![Texas Instruments logo]

Configuring the GC1115 for 3G Air Interfaces

Al Wegener   *Wireless Infrastructure Business Unit*

ABSTRACT

The GC1115 crest factor reduction (CFR) processor reduces the peak-to-average ratio (PAR) of 3G wireless signals. This application report describes how GC1115 users can configure the device to achieve the desired peak reduction for 3G applications. In this application report, the term *3G* refers both to the UMTS (3GPP) standard and to the cdma2000 (3GPP2) standards. Examples are provided for both air interfaces. Users of this document need know only which air interface they are targeting, the bandwidth of each carrier, the frequency of each carrier, and the desired output peak-to-average ratio (PAR).

Contents

## List of Figures

List of Tables

1   Introduction

This application report describes how the GC1115 crest factor reduction (CFR) processor is configured for the two dominant 3G air interface standards: UMTS (standard available at www.3gpp.org) and cdma2000 (standard available at www.3gpp2.org). The primary and secondary parameter sets that users specify to configure the GC1115 for their particular environment are described. Practical methods to optimize GC1115 performance by experimenting with a variety of cancellation pulse design techniques are also discussed.

2   GC1115 in the 3G Transmit Signal Chain

Figure 1 demonstrates the transmit signal chain of a typical 3G base station. The GC1115 is typically located after a digital upconverter, such as the Texas Instruments GC5016 or GC5316, and before a D/A converter such as the Texas Instruments DAC5687. The GC1115 can be controlled by any microprocessor or DSP chip via its microprocessor interface, which consists of an 8-bit address bus, a 16-bit data bus, and several control pins (chip select, read/write, etc.).
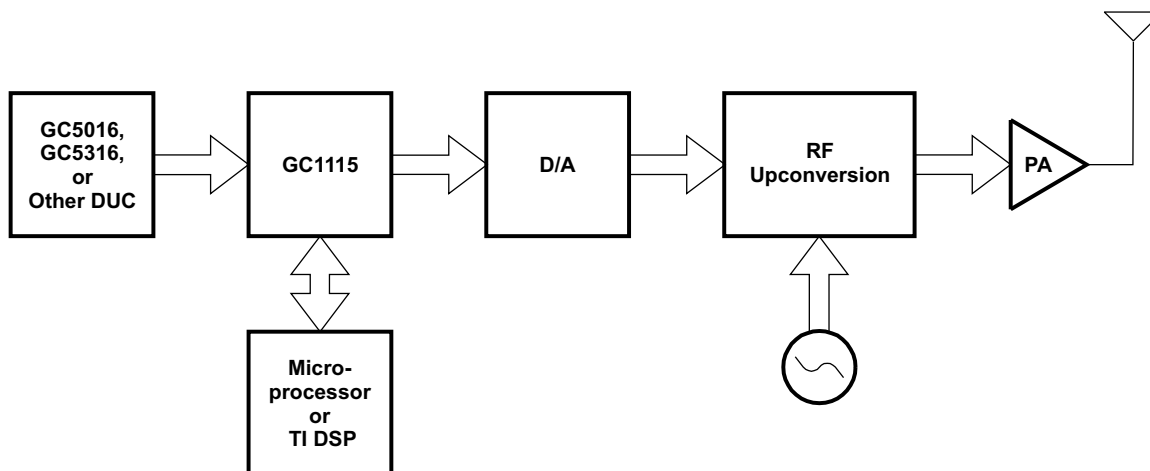
B0056-01

Figure 1. Location of the GC1115 in the 3G Transmit Signal Chain

3   Primary GC1115 Configuration Parameters

The GC1115 is configured through a sequence of register writes, and possibly a few register reads. This application report does not describe the sequence of GC1115 register initialization, which is already described in the GC1115 data sheet section entitled *GC1115 Initialization Sequence*. Rather, this application report describes from a systems perspective how the relevant air interface parameters [bandwidth, center frequency, desired output peak-to-average ratio (PAR), etc.] are translated into GC1115 register values.

