Notes on Switch setting for DMC 20 GHz source

version 2

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Brian Yee, KD6LI, has done a paper on the function of the switch-selectable synthesized 20 GHz DRO made by DMC. Brian's document describes the function of the source and how to check and tune it. The unit has a 9-position DIP switch that can be used to select the output frequency (roughly between 21 and 22 GHz on my unit) in 1.75 MHz steps. This document attempts to clarify the function of the switches, as determined on one unit that I have. This is the second version of my document and includes information on selecting outputs either above or below the reference frequency of the oscillator.

Brian's document shows the DMC source has an ovenized crystal at about 100 MHz that is multiplied up to the 10 GHz range. This 10 GHz signal is then used as a reference to phase-lock another 10 GHz signal generated by a DRO. The locked 10 GHz DRO output is then doubled to generate the 20 GHz output of the source.

Operation of the synthesizer can be modified by selecting the polarity of the input to the phase detector with jumpers. This was not noted in the first version of this document. The polarity jumpers allow the DRO output to be locked either above or below the 10 GHz reference frequency. The jumpers are located on the Loop Amp board at the bottom of the unit. Remove the bottom cover, and the jumpers are marked as E1 and E2 on the board. With E1 and E2 plugged farthest from the OP27 op amps [straight polarity], frequencies above the reference will be generated. With E1 and E2 plugged closest to the OP27's [crossed polarity], frequencies below the reference will be generated. On Brian's block diagram, these jumpers would be located in the signal lines labeled 875 Khz, at the input of the Phase Det. block.

The 10 GHz reference frequency is generated by multiplying the ovenized crystal by 104 (x4 and x26). In my unit the crystal is about 103.46 MHz. Multiplying this by 104 yields a reference frequency of approximately 10.76 GHz.

The DMC unit has an SMA connector for frequency monitoring. The monitor frequency is the difference between the 10 GHz DRO output and the 10 GHz reference frequency from the crystal oscillator. A change in this monitor frequency reflects in the output frequency, but must be doubled since the DRO is doubled to produce the output frequency.

With E1/E2 in the straight polarity (away from OP27's) the output of the DMC source will be:

$$Fout = 2 * (Fref + Fmon)$$

With E1/E2 in crossed polarity (close to OP27's) the output of the DMC source will be:

$$Fout = 2 * (Fref - Fmon)$$

The output frequency in terms of Fmon can be rewritten as:

$$Fout = (2 * Fref) + (2 * Fmon) \quad \text{straight E1/E2}$$

Fout = (2 * Fref) - (2 * Fmon) ; crossed E1/E2

In my unit, with Fref of 10.76 GHz the output will be:

Fout = 21.52 GHz +/- (2 * Fmon)

When the source is phase-locked, the synthesizer division rate, and therefore the frequency of Fmon, is determined by the switch settings of the DIP switches on the top board. The switches can be viewed as being organized in two groups: switches 9-5, and switches 4-1.

HIGH-ORDER SWITCHES

Switches 9-5 determine Fmon in steps of 8.75 MHz. A switch in the off position can be viewed as a binary one. One more than the value set in switches 9-5, is the multiple of 8.75 MHz for Fmon. Here's an example.

(x = switch off, o = switch on)

Switches 9 8 7 6 5
o x o o o = 01000 = 8 decimal

Fmon = (val + 1) * 8.75 MHz = (8 + 1) * 8.75 = 78.75 MHz

LOW-ORDER SWITCHES

The low-order switches (4-1) control the Fmon frequency to a finer resolution. The mapping of these switches is not as straight-forward as the 9-5 switches. Six settings of 4-1 repeat the same zero frequency-offset as when 4-1 are all 0 (on). The table that follows shows the frequency offsets that result from each of the 16 possible settings of switches 4-1. The Fmon frequency delta is listed for each setting. Add this value to the computed 9-5 Fmon frequency to get the Fmon of all the switches. If you are selecting a value for a needed frequency, it is recommended to avoid the values marked with (*) in the table, since these are duplicates of the zero setting.

