1/4-Inch 2-Mp CMOS Digital Image Sensor Die

MT9D012 Die Data Sheet

For the product data sheet, refer to Aptina's Web site: www.aptina.com

Features

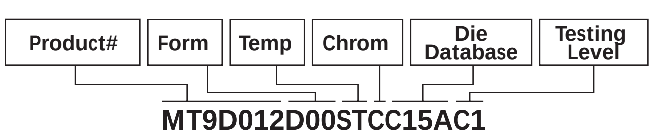
- Aptina® DigitalClarity® CMOS imaging technology
- Low dark current
- Simple two-wire serial interface
- Auto black level calibration
- Support for external mechanical shutter
- Support for external LED or xenon flash
- High frame rate preview mode with arbitrary downsize scaling from maximum resolution
- Programmable controls: Gain, frame size/rate, exposure, left-right and top-bottom image reversal, window size and panning
- SMIA compatible
- Data interfaces: Parallel and CCP2 compliant sub-low-voltage differential signaling (sub-LVDS)
- On-die phase-lock loop (PLL) oscillator
- Bayer-pattern down-size scaler
- Integrated color/lens shading correction
- Superior low-light performance

General Physical Specifications

- Die thickness: 200µm ±12µm
  (Consult factory for die thickness other than 200µm)
- Backside die surface of bare silicon
- Typical metal 1 thickness: 3.1kÅ
- Typical metal 2 thickness: 3.1kÅ
- Typical metal 3 thickness: 6.1kÅ
- Metallization composition: 99.5 percent Al and 0.5 percent Cu over Ti
- Typical topside passivation:
  2.2kÅ nitride over 6.0kÅ of undoped oxide
- Passivation openings (MIN): 75µm x 90µm

Order Information

MT9D012D00STCC15AC1



Die Database

- Die outline, see Figure 3 on page 9
- Singulated die size:
  6,003µm ±25µm x 5,404µm ±25µm
- Bond Pad Location and Identification Tables, see pages 5–8

Options

- Form
  - Die — D
- Testing
  - Standard (level 1) probe — C1

Notes: 1. Consult die distributor or factory before ordering to verify long-term availability of these die products.

Key Performance Parameters

- Optical format: 1/4-inch UXGA (4:3)
- Active imager size: 3.56mm(H) x 2.68mm(V), 4.45mm diagonal
- Active pixels: 1616H x 1216V
- Pixel size: 2.2µm x 2.2µm
- Color filter array: RGB Bayer Pattern
- Shutter type: Electronic rolling shutter (ERS)
- Maximum data rate/master clock:
  64 Mp/s at 64 MHz PIXCLK
- Frame rate:
  UXGA (1600H x 1200V) programmable up to 22 fps
  VGA (640H x 480V) programmable up to 60 fps
- ADC resolution: 10-bit, on-die (61dB)
- Responsivity: 0.53 V/lux-sec
- Dynamic range: 59.5dB
- SNR_{MAX}: 37.7dB
- Supply voltage
  Analog: 2.4–3.1V (2.5V or 2.8V nominal)
  Digital: 1.7–1.9V (1.8V nominal)
  I/O: 1.7–3.1V
- Power consumption: TBD
- Operating temperature: –30°C to +70°C

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General Description

The Aptina MT9D012 die is a UXGA-format, 1/4-inch CMOS active-pixel digital image sensor with a pixel array of 1600H x 1200V (1616H x 1216V including border pixels). It incorporates sophisticated on-die camera functions such as windowing, column and row skip mode, and snapshot mode. It is programmable through a simple two-wire serial interface and has very low power consumption.

The MT9D012 digital image sensor features DigitalClarity technology—Aptina's breakthrough, low-noise CMOS imaging technology that achieves near-CCD image quality (based on signal-to-noise ratio and low-light sensitivity) while maintaining the inherent size, cost, and integration advantages of CMOS.

When operated in its default mode, the sensor generates a UXGA image at 22 frames per second (fps). An on-die analog-to-digital converter (ADC) generates a 10-bit value for each pixel.