The following five parameters are the primary configuration and control values for the GC1115. By specifying these five primary GC1115 configuration parameters, users can initialize the GC1115 for almost all conditions:

- Input sampling rate
  - The UMTS input sampling rate is usually an integer multiple of 3.84 MSPS.
  - The cdma2000 input sampling rate is usually an integer multiple of 1.2288 MSPS.
- Bandwidth: the specified bandwidth of each carrier
  - The UMTS per-carrier bandwidth is 5 MHz.
  - The cdma2000 per-carrier bandwidth is 1.25 MHz.
- Center frequencies: the center frequencies (number of carriers) in the input signal
  - UMTS contains up to four 5-MHz carriers in a 20-MHz bandwidth.
  - cdma2000 contains up to 15 carriers in a 20-MHz bandwidth.
- Cancellation pulse length: the number of taps (coefficients) in each cancellation pulse

  The number of cancellation pulse taps determines the out-of-band rejection of each cancellation pulse. This value indirectly determines the GC1115's achievable adjacent-channel leakage ratio (ACLR). Typical cancellation pulse lengths (which are always odd numbers) are between 75 and 125 taps, although cancellation pulse lengths of up to 509 are supported in real mode (maximum of 127 taps in complex mode).
- Output peak-to-average ratio (PAR)

  The output PAR is a user-selected value that determines the degree to which the GC1115 cancels over-threshold peaks. For CDMA modulation types such as UMTS and cdma2000, typical GC1115

output PAR values are between 6 dB and 8 dB. For 3G signals (either UMTS or cdma2000), the PAR before GC1115 processing is between 10 dB and 13 dB, so the GC1115 provides peak reduction of 2 dB to 7 dB.

The first four GC1115 configuration parameters (sampling rate, bandwidth, center frequency, and cancellation pulse length) are used to design an appropriate GC1115 cancellation pulse. The cancellation pulse is designed to contain energy only where the input signal also contains energy. If the cancellation pulse were to contain energy outside the allocated frequency range of the input signal, the peak-reduced signal's ACLR measurement would be degraded. If the cancellation pulse is not wide enough, it fails to cancel the peaks effectively.

Designing an appropriate cancellation pulse is one of the GC1115 user's key contributions. Well-designed cancellation pulses can improve PCDE by several dB and can simultaneously improve cEVM by several percent. Figure 2 displays a three-carrier UMTS signal whose relevant GC1115 primary configuration parameters are:

- Input sampling rate: 61.44 MSPS (complex)
- Per-carrier bandwidth: 5 MHz
- Carrier center frequencies: –7.5 MHz, –2.5 MHz, 2.5 MHz (3 carriers)
- Example cancellation pulse lengths: 63 taps (Figure 3) or 127 taps (Figure 4)

By specifying only these four primary GC1115 configuration parameters, users can design the appropriate GC1115 cancellation pulse shown in Figure 3 and Figure 4.
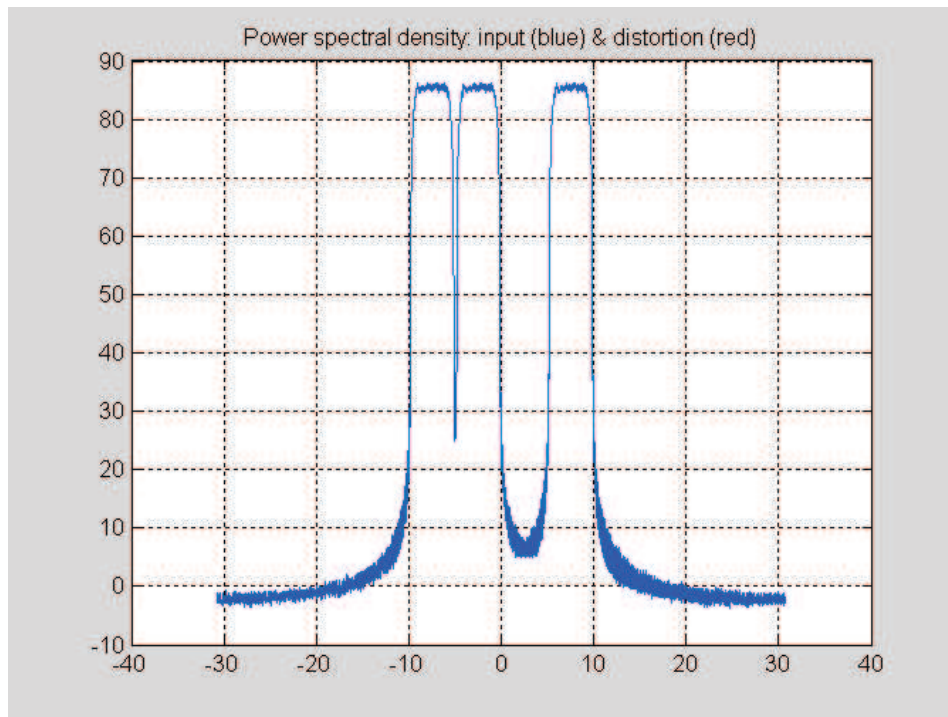

G001

Figure 2. Three-Carrier UMTS Signal

The cancellation pulses used by the GC1115 to cancel wideband peaks are simply FIR filter coefficients that are normalized to the signed 12-bit integer range. GC1115 cancellation pulses can be created by any FIR filter design routine. The largest normalized cancellation coefficient (usually the middle tap at sample N/2, where N is the cancellation pulse length) should always have the value 2047, which is the largest positive 12-bit integer ($2^{11} - 1$).

