Release Notes

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Projected Capacitive Firmware, Version 9 (MTCH6301)

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# Summary of Changes

* 12bit Touch Packets instead of 10bit
* Focused release for the PIC32 (PIC18 & PIC24 code not verified)
* Implemented multiple high offsets for RAM values to separate RAM into logical groups
  + Re-wrote RAM read/write functions for readability
  + Several New RAM structures:
    - SelfFineTune – fine tuning of individual self channels
    - MutFineTune – fine tuning of individual mutual channels
    - HWCfgRam – hardware configuration parameters
    - HWStatusRam – hardware status parameteres
* Implemented Display driver code for Touch Pad Demonstrator
* Basic Gesture Support – Swipe, touch, swipe-hold, touch-hold, double touch
* Added New packets
  + Gesture Packets
  + Status Packets
* Added functionality to enable/disable individual packet types
* Separated decode state machine from comm functionality
* Implemented a global counter for most timing functionality
* Sleep functionality
  + Select IDLE, SLEEP on PIC32
* New Sensor Files created for some sensors
* Removed CTMU functionality, now using CVD exclusively

# Code Re-organization

The firmware has now been modified to simplify implementation of customer applications:

* As many processor-specific items as possible have been moved into the processor-specific code and header files
* Processor type is now defied in the project file. The only change necessary to compile the code between processors is to select the proper communications type.
* New conditional compilation options have been added:
  + **DEVELOPMENT** – this changes version numbers to flag that this is development code
  + **DEVKIT\_HARDWARE** – this sizes all arrays to the maximum available for the given processor. If not set, arrays will be the minimum size for the given sensor.
  + **ENABLE\_DEBUG** – this enables all debug functionality
* Minimal-size code (RAM and ROM) is now achieved by leaving DEVKIT\_HARDWARE and ENABLE\_DEBUG undefined during compilation.

# User RAM

User RAM has been modified to utilize both High and Low offsets for the values. High offsets define a category of RAM values, and low offsets index into that category:

## High Offsets

|  |  |  |
| --- | --- | --- |
| Value | Name | Description |
| 0x00 | UserRam “general” | Normal access to UserRam for legacy support, also flag1, numRX, numTX, customFlag, xmul, ymul |
| 0x01 | rxPinMap | Direct access to rxPinMap |
| 0x02 | txPinMap | Direct access to txPinMap |
| 0x10 | Self Parameters | Starts at UserRam.selfScanTime |
| 0x11 | Self Tuning Array | Access to the individual channel self tuning array |
| 0x20 | Mutual Parameters | Starts at UserRam.mutScanTime |
| 0x21 | Mutual Tuning Array | Access to the individual channel mutual tuning array |
| 0x30 | Decode & Tracking | Starts at UserRam.flipState |
| 0x40 | Noise & Charge Pump | Starts at UserRam.cpTimeOut |
| 0x50 | Gestures | Starts at UserRam.swipeLengthX |
| 0xF0 | Hareware Config | Access to the Hardware Config Ram structure |
| 0xF1 | Hardware Status | Access to the Hardware Status Ram structure |

## Full Ram listing

### High Offset 0x00: UserRam “general”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | flag1 | 0x00 | 0x00 | Bitmask - Controls the operating mode of the firmware.   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** | | Unused | Disable touch functionality | Unused | Transmit Min-Max and timestamp | Transmit Raw ADC Values | Controller Processed Diagnostics | Mutual Diagnostics | Self Diagnostics | |
| unsigned char | numberOfRXChannels | 0x00 | 0x01 | Defines the number of receive channels on the sensor |
| unsigned char | numberOfTXChannels | 0x00 | 0x02 | Defines the number of transmit channels on the sensor |
| unsigned char | customFlag | 0x00 | 0x03 | Bitmask – controls acquisition parameters   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** | | Use Differential Acquisition on Mutual | Run Noise Routines on Self and Mutual Scans | Invert Mutual Scan Values | Invert Self Scan values | Pulse 2 TX during Mutual Scan | Use Charge Pump Delay | Use CVD Acquisition | Unused | |
| unsigned short | xmul | 0x00 | 0x04 | Multiplier used to convert the sensor X axis resolution data to 10-bit resolution data. |
| unsigned short | ymul | 0x00 | 0x06 | Multiplier used to convert the sensor Y axis resolution data to 10-bit resolution data. |
| unsigned char | rxDiagChannel | 0x00 | 0x08 | Selects RX channel for single-channel diagnostics |
| unsigned char | txDiagChannel | 0x00 | 0x09 | Selects TX channel for single-channel diagnostics |
| unsigned char | baseUpdateTime | 0x00 | 0x0A | Set the frequency of the base update. The time is based on loop and will vary based on all parameters. |
| unsigned char | stuckThreshold | 0x00 | 0x0B | Maximum distance a touch can move before it is no longer a possible stuck touch |
| unsigned short | stuckTimeout | 0x00 | 0x0C | Time a touch must be stationary for it to be considered “stuck” |