Die Testing Procedures

Aptina imager die products are tested with a standard probe (C1) test level. Wafer probe is performed at an elevated temperature to test product functionality in Aptina's standard package. Since the package environment is not within Aptina's control, the user must determine the necessary heat sinking requirements to ensure that the die junction temperature remains within specified limits.

Image quality is verified through various imaging tests. The probe functional test flow provides test coverage for the on-die ADC, logic, serial interface bus, and pixel array. Test conditions, margins, limits, and test sequence are determined by individual product yields and reliability data.

Aptina retains a wafer map of each wafer as part of the probe records, along with a lot summary of wafer yields for each lot probed. Aptina reserves the right to change the probe program at any time to improve the reliability, packaged device yield, or performance of the product.

Die users may experience differences in performance relative to Aptina's data sheets. This is due to differences in package capacitance, inductance, resistance, and trace length.

Functional Specifications

The specifications provided here are for reference only. For functional and parametric specifications, refer to the product data sheet found on Aptina's Web site.

Bonding Instructions

The MT9D012 imager die has 56 bond pads. Refer to Tables 1 and 2 on pages 5–8 for a complete list of bond pads and coordinates.

The MT9D012 imager die does not require the user to determine bond option features.

The die also has several pads defined as "do not use." These pads are used for engineering purposes and should not be used. Bonding these pads could result in a nonfunctional die.

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Figure 1 on page 3 and Figure 2 on page 4 show the MT9D012 typical die connections. For low-noise operation the MT9D012 die requires separate supplies for analog and digital power. Both power supply rails should be decoupled to ground using ceramic capacitors. Use of inductance filters is not recommended.