MATLAB™ users are familiar with the functions fir1, firls, and remez, which provide alternative FIR filter design algorithms that trade off pass-band ripple, transition bandwidth, stop-band attenuation, etc.

GC1115 users can distinguish the CFR performance of their GC1115-enabled products by proprietary cancellation pulse design methods that can achieve 2-dB to 3-dB better PCDE performance (vs non-optimized FIR cancellation pulse designs) by the selection of appropriate cancellation pulse parameters. Section 7 of this document describes some of the cancellation pulse design parameters whose judicious selection improves system performance.

As with all FIR filters, longer cancellation pulses provide more stop-band attenuation. For the GC1115, there is a tradeoff between making cancellation pulses as long as possible (509 taps) and decreasing the number of available cancellers. For the same distribution of peaks over the user-specified output PAR goal, longer cancellation pulses keep the GC1115 cancellers busy for a longer period of time. Figure 3 (63 complex taps) and Figure 4 (127 complex taps) demonstrate how cancellation pulse length affects transition-band sharpness and stop-band attenuation. Notice the rounded nature of the 63-tap filter pass bands in Figure 3, vs the sharper transition bands using 127 complex taps in Figure 4.
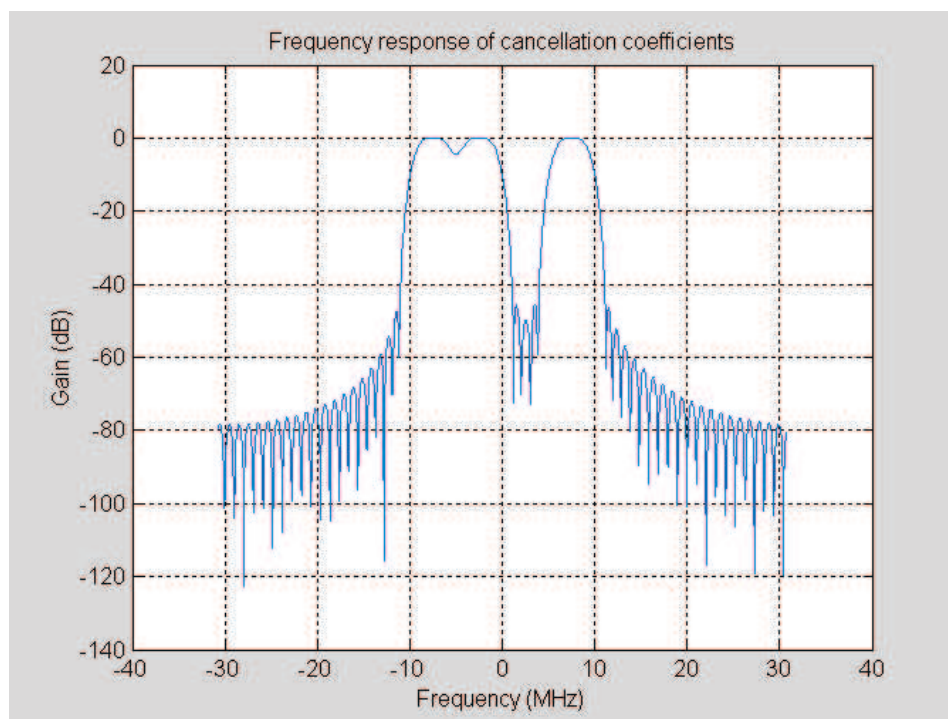
G002

