GDT and SMIP Sample Code with EHC (Using CMSIS Driver Package) for RE01 1500KB Group

GDT and SMIP Sample Code with Energy Harvesting Controller Using CMSIS Driver Package

Summary

This application note describes a sample code using the RE01 1500KB Group CMSIS driver package. The sample code can be found in the project delivered with this application note.

This application note contains sample code that runs in Energy Harvesting Mode. It can start up the MCU solely from the energy harvested from a solar cell. The sample code is also able to perform 2D graphics conversion and display images on Serial MIP LCD (Memory in Pixel LCD). The whole process of start-up, graphic conversion, and image display is powered by only using a solar cell.

Contents

1. Specifications

1.1 Description of Project

A sample code project is delivered with this application note. This sample code project is configured to match the settings of R7F0E015D2CFB mounted on the Evaluation Kit RE01 1500KB. When using another device, change the device settings in the project to those of the target device.

1.2 Pins Used

The pins used by the sample code are shown below.

Pin Used	Purpose of Use
P404	DCDC Enable bit
P605	RESET
P606	VCOM
P610	SCS

1.3 File Configuration

Table 1-1 shows the files that were added or changed in the sample code.

Table 1-1 Files Added or Changed in Sample Code

File Name	Overview of Processing or Configuration	Remarks
main.c	Main processing	
r_system_cfg.h	System configuration	Registering IRQ interrupts to NVIC
r_core_cfg.h	Clock and operating mode configuration	Changing clock configuration and enabling EHC mode.

2. Operating Environment

2.1 Device

RE Family RE01 1500KB Group

2.2 Development Environment

The sample code was developed with the following environment (Table 2-1).

Table 2-1 Sample Code Operating Environment

IDE	Compiler	Debugger
IAR EWARM V8.32 or later (IAR Embedded Workbench® for ARM)	IAR v8.32 or Later	IAR I-Jet
		Segger J-Link(OB)
Renesas e2 studio V.7.6.0 or later	GCC Version 6.3.1.20170620	Segger J-Link(OB)

2.3 Target Board

Evaluation Kit RE01 1500KB

3. Description of Software

This board is powered by a solar panel. After charging the capacitor, the program sends image data to MIP LCD. The display is toggled between original image and color-inverted image, which changes every 5 seconds. Images used in this program are shown below.

(a) Original Image	(b) Color-inverted Image
	

The block diagram of this sample program is shown in Figure 3.1.

