

Si4010 CALCULATOR SPREADSHEET USAGE

1. Introduction

This application note describes how to use the Si4010 calculator spreadsheet to determine the input parameters of the API functions, which are needed to achieve the required RF behavior of the radio chip.

The basic transmit parameters of the Si4010 such as output power, modulation type, data rate, and operating frequency are set by using applications programming interface (API) function commands. When using these functions, certain parameters can be determined by using a calculator spread sheet. The Si4010 development kit includes a calculator spread sheet that helps developers set the API function arguments to meet their desired design requirements. The latest version of the calculator spreadsheet is available on the Silicon Labs website: www.silabs.com, under the Support→Document Library→EZRadio category. A summary of the calculator operations are given below.

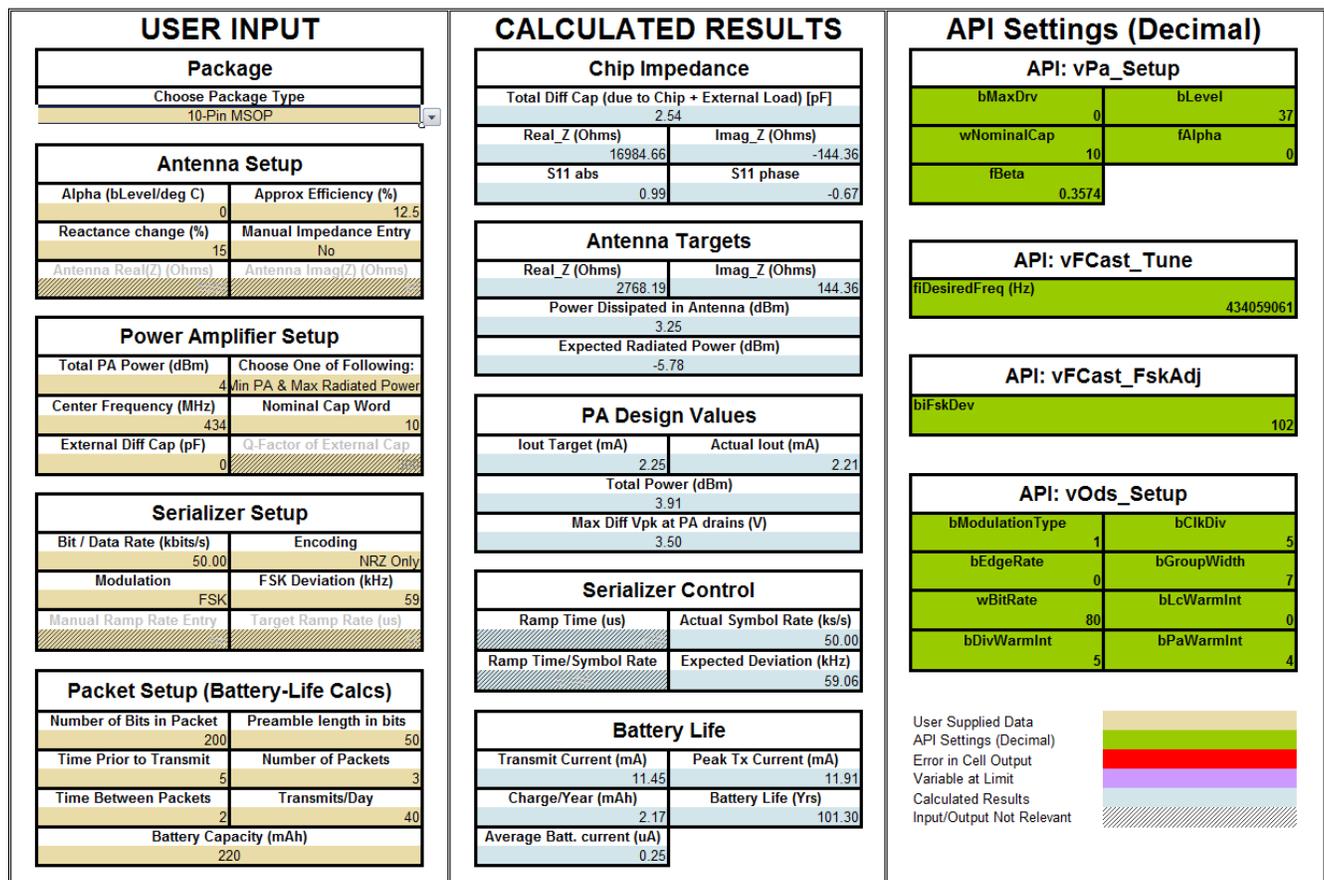


Figure 1. Screenshot of the Calculator Spreadsheet

Note: For more detailed descriptions of the Si4010 settings and API functions, consult the data sheet and application note “AN370: Si4010 Software Programming Guide.”

2. Setting up the PA

This part of the calculator is used for determining the correct parameters for the API function calls and obtaining optimal antenna impedance values.

More details can be found in Section "2.8. Usage of the Power Amplifier Setup".

2.1. User Inputs – Package Type

The Si4010 has two package type options: 10-pin MSOP or 14-pin SOIC. Select the corresponding package type to properly model the Si4010 RF behavior.

2.2. User Inputs – Antenna Setup

- **Alpha (bLevel/ °C):** Parameter for temperature variation compensation. If constant radiated power vs. temperature is desired, this constant may be used to compensate the PA drive strength. It can be calculated by measuring the output power at different temperatures while Alpha is set to 0.
Example: Assume 1 dB change in 50 °C temperature variation. The PA output power is programmable in 0.25 dB steps, so 1 dB change is a 4-step variation in PA level setting (bLevel). Therefore, Alpha should be set to $4/50 = 0.08$. This parameter has no effect if set to 0.
