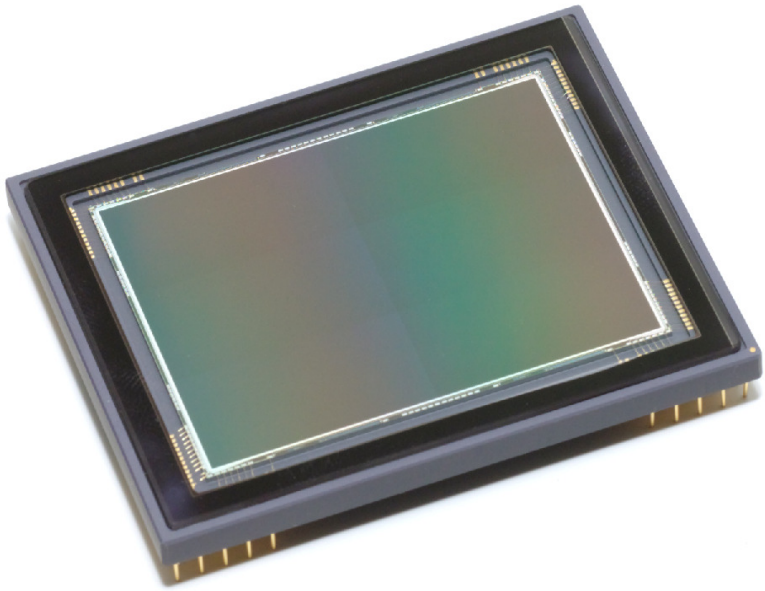
DATASHEET



FTF6080M

48M Full-Frame CCD Image Sensor

Product Specification July 2013

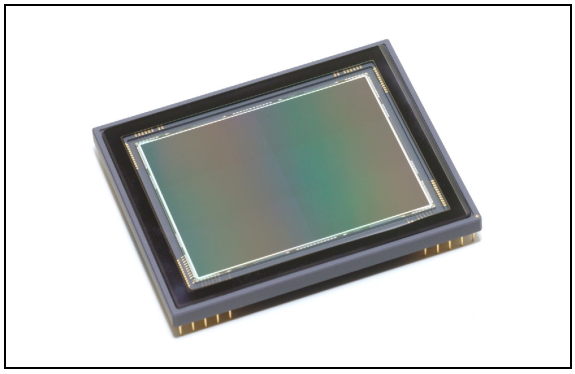
Teledyne DALSA
Professional Imaging

TELEDYNE DALSA
Everywhereyoulook™

July 2013

48M Full-Frame CCD Image Sensor FTF6080M

- **Large Image format (36 x 48 mm^2)**
- **48M active pixels (6000H x 8004V)**
- **Progressive scan**
- **Excellent anti-blooming**
- **Variable electronic shuttering**
- **Square pixel structure (6µm x 6µm)**
- **Micro-lenses with wide angular response**
- **Vertical sub-sampling**
- **95% fill factor**
- **High dynamic range (70dB)**
- **High sensitivity**
- **Low dark current and low fixed pattern noise**
- **Low readout noise**
- **Data rate up to 25 MHz per output**
- **Mirrored and split readout (4 outputs)**
- **Perfectly matched to visual spectrum**
- **RoHS compliant**



Description

The FTF6080M is a full-frame monochrome CCD image sensor designed for demanding high-resolution applications like photogrammetry, medical, scientific, and industrial. The CCD has a very low dark current and a linear dynamic range of over 11 true bits. High quantum efficiency is achieved by using transparent membrane poly-silicon electrodes and micro-lenses. The four low-noise output amplifiers, one at each corner of the chip, make the FTF6080M suitable for a wide range of high-end applications. With one output amplifier, a progressively scanned image can be read out at 0.5 frames per second. By using two or four outputs, the frame rate increases accordingly. The device structure is shown in figure 1.

Device structure

Optical size:	36.000 mm (H) x 48.024 mm (V)		
Chip size:	37.824 mm (H) x 49.731 mm (V)		
Pixel size:	6.0 µm x 6.0 µm		
Active pixels:	6000 (H) x 8004 (V)		
Total no. of pixels:	6048 (H) x 8082 (V)		
Optical black pixels:	Left:	20	Right: 20
Overscan pixels:	Left:	4	Right: 4
Dummy lines:	Bottom:	33	Top: 33
Optical black lines:	Bottom:	6	Top: 6
Dummy register cells:	Left:	23	Right: 23

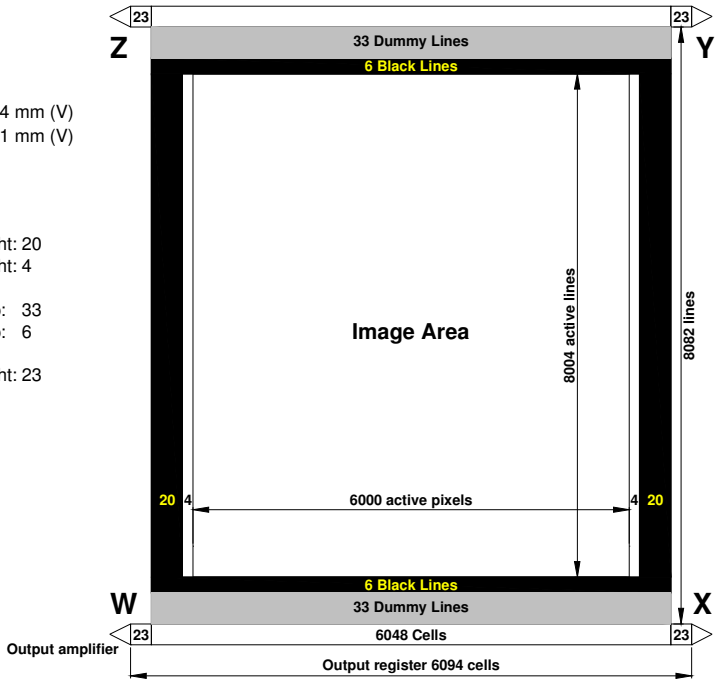


Figure 1– Device Structure

Architecture of the FTF6080M

The optical centers of all pixels in the image section form a square grid. The charge is generated and integrated in this section. Output registers are located below and above the image section for readout. After the integration time, the image charge is shifted one line at a time to either the upper or lower register or to both simultaneously, depending on the readout mode. A separate transfer gate (TG) between the image section and output register enables sub-sampling. The left and right half of each register can be controlled independently. This enables either single or multiple read-out. During vertical transport, the C3 gates separate the pixels in the register.
Each register contains a summing gate at both ends that can be used for horizontal binning (see figure 2).
The charge-to-voltage conversion is performed by a triple source follower amplifier (4 in total). The charge-to-voltage conversion node is reset to reset-drain voltage (RD) by pulsing the reset gate (RG). The amplifier power supply is SFD, the ground terminal is SFS. VNS and VPS are the bias voltages for the n-type substrate and for the CCD p-well, respectively.