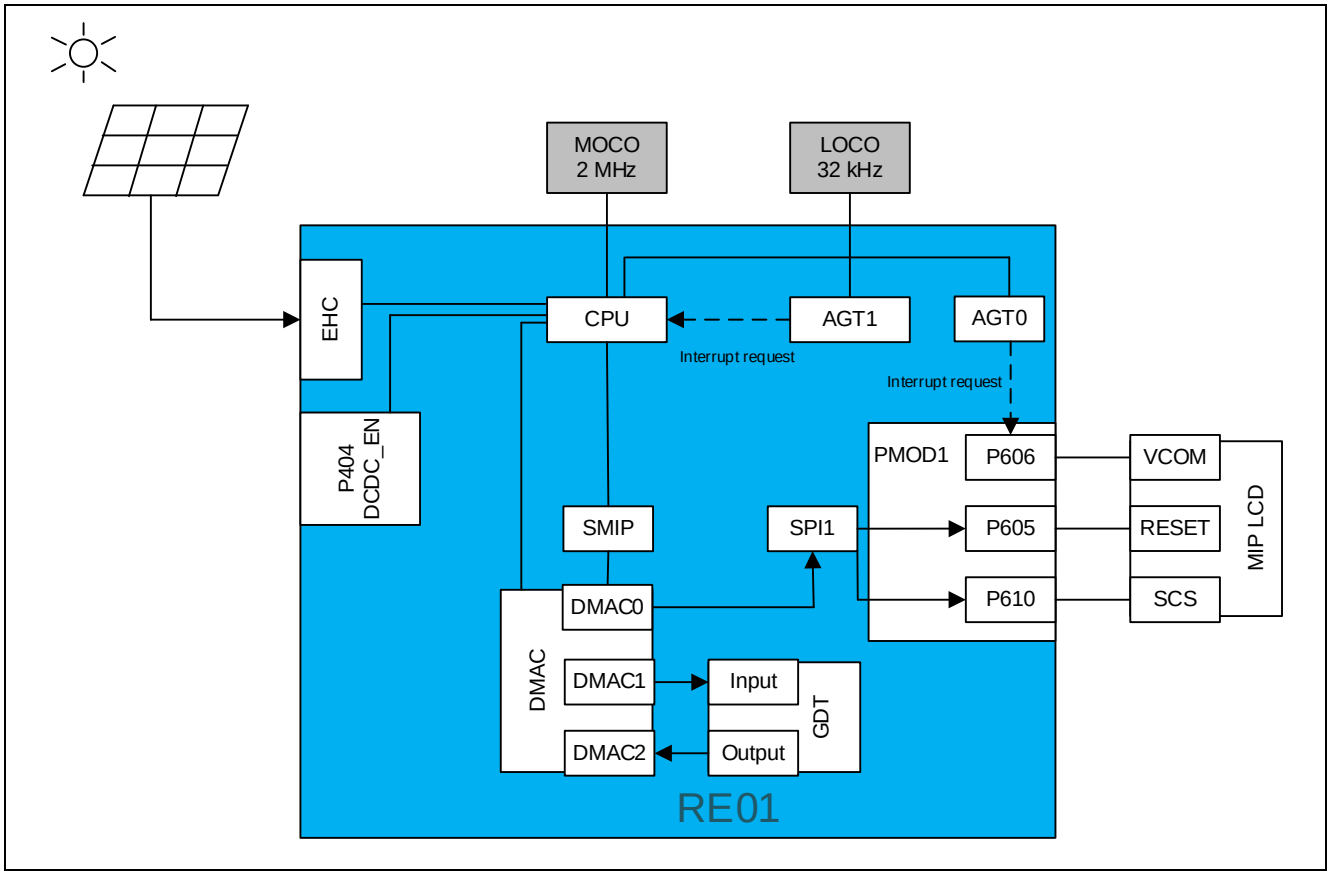

Figure 3.1 Block Diagram

This sample code uses SMIP and GDT driver. Table 3-1 shows the data format used for SMIP transmission in this sample code. Table 3-2 shows the configuration used for GDT driver.

Table 3-1 SMIP Transmission Data Format

Item	Setting
SPI Channel	1
Transmit clock frequency	500 kHz
Serial MIP Type	Kyocera MIP-LCD 256(H)x256(V) monochrome

Table 3-2 GDT Driver Configuration

Item	Setting
GDT process	Bit inversion
Image processing data size	16 x 16 bits
Interrupt signals	Convey interrupt signals to DMAC
Interrupt requests	Image Data Input Request Interrupt Image Data Output Request Interrupt

3.2 Changes in Driver Settings

Table 3-3 Changes in Drivers

Item	File Location	Details
Changing clock operation and EHC operating mode	[r_core_cfg.h]	• The setting was changed.
	SYSTEM_CFG_LOCO_ENABLE	Change to (1) : LOCO is to be used
	SYSTEM_CFG_EHC_MODE	Change to (1) : EHC mode
Registering IRQn interrupts to NVIC	[r_system_cfg.h]	• The setting was changed.
	SYSTEM_CFG_EVENT_NUMBER_DMAC0_INT	Change to: (SYSTEM_IRQ_EVENT_NUMBER0)
	SYSTEM_CFG_EVENT_NUMBER_AGT1_AGTI	Change to: (SYSTEM_IRQ_EVENT_NUMBER4)
	SYSTEM_CFG_EVENT_NUMBER_SPI1_SPII	Change to: (SYSTEM_IRQ_EVENT_NUMBER2)
	SYSTEM_CFG_EVENT_NUMBER_AGT0_AGTI	Change to: (SYSTEM_IRQ_EVENT_NUMBER3)

3.3 List of Functions

The functions added to the sample code are described in this section.

main	
Overview	Main processing
Header	None
Declaration	void main(void)
Description	This function calls the system initialization function. In this function, DCDC and VBB are enabled. The program continues and jump to sstby_on_ram() function.
Argument	None
Return Value	None

sstby_on_ram	
Overview	Send image to MIP LCD and enter SSTBY mode
Header	None
Declaration	static void sstby_on_ram(void)
Description	In this function, AGT1 is initialized and started. Next, the following processes are repeated endlessly. 1. Send image to MIP LCD by using SMIP driver 2. Invert the color of the image by using GDT driver 3. Enters SSTBY mode and waits for wake-up interrupts that occurs every 5 seconds. (AGT1 underflow) This function is allocated to RAM.
Argument	None
Return Value	None

