

R&D Technical Documentation

Dovision	Modif	ied	Check	ed	Module Name
Kevision	Date	By	Date	By	
А	Apr14-2015	BG			CSM-400UE
В	Apr24-2015	BG			
С	June25-2015	BG			Description
D	July6-2015	BG			Description
Е	July8-2015	BG			RF Transceiver module / Sub 1GHz
F	Aug11-2015	BG			
G	Aug26-2015	BG			
Н	Oct14-2015	BG			
Ι	Oct16-2015	BG			Domonka
J	Mar16-2017	GWH			Kemai KS
					3.3~5.0Vdc / USB Flash programmable
					Item Number
					66990004

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2. PROJECT DESCRIPTION

CSM-400UE is a modular 410-475MHz RF transceiver designed to provide the RF interface for Hetronic devices. The module is designed to be mounted onto Hetronic coder and decoder boards to convert digital information to RF signals and RF signals to digital information. CSM-400UE can be programmed to function in several different operating modes. Configuring the operating mode and functional settings of each mode allows CSM-400UE to be expandable to additional operating modes, new RF protocols and many frequency channels. CSM-400UE communicates with a PC using the CSM-CFG board as an USB and RS-232 adapter.

CSM-400UE uses an internal 3.1V regulator and requires a 3.3-5.0V external power supply. Absolute maximum survival supply voltage is limited to 12VDC. In applications, this will be provided by the host coder/decoder board. CSM-400UE can be configured to operate on any 6.25kHz channel from 410MHz - 475MHz. The RF output power is set to 10dBm (10mW). Depending on the protocol, CSM-400UE can operate at RF baudrates up to 50kbps. CSM-400UE is built around the TI CC1200 Sub-1GHz RF transceiver. RF front-end circuitry on the device limits effective performance to ~385MHz to ~500MHz, although the hard frequency limits for the 400 MHz range are from 410 to 475 MHz. RF sensitivity varies depending on the protocol being used.

All of the functionality of the CSM-400UE is configured in the firmware. CSM-CFG is also used to load the firmware bootloader over RS-232 and firmware application using the USB Flash Programmer tool. CSM-400UE can also connect to the PC H-Link tool over the CSM-CFG board. H-Link serves an important purpose for CSM-400UE: calibrating the on-board radio. **Every CSM-400UE module must be calibrated before use in a Hetronic product**. H-Link calibration compensates for production variation in the RF performance of the on-board radio.

CSM-400UE by default is configured to 'ELP-TRx' mode. This causes it to act as a transceiver for the Hetronic ELP protocol. In this mode it will only communicate with other ELP devices. In ELP Mode, radio control and data transfer are all handled over the DI and DO pins with 115.2k baud UART. The legacy 'AF' pin does not support audio output but is instead used for USB detection. CSM-400UE's frequency and encryption can be configured using the CSM Configuration Tool. For more information, see the CSM_CFG Technical Document.

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3. BLOCK DIAGRAM

Figure 1: CSM-400UE Block Diagram

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4. TECHNICAL SPECIFICATION

Parameter	Specification
Nominal Supply (BATT+)	3.2~5.0Vdc
Max Supply (BATT+)	5.5V
Min Supply (BATT+)	2.9Vdc
Max Input Voltage on I/O pins	5Vdc
Operating Temperature Range	$-40^{\circ}C \sim +80^{\circ}C$
Operating Frequency Range	410.0000MHz ~475.0000MHz
Channel Step	6.25 kHz minimum
Max Data Rate	50 kbps maximum
Antenna / Impedance	SMB / 50ohms
TRANSMITTER - ELP	
TX Operating Current	60mA
RF Output Power	-10 to +10dBm (configurable)
Frequency Deviation	14 kHz (ELP, 4-GFSK, 50 kbps)
Spurious emission	> -40dB
RECEIVER - ELP	
RX Operating Current	60mA
Sensitivity	-103 dBm (ELP, 4-GFSK, 50 kbps)
Adjacent Channel Selectivity	65dB

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6. FUNCTIONAL DESCRIPTION

6.1. Configuration

CSM-400UE is configured by the CSM Configuration Tool software. For more information on this tool, see the CSM_CFG Tech Doc.

6.2. ELP Mode

In ELP Mode, the CSM-400UE acts as an ELP Transceiver. ELP is the Hetronic 'Event Link Protocol', which operates at 50kbps baudrate, 4GFSK modulation and 6.25kHz deviation. In this mode the radio can only be controlled and used with an ELP coder/decoder. Default output power is set to 0dBm but can be configured to +/-10dBm. In ELP Mode, the device is centered on a 12.5kHz channel, between 410MHz and 475MHz. In ELP Mode, CSM-400UE will only communicate with other radios using ELP. ELP Mode also allows the CSM-400UE to enable/disable encryption of the wireless data. Encryption-enabled and -disabled devices cannot communicate with each other.