- **Approximate Efficiency (%):** The approximate antenna efficiency used to estimate radiated power. Setting this parameter does not affect the recommended parameters for the API function calls, but is provided to assist the user with estimating the actual radiated field strength.
- **Reactance Change (%):** Due to component spreading and the hand-effect, a small variation is possible in the reactance of the antenna. The small-signal sensitivity of antenna impedance will be examined in the specified range while calculating fBeta. The vPA_Tune() API function uses the fBeta parameter to adjust the PA level register in order to attempt to maintain constant output power in the presence of automatic wPA_CAP variations as a result of antenna reactance changes. See Section "2.9. Calculating Temperature (fAlpha) and Antenna Reactance (fBeta) Compensation Parameters" for more details.
The default value (15%) is adequate for many common antenna designs.
- **Manual Impedance Entry (Yes/No):** Selects if the antenna impedance (used while calculating the API parameters for the PA to meet the power target, if possible) is calculated by the spreadsheet, or if it is entered by the user.
- **Antenna Real(Z) (Ohms):** The antenna resistance at the operating frequency.
- **Antenna Imag(Z) (Ohms):** The antenna reactance at the operating frequency.
The two fields, Antenna Real(z) and Antenna Imag(Z), are only used if Manual Impedance Entry is selected and the fields are the equivalent PARALLEL values of the antenna resistance and reactance (that is, not modeled as series R+jX).

2.3. User Inputs – Power Amplifier Setup

The radiated output power of an Si4010 based transmitter depends on many parameters including the antenna characteristics, the output impedance of the PA, the output capacitance bank setting, and the bias current of the PA. The calculator spreadsheet can calculate the required antenna impedance needed to achieve the desired radiated output power or it can estimate the output power given a manually specified antenna impedance. The Power Amplifier Setup has the following input parameters:

- **Total PA Power (dBm):** This value represents the TOTAL power as the combined value of the power delivered to the antenna plus the power dissipated internally in the output impedance of the PA. The Total PA Power target can be estimated based on the expected efficiency of the antenna and the desired radiated power target. It represents the total amount of power dissipated in the PA and the antenna. The spreadsheet will always try to hit this target. The result is shown in the Calculated Values section under Total Power (dBm) in the PA Design Values subsection (see Section "2.6. Calculated Values—PA Design Values").
- **Choose One of the Following: Maximize Radiated Power or Minimize PA Current while Maximizing Radiated Power:** If only radiated power is to be maximized, the PA current is maximized and the antenna impedance is calculated in a way that maximizes the possible radiated power. Usually, this method tends to minimize the real antenna impedance relative to the real chip impedance; therefore, the fraction of the PA current burned on chip is lower. However, the voltage swing is also usually much lower (especially at reduced power levels) than the possible maximum, and thus the overall efficiency (i.e., the radiated power to PA current ratio) may degrade. This solution may result in increased current consumption. If the PA current is to be minimized while still maximizing radiated power, the solution tends to maximize the output voltage swing by maximizing the effective impedance of the system. As this solution increases the effective impedance of the system, it saves PA current at the expense of radiation efficiency (as more power will now be consumed on-chip). However, the overall efficiency (radiated power to PA current ration) may be better in this case.
- **Center Frequency (MHz):** The RF frequency of operation; range is 27 to 960 MHz.
- **Nominal Cap Word:** This is the nominal ("starting") setting of the power amplifier output capacitance bank that is part of the antenna tuning circuit; range is 0 to 511. It may be automatically adjusted by the vPA_TUNE API call as a result of antenna tuning.
- **External Diff Cap (pF):** This is an external capacitor placed across the TXP and TXM pins. Assuming this has a much larger quality factor than the on-chip capacitance bank, there may be antenna efficiency advantages of using this external component.
- **Q-Factor External Cap:** This is the quality factor of the external capacitor. Typical values would be 250–300.

2.4. Calculated Values—Chip Impedance

The fields of the “Chip Impedance” gives the impedances of a parallel RC equivalent of the chip; i.e., $Real_Z$ is the value of the parallel equivalent R, while the $Imag_Z$ is the impedance of the parallel equivalent C at the operation frequency.

The result of the “ $Imag_Z$ ” field takes into account the effects of any external capacitance the customer wants to add (External Diff Cap under Power Setup), bond wire inductance, bond wire resistance, package parasitic and the PA itself (bond pads, device parasitic, etc). The “Total Diff Cap (due to Chip + External Load)” field shows the capacitance value corresponding to the “ $Imag_Z$ ” value.

The value of the $Real_Z$ and $Imag_Z$ depend on the type of the package (MSOP or SOIC), frequency, and capacitance bank settings.

- **Total Diff Cap due to Chip + External Load (pF):** The equivalent differential capacitance seen looking into the package pins. It includes the on-chip capacitance bank, the package capacitance, and the external differential capacitor (if used).
- **$Real_Z$ (Ohms):** The equivalent parallel resistance of the chip at the frequency of operation.
- **$Imag_Z$ (Ohms):** The equivalent parallel reactance of the chip at the frequency of operation. This value is always negative, indicating a capacitive reactance seen looking back into the chip.

- **S11 Abs:** This is the absolute value of the reflection coefficient of the PA as seen from the chip terminals. It is calculated using the chip impedance values and assuming $50\ \Omega$ load impedance.
- **S11 Phase:** This is the phase (in Radians) of the reflection coefficient of the PA as seen from the chip terminals. It is calculated using the chip impedance values and assuming $50\ \Omega$ load impedance.

2.5. Calculated Values—Antenna Targets

The fields of the Antenna Target impedance gives the impedances of a parallel RL equivalent of the optimum termination impedance; i.e., “ $Real_Z$ ” is the value of the parallel equivalent R, while the “ $Imag_Z$ ” is the impedance of the parallel equivalent L at the operation frequency.

The value of the “ $Real_Z$ ” and “ $Imag_Z$ ” of the “Antenna Target” depends on the “Chip Impedance” values and the power setting.