agt1_init	
Overview	Initialize AGT1
Header	None
Declaration	static void agt1_init (void)
Description	This function sets AGT1 clock source division ratio and AGT1 counter. AGT1 underflow interrupt is also initialized in this function. This function is allocated to RAM.
Argument	None
Return Value	None

agt1_start	
Overview	Start AGT1
Header	None
Declaration	static void agt1_start (void)
Description	This function starts AGT1 count. This function is allocated to RAM.
Argument	None
Return Value	None

gdt_dmac_init	
Overview	Initialize DMAC1 and DMAC2 used for GDT inversion (convert original image to color-inverted image)
Header	None
Declaration	static void gdt_dmac_init (void)
Description	This function configures and enables DMAC1 and DMAC2 transfer used for GDT inversion. DMAC1 inputs original image to GDT driver. DMAC2 outputs color-converted image from GDT driver. This function is allocated to RAM.
Argument	None
Return Value	None

gdt_dmac_init_for_outputimg	
Overview	Initialize DMAC1 and DMAC2 used for GDT inversion (convert color-inverted image back to original image)
Header	None
Declaration	static void gdt_dmac_init_for_outputimg (void)
Description	This function configures and enables DMAC1 and DMAC2 transfer used for GDT inversion. DMAC1 inputs color-inverted image to GDT driver. DMAC2 outputs original image from GDT driver. This function is allocated to RAM.
Argument	None
Return Value	None

gdt_init_and_start	
Overview	Initialize and start GDT
Header	None
Declaration	static void gdt_init_and_start(void)
Description	This function configures and start GDT. This function is allocated to RAM.
Argument	None
Return Value	None

gdt_dmac_stop	
Overview	Stop and disable DMAC
Header	None
Declaration	static void gdt_dmac_stop(void)
Description	This function stops and disable DMAC interrupts, transfer, and operation. This function is allocated to RAM.
Argument	None
Return Value	None

smip_callback	
Overview	Callback function for SMIP driver
Header	None
Declaration	static void smip_callback(void)
Description	This function sets the status flag variable used to check if SMIP transmission has been completed. This function is allocated to RAM.
Argument	None
Return Value	None

3.4 Flowcharts

Figure 3.2-Figure 3.9 show the flowcharts used in the program.