6.3. Test Mode

In Test Mode, the CSM-400UE will function in one of several configurable Test Modes:

6.3.1. CW Test Mode

In CW Test Mode, the CSM-400UE will continually output a single-frequency tone for test measurement purposes. The frequency and peak output power of the CW tone are configurable.

6.3.2. ELP Random Transmit Mode

In ELP Random Transmit mode, the CSM-400UE will continually transmit a random string of data at the ELP settings: 50kbps, 4GFSK modulation with a 6.25kHz deviation.

6.3.3. ELP Random Receive Mode

In ELP Random Receive Mode, the CSM-400UE will continually receive any data broadcasted with the ELP settings in the ELP packet structure.

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7. ASSEMBLY DESCRIPTION

7.1. Lacquer Mask

Cover the marked areas of the board assembly before lacquering. Use only Hetronic approved lacquer.



Figure 3: CSM-400UE Top Lacquer Mask



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7.2. **RF Shield**

CSM-400UE should have the RF shield (Hetronic Part 18864 TEMP) soldered to the 6 ground pads on the edge of the bottom side of the board. Ground pads are highlighted below. RF shield should not be attached until after programming, testing and calibration.



Figure 5: RF Shield Solder Pads



Figure 6: CSM-400UE with Soldered Shield

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8. MECHANICAL DRAWING



9. TEST PROCEDURE

9.1. Equipment Needed

- 1. CSM_CFG Adapter Board
- 2. USB Cable
- 3. RS-232 Cable
- 4. 5V DC Power Supply
- 5. SMB RF Cable
- 6. 1GHz Spectrum Analyzer
- 7. 1GHz RF Signal Generator
- 8. PC
- 9. H-Link PC Software and Dongle
- 10. Digital Multimeter
- 11. STMicroelectronics Flash Loader software
- 12. Hetronic USB Flash Programmer software

9.2. Power Supply Verification

1. Install the device in the CSM_CFG adapter. See figure below for connector reference:



- 2. Connect the adapter to the PC using a USB cable.
- 3. Short the J_US jumper.
- 4. Using DMM, verify 3.1V on the left-most pin of JTAG connector (closest to J1)

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9.3. Bootloader Programming

- 1. Open the J_US jumper to remove power
- 2. Short connector J1 on device to start device in boot mode



- 3. Short the J_US jumper to apply power
- 4. Connect RS-232 cable to connector BOOT on CSM_CFG $\,$
- 5. Start STMicro Flash Loader
- 6. Set appropriate COM port and other UART settings, then click Next

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Select the con connection. Common for a © UART Port Name Baud Rate Data Bits	amunication port and se all families COM37 ▼ 115200 ▼ 8 ▼	et settings, ther Parity Echo Timeout(s)	Even Disabled 5	en V	
2					
	Back Ne	.t C	ancel	Close	

7. On the following 'Target is Readable' page, click Next. On the following 'Target Select' page, click Next.

8. On the following page, select 'Download to device' and browse to bootloader.hex. Then click Next.

Erase		
€ All	C Selection	
Download to device		
C:\Users\bgraefe\Do	cuments\Subversion Folders\rf\	.csm\CSM-2
Frase necessary	pages C No Erase C	Global Erase
@ (h) 8000000	Jump to th	e user program
 (h) 8000000 Optimize (Remove Apply option bytes 	Jump to th e some FFs) Verify after	e user program download
 (h) 8000000 Optimize (Remove Apply option byte: Upload from device Upload to file 	s orme FFs) Verify after	e user program download
(h) 800000 Optimize (Remove Apply option byte: Upload from device Upload to file	Jump to th some FFs) Verify after	e user program download
(h) 800000 Optimize (Remove Apply option byte: Upload from device Upload to file Enable/Disable Flash p	Jump to th some FFs) Verify after	e user program download
(h) 800000 Optimize (Remove Apply option byte: Upload from device Upload to file Enable/Disable Flash p	Jump to th some FFs) Verify after rotection	e user program

9. Wait for the Flash Loader to finish loading and the 'Download operation finished successfully' is displayed. Then click Close.