IMAGE SECTION	
Image diagonal (active video only)	60.0 mm
Aspect ratio	3:4
Active image width x height	36.000 x 48.024 mm^2
Pixel width x height	6.0 x 6.0 μm^2
Fill factor with micro-lenses	95%
Image clock pins	16 pins (4 x 4) (A1...A4)
Capacity of each clock phase	300nF per phase
Total number of lines	8082
Number of active lines	8004
Number of black lines	12 (=2 x 6)
Number of dummy lines	66 (=2 x 33)
Total number of pixels per line	6048
Number of active pixels per line	6000
Number of overscan pixels per line	8 (=2 x 4)
Number of black reference pixels per line	40 (=2 x 20)

OUTPUT REGISTERS	
Number of output registers	2 (1 top, 1 bottom), each with two output amplifiers (L/ R)
Total number of register cells per register	6094
Number of register cells below/above image	6048
Number of dummy register cells	46 (2 x 23)
Output register horizontal transport clock pins	3 pins per left/right register part (C1...C3)
Capacity of each C-clock phase	200 pF per pin
Overlap capacity between neighboring C-clocks	40 pF
Output register Summing Gates	4 pins, one per output (SG)
Capacity of each SG	15pF
Reset Gate clock phases	4 pins, one per output (RG)
Capacity of each RG	15pF
Output amplifier type	Three-stage source follower

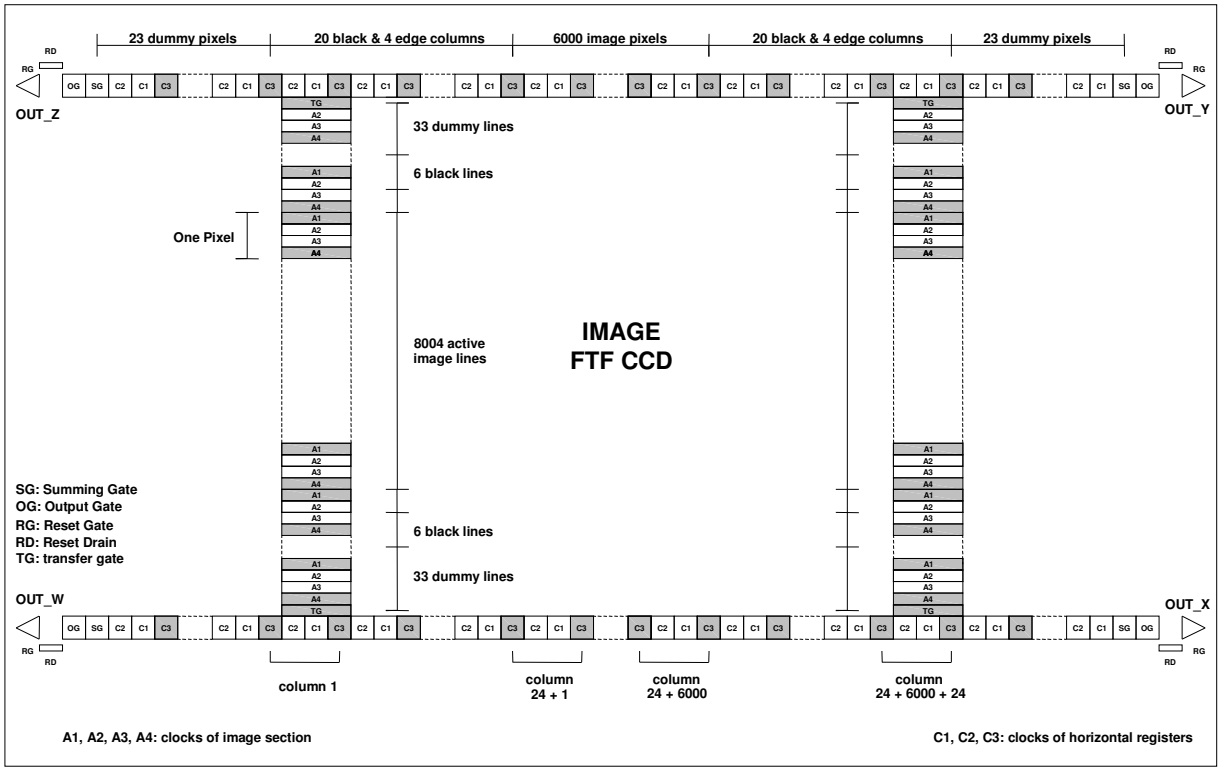


Figure 2- Detailed internal structure

Operating Conditions

Absolute Maximum Ratings

ABSOLUTE MAXIMUM RATINGS[1]	MIN	MAX	UNIT
GENERAL:			
Storage temperature	-40	+80	ºC
Ambient temperature during operation	-20	+60	ºC
Voltage between any two gates	-20	+20	V
DC current through any clock (absolute value)	-0.2	+0.2	µA
OUT current (no short circuit protection)	0	+10	mA
VOLTAGES IN RELATION TO VPS:			
VNS, SFD, RD	-0.5	+30	V
VCS, SFS	-8	+5	V
All other pins (except RG)	-20	+25	V
VOLTAGES IN RELATION TO VNS:			
SFD, RD	-15	+0.5	V
SFS, VPS	-30	+0.5	V
All other pins (except RG)	-30	+0.5	V
VOLTAGES IN RELATION TO SFD:			
RD	-5	0	V
RG Voltage	0	+30	V

[1)] During Charge reset it is allowed to exceed maximum rating levels in relation to VNS, according to the specified DC voltage settings and AC clock level conditions.

DC Voltage Settings

DC CONDITIONS[1, 2]		MIN [V]	TYPICAL [V]	MAX [V]	MAX [mA]
VNS[3]	n-substrate	20	adjusted	28	15
VPS	p-well	5.5	6	6.5	15
SFD	Source Follower Drain	19.5	20	20.5	4.5
SFS	Source Follower Source	0	0	0	1
VCS	Current Source	0	0	0	–
OG	Output Gate	5.75	6	6.25	–
RD	Reset Drain	19.5	20	20.5	–

[1] All voltages in relation to SFS; typical values are according to test conditions.
[2] Power-up sequence: VNS, SFD, RD, VPS, all others. The difference between SFD and RD should not exceed 5V during power up or down.
[3] To set the VNS voltage for optimal Vertical Anti-blooming (VAB), it should be adjustable between minimum and maximum values.

Note on Voltage Settings

Since the AC signals for operating the horizontal register (register clocks C1-C2- C3, summing gate SG) and the output stage (reset gate RG) are analog signals for the CCD, the optimal voltage settings can be influenced by the waveforms of these signals, which in turn depend on the layout and schematics of the camera electronics. Thus the optimal value of all DC biases mentioned can deviate up to +/-1V from the 'typical' values mentioned in the data sheets depending on the precise implementation of the hardware around the sensor. All DC and AC voltages settings in the following tables are measured on sensor pins.

AC Clock Level Conditions

The following voltages should be applied for operating the sensor.
A clocking scheme of 2 gates integrating and 2 gates blocking should be used.