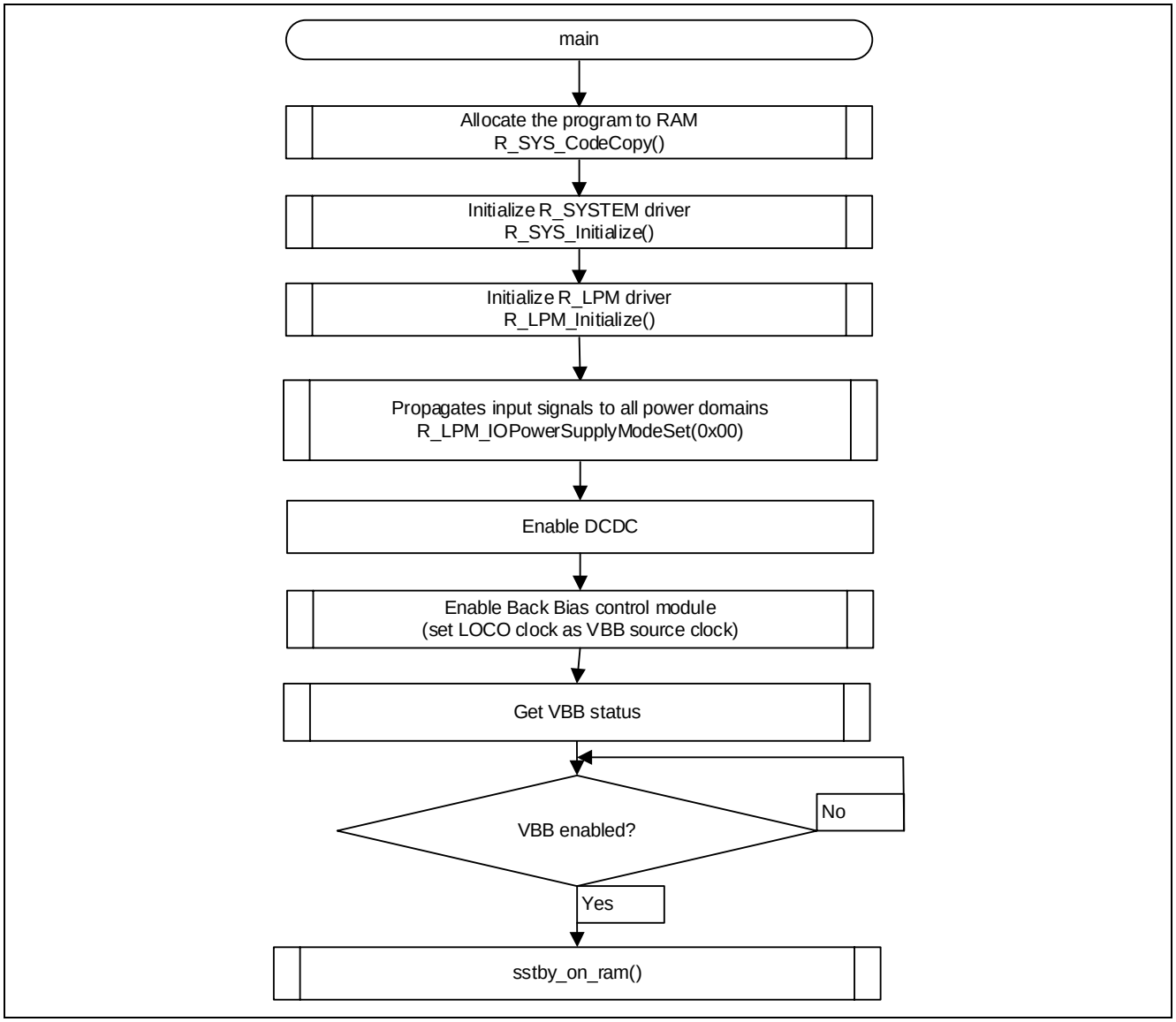

Figure 3.2 Main Processing

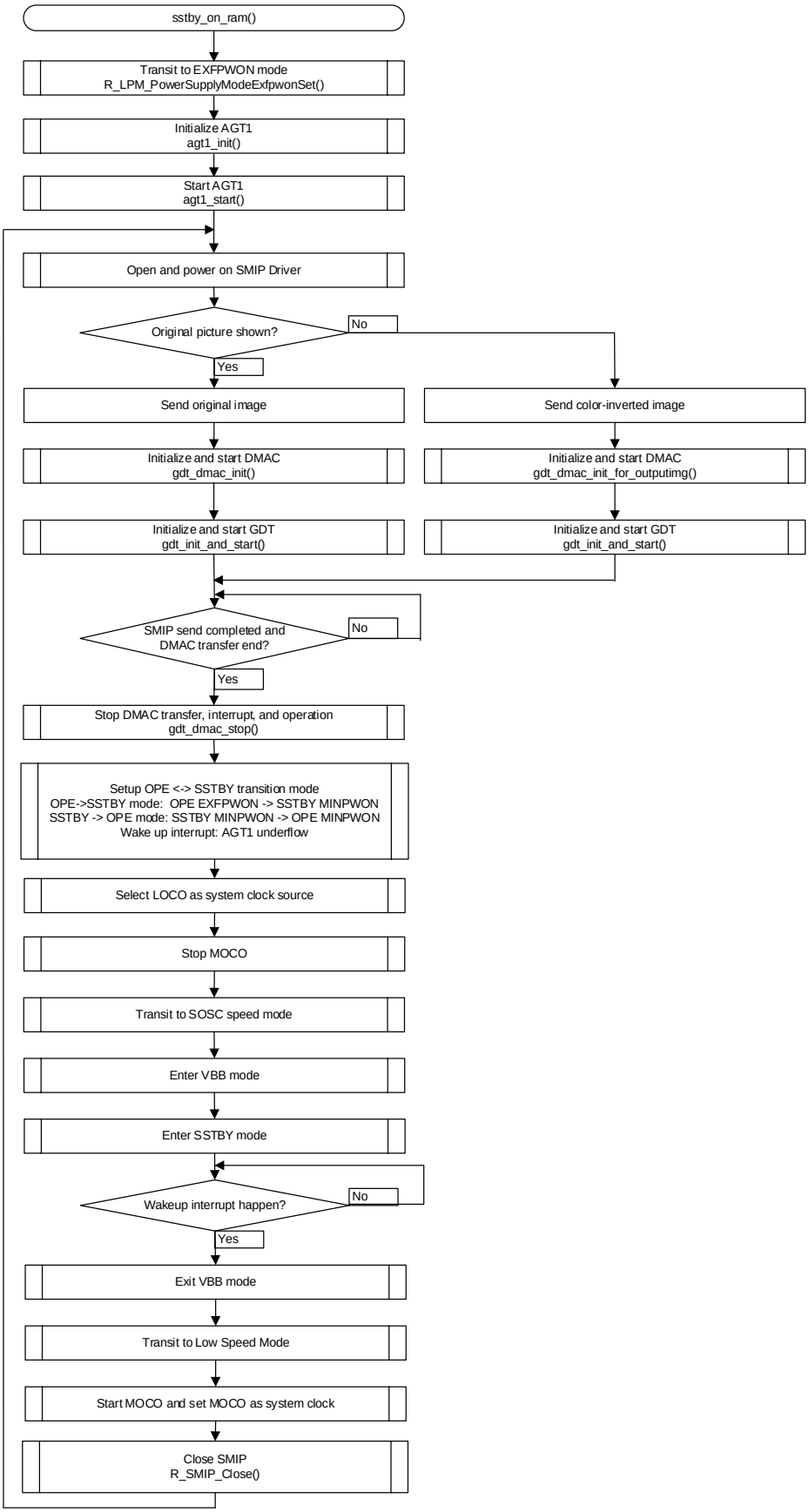

