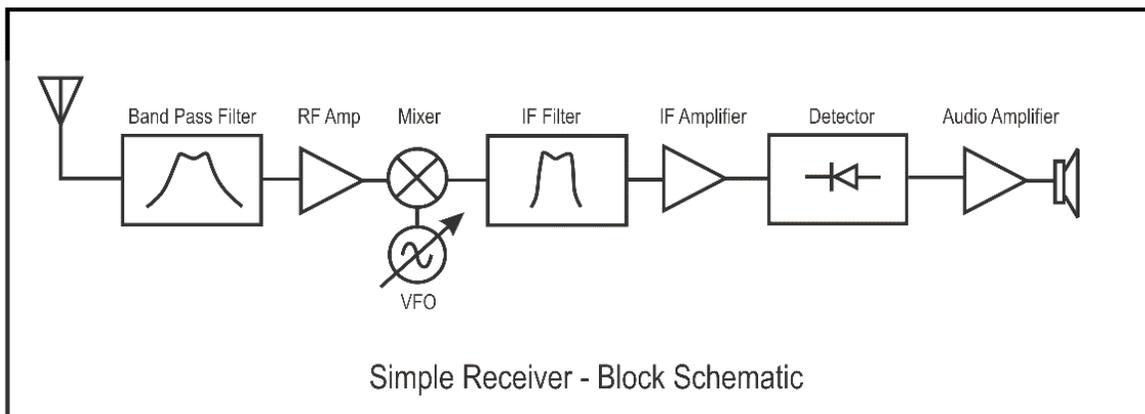
### Introduction

Some builders have recently asked for some additional information to help them use the DDS VFO with other IF (Intermediate Frequency) frequencies. The original design assumed an IF of 8.467 MHz, and a number of builders want to change the software to suit other IF frequencies.

The DDS VFO output frequency is offset by the IF frequency when in receive mode, and no IF offset is applied when in transmit mode. This design is a typical VFO arrangement for morse code (“CW”) operation, but SSB transceivers more commonly use a VFO which is offset by the IF frequency during both transmit and receive operation. Several emails asked about the changes required for that arrangement.

### An Explanation about VFOs and IFs

In most basic receivers, the incoming signal is mixed with the VFO to produce the IF frequency. This signal is then amplified and the information detected or decoded in some fashion.



For example, to receive a 10 MHz signal in a receiver with a 9 MHz IF, the VFO could either oscillate at 1 MHz (Called “low-side injection” because the VFO is lower in frequency than the frequency being received) or 19 MHz (“high-side injection”). The choice of whether to use low or high side injection is usually determined by a number of factors beyond the scope of this document.

## Understanding DDS VFO Limits

With an 80 MHz DDS reference clock, as I used in the original DDS VFO design, the maximum frequency that can be generated by the AD9850 DDS chip is 40 MHz. But “aliasing” causes interference products which limit the maximum output frequency well below this limit.

With an output of 30 MHz and a reference clock of 80 MHz, there will be an unwanted ‘alias’ frequency output produced by the chip at 50 MHz. If the output frequency is increased to 35 MHz, then the additional unwanted alias output frequency is 45 MHz.

The unwanted alias output signals must be filtered out, and this is the reason for the filtering on the output of the DDS chip. The sharper the filter cutoff, the closer the VFO can operate to 40 MHz. However, practical RF filters which filter off these unwanted aliasing outputs from the DDS chip prevent the operation of the VFO above 30 MHz in most cases.

If the maximum DDS reference clock of 120 MHz for the AD9850 is used, then the DDS VFO could operate up to about 45 MHz (with a minor change in the output filter design).

In the original design, an IF of 8.467 MHz was used, and assuming a maximum DDS VFO output frequency of 30 MHz, then the DDS VFO as originally designed will produce the following VFO output frequencies:

Band (MHz)	DDS VFO Output Frequency		IF Offset
	Transmit Mode	Receive Mode	
1.8 – 1.9	1.8 – 1.9	10.267 – 10.367	Add 8.467 MHz
3.5 – 4.0	3.5 – 4.0	11.967 – 12.467	Add 8.467
7.0 – 7.5	7.0 – 7.5	15.467 – 15.967	Add 8.467
14.0 – 14.5	14.0 – 14.5	22.467 – 22.967	Add 8.467
21.0 – 21.5	21.0 – 21.5	29.467 – 29.967	Add 8.467
28.0 – 30.0	28.0 – 30.0	19.533– 21.533	Subtract 8.467

Note: This table only details the DDS VFO output for some of the ham bands available in the DDS VFO design. See the article for more details.

The table shows that the DDS VFO output frequency never rises above 30 MHz, the desired result.

## Using Other IF Frequencies

Now, let's look at how to use a different IF frequency. In the Atlas 210X/215X HF transceivers, the IF used was 5520 kHz (5.520 MHz). Looking at the same six ham bands (For those that really want to know, the Atlas 210X covered the higher five bands, the 215X covered the lower five bands), the Atlas designers decided that the VFO should work like this:

Band (MHz)	ATLAS 210X/215X VFO Output Frequency	IF Offset
	Transmit AND Receive Mode	
1.8 – 2.1	7.320 – 7.620 MHz	Add 5.520 MHz
3.5 – 4.0	9.020 – 9.520	Add 5.520
7.0 – 7.5	12.520 – 13.020	Add 5.520
14.0 – 14.5	8.480 – 8.980	Subtract 5.520
21.0 – 21.5	15.480 – 15.980	Subtract 5.520
28.4 – 29.4	22.880 – 23.880	Subtract 5.520

Note: The Atlas designers chose to limit operation to just 1 MHz of the 10m band rather than cover the usual 28.0 – 29.7 MHz range.