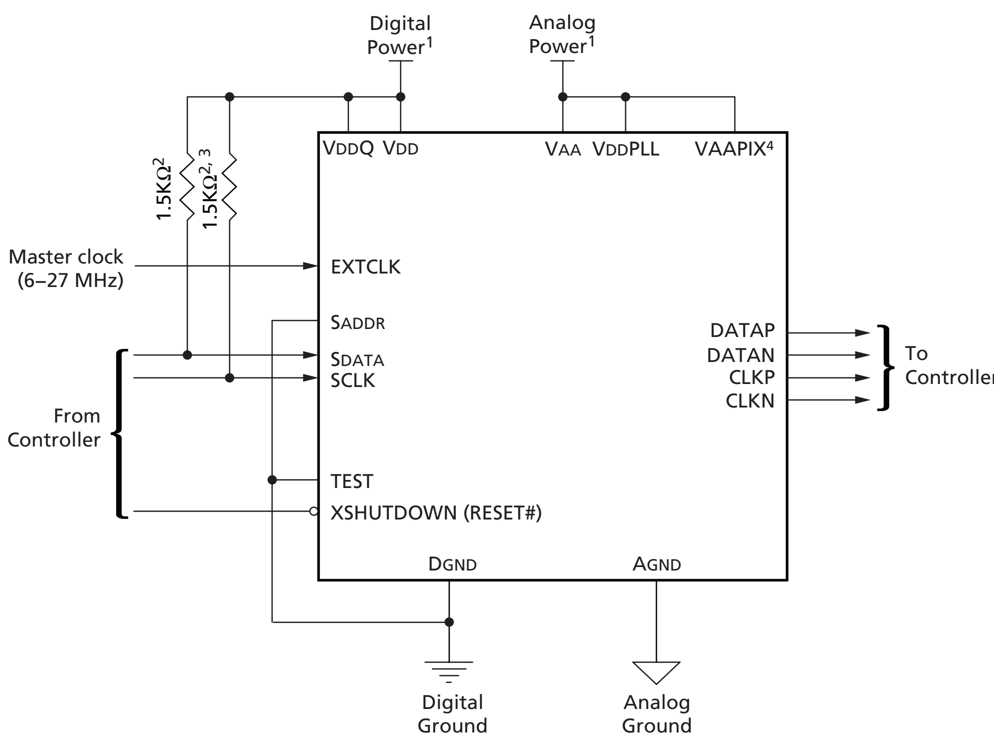
Storage Requirements

Aptina die products are packaged in a cleanroom environment for shipping. Upon receipt, the customer should transfer the die to a similar environment for storage. Aptina recommends the die be maintained in a filtered nitrogen atmosphere until removed for assembly. The moisture content of the storage facility should be maintained at 30 percent relative humidity ±10 percent. ESD damage precautions are necessary during handling. The die must be in an ESD-protected environment at all times for inspection and assembly.

Operating Modes

By default, the MT9D012 powers up as a SMIA-compatible sensor with the serial pixel data interface enabled. A typical configuration in this mode is shown in Figure 1. The MT9D012 can also be configured to operate with a parallel pixel data interface. A typical configuration in this mode is shown in Figure 2 on page 4. These two operating modes are described in the "Control of the Signal Interface" section of the product data sheet.

Figure 1: Typical Configuration: Serial Pixel Data Interface



Notes:
1. All power supplies should be adequately decoupled.
2. A resistor value of 1.5kΩ is recommended, but may be greater for slower two-wire speed.
3. This pull-up resistor is not required if the controller drives a valid logic level on SCLK at all times.
4. VAA and VAAPIX must be tied together.

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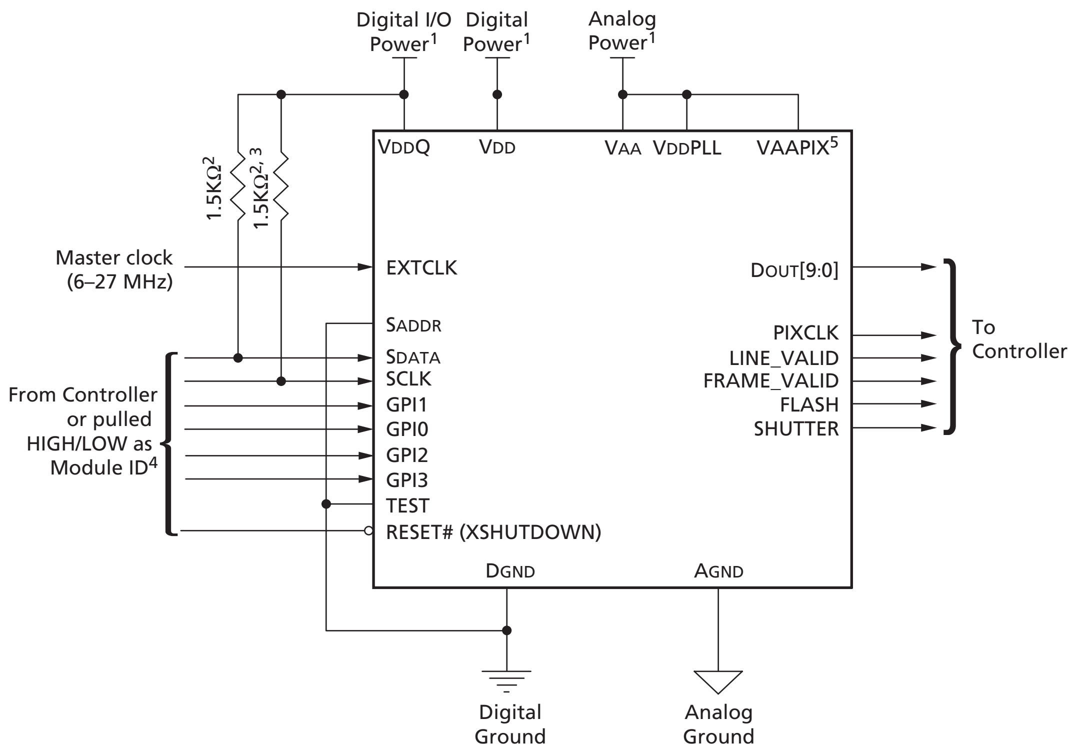
Figure 2: Typical Configuration: Parallel Pixel Data Interface