Figure 3.3 Toggled Image Sending Processing

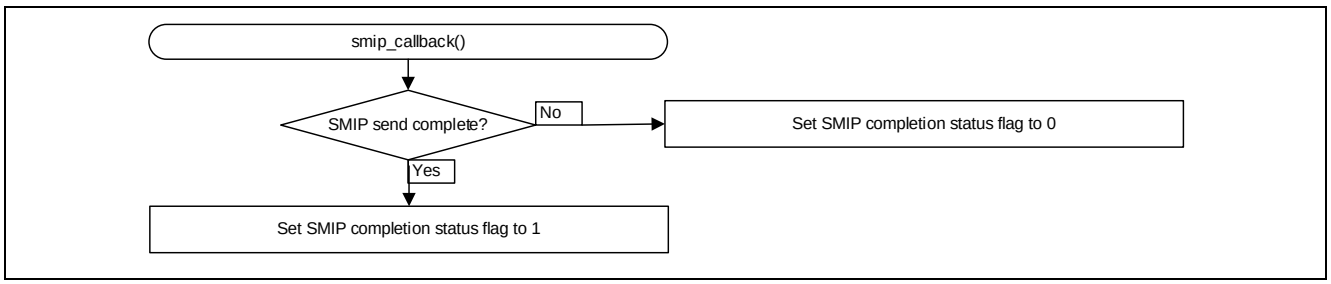

Figure 3.4 SMIP Callback Processing

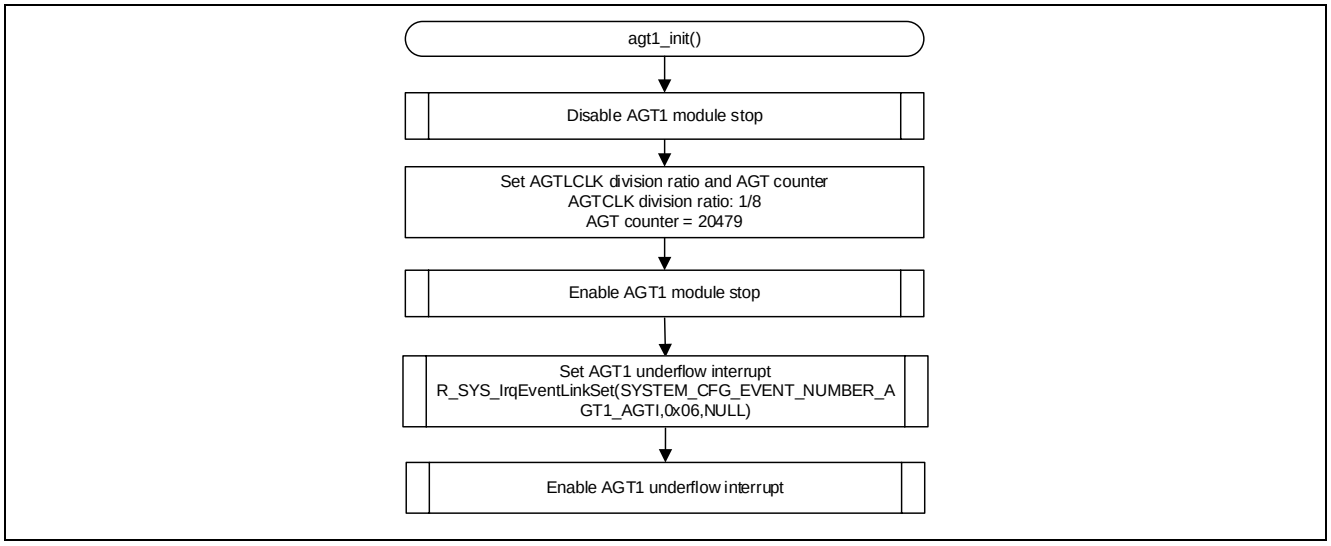