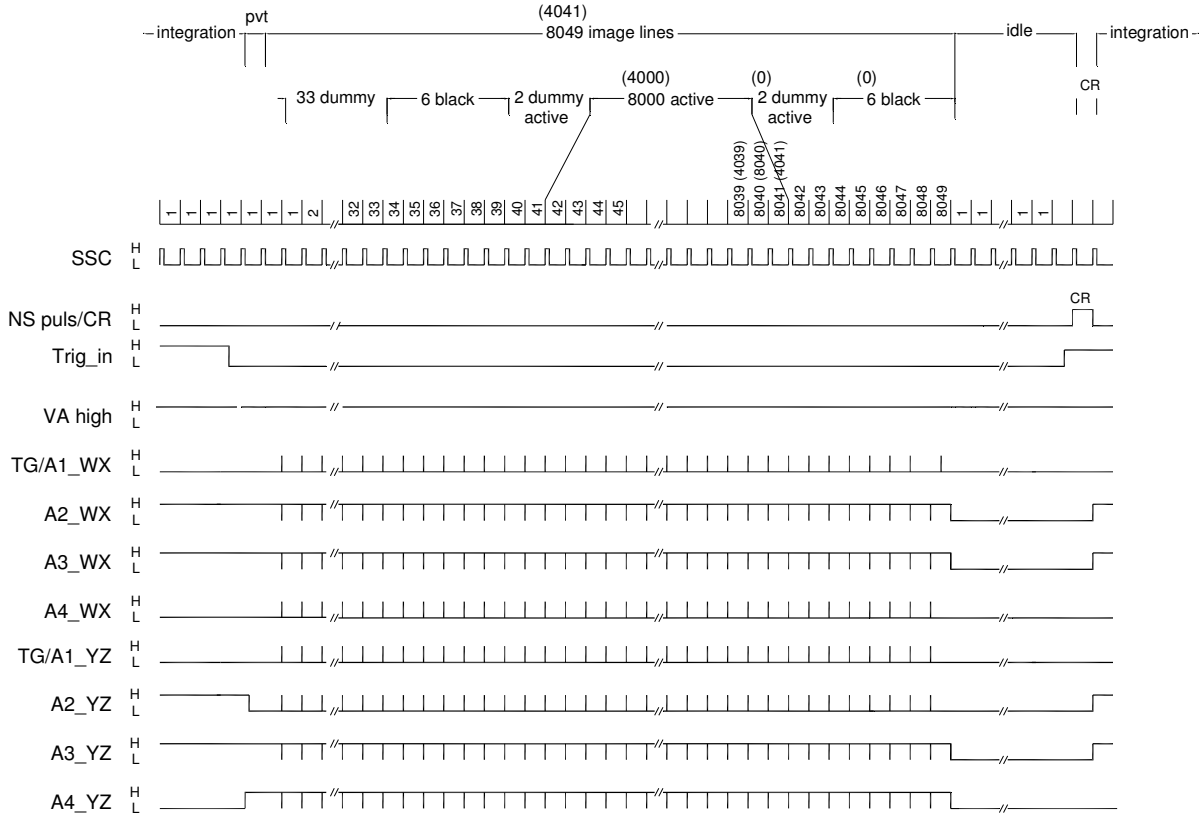
AC CLOCK LEVEL CONDITIONS[1]	**MIN**	**TYPICAL**	**MAX**	**UNIT**
IMAGE CLOCKS/ TRANSFER GATES[2]				
A-clock amplitude during integration and hold	9	9	10	V
A-clock amplitude during vertical transport (duty cycle=5/8)[3]	10.5	11.5	12.5	V
A-clock low level	-	0	-	V
Charge reset (CR) level on A-clock[4]	0	0	-	V
OUTPUT REGISTER CLOCKS:				
C-clock amplitude (duty cycle during hor. transport=3/6)	4.75	5	5.25	V
C-clock low level	-	2.75	-	V
Summing Gate (SG) amplitude	4.75	5	5.25	V
Summing Gate (SG) low level	3.75	4.25	4.75	V
OTHER CLOCKS:				
Reset Gate (RG) amplitude	5	5	10	V
Reset Gate (RG) low level	-	17	-	V
Charge Reset (CR) pulse on VNS[4]	0	5	5	V

[1] All voltages in relation to SFS; typical values are according to test conditions.
[2] Transfer gate should be clocked as A1 during normal transport or held low during a line shift to sub-sample image.
[3] Three-level clock is preferred for maximum charge.
[4] Charge Reset is achieved by applying the typical A-clock low level to all image clocks together with an additional Charge Reset pulse on VNS

Timing diagrams (for default operation)

AC CHARACTERISTICS	MIN	TYPICAL	MAX	UNIT
Horizontal frequency (1/Tp)[1]	-	25	25	MHz
Vertical frequency	-	50	50	kHz
Charge Reset (CR) time	10	Line time	-	µs
Rise and fall times: image clocks (A)	10	20	-	ns
register clocks (C)[2]	3	5	1/8 Tp	ns
summing gate (SG)[2]	3	5	1/8 Tp	ns
reset gate (RG)[3]	0	3	1/8 Tp	ns

[1] Tp = 1 clock period
[2] Duty cycle = 3/6
[3] Duty cycle = 1/6



REMARKS
* CR is applied during the first line after the transition from L to H of Trig_in
* CCD is integrating during high period of Trig_in
* After readout sequence the timing will go into idle mode.
* Linecounter values for single and dual output. For quad output see linecounter values between brackets
* Pvt means prepare for transport (only needed for readout through Y- and Z-output)

Figure 3: Frame Transport Timing Diagram (Quad Output)

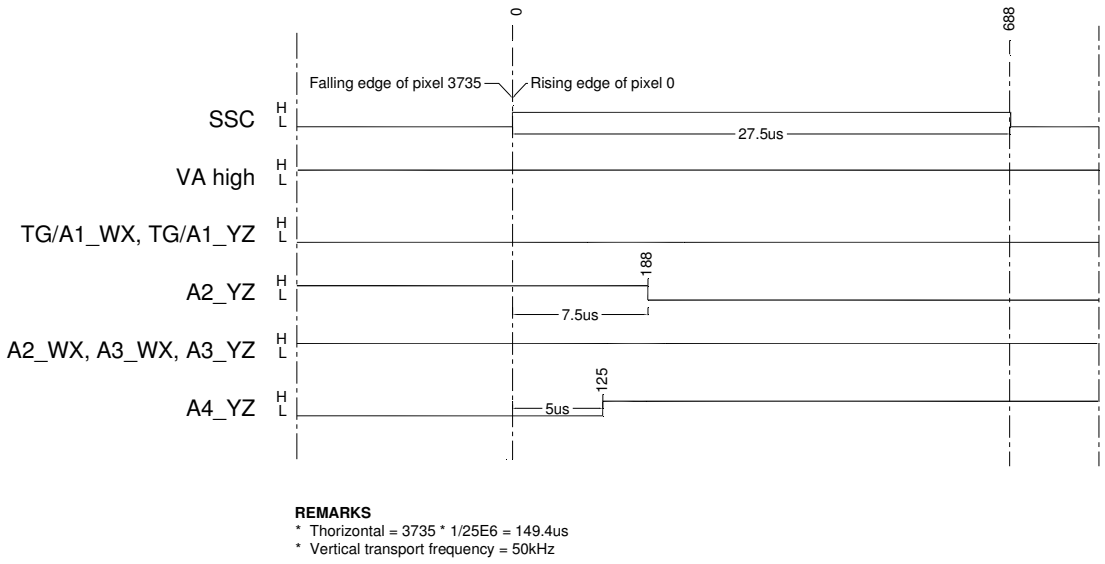
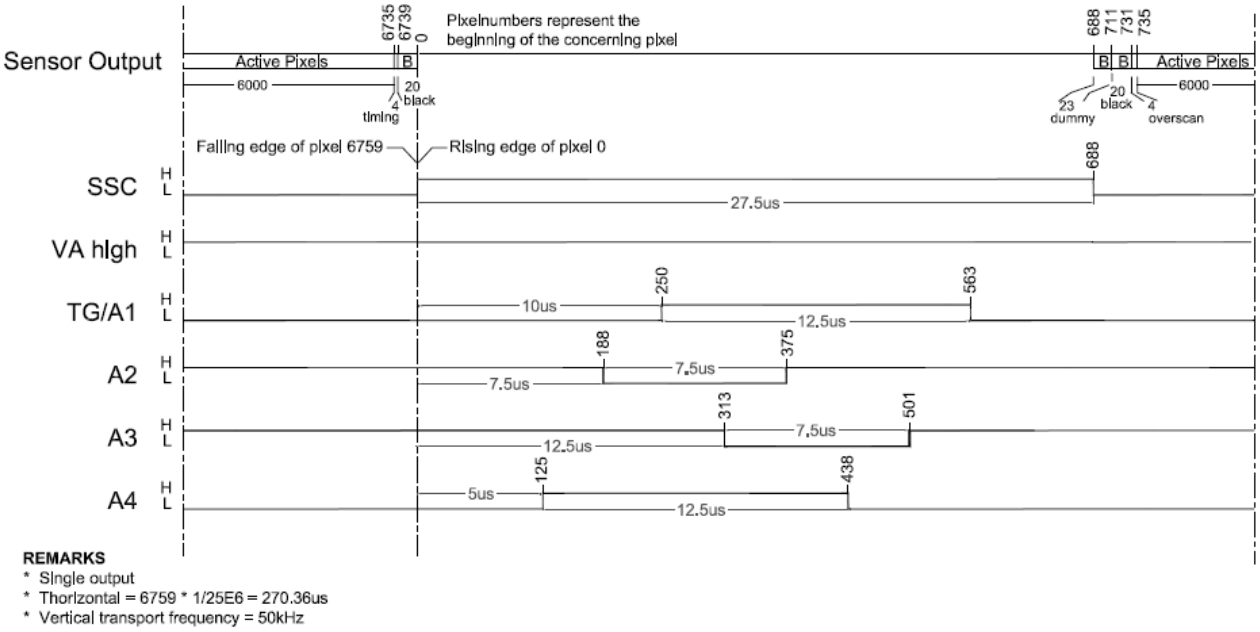