In the event of a high PA output power setting and high “ $Real_Z$ value” of the “Chip Impedance”, the “Antenna Target” impedance should limit the voltage magnitude to the allowed maximum value that prevents voltage clipping at the drain(s) of the PA devices. Thus, the “ $Real_Z$ ” value of the “Antenna Target” impedance is lower than the “ $Real_Z$ ” value of the “Chip Impedance” (i.e., the Q of the antenna is lower than the Q of the chip). This is the so-called voltage-limited operation mode of the 4010 PA. Also due to the desired condition of parallel resonance, the $Imag_Z$ value of the “Antenna Target” Impedance is the negative of that in the “Chip Impedance”. As the $Imag_Z$ value of the “Chip Impedance” is always negative (capacitive), the $Imag_Z$ value of the “Antenna Target” is always positive (inductive). Thus the antenna should always appear as a parallel RL circuit.

In the event of low PA output power settings when the RF current magnitude is low and/or at high cap bank settings when the $Real_Z$ value of the “Chip Impedance” is low, the maximum allowed voltage swing cannot be achieved even with a very high Q antenna. In this case, the 4010 PA is working in a current limited operation mode and the optimum “Antenna target” $Real_Z$ is identical to that of the “Chip Impedance”. The optimum “Antenna target” impedance is the complex conjugate of the “Chip Impedance” as if the voltage swing is not limited, which results in maximum power delivery to the antenna.

A general rule is that the “Antenna target” Real_Z impedance is equal to or lower than the Real_Z value of the “Chip Impedance”. More detailed description can be found in “AN369: Si4010 Antenna Interface and Matching Network Guide.”

- **Real_Z (Ohms):** The required parallel equivalent resistance of the antenna at the frequency of operation to meet the desired output power.
- **Imag_Z (Ohms):** The required parallel equivalent reactance of the antenna at the frequency of operation to meet the desired output power. This value is always positive, indicating an inductive reactance seen looking into the antenna.
- **Power Dissipated in Antenna (dBm):** The expected power delivered to the antenna. This value is always less than the Total PA Power (under "Power Amplifier Setup"), as some fraction of the total power is always dissipated in the PA itself.
- **Expected Radiated Power (dBm):** The expected radiated power of the device given the specified antenna efficiency.

2.6. Calculated Values—PA Design Values

- **Iout Target (mA):** Theoretical output current that meets the power target.
- **Total Power (dBm):** The estimated output power based on all loss mechanisms. This is the sum of the power delivered to the antenna and the power dissipated in the PA itself. Except for quantization effects, this should be equal to the Total PA Power selected under "Power Amplifier Setup".
- **Actual Iout (mA):** The actual output current delivered to the antenna that accounts for quantization effects and chip losses.
- **Max Diff Vpk at PA (V):** The calculated peak differential voltage swing directly at the PA output (inside the chip). The calculator will always work to keep this peak differential voltage swing below a maximum level that would result in clipping of the drain waveform.

2.7. API Settings—vPa_Setup() API Parameters

- **bMaxDrv**: Boost bias current to output DAC. Allows for maximum 11.5 mA drive. Only LSB bit (bit 0) is used.
- **bLevel**: PA transmit power level. Each step in bLevel corresponds to a 0.25 dB change in output current.
- **wNominalCap**: Value written to XREG wPA_CAP.
- **fAlpha**: Parameter for temperature variation compensation of PA output power. More details can be found in Section "2.9. Calculating Temperature (fAlpha) and Antenna Reactance (fBeta) Compensation Parameters".
- **fBeta**: Parameter for antenna reactance variation compensation of PA output power. More details can be found in Section "2.9. Calculating of Temperature (fAlpha) and Antenna Reactance (fBeta) Compensation Parameters".

2.8. Usage of the Power Amplifier Setup

This part of the spreadsheet can be used in three different scenarios:

- **Scenario 1**: The target antenna has been designed/measured/simulated, so its impedance and the target radiated power is known.
- **Scenario 2**: The target antenna has been designed and its impedance is not known, but the target radiated power is known.
- **Scenario 3**: Only the target radiated power is known; the antenna characteristics are required.

These scenarios will be discussed in detail in the following paragraphs:

Scenario 1:

The target antenna has been designed/measured/simulated, so its impedance and the target radiated power is known.