* + 1. High Offset 0x01: rxPinMap

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | rxPinMap[MAXRX] | 0x01 | 0x00 | Defines which pins, in sensor order, on the controller are utilized to perform measurements on the sensor. |

* + 1. High Offset 0x02: txPinMap

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | txPinMap[MAXTX] | 0x02 | 0x00 | Define which pins, in sensor order, on the controller are utilized to transmit pulses on the sensor. |

* + 1. High Offset 0x10: Self Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | selfScanTime | 0x10 | 0x00 | Set the number of self capacitance measurements to SUM for 1 measurement |
| unsigned char | selfTouchThres | 0x10 | 0x01 | Set the threshold to compare the self measurement, if above we may have a touch |
| unsigned char | selfSampleFreq | 0x10 | 0x02 | Sets a delay between self capacitance measurements, currently TMR6 is set 1 = 250nS |
| unsigned char | stutterMult | 0x10 | 0x03 | For self scans, pulse every <stutterMult>th channel. **Default: 1** |

* + 1. High Offset 0x11: Self Tuning Array

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | selfScanFineTune[MAXTX] | 0x11 | 0x00 | Value added to selfScanTime for individual channels |

* + 1. High Offset 0x20: Mutual Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | mutScanTime | 0x20 | 0x00 | Set the number of mutual capacitance measurements to SUM for 1 measurement |
| unsigned char | mutTouchThres | 0x20 | 0x01 | Threshold to compare mutual measurement to. If above, analyze for potential touch |
| unsigned char | mutSampleFreq | 0x20 | 0x02 | Sets a delay between mutual capacitance measurements, currently TMR6 is set 1 = 250nS |

* + 1. High Offset 0x21: Mutual Tuning Array

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | mutScanFineTune[MAXTX] | 0x21 | 0x00 | Value added to mutScanTime for individual channels |

* + 1. High Offset 0x30: Decode & Tracking

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | flipState | 0x30 | 0x00 | This determines the orientation of the sensor with respect to the coordinate output. It is a selection of bit flags, with the following values and meanings:  Bit 1 (0x01) – flip X value ( x = 1023 – x)  Bit 2 (0x02) – flip Y value ( y = 1023 – y)  Bit 3 (0x04) – Swap X and Y ( temp = X, X = Y, Y = temp)  The flip operations are performed in the above order in the firmware. |
| unsigned char | numOfAvg | 0x30 | 0x01 | This parameter configures the number of prior coordinates to average into the current value to smooth the final output. **Default: 8**, Max: TOUCH\_HISTORY, Min: 1 |
| unsigned char | minCuspDelta | 0x30 | 0x02 | Minimum positive and negative slopes to either side of a peak required to identify a potential touch. **Default: 5**, Max: 255, Min: 1, Recommended Range: Max: 20 |
| unsigned char | weightThreshold | 0x30 | 0x03 | Weight function value that no longer allows a potential match (any value below this may be a potential match). **Default: 255**, Max: 255, Min: 1 |
| unsigned char | minTouchDistance | 0x30 | 0x04 | Minimum distance (interpolated coordinates) allowed between two touch locations. If two locations are closer than minTouchDistance, one is suppressed. **Default: 150**, Max: 255, Min: 0, Recommended Range: Max: 255, Min: 100 |
| unsigned char | penDownTimer | 0x30 | 0x05 | The number of sensor scans in a row that a touch must be identified prior to touch data being transmitted. **Default: 1**, Max: 255, Min: 0, Recommended Range: Max: 5 |
| unsigned char | penUpTimer | 0x30 | 0x06 | Then number of sensor scans in a row that a touch must NOT be identified prior to a touch up packet being transmitted. Default: 3, Max: 255, Min: 0,  Recommended Range: Max: 5, Min 1 |
| unsigned char | touchSuppressNum | 0x30 | 0x07 | The maximum number of touch points to transmit. If an ID above touchSuppressNum is allocated, it will not be transmitted. **Default: 0 (disabled)** |
| unsigned short | largeActThres | 0x30 | 0x08 | Threshold above which a “large activation” |