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🧼 Flash L	oader l	Demonstr	ator				
S	тм	icroe	elect	roni	cs		
Targe	et S	TM32_Con	nectivity-	line_64K			
Map f	ile S	TM32_Con	nectivity-	line_64K.	STmap		
Opera	ation D	OWNLOAD)				
File n	ame C	Users\bg	raefe\Do	cuments\	Subversion		
	F	olders\rf\cs	m\LSM-2	2\trunk\s	oftware/booth	oader\ob	\bootloa
File si	ze 15	5.66 KB (16	036 byte	s)			
Statu:	s 18	5.66 KB (16 5.66 KB (16	3036 byte	s) of 15.6	6 KB (16036	bytesj	
Time	U	0:00:08					
	Dowr	nload op	eration	finish	ed succes	sfully	
	E	Back	Ne	est	Cancel		Close

10. Disconnect RS-232 cable from CSM_CFG. Remove 5VDC from CSM_CFG. Open jumper J1 on CSM400UE.

9.4. Main Flash Application Programming

- 1. Open jumper J_US to remove power
- 2. Close jumper J_VBUS, then close jumper J_US to put the module in boot mode
- 3. Verify solid yellow LED on CSM_CFG
- 4. Start the USB Flash Programmer program.
- 5. After the USBFP connects to the CSM400UE, set the Memory Space to Application

		, Het	tronic USBFP v0.97 🛛 🗆 🖾	
		File	Settings	
		Sta	Device: CSM-2 Flash Size: 256KB ot Loader Version: 3.00 - 3/20/2015	
			Memory Space: Start Address 0x4000 pplication Length 0xC000 Upload to Flash from File: Verify Upload Browse	
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- 6. Click Browse to select csm2_app_rx.hex.
- 7. Click Upload. On the pop-up window click Yes.
- 8. Wait for the loading to complete. On the Verification successful window click OK.

Hetronic	USBFP v0.9	7			23
File Set	tings				
Status	connecte	d on port (COM149		
Boot Loa	Device Flash Size der Version			23	7
Memory	Space:	Verification	success	ful	
Applicat	to Flash fro		0	К	
C:\Users	\bgraefe\Do	cuments\Subve	ersion Fol	ders\rf\	csr
	Verify	Upload		Brows	e

9. Close the USBFP software. Remove the USB cable from the CSM_CFG.

9.5. Calibration

After programming, each CSM-400UE must be calibrated at least once prior to operation. This calibration is to compensate for small variations in RF characteristics due to component tolerances.

9.5.1. Output Power Calibration

The output power of the module varies across its frequency range; this calibration procedure applies an internal offset to the output power depending on frequency to compensate for that variation:

1. Insert CSM-400UE into CSM_CFG and connect the USB cable. Connect CSM-400UE ANT to a calibrated Spectrum Analyzer using low-loss cable.

2. Close the J_US jumper, then J_VBUS. Insert the H-Link dongle into the PC.

3. Start the H-Link software. Press "Connect". This should load the CSM-400UE H-Link configuration menu. Go to the 'Calibration' tab.

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	Passwo	ord											
ttings Calibration	on Cha	annels	Netwo	irk Ana	lyzer								
Calibration Detai Device has bee Last Calibrated:	ls in calibra 15 June	ted* 2015							(Beg	in Calib	oration ot Begur	
Calibration Settin	as												21
Progress: n/a													
Instructions: C	alibrate F	aramete	er										
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Instructions: Instructions: Coarse Adjust: Fine Adjust:	-] 다] 다	1) 1)	1	2	7		2			- F	+	

4. If the module has not yet been calibrated, a 'WARNING: Device not calibrated!' will be displayed. If the module has been calibrated, H-Link will show the date of the last calibration. Click 'Begin Calibration'.

5. Follow the instructions listed to configure the Spectrum Analyzer to 150MHz bandwidth centered at 450MHz. You should see a peak at 390MHz. Use the Peak Search function to find the peak power at 390MHz.

		Agilent	09:36:38 Jul 2, 2015	NI 4 200 000 MIL	Peak Search	-
		Ref 20 dBi Peak	n Atten 30 dB	Mkr1 390.000 MH2 4.188 dBm	Meas Tools+	
	Ìč	10 dB/	1		Next Peak	
					Next Pk Right	
					Next Pk Left	
		H1 S2 S3 FC AA**	with have an work of the second	anangina ang panganganganganganganganganganganganganga	Min Search	
		On	larker 390.000000 MHz		Pk-Pk Search	
		Center Res BN	4.288 dBm 450 MHz 120 kHz VBH 300 kHz	Span 150 MHz Sмеер 23.98 ms (401 pts)	More 1 of 2	
		Standby				Asturn
		and the second se	Hart Zoom			
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6. Use the "+" and "-" Coarse Adjust buttons to increase or decrease the peak power at 390MHz. Continue adjusting the power until it is with +/- 0.3dB of 0dBm.



7. When the peak is within +/-0.3dBm, click 'Save and Continue', then click 'Yes' when prompted 'are you sure?'. This will move the peak frequency to 395MHz.