In this case, you will see that the Atlas analog VFO operates at the same frequency in both transmit and receive modes, and the mixing arrangement kept the VFO output below 24 MHz, probably for mixture of stability and performance reasons. The reason is due to the Atlas transmitter and receiver sharing a common IF filter stage.

## Modification 1: Changing the IF Offset Frequency

To use this 5.520 MHz IF offset with the DDS VFO, we need to change the 32 bit IF offset value used in the DDS VFO software. To match this arrangement of addition and subtraction of the IF offset, we need to change the frequency at which the DDS VFO changes offset calculations from addition to subtraction of the 32 bit IF offset value.

Here's how to do it.

**Step 1:** Calculate the new 32 bit IF offset value. This value will depend on the IF offset value and the DDS reference clock.

You can use the web-based calculator found at [www.analog.com](http://www.analog.com) for the AD9850 DDS (I found it at <http://designtools.analog.com/dtDDSWeb/dtDDSMMain.aspx?part=AD9850> but it may have moved by the time you get there) or you can download my little Excel

spreadsheet (9850wordcalc.xls) found on my website at [www.geocities.com/ZL2PD/index.html](http://www.geocities.com/ZL2PD/index.html)

Examples:

Ref Clock (MHz)	IF Offset (MHz)	32 bit Offset Value			
		W3 (MSB)	W2	W1	W0 (LSB)
80 MHz	8.467	1bh	18h	2ah	99h
80 MHz	5.520	11h	a9h	fbh	e7h

(For those new to software, the letter 'h' is used to show that the number is written in HEX or Base 16 format)

In the DDS VFO software, this IF Offset value is stored in four bytes labeled **ifword4** to **ifword1** in lines 259 – 263 of the source code listing. Replace these values with the new ones you have calculated.

Note: The Metawave 8051 assembler insists on hex values greater than 9f being written with a leading zero. i.e.

WRONG:    mov   ifword4,#a9h

CORRECT:  mov   ifword4,#0a9h

**Step 2:** Set the low-side/high-side changeover frequency. This is the value at which the IF offset changes from being added to the output frequency to being subtracted from the output frequency.

The test is done in line 1248 of the code in the subroutine **wrdds** (write data to the dds chip) with the instruction:

```
cjne a,#22d,xdds01
```

In the original source code and software, this sets the changeover frequency for the DDS VFO I built for my application at 22 MHz.

In the example here for the Atlas 210X/215X, this changeover frequency needs to be somewhere between 8 and 13 MHz. (The software only looks at the MHz digits of the nominal receive frequency for simplicity) Since we might wish to add the 30m band (10.1 – 10.12 MHz) to an Atlas, we could set the changeover frequency to be at any useful integer MHz value above this band i.e. At 11, 12, or 13 MHz. This example will use 13 MHz.

The instruction at line 1248 is changed to:

```
cjne a,#13d,xdds01
```

It might be useful to modify the comments in the lines around this instruction to reflect the change in changeover frequency from 22 MHz to 13 MHz. Your choice.

Note: The letter ‘d’ after the numeric value tells the assembler that this is a decimal number.

## Modification 2: Common Transmit/Receive Mode VFO Operation

To configure the DDS VFO software for use with common IF offset in both transmit and receive mode, we will need to make a minor change to the software.

To set the DDS VFO up to use the same IF offset at all times, i.e. in both transmit and receive modes, you could just ignore the Tx button on the front panel. However, this would mean that the RIT (receiver incremental tuning) could remain operating during transmit, generally not a good thing to do.

The required change is minor, moving the test of the transmit mode flag bit to a point in the code after the offset calculations are done, This ensures the IF offset is *always* added or subtracted and also ensures the RIT is only used in receive mode.

The transmit mode is flagged in the software with the **pttstate** flag and the relevant subroutine is again the **wrdds** routine.

**Step 1:** At line 1231, DELETE:

```
        jb      pttstate,xdds08      ;if transmit mode then no IF/RIT offset
```

Note: Be careful not to remove the label on the same line i.e. “wrdds:”

**Step 2:** Insert a new line at line 1268 and ADD the previously deleted instruction. i.e.

BEFORE:

```
xdds05:    jnb      ritstate,xdds08      ;rit in use?
           ;
           mov     r0,#ddsword1        ;yes, so add/subtract rit offset
           mov     r1,#ritword1 (etc...)
```

AFTER:

```
xdds05:    jb     pttstate,xdds08    ;if transmit mode then no RIT offset
           jnb    ritstate,xdds08 ;rit in use?
           ;
           mov    r0,#ddsword1  ;yes, so add/subtract rit offset
           mov    r1,#ritword1 (etc...)
```

Note: The “(etc...)” is there to indicate the continuation of the listing and is not a suggested addition – just in case there is anyone out there left wondering if they should also type that into their source code. No, don’t do that.

That’s it, folks. Enjoy!

73

Andrew, ZL2PD

References:

1. Solid State Design for the Radio Amateur
2. ARRL Handbook
3. RSGB Handbook
- 4.