* + 1. High Offset 0x40: Noise & Charge Pump

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | cpTimeOut | 0x40 | 0x00 | Timeout used for chargepump delay, 1 = 256us |
| unsigned char | selfNoiseThresh | 0x40 | 0x01 | threshold for self noise routines to start |
| unsigned char | mutNoiseThresh | 0x40 | 0x02 | threshold for mutual noise routines to start |
| unsigned char | frequencyChanges | 0x40 | 0x03 | number of frequencies to try before canceling touch |
| unsigned char | sampleSize | 0x40 | 0x04 | number of samples to check for noise |
| unsigned char | selfNoiseScanTime | 0x40 | 0x05 | number of self scans to take when checking for noise |
| unsigned char | mutNoiseScanTime | 0x40 | 0x06 | number of mutual scans to take when checking for noise |
| unsigned char | filterCoeff | 0x40 | 0x07 | MA filter coefficient value (tied to both self and mutual) If zero, filters are turned off |

* + 1. High Offset 0x50: Gestures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | swipeLengthX | 0x50 | 0x00 | Minimum distance (in interpolated positions) the user must swipe in the x-direction to register the gesture |
| unsigned char | swipeLengthY | 0x50 | 0x01 | Minimum distance (in interpolated positions) the user must swipe in the y-direction to register the gesture |
| unsigned char | holdSwipeBoundary | 0x50 | 0x02 | The amount of distance (in interpolated positions) a swipe can move in the direction opposite to the direction being swiped before the gesture is cancelled. |
| unsigned char | swipeHoldThresh | 0x50 | 0x03 | The maximum distance (in interpolated positions) a swipe-and-hold gesture can move before the gesture is cancelled |
| unsigned short | swipeTime | 0x50 | 0x04 | The maximum amount of time (in ms) the user has to perform a swipe after initial pen down |
| unsigned short | tapTime | 0x50 | 0x06 | The maximum amount of time (in ms) the user has to perform a click after initial pen down |
| unsigned char | tapThresh | 0x50 | 0x08 | The maximum distance (in interpolated positions) a tap gesture can move before it is no long recognized as a tap |
| unsigned char | minSwipeVelocity | 0x50 | 0x09 | The minimum velocity a swipe must maintain to be a swipe gesture. Values below this will either cancel the gesture (if touch removed) or move to the swipe-and-hold state (if touch is still present) |
| unsigned short | maxClickTime | 0x50 | 0x0A | This is the maximum amount of time allowed between the two taps of a double tap (in ms) |
| unsigned char | edgeKeepoutDistance | 0x50 | 0x0C | This value determines the width of a keepout barrier around the edge of the active touch area. This helps remove edge effect issues. |

* + 1. High Offset 0xF0: Hardware Configuration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned int | sleepTimeout | 0xF0 | 0x00 | Number of milliseconds of no interaction before the controller goes to sleep. Value of 0 disables sleep. |
| unsigned char | sleepConfig | 0xF0 | 0x04 | Configures type of sleep: None=0, Idle=1, Sleep=2 |
| unsigned char | wdtTimeout | 0xF0 | 0x05 | Timeout for the watchdog timer in the controller (hardware disabled on the MTCH6301) |
| unsigned char | diagPacketCfg | 0xF0 | 0x06 | Diagnostic Packet Configuration – Enabled: 0x81, Disabled: 0x01 |
| unsigned char | touchPacketCfg | 0xF0 | 0x07 | Touch Packet Configuration –  Enabled: 0x81, Disabled: 0x01 |
| unsigned char | commandPacketCfg | 0xF0 | 0x08 | Command Packet Configuration –  Enabled: 0x81, Disabled: 0x01 |
| unsigned char | gesturePacketCfg | 0xF0 | 0x09 | Gesture Packet Configuration –  Enabled: 0x81, Disabled: 0x01 |
| unsigned char | statusPacketCfg | 0xF0 | 0x0A | Status Packet Configuration –  Enabled: 0x81, Disabled: 0x01 |

