ISC NIRScan Bluetooth Communications

1 Bluetooth Communications

The ISC NIRScan wirelessly communicates using Bluetooth Low Energy version 4.0 This wireless communication uses two main profiles for discovery and communication with a remote host:

- GAP: Generic access profile for basic discovery and establishing connections.
- GATT: Generic attribute profile for commands and data transfer.

The ISC NIRScan supports Bluetooth version 4.0 specification. When the Bluetooth sub-system is activated, the ISC NIRScan broadcasts its availability while a smartphone, tablet or PC acts as an observer. Once connected, the ISC NIRScan acts as a server for the GATT profile while the smartphone, tablet, or PC acts as a client.

1.1 GATT Supported Services

The ISC NIRScan Bluetooth GATT Profile supports the following services:

- Battery Service (BAS) to provide battery charge capacity.
- Device Information Service (DIS) to provide manufacturer Name, model number, serial number, hardware revision, spectrum library revision, and Tiva software revision.
- GATT General Information Service to provide temperature, humidity, status, hours of use, lamp hours, and battery recharge cycles.
- GATT Date and Time Service to synchronize date and time information between smartphone, tablet, or PC to the Tiva's realtime clock.
- GATT Calibration Information Service to provide calibration coefficients
- GATT Scan Configuration Information Service to provide stored configurations and scan configuration data.
- GATT Scan Data Information Service to initiate scan, clear scan data, and return stored scan data.
- GATT Command Service to send generic commands.

A GATT service has a universally unique identifier (UUID) used to identify every service. A UUID is a 128- bit value. However, common or frequently used services that are included in the BLE specifications and/or certified by Bluetooth.org are shortened to 16-bit UUID to improve efficiency.

Each service is composed of a set of characteristics. Each characteristic contains a value with properties for how the value is accessed and information on how the value is displayed or represented. The properties are:

- R = Read.
- W = Write.
- WWoR = Write without response. Not used in ISC NIRScan Bluetooth implementation.
- S = Signed write. Not used in ISC NIRScan Bluetooth implementation.
- N = Notify.
- I = Indicate.
- WA = Writable auxiliaries. Not used in ISC NIRScan Bluetooth implementation.
- B = Broadcast. Not used in ISC NIRScan Bluetooth implementation.
- EP = Extended properties. Not used in ISC NIRScan Bluetooth implementation.

An "X" in a supported property indicates the properties supported by a characteristic. Empty columns indicate properties not supported by the characteristic.

A data size entry with an MP value represents multiple packets. All data is transmitted little-endian.

Table 1. Device Information Service (DIS)

Service UUID	Description						
0x180A	**Device Information Service (DIS)**						
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**				**Notes**
				R	**W**	**N**	**I**	
0x2A29	Manufacturer name string	string	1	X				org.bluetooth.characteristic. manufacturer_name_string
0x2A24	Model number string	string	1	X				org.bluetooth.characteristic. model_number_string
0x2A25	Serial number string	string	1	X				org.bluetooth.characteristic. serial_number_string
0x2A27	Hardware revision string	string	1	X				org.bluetooth.characteristic. hardware_revision_string
0x2A26	Tiva firmware revision string	string	1	X				org.bluetooth.characteristic. firmware_revision_string
0x2A28	Spectrum library revision string	unsigned integer	2	X				org.bluetooth.characteristic. software_revision_string

Table 2. Battery Service (BAS)

Service UUID	Description						
0x180F	**Battery Service (BAS)**						
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**				**Notes**
				R	**W**	**N**	**I**	
0x2A19	Battery level	unsigned integer	1	X				org.bluetooth.service.battery_service. Value reported in the range of 0-100.

Table 3. GATT General Information Service (GGIS)

Service UUID	Description						
0x53455201-444C-5020-4E49-52204E616E6F	**GATT General Information Service**						
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**				**Notes**
				R	**W**	**N**	**I**	
0x43484101-444C-5020-4E49-52204E616E6F	Temperature measurement	integer	2	X		X		Integer value returned in hundredths. Divide by 100 to get the actual floating point number.
0x43484102-444C-5020-4E49-52204E616E6F	Humidity measurement	unsigned integer	2	X		X		
0x43484103-444C-5020-4E49-52204E616E6F	Device status (Reserved for future support)	unsigned integer	2	X		X		
0x43484104-444C-5020-4E49-52204E616E6F	Error status (Reserved for future support)	unsigned integer	2	X		X		
0x43484105-444C-5020-4E49-52204E616E6F	Temperature threshold	integer	2		X			Value set in hundredths. Input truncated integer of actual value multiplied by 100.
0x43484106-444C-5020-4E49-52204E616E6F	Humidity threshold	unsigned integer	2		X			