1. Set the desired frequency.
2. Set the desired total PA power (see notes below).
3. Select Yes for Manual Impedance Entry.
4. Enter the antenna impedance (parallel equivalent resistance and reactance). The Antenna $\text{Imag}(Z)$ parallel equivalent reactance must be a positive (inductive) value.
5. The spreadsheet calculates wCap, bLevel and bMaxDrv.
6. Verify the following:
 - **Chip Impedance Imag_Z Entry**: It should be the complex conjugate of the Antenna $\text{Imag}(Z)$ entered in the Antenna Setup. If not, it is because the antenna reactance falls outside the range of the PA.
 - **API parameter wNominalCap**:
 - It should be between 0 and 511.
 - It should fit into one of the ranges shown in Table 1 based on the target operating frequency.
 - If the obtained wNominalCap is 511, then an External Diff Cap is required.
 - If the obtained wNominalCap is 0, then the antenna should be redesigned because the input capacitance of the PA is too large to support the antenna.

Notes:

1. The Total PA Power target can be estimated based on the expected efficiency of the loop antenna (generally between 1-15%) and the desired radiated power target. For instance, if 0 dBm radiated power is required and the loop antenna efficiency is 12.5%, then the Total PA Power is roughly $0 \text{ dBm} - 10\log(0.125) + 0.8 = 9.8 \text{ dBm}$. In the equation, the 0.8 dBm is simply an estimate for the losses that will be encountered in the PA itself and is a good rule of thumb for 300—500 MHz of operation. For higher frequencies, a loss estimate of 1–1.2 dB should be used.
2. Verify also that Max Diff Vpk at the PA does not exceed 3.5 V. If the Max Diff Vpk exceeds 3.5 V, then the driver begins to seriously clip and linear analysis breaks down.
3. Look at the settings for bMaxDrv and bLevel. If these are highlighted in purple, then the setting is as high as possible. This setting is acceptable unless the drive level needs to be adjusted to keep the power constant due to temperature or antenna reactance changes. If so, having the nominal drive level at maximum will not allow the PA to adjust the power upwards if required. For this case, it is a good idea to keep the nominal drive setting 4-6 steps below the maximum or above the minimum value to allow room for the power adjustment algorithms. If constant power is not required, fAlpha and fBeta will always be set to zero, and having the bLevel at its maximum or minimum value is acceptable.

Scenario 2:

The target antenna has been designed and its impedance is not known, but the target radiated power is known.

1. Prototype the Si4010 board with the uncharacterized antenna and measure the radiated power.
2. Read out from the Si4010 the wNominalCap setting (XREG wPA_CAP @ Address = 0x400C) after running the PA auto-tune function (vPA_TUNE).
 - It should be between 0 and 511.
 - It should fit into one of the ranges shown in Table 1 based on the target operating frequency.
 - If the obtained wCap is 511, then an External Diff Cap is required.
 - If the obtained wCap is 0, then the antenna should be redesigned because the input capacitance of the PA exceeds the requirements of the antenna.
3. Do a number of experiments on radiated power vs. bLevel setting. Adjust bLevel until significant output compression is seen in the radiated power. Normally, the change in the output power is 0.25 dBm/LSB change in bLevel. When this is no longer true, the PA is beginning to clip and the output swing at the PA is roughly 3.5 V peak. Record the bLevel and bMaxDrv settings where the gain compression begins to occur.
4. Change the Manual Impedance Entry to No.
5. Enter the wCap setting (determined in step 2) into the Nominal Cap Word field.
6. Now the Real and Imag PA impedance values under Chip Impedance are available (equivalent parallel values!).
7. Adjust the Total PA Power until the bLevel and bMaxDrv align with the settings determined in step 3.
8. Now the Real_Z and Imag_Z estimates of the antenna are available out of the spreadsheet (under Antenna Targets).
9. The Approximate Efficiency term under Antenna Setup can also be obtained by adjusting it to match the radiated power that was measured in step 1 with what is seen under Antenna Targets.