Figure 3. 63-Tap Cancellation Pulse
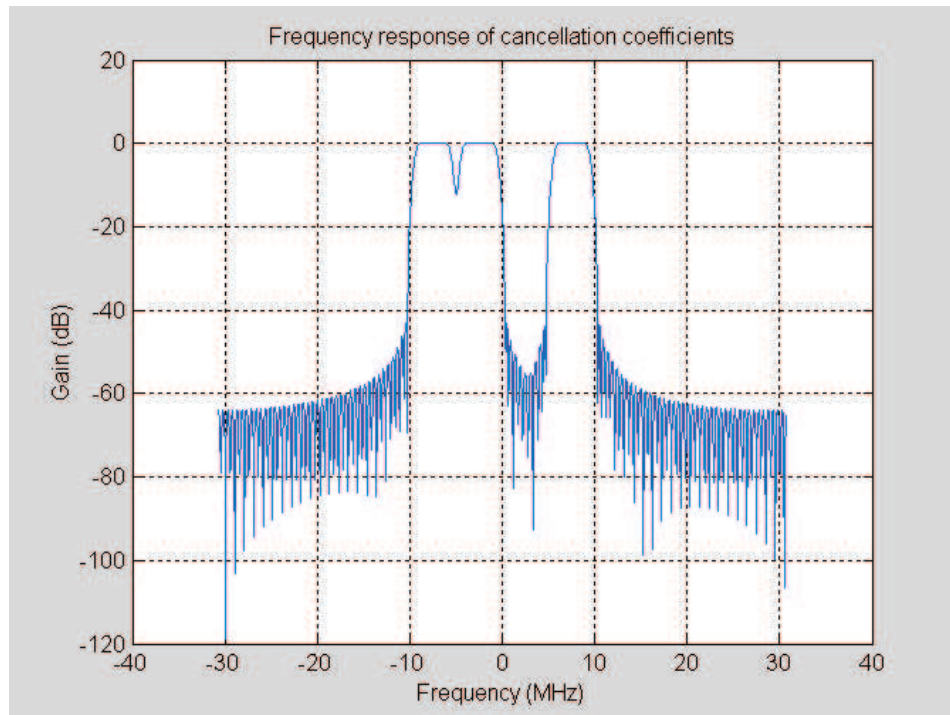
G003

Figure 4. 127-Tap Cancellation Pulse

Because the primary function of the GC1115 is peak reduction, the fifth primary GC1115 configuration parameter, output peak-to-average ratio (PAR), is also required. In order to specify the output PAR, the average power of the GC1115 input signal must be calculated or measured, either by capturing the GC1115 I/Q input samples in a file and measuring their power or by using the GC1115 built-in power meter.

3.1 *Determining Average Power From a File of Complex Input Samples*

The following procedure, describing how to determine the average signal power from a file of complex input samples, is taken from the GC1115 data-sheet section entitled *Setting Detection Thresholds and Target Peak Levels*.

The most obvious user-specified parameter for a CFR processor is the desired output PAR. The output PAR determines the largest sample magnitude on the output ports of the GC1115. Ultimately, the PAR determines the maximum V_{in} voltage of the PA. This maximum value is then adjusted to fit just under the 1-dB compression point of the PA. The average power of the GC1115 input samples (0-dB point on the CCDF curve) can be calculated from a group of input samples. TI provides a MATLAB function that uses a group of input samples to calculate the 16-bit threshold-squared values that are loaded into the GC1115 DETECT_TSQD and GAIN_TSQD registers (one pair of registers for each of four stages; total of eight TSQD registers). On request, TI provides the MATLAB source code (m-file) for the threshold calculations based on input samples.

Alternatively, GC1115 users can use the GC1115's built-in power-measurement capability to determine the average input power. The detection thresholds and target peak levels can then be calculated from the average input power.

GC1115 threshold settings are based on a threshold-squared (power) value, not a threshold (magnitude) value. The following example demonstrates how the GC1115 threshold-squared values are calculated, using the MATLAB language:

```
%
%      Calculate the average power of the complex input array x, and the desired
%      fractional (magnitude) threshold, given the user-specified target peak level
%      (in dB).

avgMag = sqrt(mean(abs(x).^2));
frac   = avgMag * 10 ^ (dB_target / 20);

%
%      Derive the following threshold-related values from the target PAR magnitude:
%
%      thresh     a signed, 14-bit threshold value (a magnitude!)
%      threshSqd  threshold set as a 16-bit mag-squared value
%                 (reduced from a 29-bit mag-squared value)
%
thresh   = floor (frac * 2^13);          %  set the threshold relative to
                                         %  signed 14-bit samples
threshSqd = floor((thresh ^ 2)/ (2^13)); %  mag-sqd of a 14-bit value =
                                         %  28 bits, plus an add =
                                         %  29 bits, then divide by 2^13
                                         %  to convert to 16-bit thresh-sqd
                                         %  value
```

3.2   *Determining Average Power by Using the GC1115 Power Meter*

The following procedure, describing how to determine the average signal power by using the GC1115 power meter, is taken from the GC1115 data-sheet section entitled *Power Measurement*.