Notes:
1. All power supplies should be adequately decoupled.
2. A resistor value of 1.5KΩ is recommended, but may be greater for slower two-wire speed.
3. This pull-up resistor is not required if the controller drives a valid logic level on SCLK at all times.
4. The GPI pins can either be statically pulled HIGH/LOW and used as module IDs, or they can be programmed to perform special functions (TRIGGER, OE#, STANDBY) and be dynamically controlled.
5. VAA and VAAPIX must be tied together.

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Bond Pad Location and Identification Tables

Table 1: MT9D012 Bond Pad Location From Center of Pad 1

Pad	MT9D012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
1	VDD2	0.00	0.00	0.0000000	0.0000000
2	DGND2	131.04	0.00	0.0051591	0.0000000
3	VDDQ5	491.04	0.00	0.0193323	0.0000000
4	RESET# (XSHUTDOWN)	644.46	0.00	0.0253722	0.0000000
5	SCL	814.38	0.00	0.0320620	0.0000000
6	SDA	1002.40	0.00	0.0394646	0.0000000
7	GPI0	1217.58	0.00	0.0479360	0.0000000
8	GPI1	1381.63	0.00	0.0543947	0.0000000
9	GPI2	1557.42	0.00	0.0613156	0.0000000
10	GPI3	1721.47	0.00	0.0677742	0.0000000
11	TEST[2]	1897.26	0.00	0.0746951	0.0000000
12	SADDR	2061.31	0.00	0.0811537	0.0000000
13	PIXCLK	3154.16	0.00	0.1241795	0.0000000
14	LINE_VALID	3366.16	0.00	0.1325260	0.0000000
15	FRAME_VALID	3620.72	0.00	0.1425480	0.0000000
16	DOUT9	3908.79	–468.79	0.1538892	–0.0184561
17	DOUT8	3908.79	–723.35	0.1538892	–0.0284781
18	VDDQ3	3908.79	–905.67	0.1538892	–0.0356561
19	DGND3	3908.79	–1036.71	0.1538892	–0.0408152
20	VDD3	3908.79	–1178.55	0.1538892	–0.0463994
21	DOUT7	3908.79	–1350.07	0.1538892	–0.0531522
22	DOUT6	3908.79	–1604.63	0.1538892	–0.0631742
23	DOUT5	3908.79	–1816.63	0.1538892	–0.0715207
24	DOUT4	3908.79	–2071.19	0.1538892	–0.0815427
25	DOUT3	3908.79	–2283.19	0.1538892	–0.0898892
26	VDD4	3908.79	–2486.79	0.1538892	–0.0979049
27	DGND4	3908.79	–2617.83	0.1538892	–0.1030640
28	VDDQ4	3908.79	–2759.67	0.1538892	–0.1086482
29	DOUT2	3908.79	–2952.47	0.1538892	–0.1162388
30	DOUT1	3908.79	–3164.47	0.1538892	–0.1245852
31	DOUT0	3908.79	–3419.03	0.1538892	–0.1346073
32	SHUTTER	3908.79	–3631.03	0.1538892	–0.1429537
33	FLASH	3908.79	–3885.59	0.1538892	–0.1529758
34	DNU[3]	3908.79	–4588.47	0.1538892	–0.1806482
35	DNU	3908.79	–4719.51	0.1538892	–0.1858073
36	DNU	3908.79	–4850.55	0.1538892	–0.1909663
37	VAAPIX1	3661.20	–5098.13	0.1441417	–0.2007138
38	VAAPIX2	3530.16	–5098.13	0.1389827	–0.2007138

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Table 1: MT9D012 Bond Pad Location From Center of Pad 1 (continued)

