NXP Semiconductor
User Guide

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User Guide About Spread Spectrum Support for i.MX 8QuadMax and i.MX 8QuadXPlus Display

1. Introduction

This document describes the Spread Spectrum support for displays on i.MX 8QuadMax and i.MX 8QuadXPlus, specific for LVDS display. It describes the underlying HW function, how to enable it and the intended capability.

The display controller (DC) subsystem on i.MX 8QuadMax and i.MX 8QuadXPlus uses an AVPLL to generate the reference clock for operation of the LVDS PHYs. Enabling Spread Spectrum on the reference clock will result in the PHY interfaces being spread as well. This Spread Spectrum feature is controlled by the SCU firmware and can be enabled or disabled by configuring the board file of the SCU firmware porting kit.

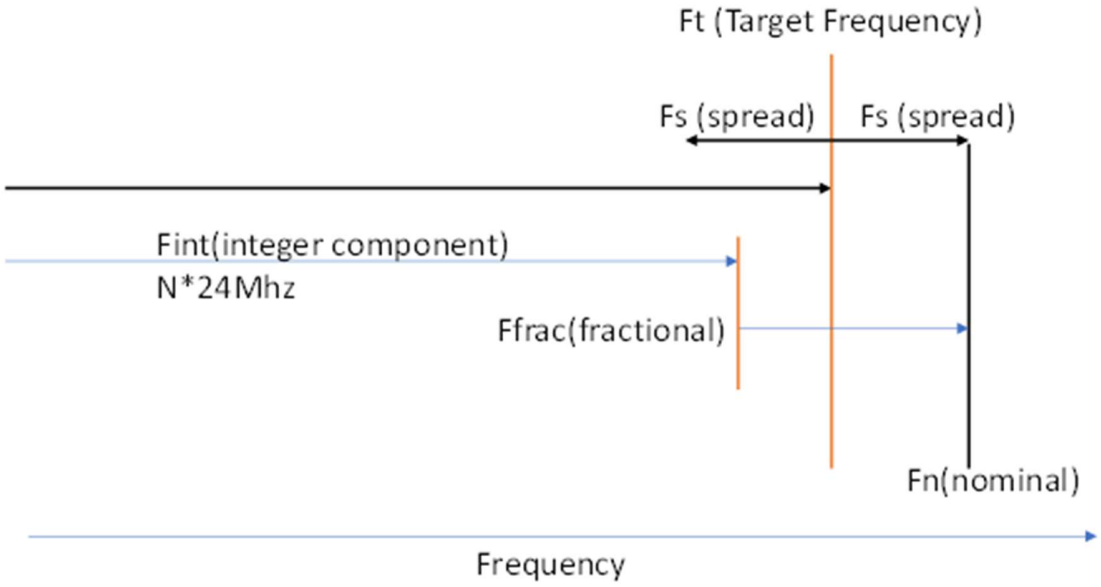
Note: The PLLs embedded into LVDS PHY can follow the modulation generated by the AVPLL reference to support Spread Spectrum feature. While these interfaces can implement Spread Spectrum, the user must decide if the modulation is appropriate and compatible with their application.

2. Configuration of the frequency modulation

Note: This section describes the function carried by SCU firmware and relative codes are not accessible by the user.

When enabled and configured, the output modulation will be spread with a triangle frequency waveform over time. This is accomplished to spreading the reference clock to the PHY and letting the PHY track it. The reference clock to the PHYs is generated and configured in a AVPLL whose parameters are defined below.

At the clocking level, the variation is enabled by changing one (or more) of the AVPLLs to vary the frequency over time. The variation is restricted in amount 2% and hence will not cause relock of the VCO or any downstream functions.



The frequency can be described as follows:

- **F(t) target frequency** – the intended or nominal frequency for the function, in the case of LVDS the pixel rate
- **F(s) the spread frequency** – the variation in frequency above and below the F(t) value.
- **F(n) the nominal frequency** – the maximum frequency which can be reached by the clock

For spread spectrum NOT enabled the F(s) will be zero, for enabled it will be calculated to be around 1% of the F(t) value – for a total variation of 2%

The nominal frequency is made up of an integer amount (ie an integer multiple of the Reference Frequency 24Mhz) called F(int) plus a fractional part F(frac) which is a fraction of the reference frequency.
Thus

F(n) = F(t) + F(s)
F(n) = F(int) + F(frac) = 24Mhz*(DIV_SELECT + NUM/DENOM)

The F(s) value

F(s) = F(t)/100
F(s) = (24Mhz*(MAX_VAR/DENOM))/2

Note that at any point in time the actual generated frequency F(actual) is always lower than the F(n) and the maximum drop is 2F(s)

F(actual) = F(n) – 24Mhz*(ACCUM/DENOM)

The variable in the formula can be described as follows:

- **DIV_SELECT** – the integer part of the VCO frequency calculation
- **NUM** – the numerator of the fractional part of the VCO frequency, this depends on the target frequency fraction
- **DENOM** – the denominator of the fractional part of the VCO frequency, this is fixed to 960000 for all non spread spectrum PLLs, but it's a variable for spread spectrum
- **ACCUM** – a variable offset which is made by repeatedly adding the STEP to an accumulated value until it reaches STOP
- **MAX_VAR** – the maximum value which can be accumulated before direction of increment changes
- **FMODULATION** (KHz) – the rate at which the triangle modulation repeats over time. Typically this is set as low as possible without being in the traditional audio frequency range, e.g. 30KHz.