Figure 3.5 AGT1 Initialization

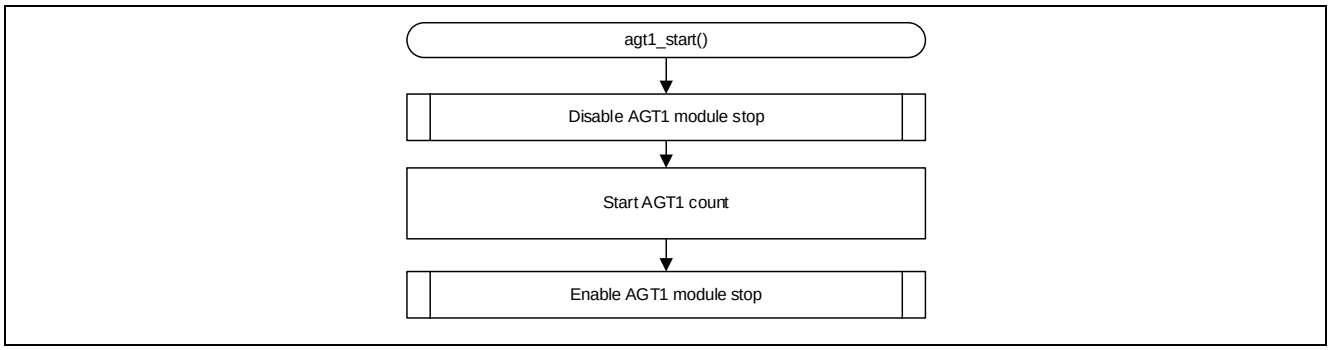

Figure 3.6 AGT1 Start Processing