Pad	MT9D012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
39	VAAPIX3	3399.12	–5098.13	0.1338236	–0.2007138
40	VAA1	3257.28	–5098.13	0.1282394	–0.2007138
41	VAA2	3115.44	–5098.13	0.1226551	–0.2007138
42	VAA3	2973.60	–5098.13	0.1170709	–0.2007138
43	AGND1	2842.56	–5098.13	0.1119118	–0.2007138
44	AGND2	2711.52	–5098.13	0.1067528	–0.2007138
45	AGND3	2580.48	–5098.13	0.1015937	–0.2007138
46	VDDQ2	2125.44	–5098.13	0.0836787	–0.2007138
47	DGND5	1994.40	–5098.13	0.0785197	–0.2007138
48	CLKN	1776.16	–5098.13	0.0699276	–0.2007138
49	CLKP	1486.16	–5098.13	0.0585102	–0.2007138
50	DATAN	1119.52	–5098.13	0.0440756	–0.2007138
51	DATAP	829.52	–5098.13	0.0326583	–0.2007138
52	VDDPLL	–204.48	–5098.13	–0.0080504	–0.2007138
53	EXTCLK	–617.60	–5098.13	–0.0243150	–0.2007138
54	VDDQ1	–799.92	–5098.13	–0.0314929	–0.2007138
55	VDD1	–941.76	–5098.13	–0.0370772	–0.2007138
56	DGND1	–1072.80	–5098.13	–0.0422362	–0.2007138

Notes:
1. Reference to center of each bond pad from center of bond pad number 1.
2. Must be connected to DGND for proper device functionality.
3. DNU = "do not use." See "Bonding Instructions" on page 2.

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Table 2: MT9D012 Bond Pad Location From Center of Die (0, 0)

Pad	MT9D012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
1	VDD2	–1060.20	2549.07	–0.0417402	0.1003569
2	DGND2	–929.16	2549.07	–0.0365811	0.1003569
3	VDDQ5	–569.16	2549.07	–0.0224079	0.1003569
4	RESET# (XSHUTDOWN)	–415.75	2549.07	–0.0163679	0.1003569
5	SCL	–245.83	2549.07	–0.0096781	0.1003569
6	SDA	–57.80	2549.07	–0.0022756	0.1003569
7	GPI0	157.38	2549.07	0.0061959	0.1003569
8	GPI1	321.43	2549.07	0.0126545	0.1003569
9	GPI2	497.22	2549.07	0.0195754	0.1003569
10	GPI3	661.27	2549.07	0.0260341	0.1003569
11	TEST[2]	837.06	2549.07	0.0329549	0.1003569
12	SADDR	1001.11	2549.07	0.0394136	0.1003569
13	PIXCLK	2093.96	2549.07	0.0824394	0.1003569
14	LINE_VALID	2305.96	2549.07	0.0907858	0.1003569
15	FRAME_VALID	2560.52	2549.07	0.1008079	0.1003569
16	DOUT9	2848.59	2080.28	0.1121490	0.0819008
17	DOUT8	2848.59	1825.72	0.1121490	0.0718787
18	VDDQ3	2848.59	1643.40	0.1121490	0.0647008
19	DGND3	2848.59	1512.36	0.1121490	0.0595417
20	VDD3	2848.59	1370.52	0.1121490	0.0539575
21	DOUT7	2848.59	1199.00	0.1121490	0.0472047
22	DOUT6	2848.59	944.44	0.1121490	0.0371827
23	DOUT5	2848.59	732.44	0.1121490	0.0288362
24	DOUT4	2848.59	477.88	0.1121490	0.0188142
25	DOUT3	2848.59	265.88	0.1121490	0.0104677
26	VDD4	2848.59	62.28	0.1121490	0.0024520
27	DGND4	2848.59	–68.76	0.1121490	–0.0027071
28	VDDQ4	2848.59	–210.60	0.1121490	–0.0082913
29	DOUT2	2848.59	–403.40	0.1121490	–0.0158819
30	DOUT1	2848.59	–615.40	0.1121490	–0.0242283
31	DOUT0	2848.59	–869.96	0.1121490	–0.0342504
32	SHUTTER	2848.59	–1081.96	0.1121490	–0.0425969
33	FLASH	2848.59	–1336.52	0.1121490	–0.0526189
34	DNU[3]	2848.59	–2039.40	0.1121490	–0.0802913
35	DNU	2848.59	–2170.44	0.1121490	–0.0854504
36	DNU	2848.59	–2301.48	0.1121490	–0.0906094
37	VAAPIX1	2601.00	–2549.07	0.1024016	–0.1003569
38	VAAPIX2	2469.96	–2549.07	0.0972425	–0.1003569