The GC1115 can measure signal power of a complex I/Q signal at one of two locations in the GC1115 data path:

- At the input to PDC stage 1
- At the output of PDC stage 4

The POWER_CTL and POWER_CNT registers configure the GC1115 to measure power at one of these two locations. The total number of samples observed during power measurement is POWER_CNT $\times$ POWER_CTL[13:0]. After power measurement has completed, the resulting average power value is available in the POWER register.

The total number of samples used for the power calculation is the product of an inner loop count (determined by the POWER_CNT register) and an outer loop count (determined by bits [13:0] of POWER_CTL):

POWER_CNT	Inner Loop Count (# Samples)
0x1	16
0x3	256
0x7	4096
0xF	65536

The outer loop count is specified by the lower 14 bits of the POWER_CTL register, but only the most-significant 1 matters; the other bits are ignored:

POWER_CNT[13:0]			Outer Loop Count (# Samples)
1			1
2	–	3	2
4	–	7	4
8	–	15	8
16	–	31	16
32	–	63	32
64	–	127	64
128	–	255	128
256	–	511	256
512	–	1023	512
1024	–	2047	1024
2048	–	4095	2048
4096	–	8191	4096
8192	–	16383	8192

For example, to calculate the average power over about a million samples, the GC1115 registers would be initialized as follows:

POWER_CNT = 0xF (inner loop count = 65536)
POWER_CTL = 0x10 (outer loop count = 16)

Total number of samples used to calculate power: 16 × 65,536 = 1,048,576 samples

To summarize, the GC1115 performs the following steps during power measurement:

1. Use 18 bits I and 18 bits Q from each sample to calculate a 37-bit power value. ***NOTE: Input samples must be left-justified, i.e., the most significant bit of the input sample is always aligned to bit 17 (MSB) of input ports IN_A and IN_B.***
2. Add the upper 16 bits of each 37-bit power value to a 40-bit power accumulator.
3. Accumulate N = POWER_CNT × POWER_CTL[13:0]) sample powers.
4. Shift the final accumulator value by 4 to 18 bits to calculate the average power over N samples, depending on how POWER_CNT and POWER_CTL are set. The GC1115 does this shifting (divide by N) automatically.
5. Transfer the resulting 16 bits to the POWER register.

GC1115 users also must properly set the two MSBs of the POWER_CTL register to specify whether the input or output power is to be measured, and (in two-channel configuration) the channel number (channel 0 or channel 1) whose power is to be measured.

3.3 Calculating DETECT_TSQD and GAIN_TSQD Register Values

Once the average input power (0-dB level) has been determined, values for the GC1115 PAR threshold registers are calculated from the desired output PAR level (6 dB, for example). The POWER register value should be scaled by a value (larger than 1) that represents the desired output threshold according to the following table:

Scale value = $10^{(PAR\_target/10)}$

.

the last two PDC stages. For that reason, the first two PDC stages are assigned fewer cancellers than the last two stages. Because the last two PDC stages are normally assigned the same DETECT_TSQD thresholds, the fourth (last) PDC stage requires fewer cancelers than the third PDC stage. The fourth PDC stage only removes the peaks that were regrown by the third stage. The fourth PDC stage also cancels those peaks that passed through the third stage because no stage-3 cancellers were available.

The normal allocation of cancelers to the four PDC stages is:

Stage 1: 4 cancellers
Stage 2: 8 cancellers
Stage 3: 12 cancellers
Stage 4: 8 cancellers
TOTAL: 32 cancellers

At output PAR levels of 8 dB or higher, only two PDC stages are needed. When the GC1115 output PAR is 8 dB or higher, PDC stages 3 and 4 can be disabled by clearing their corresponding *enable* bits in the CONTROL register (address 0x3).

4 Secondary GC1115 Configuration Parameters

The five primary GC1115 configuration parameters discussed in Section 3 are normally all that is required to configure the GC1115. In certain circumstances, additional GC1115 parameters or operating modes must be configured to achieve the desired GC1115 performance. This section discusses when these additional parameters or operating modes should be used, and how to determine their configuration values.