* + 1. High Offset 0xF1: Hardware Status

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | Name | HIGH | LOW | Description |
| unsigned char | generalStatus | 0xF1 | 0x00 | General operational status of the firmware (reserved for future) |
| unsigned int | txShortStatus | 0xF1 | 0x02 | Identifies which TX pins are shorted after calling checkIO |
| unsigned int | rxShortStatus | 0xF1 | 0x06 | Identifies which RX pins are shorted after calling checkIO |

# Communications Protocol

## Touch Packet

This packet is transmitted whenever a touch is detected on the sensor.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Packet\Bit** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| **0** | 1 | **T3** | **T2** | **T1** | **T0** | 0 | 0 | P0 |
| **1** | 0 | X6 | X5 | X4 | X3 | X2 | X1 | X0 |
| **2** | 0 | 0 | 0 | X11 | X10 | X9 | X8 | X7 |
| **3** | 0 | Y6 | Y5 | Y4 | Y3 | Y2 | Y1 | Y0 |
| **4** | 0 | 0 | 0 | Y11 | Y10 | Y9 | Y8 | Y7 |

T3, T2, T1, T0: Touch Packet ID (Currently uses T2,T1,T0 for IDs 0-7)

P0: Pen State - P0 for Pen Down/Pen Up

X11,X10,…,X0: X Coordinate of touch

Y11,Y10,…,Y0: Y Coordinate of touch

## Gesture Packet

This packet is transmitted whenever a gesture is detected on the sensor. NOTE: Gestures are disabled by default via “gesturePacketCfg”.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Packet\Bit** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| **0** | 1 | **T3** | **T2** | **T1** | **T0** | 1 | 0 | 0 |
| **1** | 0 | G6 | G5 | G4 | G3 | G2 | G1 | G0 |

T3, T2, T1, T0: Touch Packet ID (Currently uses T2,T1,T0 for IDs 0-7)

G6,..,G0: Gesture ID

Gesture IDs:

|  |  |
| --- | --- |
| Gesture Name | Gesture Value |
| GESTURE\_SINGLETAP | 0x10 |
| GESTURE\_HOLDTAP | 0x11 |
| GESTURE\_DOUBLETAP | 0x20 |
| GESTURE\_RIGHT\_SWIPE | 0x41 |
| GESTURE\_RIGHT\_SWIPE\_HOLD | 0x42 |
| GESTURE\_LEFT\_SWIPE | 0x61 |
| GESTURE\_LEFT\_SWIPE\_HOLD | 0x62 |
| GESTURE\_UP\_SWIPE | 0x31 |
| GESTURE\_UP\_SWIPE\_HOLD | 0x32 |
| GESTURE\_DOWN\_SWIPE | 0x51 |
| GESTURE\_DOWN\_SWIPE\_HOLD | 0x52 |

## Command Communications

This protocol is used for all bi-directional communications with the controller.

Command (Sent to firmware):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **0x55** | <size> | <command> | <data 0> | … | <data N> |

Command Response (from firmware):

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **0x55** | <size> | <result> | <command> | <data 0> | … | <data N> |

Size: Number of bytes remaining in the packet. Minimum size for a response is 2 – result and command, with no data.

Result: 0 for success, Non-zero for failure.

Command: The command the firmware is responding to (for synchronization)

Data 0 – Data N: The bytes of data in the response.

Potential Command Results:

|  |  |  |
| --- | --- | --- |
| Value | Name | Description |
| 0xFC | PARAMETERCOUNTERROR | Missing or Extra parameter for the given command |
| 0xFD | INVALIDPARAMETER | Invalid parameter for the given command |
| 0xFF | UNRECOGNIZEDCOMMAND | Response to an unrecognized command |
| 0xFE | COMMANDTIMEOUT | Response to a partial command |
| 0x80 | PARAMETEROUTOFRANGE | Response if a command is sent with data that is out of range |
| 0x00 | DEFAULTSUCCESS | Response when the controller successfully completes a command |

## Diagnostic Messages

Diagnostic messages, if enabled via the diagnostic mask, may be inserted into the standard data stream.