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Table 2: MT9D012 Bond Pad Location From Center of Die (0, 0) (continued)

Pad	MT9D012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
39	VAAPIX3	2338.92	–2549.07	0.0920835	–0.1003569
40	VAA1	2197.08	–2549.07	0.0864992	–0.1003569
41	VAA2	2055.24	–2549.07	0.0809150	–0.1003569
42	VAA3	1913.40	–2549.07	0.0753307	–0.1003569
43	AGND1	1782.36	–2549.07	0.0701717	–0.1003569
44	AGND2	1651.32	–2549.07	0.0650126	–0.1003569
45	AGND3	1520.28	–2549.07	0.0598535	–0.1003569
46	VDDQ2	1065.24	–2549.07	0.0419386	–0.1003569
47	DGND5	934.20	–2549.07	0.0367795	–0.1003569
48	CLKN	715.96	–2549.07	0.0281874	–0.1003569
49	CLKP	425.96	–2549.07	0.0167701	–0.1003569
50	DATAN	59.32	–2549.07	0.0023354	–0.1003569
51	DATAP	–230.68	–2549.07	–0.0090819	–0.1003569
52	VDDPLL	–1264.68	–2549.07	–0.0497906	–0.1003569
53	EXTCLK	–1677.80	–2549.07	–0.0660551	–0.1003569
54	VDDQ1	–1860.12	–2549.07	–0.0732331	–0.1003569
55	VDD1	–2001.96	–2549.07	–0.0788173	–0.1003569
56	DGND1	–2133.00	–2549.07	–0.0839764	–0.1003569

Notes:
1. Reference to center of each bond pad from center of die (0, 0).
2. Must be connected to DGND for proper device functionality.
3. DNU = "do not use." See Bonding Instructions on page 2.