4.1 Asymmetric or Symmetric Spectra

Whenever the input spectrum is symmetric (identical to the left and to the right of DC), real cancellation coefficients can be used. GC1115 customers should try to use real coefficients whenever possible, because the maximum cancellation pulse length (and hence the achievable ACLR) is greater than when using complex cancellation pulses. However, for input signals with an asymmetric spectrum such as that shown in Figure 1, the spectrum asymmetry requires the use of complex cancellation coefficients. Complex cancellation pulses are limited to at most 127 taps, while real cancellation coefficients can contain up to 509 taps (in mirrored coefficient mode). The use of real or complex coefficients is specified in the CANCEL_MODE register (address 0xF).

4.2 Shortening Coefficient Download Time

When the GC1115 input signal has a symmetric spectrum, real cancellation pulses are used. Real cancellation coefficients are symmetric around the middle sample of the N coefficients. A set of N real cancellation coefficients has its largest coefficient value (2047) at the middle coefficient M = N/2. For example, when N = 101 real coefficients are used, the middle coefficient is at location M = 51, and coef(50) = coef(52), coef(49) = coef(53), etc. In this case (real, symmetric coefficients), the GC1115 only needs to be initialized with 51 unique coefficients, as long as the *mirrored coefficients* mode is enabled by setting bit 1 of the CANCEL_MODE register. By using *mirrored coefficients* mode, the GC1115's controlling microprocessor or DSP need only load M = 51 coefficients into GC1115 shadow RAM, instead of N = 101 coefficients. This shortens download time and allows the GC1115's cancellation SRAMs to be initialized more quickly.

4.3 Shortening Cancellation Pulse Delay

As described in the GC1115 data sheet, GC1115 users can consider minimum-phase cancellation pulses, whose delay for an N-tap cancellation pulse is shorter than N/2. In most circumstances, cancellation pulse phase response is not a critical design parameter. What matters most is the magnitude response of the cancellation pulse. GC1115 users can therefore also use minimum-phase filters, whose largest coefficient is significantly less than N/2.

Minimum-phase filters create a shorter latency through each PDC stage. If GC1115 users want to minimize the end-to-end latency caused by the normal N/2 delay in each PDC stage, they can do so by using a minimum-phase filter in the GC1115. Under normal (non-minimum-phase) circumstances, the CANCEL_DELAY1 through CANCEL_DELAY4 registers are initialized to half of the filter delay (CANCEL_LENGTH). However, when using minimum-phase cancellation pulses, these CANCEL_DELAY registers are set to a value that is less than half of the CANCEL_LENGTH value.

4.4 *Using the Post-PDC Interpolator (2x Real, 2x Complex, 4x Real)*

The GC1115 includes an interpolator after the four PDC stages. The interpolator is useful when a higher GC1115 output sampling rate is needed, such as when driving an interpolating DAC whose performance improves with sampling rate, or when a nonzero IF frequency is desired at the GC1115 output. The GC1115 interpolator is described in detail in the GC1115 data sheet. It provides 2x complex interpolation, 2x real interpolation with $f_s/4$ mix, and 4x real interpolation with $f_s/4$ mix. The 40 standard interpolator coefficients are listed in the GC1115 data sheet. However, because these 40 coefficients are stored in GC1115 RAM (at addresses 0x82 through 0xA9), GC1115 users are free to modify the interpolator coefficients to modify the interpolator filter bandwidth from its usual $0.25 \times f_s$ cutoff frequency. Contact TI for additional recommendations regarding changes to the GC1115 standard interpolator coefficients.

5 Example UMTS Configurations

GC Studio is the software provided by Texas Instruments to aid in the evaluation of GC devices such as the GC1115. The following GC1115 configuration parameters are used for the 3GPP examples delivered with the GC1115 GC Studio software.

5.1 Single-Carrier UMTS Configuration

The GC1115 configurations for the single-carrier 3GPP UMTS example test 1 are:

- **fsamp**   61.44 MSPS
- **bw**   4.5 MHz (90% of the 5-MHz UMTS bandwidth)
- **freqs**   0 MHz – the single carrier is centered at DC
- **ncoefs**   91 cancellation pulse coefficients
- **match**   0 or 1 (the *match* parameter is ignored for 1-carrier cancelers)
- **method**   1 (use MATLAB's *fir1* FIR filter design method)
- **cancelAlloc** [4 8 12 8], the recommended setting
- **PAR**   7, for a 7-dB output PAR threshold in this example
- **iMode**   1 (interpolator is bypassed)

5.2 Multicarrier UMTS Configuration

The GC1115 configurations for the multicarrier 3GPP UMTS example test 2 are:

- **fsamp**   61.44 MSPS
- **bw**   4.5 MHz (90% of the 5-MHz UMTS bandwidth)
- **freqs**   –7.5, –2.5, 2.5, 7.5 MHz (four 5-MHz carriers)
- **ncoefs**   91 cancellation pulse coefficients
- **match**   1 (notches between carriers) or 0 (no notches between carriers)
- **method**   0 (using MATLAB's *firls* FIR filter design method [better stop band])
- **cancelAlloc** [4 8 12 8], the recommended setting
- **PAR**   6, for a 6-dB output PAR threshold in this example
- **iMode**   1 (interpolator is bypassed)

6 Example cdma2000 Configurations

The following GC1115 configuration parameters are used for the cdma2000 examples delivered with the GC1115 GC Studio software.

6.1 Single-Carrier cdma2000 Configuration

The GC1115 configurations for the single-carrier cdma2000 example test 1 are:

- **fsamp**   29.49 MSPS (24× the 1.2288 chip rate)
- **bw**   1.125 MHz (90% of the 1.25-MHz cdma2000 bandwidth)
- **freqs**   0 MHz – the single carrier is centered at DC
- **ncoefs**   121 cancellation pulse coefficients
- **match**   0 or 1 (the1-carrier canacellation pulses are unaffected by the *match* parameter)
- **method**   0 (use MATLAB's *firls* FIR filter design method [better stop band])
- **cancelAlloc** [4 8 12 8], the recommended setting
- **PAR**   6, for a 6-dB output PAR threshold in this example
- **iMode**   1 (interpolator is bypassed)

6.2 Multicarrier cdma2000 Configuration

The GC1115 configurations for the multicarrier cdma2000 example test 2 are:

- **fsamp**   29.49 MSPS
- **bw**   1.125 MHz (90% of the 1.25-MHz cdma2000 bandwidth)
- **freqs**   –5, –1.25, 1.25, 5 MHz (four 1.25-MHz carriers with gaps)
- **ncoefs**   85 cancellation pulse coefficients
- **match**   1 (notches between carriers) or 0 (no notches between carriers)
- **method**   1 (using MATLAB's *fir1* FIR filter design method
- **cancelAlloc** [4 8 12 8], the recommended setting
- **PAR**   7, for a 7-dB output PAR threshold in this example
- **iMode**   1 (interpolator is bypassed)

7 Cancellation Pulse Design Optimization Techniques

As with any device that uses user-generated filter coefficients, careful design of GC1115 cancellation pulses optimizes GC1115 performance. GC1115 users can improve their ACLR, cEVM, and PCDE results by experimenting with the following FIR filter design parameters:

- Filter design technique (remez, fir1, firls, raiscos, ScopeFIR, etc.)
- Pass-band flatness (dB)
- Stop-band attenuation (dB)
- Transition bandwidth (Hz)
- Windowing techniques (Hanning, Hamming, Kaiser, etc.)

GC1115 users are encouraged to take some time optimizing CFR performance through cancellation pulse design tradeoffs. Optimizing GC1115 cancellation pulse coefficients is well worth the effort, because it results in measurably improved performance that ships with each GC1115.

7.1 FIR Filter Design Techniques

Many FIR filter design routines are available. GC1115 users should feel free to use the method with which they are most familiar, keeping in mind that experimenting with the many parameters of FIR filter design programs can improve GC1115 performance (ACLR, PCDE, and cEVM).

TI has used the following FIR filter design methods to create GC1115 cancellation pulses. The first four methods are MATLAB fitler design routines, while the last (ScopeFIR) is a shareware program for PCs.

fir1 — a simple MATLAB low-pass FIR filter design routine with a single cutoff parameter

firls — a MATLAB least-squares error minimization FIR filter design routine providing additional controls over stop-band attenuation levels over specified frequency ranges

remez — a MATLAB equi-ripple FIR filter design routine that results in a flat stop-band response. The remez routine uses the Parks-McClellan remez exchange algorithm, and the various frequency ranges can be weighted.

rcosine — a MATLAB raised-cosine FIR filter design technique. Set the MATLAB *type_flag* parameter to *sqrt* to design a root-raised-cosine (RRC) filter. Set the rolloff factor to 0.22 to exactly match the 3GPP UMTS RRC alpha parameter. Set the rolloff factor to less than 0.22 (such as 0.18) if a follow-on windowing function will be applied to the RRC coefficients.