Diagnostic Message format (from firmware):

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **0xAA** | **0x55** | <size> | <diagnostic ID> | <data 0> | … | <data N> |

Command Set

All commands are documented in comm.c – this is an overview of the available commands:

|  |  |  |
| --- | --- | --- |
| ID | Name | Description |
| 0x00 | ENABLECONTROLLER | Enable touch functionality |
| 0x01 | DISABLECONTROLLER | Disable touch functionality |
| 0x14 | SCANBASELINE | Force the firmware to scan a new baseline of the entire sensor |
| 0x15 | WRITERAM | Write a given byte at a given offset in RAM |
| 0x16 | READRAM | Read a given offset in RAM |
| 0x17 | WRITEUSEREEPROM | Write RAM to EEPROM (on devices that support EEPROM) |
| 0x18 | SOFTWARESLEEP | Enter a sleep mode |
| 0x19 | ERASEEEPROM | Erase the contents of EEPROM |
| 0x1A | CHECKIO | Perform a check of the sensor |
| 0x80 | CFGIDHIGHCMD | Return the HIGH config ID of the firmware |
| 0x81 | CFGIDLOWCMD | Return the LOW config ID of the firmware |
| 0xD0 | GETDIAGMASKCMD | Retrieve the current Diagnostic Mask (which Diagnostic IDs will be transmitted) |
| 0xD1 | SETDIAGMASKCMD | Set the current Diagnostic Mask |

# Diagnostic Message IDs

All Diagnostic Messages now have a valid, unique ID and are all transmitted by the sendDebugData function. That function implements a fairly simple diagnostic mask system. It will only transmit diagnostic messages with an ID that is present in the current diagnostic mask. Use the SETDIAGMASKCMD and GETDIAGMASKCMD commands to modify which entries are in the diagnostic mask.

|  |  |  |
| --- | --- | --- |
| **ID** | **Name** | **Description** |
| **0x01** | SELFRAWDIAGNOSTICS | Self Raw data |
| **0x02** | MUTUALRAWDIAGNOSTICS | Mutual Raw data |
| **0x05** | SELFCONTROLLERDIAGNOSTICS | Self Controller Processed data (after baselining) |
| **0x06** | MUTUALCONTROLLERDIAGNOSTICS | Mutual Controller Processed data |
| **0x09** | RAWSELFADCDIAGNOSTICS | Self Raw ADC measurements (typically for noise testing) |
| **0x0A** | RAWMUTUALADCDIAGNOSTICS | Mutual Raw ADC measurements |
| **0x11** | LONGSELFSCANDIAGNOSTICS | Bulk Self Raw ADC measurements – 512 values |
| **0x12** | LONGMUTUALSCANDIAGNOSTICS | Bulk Mutual Raw ADC measurements – 512 values |
| **0x1A** | FINDTOUCHES | Diagnostics for the findTouches function |
| **0x1B** | FINDNEXTPEAK | Diagnostics for the findNextPeak function |
| **0x1C** | FINDFINELOCATION | Diagnostics for touch interpolation (findFineLocation) |
| **0x1F** | DIAGIMAGESTART | Diagnostic message that indicate the beginning of a decode cycle |
| **0x1E** | DIAGIMAGEEND | Not used |
| **0x20** | DIAGSELFDATA | Self Data captured during touch decoding |
| **0x21** | DIAGMUTDATA | Mutual Data captured during touch decoding |
| **0x22** | TOUCHDATAROUGH | Rough touch location early in the processing cycle |
| **0x23** | TOUCHDATAFINE | Fine(interpolated) touch location early in the processing cycle |
| **0x24** | DIAGNUDGE | Diagnostic information for the Nudge function |
| **0x25** | DIAGCOLCACHE | Diagnostics for the mutual measurement column cache  This ID has several “sub-IDs” for different data. |
| **0x26** | DIAGTOUCHREPORT | Touch Report Diagnostics – contains all information on final touch location. |
| **0x27** | DIAGASSOCIATETOUCH | Diagnostics for the touch association function. |
| **0x30** | DIAGFINEX | Fine X Location from the interpolation function |
| **0x31** | DIAGFINEY | Fine Y Location from the interpolation function |
| **0x32** | SELFNOISEDEV | Self Noise Deviation information |
| **0x33** | SELFNOISEFREQ | Self Noise Frequency information |
| **0x34** | MUTNOISEDEV | Mutual Noise Deviation information |
| **0x35** | MUTNOISEFREQ | Mutual Noise Frequency information |