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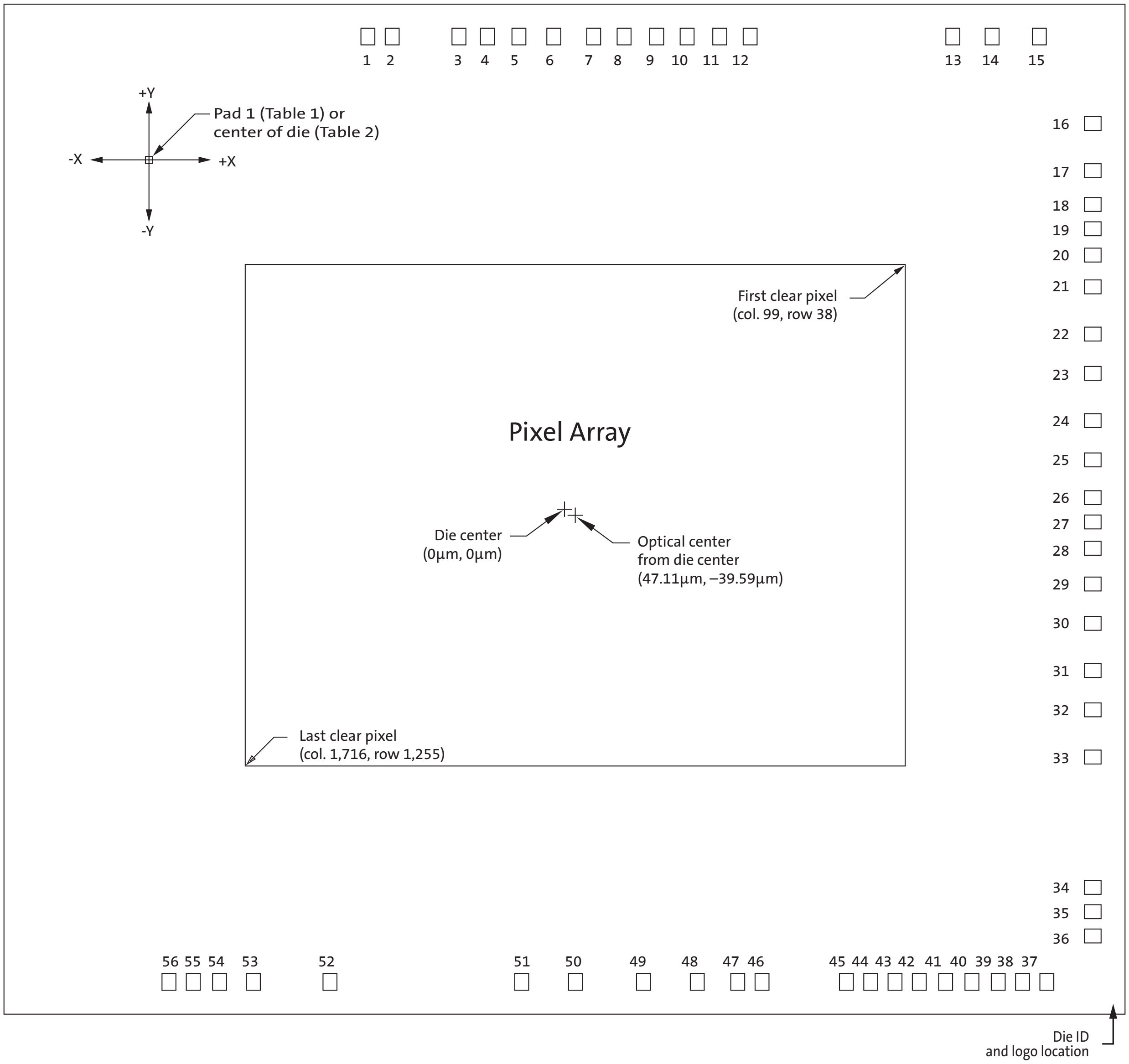
Die Features

Figure 3: Die Outline (Top View)



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Physical Specifications

Table 3: Die Dimensions

Feature	Dimensions
Wafer diameter	200mm (8in)
Die thickness	200µm ±12µm
Singulated die size Width: Length:	 6,003µm ±25µm 5,404µm ±25µm
Bond pad size (MIN)	85µm x 100µm (3.35 mil x 3.94 mil)
Passivation openings (MIN)	75µm x 90µm (2.95 mil x 3.54 mil)
Minimum bond pad pitch	131.04µm (5.159 mil)
Optical array Optical center from die center: Optical center from center of pad 1:	 X = 47.11µm, Y = –39.59µm X = 1,207.30µm, Y = –2,588.65µm
First clear pixel (col. 99, row 38) From die center: From center of pad 1:	 X = 1,825.81µm, Y = 1,299.12µm X = 2,886.00µm, Y = –1,249.95µm
Last clear pixel (col. 1,716, row 1,255) From die center: From center of pad 1:	 X = –1,731.60µm, Y = –1,378.29µm X = –671.40µm, Y = –3,927.35µm
Wafer saw offset From die center (after 30?m wafer saw shift) to the left edge: to the right edge:	 2971.5µm 3031.5µm