Table 3. GATT General Information Service (GGIS) (continued)

Service UUID	Description						
0x53455201-444C-5020-4E49-52204E616E6F	**GATT General Information Service**						
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**				**Notes**
				R	**W**	**N**	**I**	
0x43484109-444C-5020-4E49-52204E616E6F	Total lamp hours	unsigned integer	4	X				Lamp usage data in mini-seconds (uint32_t).

Table 4. GATT Date and Time Service (GDTS)

Service UUID	Description						
0x53455203-444C-5020-4E49-52204E616E6F	**GATT Current Date and Time**						
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**			
				R	**W**	**N**	**I**
0x4348410C-444C-5020-4E49-52204E616E6F	Current year (0-99: starting in year 2000)	unsigned integer	1		X		
	Current month (1-12)	unsigned integer	1				
	Current day (1-31)	unsigned integer	1				
	Current day of the week (0-6)	unsigned integer	1				
	Current hour (0-23)	unsigned integer	1				
	Current minute (0-59)	unsigned integer	1				
	Current second (0-59)	unsigned integer	1				

Table 5. GATT Calibration Information Service (GCIS)

Service UUID	Description					
0x53455204-444C-5020-4E49-52204E616E6F	GATT Calibration Information Service					
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**		**Notes**
				R	W	N	I	

Characteristic UUID	Description	Data Format	Data Size (Bytes)	R	W	N	I	Notes
0x4348410D-444C-5020-4E49-52204E616E6F	Request Spectrum Calibration Coefficients	unsigned integer	1		X			Indicate intent to read. No data transferred.
0x4348410E-444C-5020-4E49-52204E616E6F	Return Spectrum Calibration Coefficients		MP(1)			X		Send 6 coefficients. Each coefficient is a double data-type of 8 bytes. The data is sent in serialized manner.
0x4348410F-444C-5020-4E49-52204E616E6F	Request Reference Calibration Coefficients	unsigned integer	1		X			Indicate intent to read. No data transferred.
0x43484110-444C-5020-4E49-52204E616E6F	Return Reference Calibration Coefficients		MP(1)			X		Serialized data; refer to spectrum C library for data structure.
0x43484111-444C-5020-4E49-52204E616E6F	Request Reference Calibration Matrix	unsigned integer	1		X			Indicate intent to read. No data transferred.
0x43484112-444C-5020-4E49-52204E616E6F	Return Reference Calibration Matrix		MP(1)			X		Serialized data; refer to spectrum C library for data structure.

(1) Refer to Table 9

Table 6. GATT Scan Configuration Information Service (GSCIS)

Service UUID	Description					
0x53455205-444C-5020-4E49-52204E616E6F	GATT Scan Configuration Information Service					
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**		**Notes**
				R	W	N	I	

Characteristic UUID	Description	Data Format	Data Size (Bytes)	R	W	N	I	Notes
0x43484113-444C-5020-4E49-52204E616E6F	Number of stored configurations	unsigned integer	2	X				
0x43484114-444C-5020-4E49-52204E616E6F	Request stored configurations list	unsigned integer	1		X			No data transmitted.
0x43484115-444C-5020-4E49-52204E616E6F	Return stored configurations list		MP(1)			X		List of 2 byte indices.
0x43484116-444C-5020-4E49-52204E616E6F	Request scan configuration data	unsigned integer	2		X			Index to read.
0x43484117-444C-5020-4E49-52204E616E6F	Return scan configuration data		MP(1)			X		Serialized data; refer to spectrum C library for data structure.
0x43484118-444C-5020-4E49-52204E616E6F	Active scan configuration		2	X	X		Get/Set function. Parameter transmitted is a 2-byte index.	
0x43484140-444C-5020-4E49-52204E616E6F	Request current scan configuration	unsigned integer	1		X			No data transmitted.
0x43484141-444C-5020-4E49-52204E616E6F	Return current scan configuration		MP(1)			X		Serialized data; refer to spectrum C library for data structure.

