Tech Brief 15: DS1075 EconOscillator: Power Dissipation Models

The data sheet specification for DS1075 supply current is a worst-case parameter representing the highest current configuration under worst-case operating conditions. However, in the majority of applications the DS1075 will consume less than this value. This application brief describes some models which can be used to predict the supply current of the DS1075 for any given operating configuration. Different factors such as master oscillator frequency, divider setting, output configuration (dual or single) or output loading can drastically effect current consumption in the device. This application note is intended as a tool to help the design engineer predict accurately the current consumption of the DS1075 in a specific configuration/application. An [Online calculator](#) *is available to make these calculations.*

The data sheet specification for DS1075 supply current is a worst-case parameter representing the highest current configuration under worst-case operating conditions. However, in the majority of applications the DS1075 will consume less than this value. This application brief describes some models which can be used to predict the supply current of the DS1075 for any given operating configuration.

Power Dissipation Capacitance

This power dissipation parameter is often used with CMOS circuits to provide an indication of operating current. Simple CMOS circuits have a linear relationship between current drawn and operating frequency. Hence at any given frequency the current can be shown in this form:

$$I_{CC} = C_{pd} V_{CC} f + k$$

Where

I_{CC}	=	Supply current
C_{pd}	=	Power dissipation capacitance
V_{CC}	=	Supply voltage
f	=	Operating frequency
k	=	A constant equal to the current drawn in the quiescent (dc) state

If the device is driving a load that must also be comprehended, the expression now becomes:

$$I_{CC} = C_{pd} \, V_{CC} \, f + k + C_L \, V_O^2 \, f \, / \, V_{CC}$$

Where

C_L = Load capacitance

V_O = Output voltage swing

Except at high frequencies or with highly capacitive loads this can be simplified to:

$$I_{CC} = (C_{pd} + C_L) \, V_{CC} \, f + k$$

Applying this model to the DS1075

A similar model can be applied to the DS1075, but since the DS1075 is a complex device several additional items must be considered:

Two outputs are available which may be operated at different frequencies. In the quiescent state (with both outputs off) the onchip oscillator will still contribute to the overall current drain. When one of the outputs is disabled some corresponding circuitry is also disabled. Depending on how the programmable divider is configured the internal circuitry may also be reconfigured.

Taking this into account, the following model has been developed. In comparisons with measured data this model is typically accurate to about 10%, comparable to the amount of variation which can be expected from device to device.

The total current drawn can be considered to be the sum of three terms:

$$I_{TOT} = I_Q + I_M + I_O$$

Where

I_{TOT} = The total current drawn

I_Q = The quiescent current which is drawn when both outputs are disabled (but with the onchip oscillator running)

I_M = The current associated with the main output (I/O)

I_O = The current associated with the Reference output (OUT0)

The following discussion considers each of these terms individually:

I_Q: Quiescent Current

With both outputs off, the current is approximated by:

$$I_Q = C_{pd0} \, V_{CC} \, f_0 / M + k1$$

Where

C_{pd0}	=	Power dissipation capacitance	(9pF)
V_{CC}	=	Supply voltage	(5V)
f_0	=	Master oscillator frequency	(60 - 100MHz)
M	=	Value of the M prescaler	(1, 2 or 4)
k1	=	A constant	(3.1mA)

(nominal values for each are shown in parentheses)

Applying the nominal values for the constants we can simplify the equation as follows:

$$I_Q = 0.045 \, f_0 / M + 3.1 \ (mA)$$

In practice, the values of I_Q vary in the range 4 - 8mA depending on master oscillator frequency and the prescaler setting.
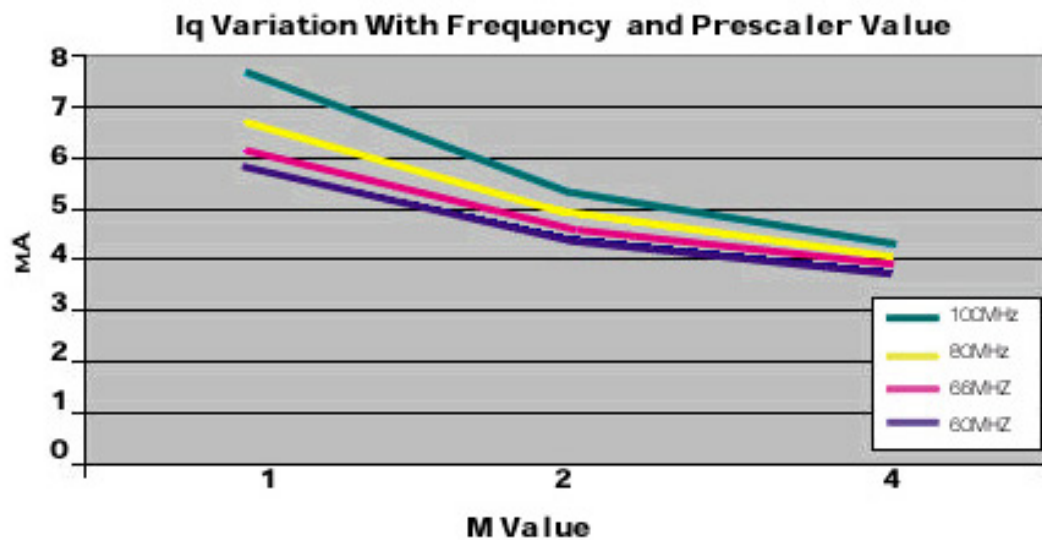
I_M: Main Output Current 1/0