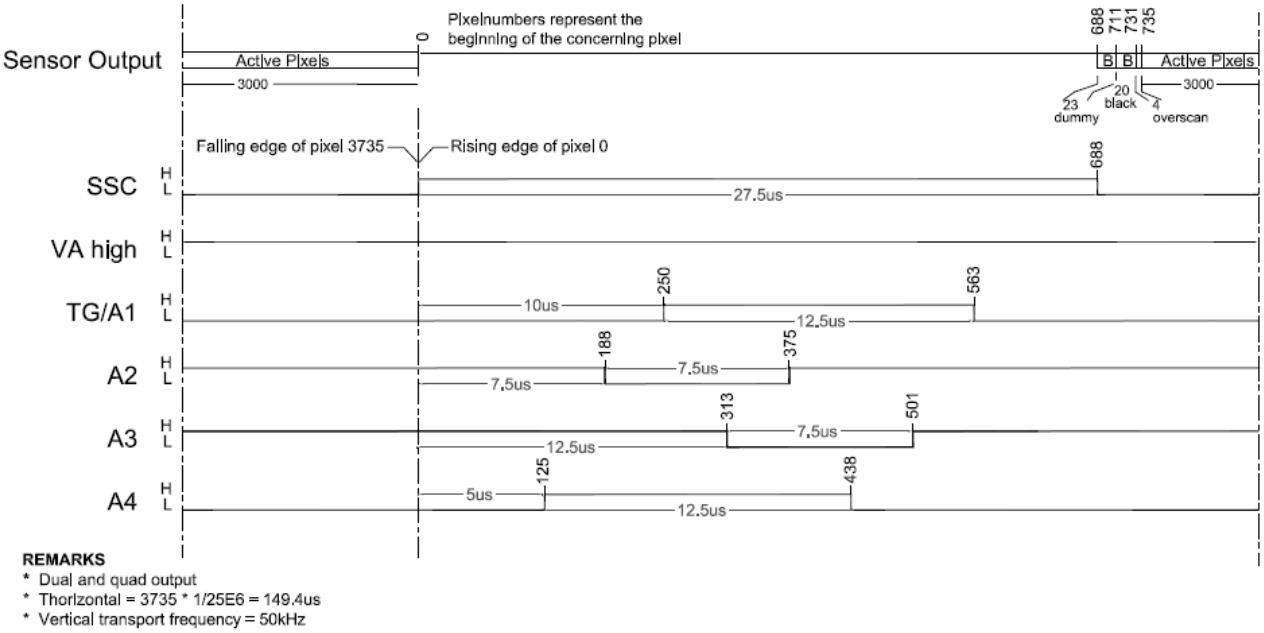
Figure 4: Prepare for Vertical Transport (pvt), Set A-Clocks for Split Vertical Readout

Line Timing, Single Output Mode



REMARKS
* Single output
* Thorizontal = 6759 * 1/25E6 = 270.36us
* Vertical transport frequency = 50kHz

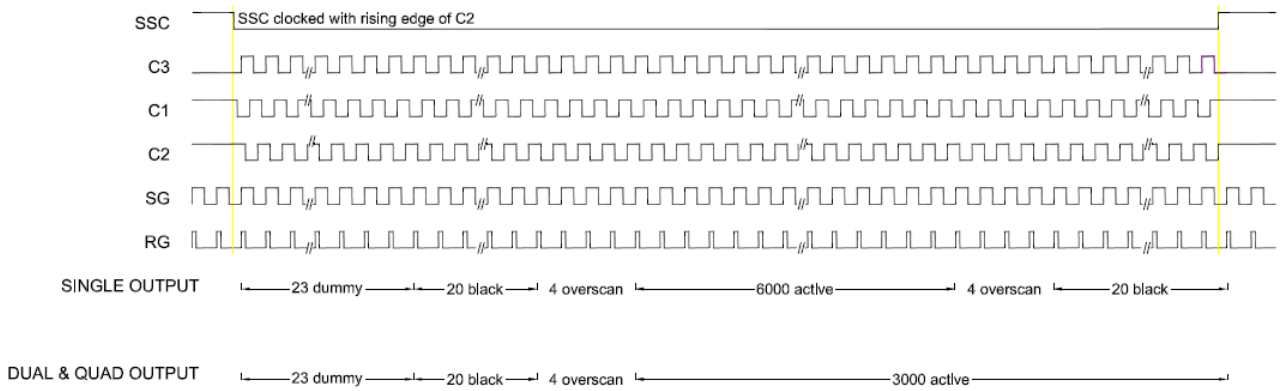
Line Timing, Dual and Quad Output Mode



REMARKS
* Dual and quad output
* Thorizontal = 3735 * 1/25E6 = 149.4us
* Vertical transport frequency = 50kHz

Figure 5- Vertical Readout, Single, Dual, Quad Output Modes

Pixel Timing



SENSOR PIN	C1W	C2W	C3W	C1X	C2X	C3X	C1Y	C2Y	C3Y	C1Z	C2Z	C3Z
SINGLE OUTPUT W	C1	C2	C3	C1	C2	C3	GND	GND	GND	GND	GND	GND
SINGLE OUTPUT X	C2	C1	C3	C2	C1	C3	GND	GND	GND	GND	GND	GND
SINGLE OUTPUT Y	GND	GND	GND	GND	GND	GND	C2	C1	C3	C2	C1	C3
SINGLE OUTPUT Z	GND	GND	GND	GND	GND	GND	C1	C2	C3	C1	C2	C3
DUAL OUTPUT WX	C1	C2	C3	C2	C1	C3	GND	GND	GND	GND	GND	GND
DUAL OUTPUT YZ	GND	GND	GND	GND	GND	GND	C2	C1	C3	C1	C2	C3
QUAD OUTPUT	C1	C2	C3	C2	C1	C3	C2	C1	C3	C1	C2	C3

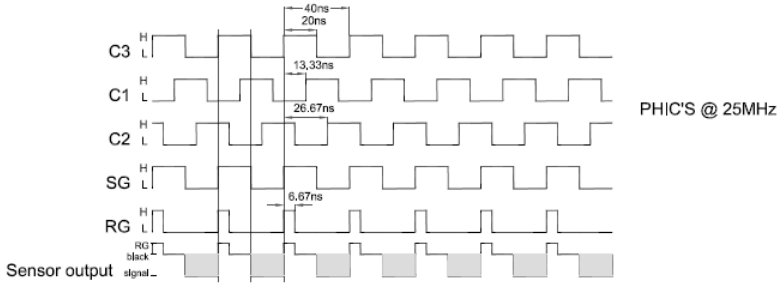


Figure 6- Horizontal Readout, Single, Dual, Quad Output Modes

Performance

The test conditions for the performance characteristics are as follows:

- All values are measured using typical operating conditions.
- VNS is adjusted as low as possible while maintaining proper vertical anti-blooming
- Sensor temperature = 60°C (333K)
- Horizontal transport frequency = 25MHz
- Vertical transport frequency = 50kHz
- Integration time = 100ms