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Scenario 3:

Only the target radiated power is known; the antenna characteristics are required

1. Set the desired frequency.
2. Set the total PA power (see notes below).
3. Select Maximize Radiated Power or Min PA & Max Radiated Power (see notes below).
4. Choose the Nominal Cap Word roughly based on Table 1.
5. The spreadsheet gives then the antenna characteristics to meet the power target.

Notes:

1. The Total PA Power target can be estimated based on the expected efficiency of the loop antenna (generally between 1–15%) and the desired radiated power target. For instance, if 0 dBm radiated power is required and the loop antenna efficiency is 12.5%, then the Total PA Power is roughly $0 \text{ dBm} - 10\log(0.125) + 0.8 = 9.8 \text{ dBm}$. In the equation, the 0.8 dBm is simply an estimate for the losses that will be encountered in the PA itself and is a good estimate for 300–500 MHz of operation. For higher frequencies, using an estimate of 1–1.2 dB may be a better guess.
2. Normally, the “Min PA and Max Radiated Power” setting is recommended because battery life is usually a premium. If the “Max Radiated Power” is set, then the algorithm tries to build an antenna with the lowest possible real impedance relative to the real PA impedance to get as much power as possible delivered to the antenna. This maximizes radiation power at the expense of making the PA current as large as possible (generally speaking). For instance, when Max Radiated Power is chosen, sometimes the Max Diff Vpk at PA (under PA Design Values) dips below 3.5 V and the bMaxDrv and bLevel are highlighted in purple because they are at their max values. Alternatively, if the Min PA and Max Radiated Power Option is chosen, the Max Diff Vpk at PA is always at 3.5 V because the antenna impedance will be chosen as large as possible to conserve PA current.

Table 1. Expected wCap Values for Different Frequency Ranges

| Frequency (MHz) | Expected wCap Range |
|-----------------|---------------------|
| < 300 | 100–400 |
| 315 | 100–350 |
| 434 | 100–250 |
| 868 | < 80 |
| 915 | < 64 |

2.9. Calculating Temperature (fAlpha) and Antenna Reactance (fBeta) Compensation Parameters

2.9.1. fAlpha:

Parameter for temperature variation compensation of the PA output power. If constant radiated power vs. temperature is desired, this constant may be used to let the radio compensate the PA drive strength as a function of temperature. It can be calculated by measuring the output power at different temperatures while Alpha is set to 0.

Example: Assume 1 dB change in 50 °C temperature variation. The PA output power is programmable in 0.25dB steps, so 1 dB change is a 4-step variation in PA level setting (bLevel). Therefore Alpha should be set to $4/50 = 0.08$.

2.9.2. fBeta:

Parameter for antenna reactance variation compensation of the PA output power. If constant radiated power vs. antenna reactance change (due to component variations or hand-effect issues) is desired, this constant may be used to let the radio compensate the PA drive level. fBeta is a small-signal parameter that automatically adjusts the PA drive level based on where the PA was tuned during the vPa_Tune() API. In order for fBeta to function correctly, the expected value of wPA_CAP (wNominalCap in tPa_Setup) MUST be known for the target system.

If the reactance of the antenna changes, the PA must also compensate to keep the system properly tuned. This is done by the vPA_Tune() API function. For instance, if the effective inductance in the antenna drops due to an increase in the antenna capacitance, the PA capacitance must increase (by vPA_Tune()) to keep the resonance the same. Effectively, this drops the PA load resistance, lowers swing, and decreases radiated power. This effect is compensated by fBeta if it is provided in the tPa_Setup structure.

fBeta is calculated by the spreadsheet. Once the antenna target is established, the calculator simply looks at the sensitivity of changes to the reactance in the antenna to the total radiated power. Since fBeta represents a small-signal sensitivity, the calculation has to make an assumption about how much variation in reactance the antenna sees. Currently, the calculator assumes a $\pm 15\%$ shift.