8. Repeat Step 6 and 7 for 395MHz, and each incremental frequency after that. The frequency will continue to increment by 5MHz up to 475MHz. After the 475MHz peak is calibrated, click 'Save and Continue' to continue to Frequency Calibration.

		RF CSM-2 01.00	0.128	
		File Transfer	Password	
		Settings Calibrat	tion Channels Network Analyzer	
		Calibration Deta	ails	
		Device has be	en calibrated Begin Calibration	
		Last Calibrated:	15 June 2015 Calibration in process	
		Calibration Setti	ings	
		Progress (2/24)		
		Instructions: 0	Calibrate Parameter	
		Spectrum Ana	alyzer - Center=450MHz - Span=150MHz	
		Measure Peal	k Power at 395MHz	
		Use buttons to	o toggle until peak output power is within +/-0.3dBm	
		Coarse Adjust:		
		0		
		Fine Adjust:	• • • • • • • • • • • • •	
			Save and Continue	
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9.5.2. Frequency Calibration

This procedure fine-tunes the frequency setting of the module by applying a constant offset to the Frequency Synthesizer.

1. Follow the instructions displayed to configure the Spectrum Analyzer: set Center Frequency to 450MHz, Span to 100kHz, Resolution BW to 100Hz and Video BW to 30Hz. This should show the frequency synthesizer error more precisely.



2. Use the "+" and "-" Coarse Adjust buttons to increase/decrease the frequency from the module until it is approximately centered at 450MHz.

		RF CSM-2 0	1.00.128	
		File Transf	er Password	
		Settings Cal	ibration Channels Network Analyzer	
		Calibration	Details	
		Device ha	s been calibrated Begin Calibration	
		Last Calibra	ted: 15 June 2015 Calibration in process	
		Calibration	Settings	
		Progress (2	3/24):	
		Instruction	ns: Calibrate Parameter	
		Spectrum	Analyzer - Center=450MHz,Span=100kHz,RBW=100Hz,VBW=30Hz	
		1. Use co	arse buttons to center frequency at 450.0000MHz	
		2. Change	e Span to 10kHz. Use fine buttons to center frequency at 450.000000MHz	
		Coarse Adj	ust: ale a real a a second a a second a	
		Fine Adjust		
			Save and Continue	
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3. Configure the Spectrum Analyzer span to 10kHz to see the frequency error more precisely. Use the "+" and "-" Fine Adjust buttons to increase/decrease the frequency from the module until it is exactly 450MHz.



4. When finished, press 'Save and Continue'.

9.5.3. RSSI Calibration

The CSM-400UE has a built-in power detector capability. This calibration sets the reference level so the power detector can return received RF power in dBm:

1. Connect the output of the RF Signal Generator to the antenna port of the radio module using a low-loss cable. Configure the Signal Generator to output 450.000000MHz, no modulation, at a power of exactly -60dBm.

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2. The PC should display what the current un-calibrated power measurement is as "RSSI = [x]dBm". Use the "+" and "-" Coarse Adjust buttons to adjust the measured power level until it reads "-60dBm".

-wine Calibration C	Nervel Nickers Andrew	
calibration (nanneis Network Analyzer	
Calibration Details	Long.	
Device has been call	brated	Begin Calibration
Last Calibrated: 15 Jur	Calibration in process	
Calibration Settings		
Progress (24/24):		
Instructions: Calibrat	e Parameter	
Instructions, calibrat		
Sized Constants	er didileter	
Signal Generator - Fr	req=450MHz - Power=-60dBm	
Signal Generator - Fr Turn on SigGen, no	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI∼=-60dBm
Signal Generator - Fr Tum on SigGen, no RSSI = -60dBm	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS:	SI∼=-60dBm
Signal Generator - Fr Turn on SigGen, no RSSI = -60dBm	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI∼=-60dBm
Signal Generator - Fr Turn on SigGen, no RSSI = -60dBm	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI∼=-60dBm
Signal Generator - Fr Tum on SigGen, no RSSI = -60dBm	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI~=-60dBm
Signal Generator - Fr Tum on SigGen, no RSSI = -60dBm	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI~=-60dBm
Signal Generator - Fr Tum on SigGen, no RSSI = -60dBm	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI~=-60dBm
Signal Generator - Fr Tum on SigGen, no RSSI = -60dBm Coarse Adjust:	req=450MHz - Power=-60dBm modulation. Use buttons to toggle until RS	SI~=-60dBm

3. When finished, press 'Save and Continue'. Device Calibration is now complete. Before disconnecting the module, go to the 'Transfer' drop-down on the top bar and select 'Save Settings to Device'. Click 'Yes' when asked if user is sure, and wait for the settings to fully download.

4. When settings are finished downloading, close H-Link, open the J_US and J_VBUS jumpers before removing the module.

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