Performance Indicators	MIN	TYPICAL	MAX	UNIT
Qmax (full well capacity)[1]		35000		e^-
Qlin (full well capacity, linear part)[2]		32000		e^-
Conversion factor	35	37	40	$\mu V/e^-$
Vout (at full well capacity)		1330		mV
Mutual conversion factor mismatch (ΔACF)[4]		0	3	$\mu V/e^-$
Amplifier noise over full bandwidth after CDS		12		e^-
Linear Dynamic Range (at 25 MHz)		68.5		dB
Overexposure[3] handling		200		X Qmax
Charge Transfer Efficiency[5]	-	>0.999999	-	-
Image lag	-	0	0	%
Resolution (MTF) @ 83.3 lp/mm	55	-	-	%
Spectral response (with micro-lenses):				
QE Blue (450nm)		25		%
QE Green (540nm)		35		%
QE Red (650nm)		25		%
QE NIR(750nm)		12		%
Sensitivity @3200K without IR cut off filter [6]		160		kel/lux.s
Sensitivity @3200K with IR cut off filter [6]		95		kel/lux.s
Low Pass Shading[7]		2	5	%
Random Non-Uniformity (RNU)[8]		1	2	%
Block-to-block difference[9]		1	3	%
Stitching Effect[10]		1	3	%

[1]Qmax is determined from the low-pass filtered image
[2]The linear full-well capacity Qlin is calculated from linearity test (see dynamic range). The test guarantees 97% linearity.
[3]Overexposure over entire area while maintaining good Vertical Anti-Blooming (VAB) is tested by measuring the dark line along the image section.
[4]Misatch of the outputs is specified as ΔACF with respect to reference W output measured at the operating point ($Q_{lin}/2$)
[5]Charge Transfer Efficiency values are tested by evaluation and expressed as the value per gate transfer
[6]Sensitivity is measured using illumination with a light source of 3200K color temperature and a CM500, 1mm thick IR filter.
[7]Low Pass Shading is defined as the ratio of the one-σ value of an 8x8 pixel blurred image (low-pass) to the mean signal value
[8]RNU is defined as the ratio of the one-σ value of the high-pass image to the mean signal of nominal light
[9]Block-to-block difference is defined as the difference in average signal between different stitching blocks under illumination
[10]Stitching effect is defined as the deviation of response under illumination of the lines or rows at the stitch lines compared to the average response