The current consumption associated with the primary output (I/O) can be represented as follows:

$$I_M = (f_0 / MN)(k2 \, V_O^2 \, C_{LM} / V_{CC} + C_{pdM} \, V_{CC}) + k3$$

Where

C_{pdM}	=	Power dissipation capacitance	(24pF or 9pF, see Notes)
C_{LM}	=	Load capacitance	(0 - 50pF)
V_O	=	Output voltage swing	(5V)

f_0	=	Master oscillator frequency	(60 - 100MHz)
M	=	Value of the M prescaler	(1, 2 or 4)
N	=	Divider value	(1 - 513)
k2	=	A constant	(0.7)
k3	=	A constant	(2.1mA)

(nominal values for each are shown in parentheses)

Notes: If the output is disabled the internal dividers are also disabled, this term becomes 0.
If the device is configured to divide by 1 (DIV1=1) the internal divider is bypassed resulting in reduced current:

If DIV1 = 1 C_{pdM} = 9pF,

If DIV1 = 0 C_{pdM} = 24pF

As before, we can substitute nominal values into the above equations and simplify it to:

$I_M = 0.17 f_M + 2.1$ (mA)   - For cases where DIV1 does not equal 1
                                      - f_M = device output frequency (f_0 / MN) in MHz

$I_M = 0.1 f_M + 2.1$ (mA)   - For the case where DIV1 = 1
                                      - f_M = f_0 in MHz

Note: A 15pF load and a nominal 5V supply were assumed above.

Im Variation With Frequency and Load
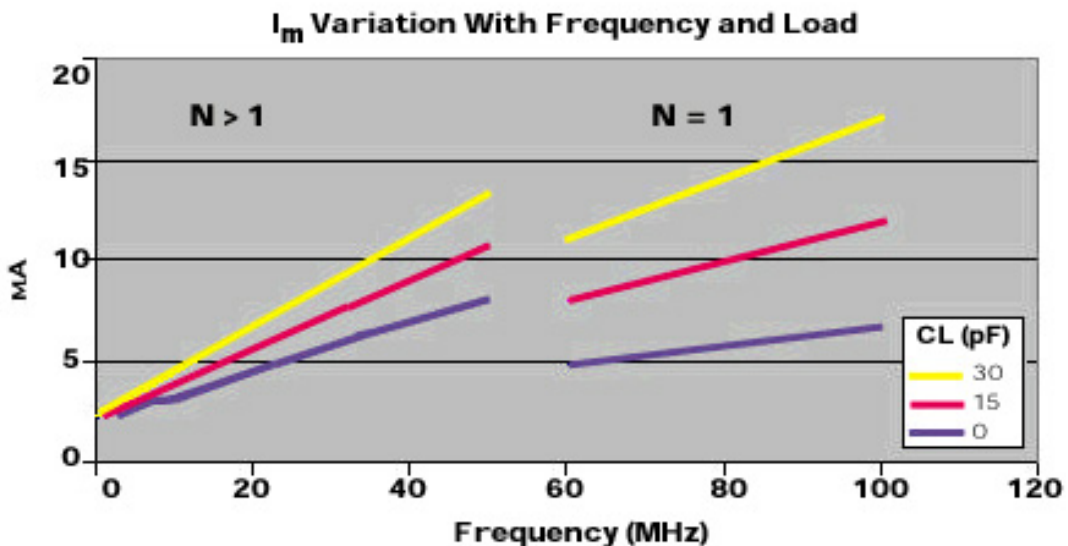
I_O: Reference Output Current

A similar expression can be used to calculate the current consumption associated with the reference output (OUT0):

$$I_O = (f_0 / M) (V_O^2 C_{L0} / V_{CC} + C_{pd0} V_{CC})$$

Where

C_{pd0}	=	Power dissipation capacitance	(12pF)
C_{L0}	=	Load capacitance	(0 - 50pF)
V_9	=	Output voltage swing	(5V)
f_0	=	Master oscillator frequency	(60 - 100MHz)
M	=	Value of the M prescaler	(1, 2 or 4)
		(nominal values for each are shown in parentheses)	

Note: If this output is disabled, I_O can be assumed to have a value of 0.