ACCUM is calculated as follows using a STEP and STOP value:

```
DIRECTION = COUNTUP
ACCUM=0
LOOP:
IF ACCUM = 0 THEN
        DIRECTION = COUNTUP
        ACCUM = ACCUM + STEP
ELSE IF ACCUM > STOP THEN
        DIRECTION = COUNTDOWN
        ACCUM = ACCUM – STEP
ELSE IF DIRECTION = COUNTDOWN THEN
        ACCUM = ACCUM - STEP
ELSE IF DIRECITON = COUNTUP THEN
        ACCUM = ACCUM + STEP
```

ELSE
error case
FI
GOTO LOOP

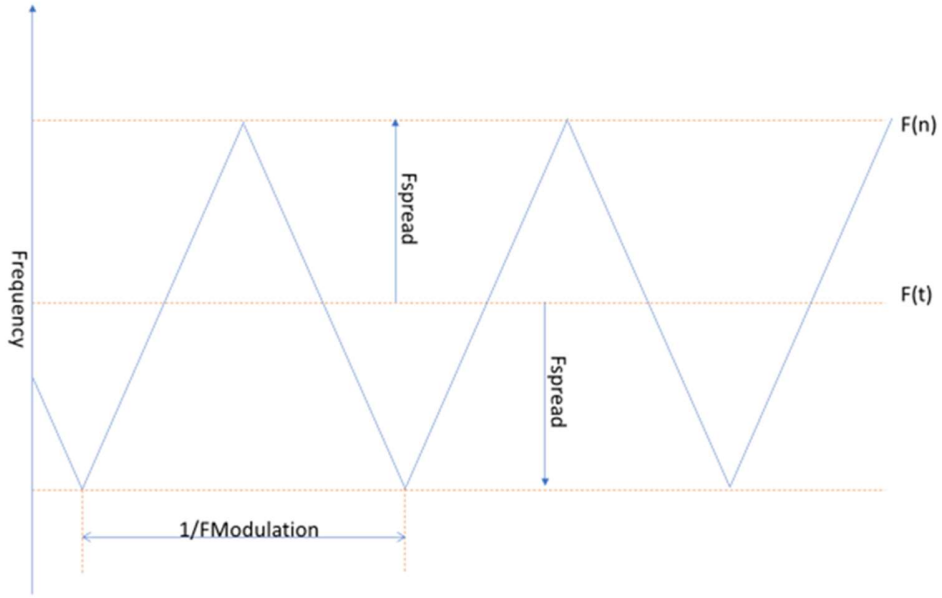
- **STEP** – the increment/decrement used to vary the frequency, the size of the step is used to set the frequency of modulation (i.e. the rate of change of the frequency). The relation between STEP and the modulation frequency, the reference clock and the STOP:

  STEP = FMODULATION / 24MHz * 2 * STOP

- **STOP** – the limit of the increment/decrement, which when reached, will change to a decrement/increment.

It's important to choose STOP value to prevent rolling over. The maximum value of STOP is 0xFFFF (as the register field is 16 bits). If we define STOP to be fixed at 64000 and want to get FModulation as 30KHz, then we can calculate the STEP value as:

STEP = 30K/24M * 2 * 64000 = 160.



3. Support in SCFW Porting Kit

The Spread Spectrum feature is added starting from SCFW porting kit V1.2.2 release which can be download from NXP web site "i.MX Software and Development Tool". Note that SCFW porting kit is coupled with Linux BSP release and tested as a complete kit.

The Spread Spectrum function is controlled via a function board_parameter(board_parm_t parm) included in the board.c file (which is the customized file in the SCU firmware).
Take the iMX 8QuadXPlus MEK as an example, the file path is "imx-scfw-porting-kit-x.x\src\scfw_export_mx8qx_b0\platform\board\mx8qx_mek\board.c".

This board parameter will be checked when the AVPLL is enabled for related LVDS display.

The "parm" values (the first 2 values are available for i.MX 8QuadXPlus, the four values are available for i.MX 8QuadMax) could be:

- BOARD_PARM_DC0_PLL0_SSC - DC0 PLL0 Spread Spectrum enable
- BOARD_PARM_DC0_PLL1_SSC - DC0 PLL1 Spread Spectrum enable
- BOARD_PARM_DC1_PLL0_SSC - DC1 PLL0 Spread Spectrum enable
- BOARD_PARM_DC1_PLL1_SSC - DC1 PLL1 Spread Spectrum enable

And the return value could be set as:

- BOARD_PARM_RTN_NOT_USED if not to be enabled
- BOARD_PARM_RTN_USED if it is to be enabled

This setting controls the function for each display channel, and it's a necessary configuration besides the pixel clock frequency which is used to setup the PLL_TARGET value for AVPLL.
If the return value is set to be "BOARD_PARM_RTN_USED", then the modulation is enabled.