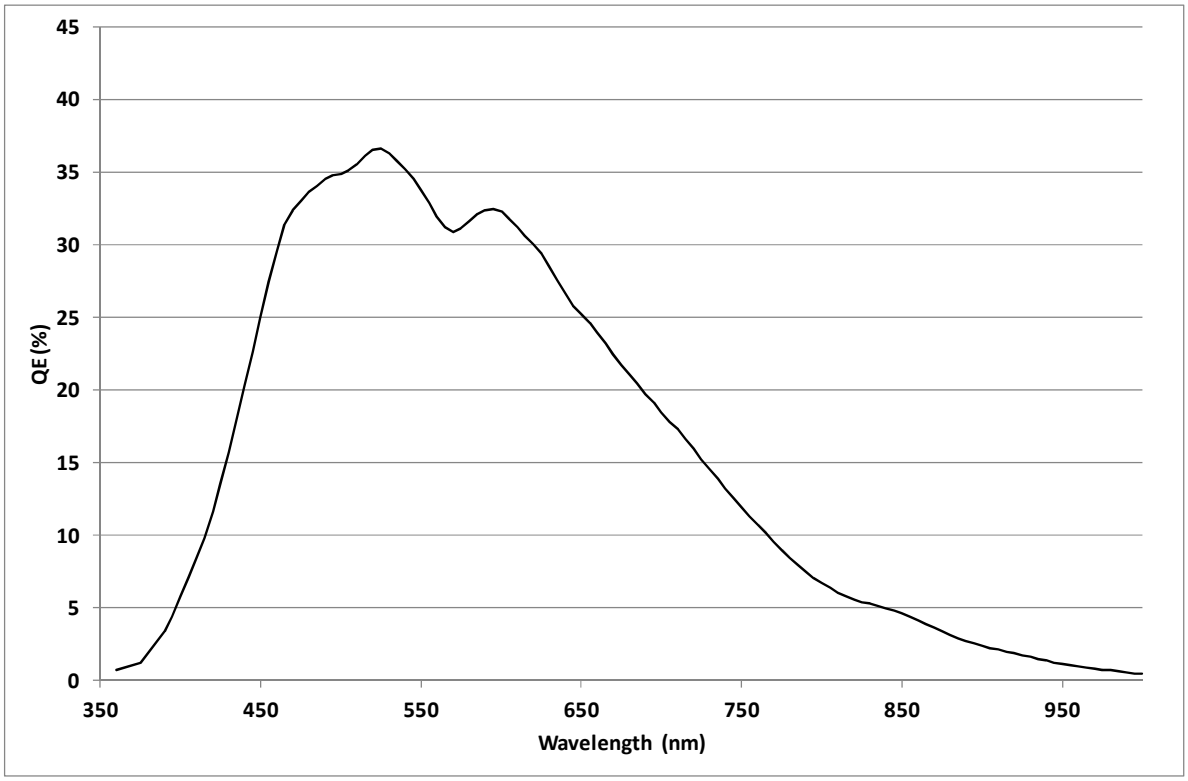


Figure 7- Typical Quantum Efficiency versus wavelength

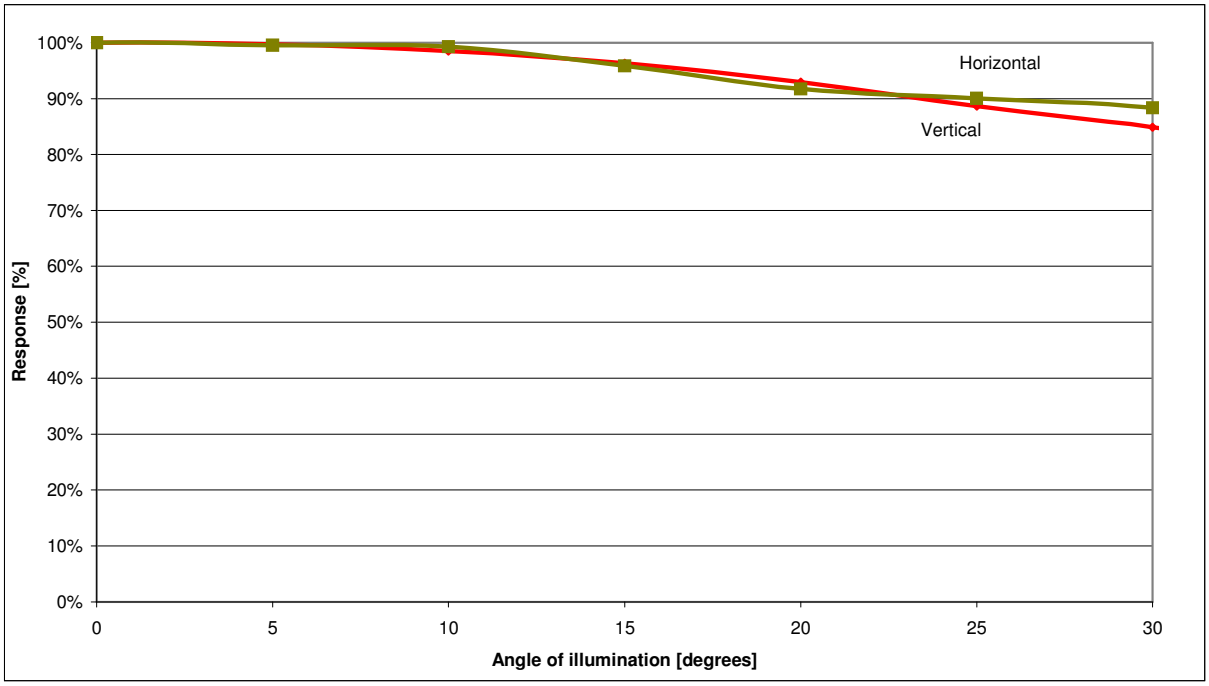


Figure 8- Angular response versus angle of illumination

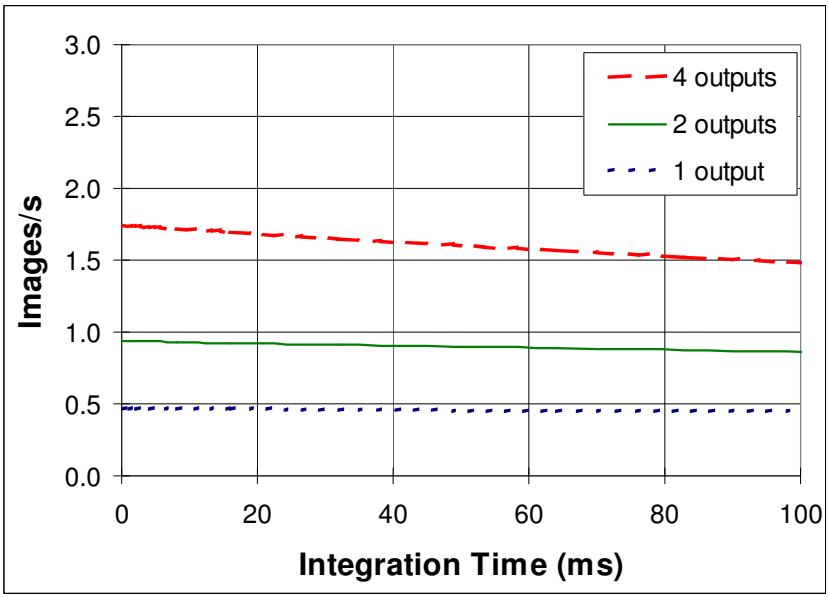


Figure 9- Maximum number of images/second versus integration time

OUTPUT BUFFERS	MIN	TYPICAL	MAX	UNIT
Supply current	-	5	-	mA
Bandwidth (R_{load}=3.3 kΩ)	100	130	-	MHz
Output impedance buffer (R_{load}=3.3 kΩ, C_{load}=2pF)	-	250	-	Ω

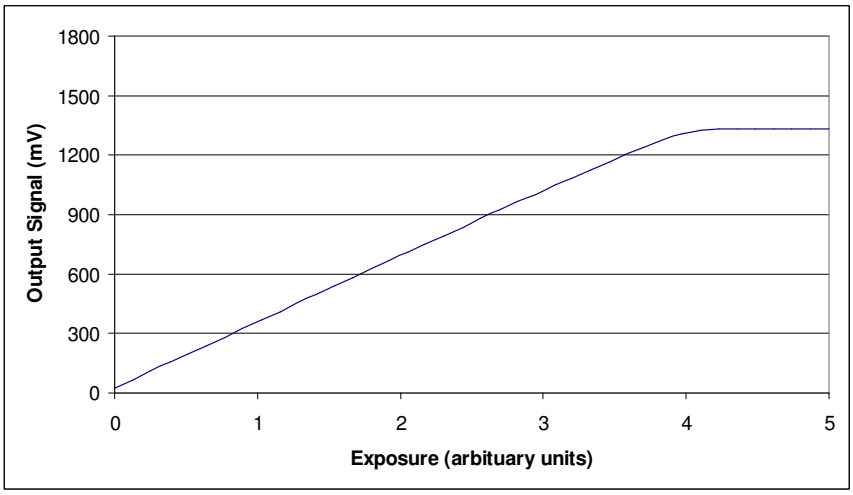


Figure 10- Charge handling

DARK CONDITION	MIN	TYPICAL	MAX	UNIT
Dark current level @ 40℃	-	16	35	pA/cm^2
Dark current level @ 60℃	-	100	200	pA/cm^2
Fixed Pattern Noise[1] (FPN) @ 60ºC	-	500	1000	e^-/s

[1]FPN is one-σ value of the high-pass image and normalized at 1 sec integration time

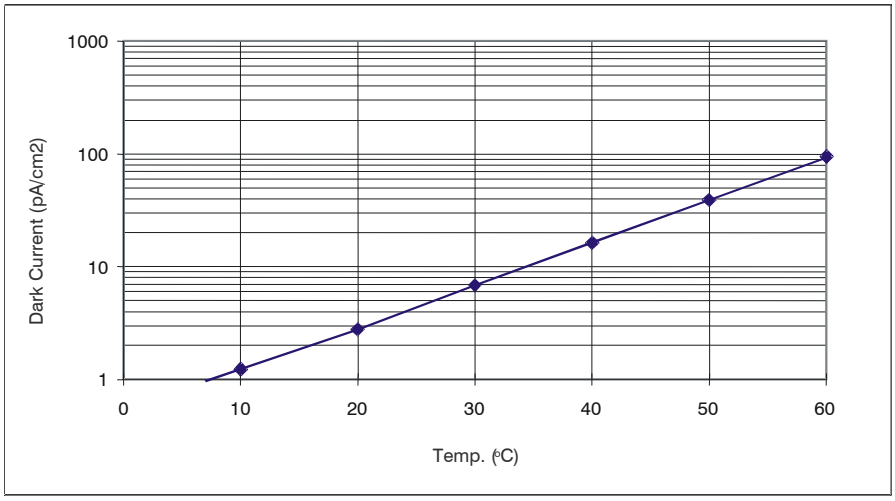


Figure 11- Dark current versus temperature

Application information

Current handling
One of the purposes of VPS is to drain the holes that are generated during exposure of the sensor to light. Free electrons are either transported to the VRD connection and, if excessive (from overexposure), free electrons are drained to VNS. No current should flow into any VPS connection of the sensor. During high overexposure, a total current of 5 to 10mA through all VPS connections together may be expected. The pnp emitter follower in the circuit diagram (figure 11) serves these current requirements.

VNS drains superfluous electrons as a result of overexposure. In other words, it only sinks current. During high overexposure, a total current of 5 to 10mA through all VNS connections together may be expected. The clamp circuit, consisting of the diode and electrolytic capacitor, enables the addition of a Charge Reset (CR) pulse on top of an otherwise stable VNS voltage. To protect the CCD, the current resulting from this pulse should be limited. This can be accomplished by designing a pulse generator with a rather high output impedance.

Decoupling of DC voltages
All DC voltages (not VNS, which has additional CR pulses as described above) should be uncoupled with a 22nF uncoupling capacitor. This capacitor must be mounted as close as possible to the sensor pin. Further noise reduction (by bandwidth limiting) is achieved by the resistors in the connections between the sensor and its voltage supplies. The electrons that build up the charge packets that will reach the floating diffusions only add up to a small current, which will float through VRD. Therefore, a large series resistor in the VRD connection may be used.

Image clocks
Though The image clock phases of quadrant W are internally connected to X, and the phases of Y are connected to Z, it is necessary to apply the driving voltages to all 4 quadrants (W, X, Y,Z).

Outputs
To limit the on-chip power dissipation, the output buffers are designed with open source outputs. Outputs to be used should therefore be loaded with a current source or more simply with a resistance to GND. In order to prevent the output (which typically has an output impedance of about 250Ω) from bandwidth limitation as a result of capacitive loading, load the output with an emitter follower built from a high-frequency transistor. Mount the base of this transistor as close as possible to the sensor and keep the connection between the emitter and the next stage short. The CCD output buffer can easily be destroyed by ESD. By using this emitter follower, this danger is suppressed; do NOT reintroduce this danger by measuring directly on the output pin of the sensor with an oscilloscope probe. Instead, measure on the output of the emitter follower. Slew rate limitation is avoided by avoiding a too-small quiescent current in the emitter follower; about 10mA should do the job. The collector of the emitter follower should be uncoupled properly to suppress the Miller effect from the base-collector capacitance.
A CCD output load resistor of 3.3kΩ typically results in a bandwidth of 120 MHz for X, W, Y and Z outputs.