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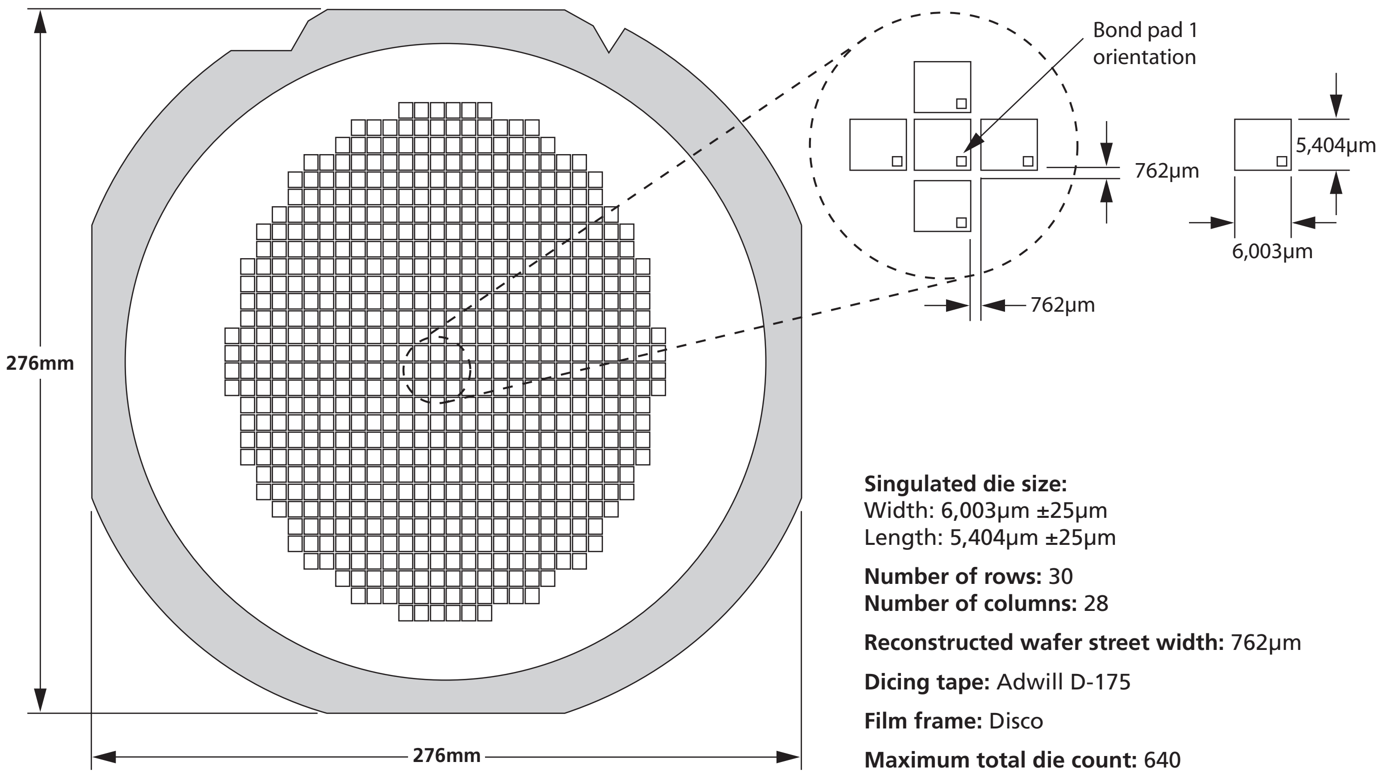
Figure 4: MT9D012 Die Orientation in Reconstructed Wafer



Singulated die size:
Width: 6,003µm ±25µm
Length: 5,404µm ±25µm

Number of rows: 30
Number of columns: 28

Reconstructed wafer street width: 762µm

Dicing tape: Adwill D-175

Film frame: Disco

Maximum total die count: 640

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Revision History

Rev. F **5/10**

- Updated to non-confidential

Rev. E, Advance **11/09**

- Updated to Aptina template

Rev. D, Advance **4/07**

- Updated template
- Updated Figure 4 on page 11

Rev. C, Advance **2/07**

- Added 30µm wafer saw shift to the right from center of street, Table 3 on page 10

Rev. B, Advance **10/06**

- Updated Figures 1 and 2, pages 3 and 4

Rev. A, Advance **2/06**

- Initial release

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