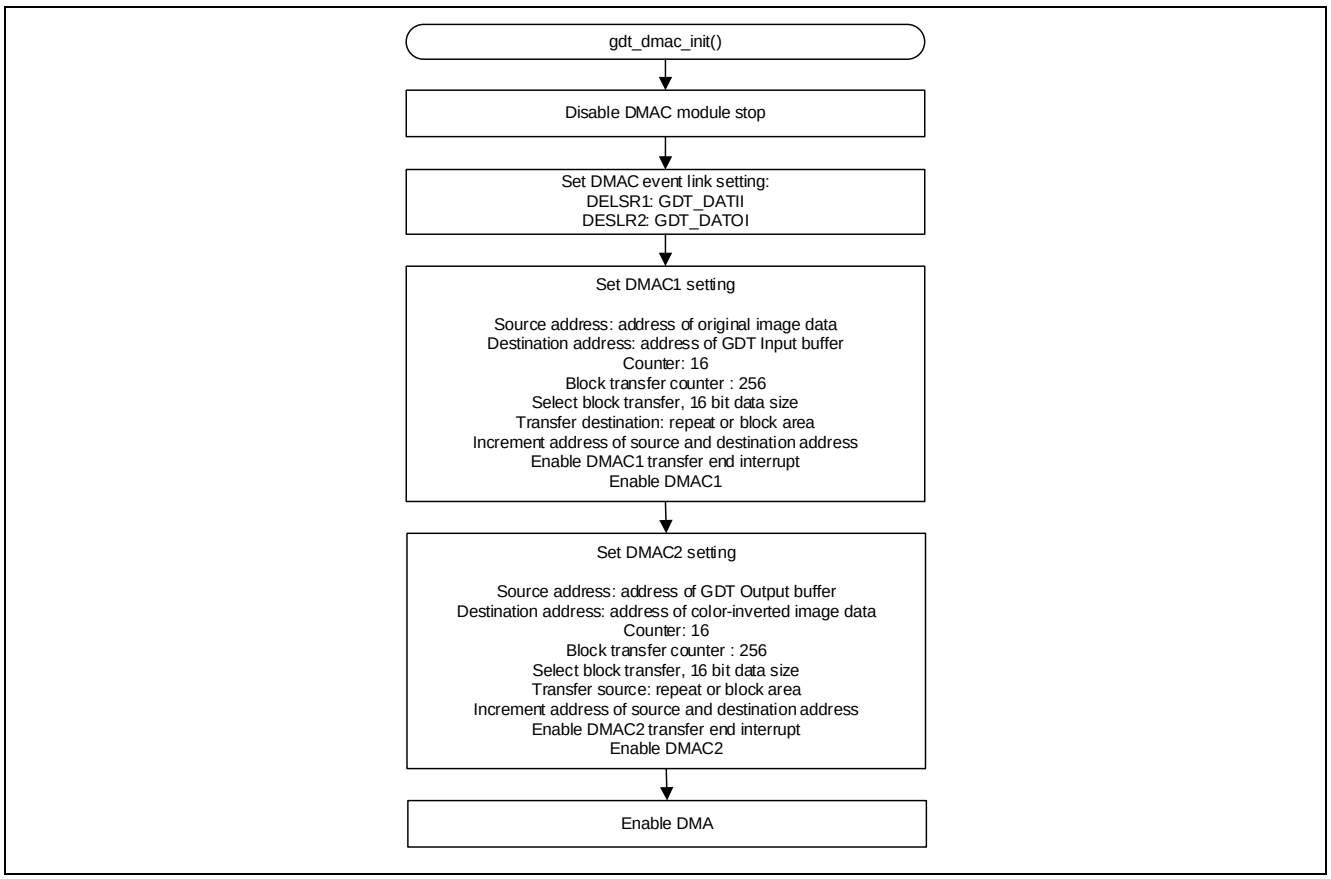

Figure 3.7 DMAC Initialization for GDT Inversion (Original Image to Color-inverted Image)