TABLE - Low order switch settings (switches 4-1)
x = switch off,
* = duplicate effect, skip these settings

Switches 4 3 2 1	Hex val. (4-1)	Fmon Freq Delta (MHz)	20 GHz Sources
	0	0.0 (0 * .875)	
x	1 *	0.0	
x	2	0.875	(1 * .875)
x x	3	1.75	(2 * .875)
x	4	2.625	(3 * .875)
x x	5	3.5 (4 * .875)	
x x	6	4.375	(5 * .875)
x x x	7	5.25	(6 * .875)
x	8	6.125	(7 * .875)
x x	9	7.0 (8 * .875)	

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  x   x   |    A     |   7.875    (9 * .875)
  x   x x |    B  *  |   0.0
  x x     |    C  *  |   0.0
  x x   x |    D  *  |   0.0
  x x x   |    E  *  |   0.0
  x x x x |    F  *  |   0.0
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If the switch settings are changed, the source may lose phase-lock. The lock can be monitored by measuring the tune voltage on the external monitor pin. When in lock, this voltage should be steady and between 3 to 18 volts. When changing settings of the switches, monitor the Fmon frequency with a counter on the Fmon SMA connector, and monitor the Tune voltage from the external pin. After changing the settings, if lock is lost, the Fmon frequency will not be stable and the tune voltage will be max low or high -- about 2 volts or about 19 volts.

To reattain lock, slowly adjust the DRO tuning screw and watch for the tune voltage to stabilize between 3 and 18 volts. When in lock the Fmon frequency should be as predicted by the switches. It is desireable to set the tune voltage at mid range (about 9 V). Slight tuning of the DRO should move the tune voltage while still in lock.

Not all switch settngs can attain lock. On my unit I could lock Fmon in the range from about 61 MHz to 276 MHz. The minimum of 61 MHz means that output frequencies within 122 MHz above and below (2 * Fref) can't be generated.

The following table shows the end frequencies of the ranges my DMC source could generate.

Switches	Monitor Freq	Approx. Output Freq. (GHz)	
9 8 7 6 5 4 3 2 1	(MHz)	Straight	Crossed
x x	61.25 (min)	21.64	21.40
x x x x x x	276.50 (max)	22.07	20.97

Notes on Switch setting for DMC 11 GHz source

DMC made another version of microwave synthesized sources that generate frequencies in the neighborhood of 11 Ghz. In these sources there is no doubling of the DRO oscillator so the output is:

Fout = Fmw + Foff ; straight E1/E2

Fout = Fmw - Foff ; crossed E1/E2

where Fmw = microwave reference frequency
Foff = synthesized offset

In these units the monitor SMA connector does not vary with the synthesizer setting. It is simply the output of the crystal reference

oscillator. This frequency is multiplied by 108 to generate the microwave reference frequency for the synthesizer.

Fmw = Fosc * 108

It is possible that other versions of the sources may use different multipliers (not 108) but in the unit I examined the frequencies were:

Fosc = 102.0312 MHz
Fmw = 11.019373 GHz

On these units there are 8 switches (1-8) that are used to set the synthesizer frequency. As in the 20 GHz unit, they are in two groups.

HIGH-ORDER SWITCHES

Switches 8-5 determine Fmon in steps of 6.25 MHz. A switch in the off position can be viewed as a binary one. One more than the value set in switches 8-5, is the multiple of 6.25 MHz for Fmon. Here's an example:

(x = switch off, o = switch on)

Switches 8 7 6 5
x o o o = 1000 = 8 decimal

Fmon = (val + 1) * 6.25 MHz = (8 + 1) * 6.25 = 50 MHz

LOW-ORDER SWITCHES

The low-order switches (4-1) control the Fmon frequency to a finer resolution. Again, six settings of 4-1 are not useful for setting the frequency. The table that follows shows the frequency offsets for the useful settings of switches 4-1

11 Ghz Sources

TABLE - Low order switch settings (switches 4-1)
x = switch off,

Switches 4 3 2 1	Hex val. (4-1)	Fmon Freq Delta (MHz)
	0	0.0 (0 * .625)
x	2	0.875 (1 * .625)
x x	3	1.25 (2 * .625)
x	4	1.875 (3 * .625)
x x	5	2.5 (4 * .625)
x	8	3.125 (5 * .625)
x x	A	3.75 (6 * .625)
x x x	B	4.375 (7 * .625)
x x	C	5.0 (8 * .625)
x x x	D	5.625 (9 * .625)

RANGE OF 11 GHz FREQUENCIES

In the unit I examined the switches had the following minimum and maximum setting values, that would generate output:

Min Value = 0011 0000
Max Value = 1111 1101

This corresponds to the following approximate frequency ranges:

10.916873 - 10.997499 GHz
11.041249 - 11.121874 GHz

Tuning the Ref Oscillator adjustment slug allows some fine adjustment of the output frequencies.