Device protection
The output buffers of the FTF6080M are likely to be damaged if VPS rises above SFD or RD at any time. This danger is most realistic during power-on or power-off of the camera. The RD voltage should always be lower than the SFD voltage.

Never exceed the maximum output current. This may damage the device permanently. The maximum output current should be limited to 10mA. Be especially aware that the output buffers of these image sensors are very sensitive to ESD damage.

Because of the fact that our CCDs are built on an n-type substrate, we are dealing with some parasitic npn transistors. To avoid activation of these transistors during switch-on and switch-off of the camera, we recommend the application diagram of figure 11.

Color imaging
The CCD is sensitive from 300nm up to 1100nm. This should be taken into account when using external colors filters. The cover glass is not an IR filter.

Unused sections
To reduce power consumption, the following steps can be taken. Connect unused output register pins (C1...C3, SG, OG) and unused SFS pins to zero Volts.

More information
Detailed application information is provided in the application note **AN14.**

Device Handling

An image sensor is an MOS device, which can be destroyed by electro-static discharge (ESD). Therefore, the device should be handled with care.

Always store the device with short-circuiting clamps or on conductive foam. Always switch off all electric signals when inserting or removing the sensor into or from a camera (the ESD protection in the CCD image sensor process is less effective than the ESD protection of standard CMOS circuits).

Being a high quality optical device, it is important that the cover glass remains undamaged. When handling the sensor, use finger cots.
When cleaning the glass, we strongly recommend using ethanol. Use of other liquids is strongly discouraged:

- if the cleaning liquid evaporates too quickly, rubbing is likely to cause ESD damage.
- the cover glass and its coating can be damaged by other liquids.

Rub the window carefully and slowly.
Dry rubbing of the window may cause electro-static charges or scratches, which can destroy the device.

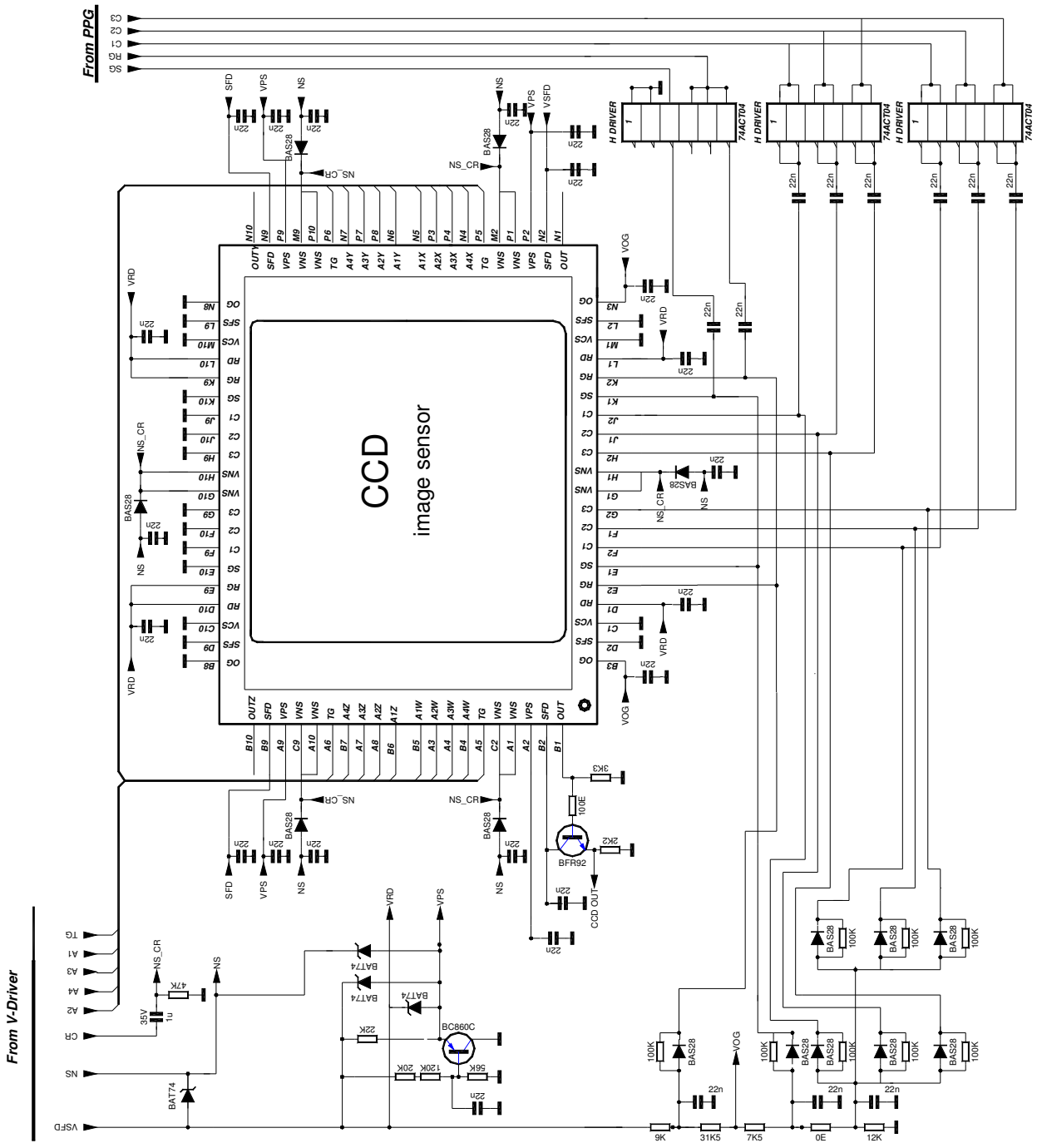


Figure 12- Application diagram for single output operation

Pin configuration

The FTF6080M is mounted in a Pin Grid Array (PGA) package with 80 pins in a 20x25 grid of 51.30 x 64.00mm^2. The position of pin A1 (quadrant W) is marked with a gold dot on top of the package. The image clock phases of quadrant W are internally connected to X, and the phases of Y are connected to Z.

SYMBOL	FUNCTION	PIN # W	PIN # X	PIN # Y	PIN # Z
VNS	n-substrate	A1	P1	P10	A10
VNS	n-substrate	C2	M2	M9	C9
VNS	n-substrate	G1	H1	H10	G10
VPS	p-well	A2	P2	P9	A9
SFD	Source Follower Drain	B2	N2	N9	B9
SFS	Source Follower Source	D2	L2	L9	D9
VCS	Current Source	C1	M1	M10	C10
OG	Output Gate	B3	N3	N8	B8
RD	Reset Drain	D1	L1	L10	D10
TG	Image Clock Transfer Gate (Phase 1)	A5	P5	P6	A6
A1	Image Clock (Phase 1)	B5	N5	N6	B6
A2	Image Clock (Phase 2)	A3	P3	P8	A8
A3	Image Clock (Phase 3)	A4	P4	P7	A7
A4	Image Clock (Phase 4)	B4	N4	N7	B7
C1	Register Clock (Phase 1)	F2	J2	J9	F9
C2	Register Clock (Phase 2)	F1	J1	J10	F10
C3	Register Clock (Phase 3)	G2	H2	H9	G9
SG	Summing Gate	E1	K1	K10	E10
RG	Reset Gate	E2	K2	K9	E9
OUT	Output	B1	N1	N10	B10