Note:
For SCFW porting kit V1.2.10 and later versions, users can choose the percentage of frequency spread from following values: 0%, 0.4%, 1.0%, 1.4%, 2.0%, by setting the return value accordingly:

- BOARD_PARM_RTN_NOT_USED
- BOARD_PARM_SSC_N_0P4
- BOARD_PARM_SSC_N_1P0
- BOARD_PARM_SSC_N_1P4
- BOARD_PARM_SSC_N_2P0

4. Modulation Characteristics

The intent of the modulation is to make the variation equal to 1% above and 1% below of the target frequency with a modulation rate of 30Khz. This can be achieved over all frequency points. The intent is to keep the average frequency the same with or without spread spectrum enabled, however there can be a small difference due to rounding (typically much less than 200ppm).

5. Enablement Example

This section takes i.MX 8QuadXPlus LVDS Spread Spectrum enablement as an example.

The required code modification in SCU firmware board.c is listed as follows:

```
diff --git a/firmware/platform/board/mx8qx_mek/board.c
b/firmware/platform/board/mx8qx_mek/board.c
index d729444..a009751 100755
--- a/firmware/platform/board/mx8qx_mek/board.c
+++ b/firmware/platform/board/mx8qx_mek/board.c
@@ -420,6 +420,12 @@ board_parm_rtn_t board_parameter(board_parm_t parm)
        case BOARD_PARM_KS1_ONOFF_WAKE:
            rtn = BOARD_KS1_ONOFF_WAKE;
            break;
+       case BOARD_PARM_DC0_PLL0_SSC:
+           rtn = BOARD_PARM_RTN_USED;
+           break;
+       case BOARD_PARM_DC0_PLL1_SSC:
+           rtn = BOARD_PARM_RTN_USED;
+           break;
        default:
            ; /* Intentional empty default */
            break;
```

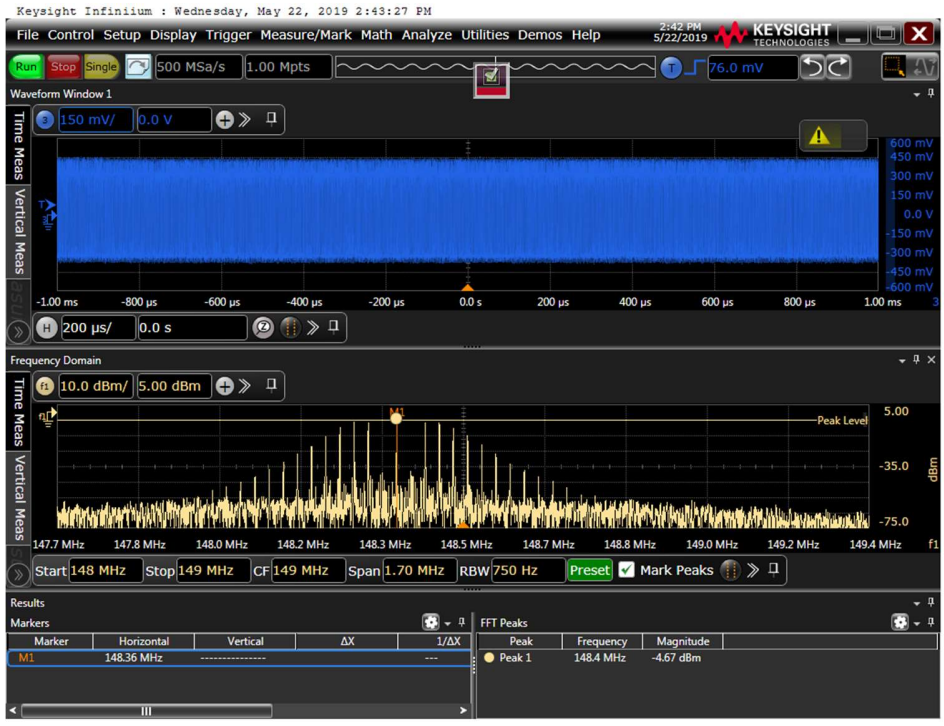
Note:

For SCFW porting kit V1.2.10 and later versions, users can choose the percentage of frequency spread from following values: 0%, 0.4%, 1.0%, 1.4%, 2.0%, by setting the return value accordingly:

- BOARD_PARM_RTN_NOT_USED
- BOARD_PARM_SSC_N_0P4
- BOARD_PARM_SSC_N_1P0
- BOARD_PARM_SSC_N_1P4
- BOARD_PARM_SSC_N_2P0

Before enabling Spread Spectrum feature (Magnitude is 2.106dBm)

After enabling Spread Spectrum feature, Magnitude is -4.67dBm.



6. Revision History

Revision number	Date	Substantive changes
1.0	2019/5/29	Initial release
2.0	2019/8/22	Update for new algorithm and SCFW
2.1	2020/5/22	Update for fspread selection in SCFW

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