Note: For a given target power and wCap setting, the antenna impedance is adjusted to hit the power target and the fBeta is given based on these antenna and PA impedances for that power target. However, if less power is needed, and the current PA and antenna impedances are the same respectively, then only the bLevel (bMaxDrv) should be decreased and the SAME fBeta would still apply because the sensitivity to changes in the antenna impedance have not changed. In other words, fBeta applies for a given PA and Antenna Impedance, independent of the bLevel ultimately chosen.

3. Modulation, Encoding, and Data Rate Setup

The output data serializer (ODS) API function commands set the modulation type, encoding method, and data rate of the transmitter. The calculator has the following inputs:

3.1. User Inputs—Serializer Setup

- **Bit (or Data) Rate (Kbits/s):** This is the bit or data rate of the transmitter.
- **Encoding:** The encoding methods supported are Manchester, NRZ+4b/5b, and NRZ encoding.
- **Modulation:** OOK or FSK.
- **FSK Deviation (kHz):** This is the FSK frequency deviation of the output frequency in response to a data signal. It is equal to half of the frequency difference between the frequency of the logical zero and the frequency of the logical one.

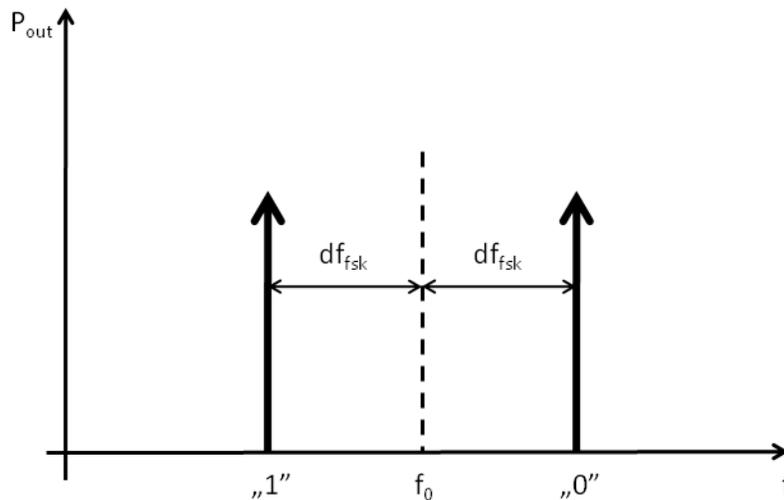


Figure 2. FSK Modulation

- **Manual Ramp Rate Entry:** If Yes is selected, then the Target Ramp Rate field is used to set the ramp rate for turning on and off the PA, otherwise the ramp rate will be automatically calculated.
- **Target Ramp Rate (μ s):** This parameter is the target ramp rate. Only used if the Manual Ramp Rate Entry is Yes.

3.2. Calculated Values—Serializer Control

- **Ramp Time (μ s):** The actual ramp time of turning on and off the PA. If Manual Rate Entry is Yes, this will represent the closest possible match to the user entry. If Manual Rate Entry is No, this is automatically calculated based on the target bit rate. The chosen rate ensures the resulting spectrum will be FCC/ETSI compliant.
- **Actual Symbol Rate (Ksym/s):** The actual symbol rate produced by the chip after taking into account encoding and quantization effects due to the timers.
- **Ramp Time/Symbol Rate:** The ratio of the ramp time divided by the symbol rate.
- **Expected FSK Deviation (kHz):** The expected FSK deviation with quantization error.