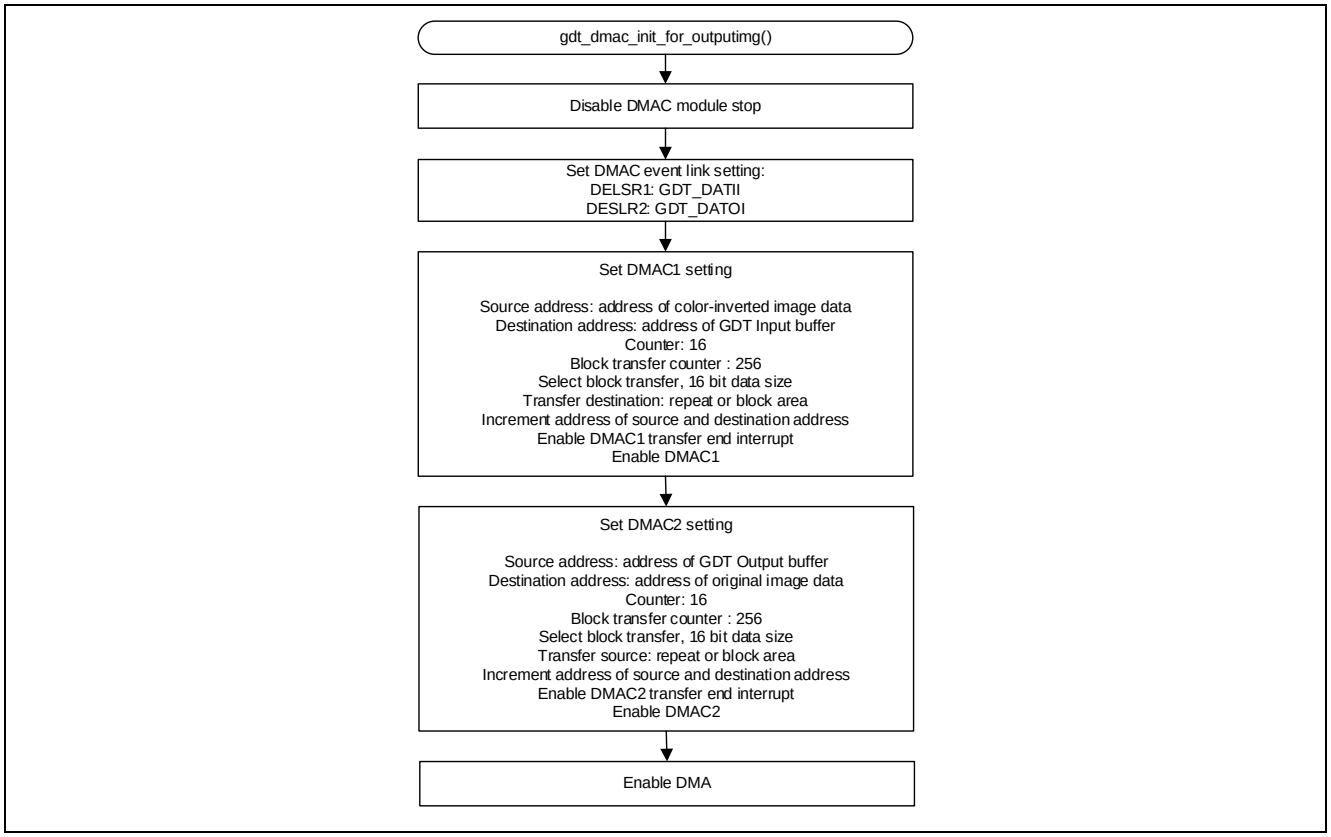

Figure 3.8 DMAC Initialization for GDT Inversion (Color-inverted Image to Original Image)

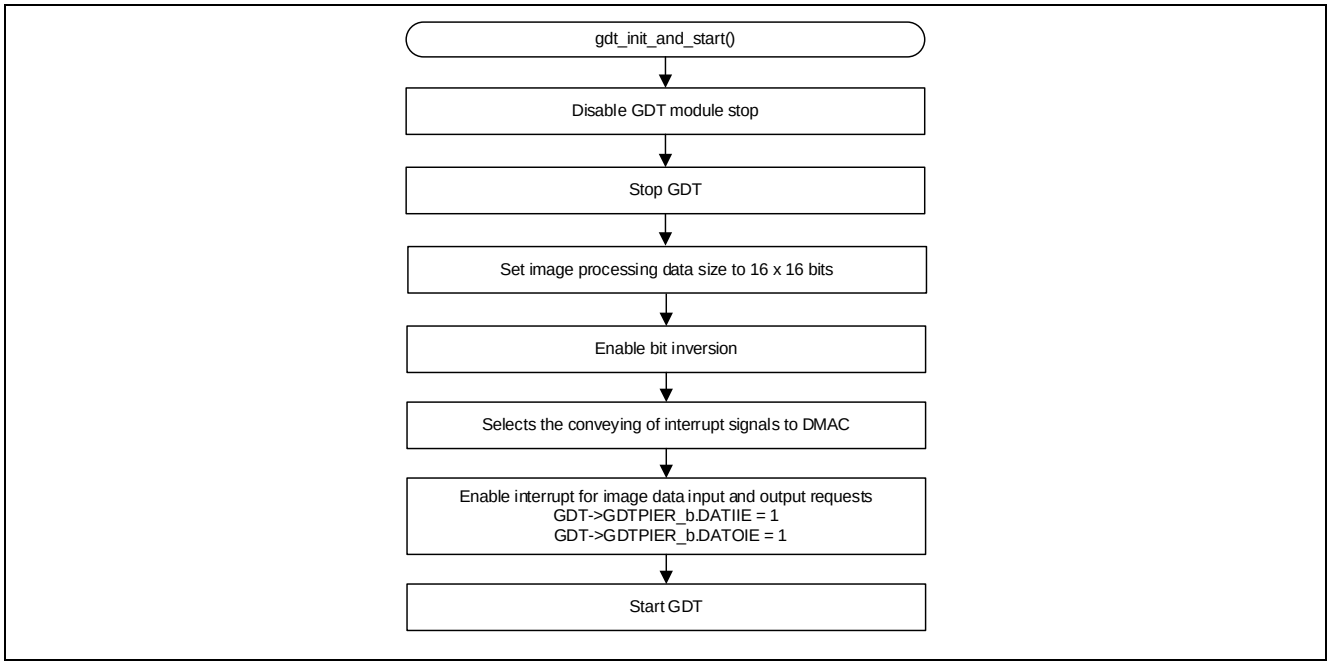

Figure 3.9 GDT Initialization

4. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

5. Reference Documents

User's Manual: Hardware

RE01 1500KB Group User's Manual: Hardware R01UH0796

(The latest version can be downloaded from the Renesas Electronics website.)

Technical Update/Technical News

(The latest version can be downloaded from the Renesas Electronics website.)

User's Manual: Development Tools

(The latest version can be downloaded from the Renesas Electronics website.)

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov. 29, 2019	—	First edition issued

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1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

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