ScopeFIR — a powerful Windows-based FIR filter design routine with many design options. Obtain ScopeFIR from www.iowegian.com/scopefir.htm.

As with all FIR filter design methods, each method has advantages and disadvantages.

To create GC1115 cancellation coefficients, TI does not recommend one FIR filter design method over another. Instead, TI encourages GC1115 users to experiment with several cancellation pulse design methods. Results using different methods may not differ appreciably, especially at output PAR levels of 8 dB or higher. However, at output PAR levels approaching 6 dB, cancellation pulse design becomes the determining factor in achieving optimal PCDE and cEVM results.

Experience at output PAR levels of 6 dB or lower inclines toward a preference for the root-raised-cosine (RRC) filter design technique followed by windowing to provide additional stop-band attenuation. Remember that when designing such RRC filters, the RRC alpha parameter should be made slightly smaller than specified by the standard (for example, use an RRC alpha = 0.18 for 3GPP UMTS cancellation pulses instead of the 3GPP UMTS standard alpha of 0.22) to compensate for the transition bandwidth expansion caused by the windowing function being applied to the RRC coefficients.

7.2 Multicarrier Cancellation Pulses and the match Parameter

During GC1115 development, TI developed two primary methods for designing multicarrier cancellation pulses. These methods differ in how a prototype cancellation pulse is *matched* to the desired input signal spectrum. For this reason, the TI-provided MATLAB cancellation pulse design functions allow two different *match* parameters: 0 or 1.

A *match* parameter of 0 indicates that exactly matching the frequency response of the input signal [including any notches (lowering of the spectral response) between carriers] is not a critical design parameter. Symmetric input spectra can usually set the *match* parameter to 0 if they do not need to match the notches between carriers.

A *match* parameter of 1 indicates that the input spectra (including notches between carriers) should be matched exactly.

When designing multicarrier cancellation pulses for input spectra where carriers are missing, the *match* parameter must be set (*match* = 1). For instance, in a two-carrier 3GPP UMTS configuration where the two carriers are located at –7.5 MHz and 7.5 MHz, there are two *missing* carriers (at –2.5 and 2.5 MHz). In order to properly account for the two *missing* carriers, the *match* parameter for this configuration must be set (*match* = 1).

7.3 *Pass-Band Flatness, Stop-Band Attenuation, Transition Bandwidth, and Windowing*

The GC1115 is not particularly sensitive to pass-band flatness. Pass-band ripple of up to 3 dB appears to be acceptable when designing GC1115 cancellation pulses.

Cancellation pulse stop-band attenuation significantly affects the GC1115 ACLR performance. As a visualization aid, GC1115 users can picture the cancellation pulse frequency response as floating at a level below the input signal response. The cancellation-pulse in-band frequency response ordinarily floats 15 to 30 dB below the level of the input signal frequency response. For instance, a single-carrier 3GPP UMTS test model being peak-reduced to a 6-dB output PAR level has an in-band distortion level that is about 20 dB below the input signal carrier power. If the GC1115 cancellation pulse was designed with 50-dB stop-band attenuation (relative to the 0-dB pass-band level of the cancellation pulse), this cancellation pulse should result in an ACLR level of about 70 dB (50 dB of stop-band attenuation plus 20 dB of in-band *float* attenuation at 6-dB PAR), relative to the input signal spectrum. Given that the in-band distortion caused by GC1115 cancellation pulses is 20 dB or more below the input signal carrier level, GC1115 users should aim to achieve at least 50 dB of stop-band attenuation in their cancellation pulse frequency response to achieve a 70-dB ACLR.

GC1115 users should be aware that the application of windows (such as Hanning, Hamming, Kaiser, Blackman-Harris, etc.) to FIR filter coefficients can significantly increase stop-band attenuation, at the expense of a wider transition bandwidth. If GC1115 users plan to window the GC1115 cancellation coefficients, they should ensure that the transition band of the FIR filter before windowing is slightly narrower than needed, to compensate for the transition-band expansion caused by windowing.

Transition bandwidth, like pass-band flatness, does not appear to be a particularly critical GC1115 cancellation pulse design parameter. However, users should ensure that the per-carrier cancellation pulse bandwidth does not exceed the input bandwidth. Failure to do so can result in a slight widening of the desired input signal bandwidth, which degrades the GC1115 ACLR performance.

Contact TI for additional guidance regarding GC1115 cancellation pulse design.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments

Post Office Box 655303 Dallas, Texas 75265

Copyright © 2005, Texas Instruments Incorporated