3.3. API Settings—vOds_Setup() API Parameters

- **bModulationType**: 0 = OOK or 1 = FSK.
- **bClkDiv**: controls the clock of the ODS. Sets the division factor of the 24 MHz system clock (LPOSC) to produce clk for the ODS module. Division factors are 1–8 (bClkDiv+1). Generally, the ODS clock should be in the range of ~3-8 MHz; the division factor should be selected accordingly.
- **bEdgeRate**: controls the PA edge time. This is an additional division factor in range 1–4 (bEdgeRate+1) to produce the PA edge time. The PA edge time can be calculated as: $8 \cdot (bClkDiv+1) \cdot (bEdgeRate+1) / 24 \text{ MHz}$. When clk_ods is in range of 3–8 MHz, edge rate can be selected from 1 μ s to 10.7 μ s.
- **bGroupWidth**: controls symbol group width from 2–8 symbols. Currently in the calculator, it is fixed to value = 4 to transmit 5 symbol groups if 4/5 encoding is selected, or to value = 7 to send 8 symbol groups if NRZ or Manchester encoding is selected.
- **wBitRate**: bit rate setting of ODS. Symbol rate produced by the serializer is $24 \text{ MHz} / (wBitRate \cdot (bClkDiv+1))$.
- **bPaWarmInt**: Sets the "warm up" interval for the PA, where it is biased up prior to transmission or on the transition from OOK zero bit to OOK one bit.
Interval is directly in clk_ods cycles.
Interval = $bPaWarmInt \cdot (bClkDiv + 1) / 24 \text{ MHz}$.
This value is calculated automatically in such a way that the warm-up interval of the PA is kept at 1 μ s for a given ODS clock rate.
- **bDivWarmInt**: Sets the "warm up" interval for the DIVIDER, where it is biased up prior to transmission or on the transition from OOK zero bit to OOK one bit.
Interval is in 4 x clk_ods cycles resolution.
Interval = $4 \cdot bDivWarmInt \cdot (bClkDiv+1) / 24 \text{ MHz}$.
This value is calculated automatically in such a way that the warm-up interval of the divider is kept at 5 μ s for a given ODS clock rate.
- **bLcWarmInt**: Sets the "warm up" interval for the LC oscillator, where it is biased up prior to transmission or on the transition from OOK zero bit to OOK one bit.
Interval is in 64 x clk_ods cycles resolution.
Interval = $64 \cdot bLcWarmInt \cdot (bClkDiv + 1) / 24 \text{ MHz}$.
This value is calculated automatically in such a way that the warm-up interval of the LCOSC is kept at 125 μ s for a given ODS clock rate.

3.4. API Settings – vFcast_FskAdj() API Parameters

- **biFskDev**: calculated parameter for vFcast_FskAdj().

4. Frequency Setting

Setting the target center frequency means simply calling the `vFCast_Tune(frequency)` function with the correct parameter. The parameter for this API function should be calculated as follows:

- **OOK mode:**

Frequency = desired center frequency

- **FSK mode:**

Frequency = desired center frequency + deviation

In other words, the frequency should be equal to the higher FSK frequency.

4.1. User Inputs—Frequency Setting

The desired target frequency should be set in the Power Amplifier Setup section of the spreadsheet (see Section "2.3. User Inputs – Power Amplifier Setup").*

***Note:** This value should always be the desired channel center frequency.

4.2. API Settings —vFCast_Tune() API Parameters

In both FSK and OOK mode, the correct value of the `vFCast_Tune` parameter can be obtained from the calculator.

5. Battery Life Calculation

The calculator also estimates battery life of a system given the packet setup and number of button pushes per day. The inputs to the calculator are all of the above inputs plus the following:

5.1. User inputs—Packet Setup

- **Number of Bits in Packet:** Number of bits in the packet excluding the preamble bits.
- **Preamble Bits:** Number of bits in the preamble.
- **Time Prior to Transmit (ms):** The time required to boot the chip and send a packet out.
- **Number of Packets:** The number of packets sent out per button press.
- **Time Between Packets (ms):** The time between repeating packets.
- **Transmits/Day:** The number of transmits per day.
- **Battery Capacity (mAh):** The capacity of the desired battery in mAh.

5.2. Calculated values—Battery Life

- **Average Transmit Current (mA):** The average transmit current.
- **Peak Transmit Current (mA):** The peak transmit current.
- **Charge/Year (mAH):** The charge per year in mAH.
- **Battery Life (Years):** The estimated battery life of the specified battery.
- **Average Battery Current (µA):** The average current drawn from the battery.

NOTES:



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