0x43484142-444C-5020-4E49-52204E616E6F	Save/Set scan configuration		MP(1)		X		Serialized data; refer to spectrum C library for data structure.
0x43484143-444C-5020-4E49-52204E616E6F	Return save/set scan configuration result	unsigned integer	4			X	
0x43484144-444C-5020-4E49-52204E616E6F	Set scan lamp mode	unsigned integer	1		X		
0x43484145-444C-5020-4E49-52204E616E6F	Set scan lamp delay time	unsigned integer	4		X		Data in mini-seconds (uint32_t)
0x43484146-444C-5020-4E49-52204E616E6F	Set scan PGA	unsigned integer	1		X		
0x43484147-444C-5020-4E49-52204E616E6F	Set number of scan repeats for average	unsigned integer	1		X		
0x43484148-444C-5020-4E49-52204E616E6F	Reset Scan Config	unsigned integer	1		X		Write 0x5A to erase all custom configurations and restore with the default two configurations

(1) Refer to Table 9

Note:

1. Request / return current scan configuration:
   a. Send any one byte data to 0x43484140 to get the scan configuration currently set in the device memory which is ready for scan.
   b. Get the serialized scan configuration data from notify of 0x43484141.
2. Save / set scan configuration:
   a. First you need to send the command package as following format.
      >> The first byte of the package is fixed as 0x12 for "CMD", the 2nd byte is the action flag for "Set Configuration to Device Memory", the 3rd byte is the action flag for "Save Configuration into EEPROM", the 4th byte is the total serialized configuration data size to be sent in follow-on packages.
      >> Set the flags to 1 to run the action, other values will be skipped.
   b. The second and further packages are the serialized scan configuration data as following format.
      >> The first byte of the package is fixed as 0x34 for "Data", the 2nd byte indicates the bytes remaining to send and data payload starts from 3rd byte.
      >> The total package size is allowed under 127bytes per the maximum supported MTU size. You could keep the maximum 20bytes for Bluetooth LE maximum command size.
3. Return save / set scan configuration result:
   • Once you complete sending the data, you will get notify from 0x43484143 as following return format.
      >> byte[0]: Communication Result => 1: Received Success, -1: Failed
      >> byte[1]: Saved to EEPROM Result => 1: Saved, 0: Skipped, -1: Save Failed
      >> byte[2] (Low byte) - byte[3] (High byte): Set to Memory Result => 1: Set and return the scan pattern numbers, 0: Skipped, -1: Set Failed
4. Set scan lamp mode:
   • Send one byte for lamp mode control: 0 -> Auto, 1 -> Lamp-always-on, 2 -> Lamp- always-off.
5. Set scan lamp delay time:
   • This parameter is valid only in lamp mode is auto. Set the value for lamp warm-up before performing a scan. The system default delay time is 635ms, set this value will override the default in a single scan. You need to set this before every scan if you want a value other than default.
   • Value is uint64_t. Byte[0]: Low byte, Byte[3]: High byte.
6. Set scan PGA:
   • Set this to get fixed PGA in scan. The set value valid until system shut-down.
   • Set value 0 to get the system chooses the best PGA automatically.
   • Other valid values are 1, 2, 4, 8, 16, 32 and 64.
7. Set number of scan repeat for average:
   • Set this to get override of the number of scan repeat to average in the configuration that has set in the memory.
8. Reset Scan Config:
   • Write 0x5A to erase all the configurations in the device and restore with the default two configurations – Column 1 and Hadamard 1.

Table 7. GATT Scan Data Information Service (GSDIS)