I_O Variation With Frequency and Load
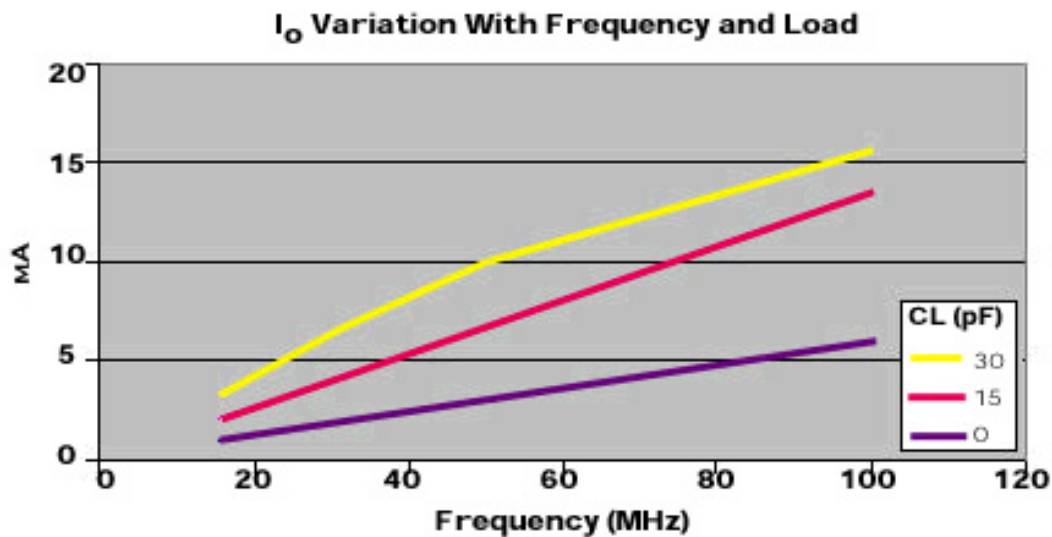
Substituting nominal values into the above equations it simplifies to:

$I_O = 0.14 * f_{OUT0}(mA)$ - f_{OUT0} = device output frequency (f_0/ M) in MHz

A 15pF load and a nominal 5V supply were assumed above.

At higher frequencies and large capacitive loads, the voltage swing at OUT0 is reduced and consequently the current drain. For example, in the case where M=1 and driving a 30pF load a value of 4V for output voltage swing will yield closer results.

I_{TOT}: Total Current

The simplified expressions for the total current can now be shown as follows:

$$I_{TOT} = (f_0/M) (0.2 + 0.17/N) + 5.2 (mA)$$

- Assuming neither M nor DIV1 = 1. Modify I_M and/or I_O accordingly (as detailed above) for the special cases when this does not apply.
- Assuming both outputs are active. If OUT0 is off then the "0.2" term equals 0. If I/O is off the "0.17/N" term equals 0.
- For cases where the load capacitance is significantly different from 15pF or to explore variations in supply voltage use the full equations detailed above.

Typical Results

A quick approximation can be obtained from the following table. Simply pick the values for I_O and I_M that fit the application values for f_M and f_{OUT0} respectively and add to the value shown for I_Q. All values shown are in mA.

Frequency	I_Q	I_M	I_O	I_{TOT}
50 - 100MHz	4 - 8	8 - 16	6 - 13	18 - 37
25 - 50 MHz	NA	5 - 10	3 - 7	8 - 17
10 - 25MHz	NA	3 - 4	1 - 4	4 - 8
< 10MHz	NA	2 - 3	NA	2 - 3

Temperature Variations

The current consumed by the DS1075 varies little with temperature and will typically stay within a few milliamps over the entire operating temperature range.

Voltage Variations

The current draw varies by only a few percent over the operating voltage range, so the simplified equations are normally sufficient. The full equations can be used to calculate the variation with supply voltage, but please note that the voltage swing should be adjusted accordingly (except for high frequencies and highly capacitive loads the output swing is typically rail to rail).

The following online calculator actually calculates the supply current for both a nominal 5V supply and the (typically) worst-case value of 5.25V.

DS1075 Power Dissipation Model

Master	Reference Output (OUT0)		Main Output (VO)	
Frequency	Frequency	Load Capacitance	Frequency	Load Capacitance
100 MHz	50	30	10	15
	Enabled? N (Y or N)		Enabled? Y (Y or N)	

IQ	5.4	mA	IO	0.0	mA	
			IM	3.8	mA	

Total Current	Vcc = 5V	9.2 mA	M	2
	Vcc = 5.25V	9.4 mA	N	5

Calculator Available

The equations noted previously in "Typical Results" have been written into an on-line calculator.

Using the online calculator, enter the frequency for each of the outputs and an estimated total current will be displayed.

Note: In cases where more than one combination of M and N yields the desired main output frequency (e.g. 25MHz can be M = 1, N = 4 or M = 2, N = 2 or M = 4, N = 1) you can "force" the value of M to a desired number by entering the corresponding frequency for the reference output even if the reference output is disabled.

Contact Information

For applications questions relating to the DS1075, contact our applications hotline: 972-371-6688 or your local Dallas/Maxim Sales Representative or distributor.

Additional contact information and more information on the DS1075, other members of the EconOscillator family, and other Dallas products can be found on the Web site.

More Information

DS1075: QuickView -- Full (PDF) Data Sheet -- Free Samples