Service UUID	Description						
0x53455206-444C-5020-4E49-52204E616E6F	**GATT Scan Data Information Service**						
Characteristic UUID	**Description**	**Data Format**	**Data Size (Bytes)**	**Supported Properties**				**Notes**
				R	**W**	**N**	**I**	
0x4348411C-444C-5020-4E49-52204E616E6F	Set scan name stub	string	2		X			Limited to 15 bytes.
0x4348411D-444C-5020-4E49-52204E616E6F	Start scan	unsigned integer	1		X	X		Parameter value: 0x00 = do not store scan in microSD card 0x01 = store scan in microSD card. Notification returned: 0xFF = scan completed 4 bytes with the scan index of the current scan
0x4348411E-444C-5020-4E49-52204E616E6F	Clear scan	unsigned integer	4		X	X		Index of scan data to clear. Notification returned: 0x00 = success non-zero return is an error
0x4348411F-444C-5020-4E49-52204E616E6F	Request scan name	unsigned integer	4		X			Index of scan data to read.
0x43484120-444C-5020-4E49-52204E616E6F	Return scan name	string	20			X		Scan name limited to 20 characters.
0x43484121-444C-5020-4E49-52204E616E6F	Request scan type	unsigned integer	4		X			Index of scan data to read.
0x43484122-444C-5020-4E49-52204E616E6F	Return scan type	unsigned integer	1			X		
0x43484123-444C-5020-4E49-52204E616E6F	Request scan date/time	unsigned integer	4		X			Index of scan data to read.
0x43484124-444C-5020-4E49-52204E616E6F	Return scan date/time	unsigned integer	7			X		Seven bytes returned. Same format as GATT Date and Time Service.
0x43484125-444C-5020-4E49-52204E616E6F	Request packet format version	unsigned integer	4		X			Index of data to read.
0x43484126-444C-5020-4E49-52204E616E6F	Return packet format version	unsigned integer	4			X		
0x43484127-444C-5020-4E49-52204E616E6F	Request serialized scan data structure	unsigned integer	4		X			Index of data to read
0x43484128-444C-5020-4E49-52204E616E6F	Return serialized scan data structure		MP [(1)]			X		Serialized data; refer to spectrum C library for data structure.

[(1)] Refer to Table 9

Table 8. GATT Command Service (GCS)

Service UUID	Description					
0x53455202-444C-5020-4E49-52204E616E6F	GATT Command Service					

Characteristic UUID	Description	Data Format	Data Size (Bytes)	Supported Properties				Notes
				R	W	N	I	
0x43484130-444C-5020-4E49-52204E616E6F	Read activation status Write activation code	unsigned integer	R:1 W:12	X	X			Read one byte of current activation status Write 12 bytes activation code
0x43484131-444C-5020-4E49-52204E616E6F	Return activation result	unsigned integer	1			X		Return the result of wr t ng activation key.
0x43484132-444C-5020-4E49-52204E616E6F	Replace Built-in Scan Reference Data	unsigned integer	1			X		Write 0x5A to replace the built-in scan reference data with the latest scan data performed and stored in the device. Note the configuration should be the same as default "Colum 1", or this will cause reference interpret error.

Note:

1. Activation key R/W and result
    a. These two characteristics provide the functions for Read/Write and Notify for the device activation.
    b. Write a 12-bytes activation key and will get notify for the verification result.
    c. Read this characteristic returns the current device activation status.
    d. Return 1 for PASS and 0 for FAIL.
    e. In Tiva V2.1.0.67+, the correct activation key set will be also stored in the device memory for self-activation at device boot-up. To clear the stored activation key, write all the 12 bytes with "0" and then Tiva clears the stored code in the device memory.
2. Replace Built-in Scan Reference Data
    a. This characteristic provides the ability to replace the built-in reference that calibrated by SRS99 in factory with your own reference.
    b. The scan configuration for the replacing reference should be only one scan section with Colum type and setting wavelength for 900nm-1700nm, or there might be unexpected result for reference scan interpret in normal scan.
    c. Write 0x5A to save the current scan result as built-in reference.

2 Bluetooth Packet

Bluetooth transmits in short packet sizes. The typical maximum transmission unit for an iOS App is 20 bytes. Multiple packets are needed to transfer the following information to ISC NIRScan:

- Spectrum Calibration Coefficients
- Reference Calibration Coefficients
- Stored Configurations List
- Scan Configuration Data
- Stored Scan Indices
- Serialized Scan Data Structure
- Command Service Parameters

The previous tables label the data size as MP to denote that multiple packets are used during transfer. The packet structure is shown in Table 9.

Table 9. Bluetooth Multiple Packet Structure

Packet	Byte	Type	Field	Description
0	0	Packet Header	Index	Number of packet: 0
	1	Data Payload	Size	Length of data payload in bytes
	2			
	3			
	4			
1	0	Packet Header	Index	Number of packet: 1
	1	Data Payload	Acknowledge	ACK/NACK (if required by command response)
	2		Data Returned	Packet 1 Data byte 0
	...			...
	19			Packet 1 Data byte 19
2	0	Packet Header	Index	Number of packet: 2
	1	Data Payload	Data Returned	Packet 2 Data byte 0
	...			...
	19			Packet 2 Data byte 19
...				
N	0	Packet Header	Index	Number of packet: N
	1	Data Payload	Data Returned	Packet N Data byte 0
	...			...
	19			Packet N Data byte 19

Reference

- *Texas Instruments – DLPU030G – June 2015 – Revised August 2017.*