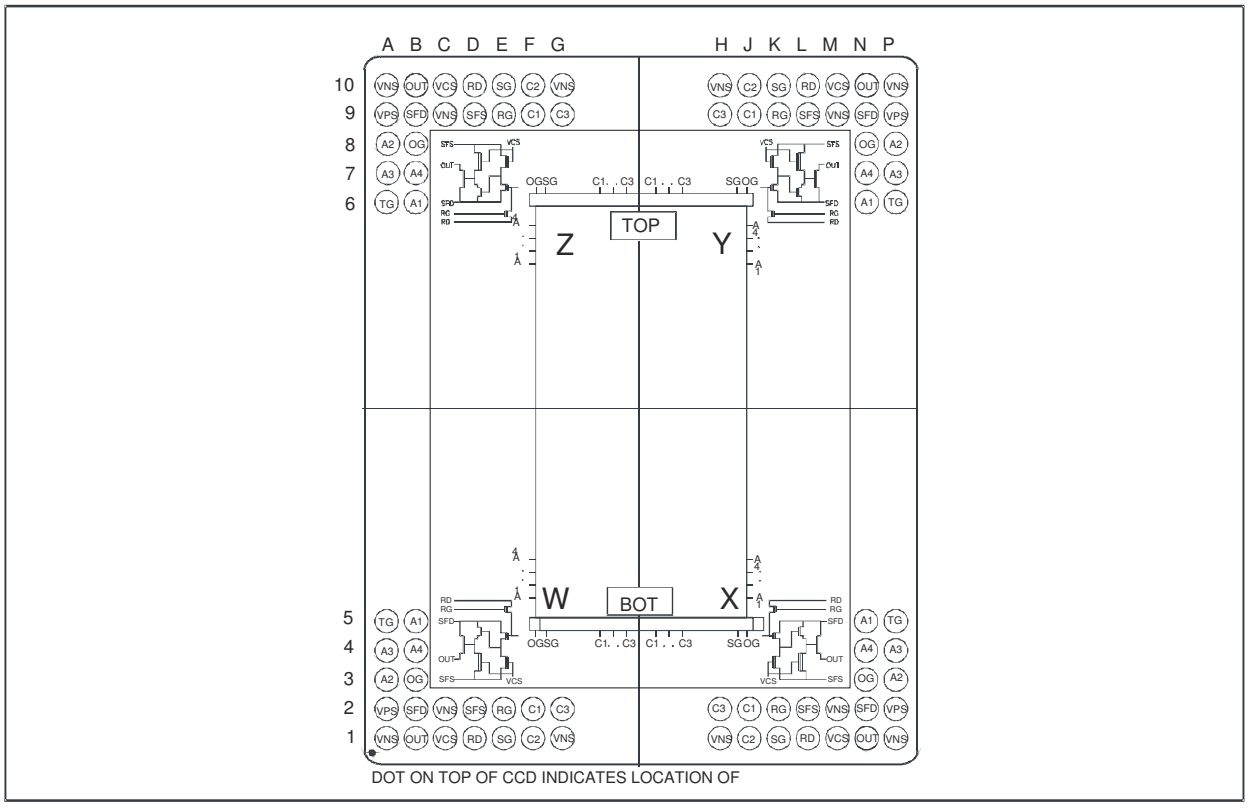


Figure 13- Pin configuration (top view)

Package information

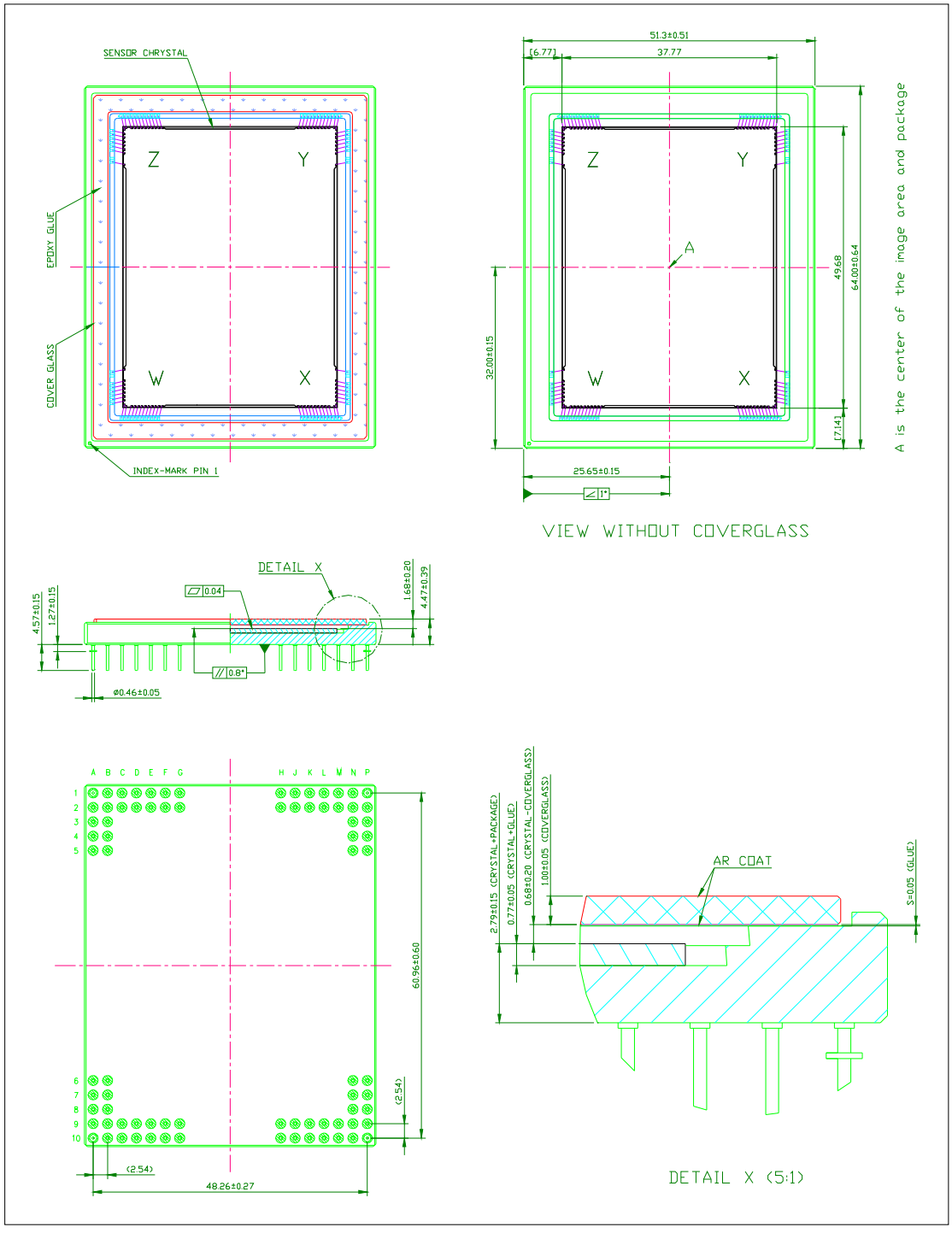


Figure 14- Package configuration

48M Full-Frame CCD Image Sensor FTF6080M

Order codes

The sensor can be ordered using the following code:

FTF6080M sensor		
Description	**Quality Grade**	**Order Code**
FTF6080M/HG	High Grade	9922-157-87111
FTF6080M/IG	Industrial Grade	9922-157-87121
FTF6080M/TG	Test Grade	9922-157-87131
FTF6080M/EG	Economy Grade	9922-157-87151
FTF6080M/CG	Customer Grade	9922-157-87161

Defect Specifications

The CCD image sensor can be ordered in a specific quality grade. The grading is defined with the maximum amount of pixel defects, column defects, row defects and cluster defects, in both illuminated and non-illuminated conditions. For detailed grading information, please contact your local Teledyne DALSA representative.

For More Information

For more detailed information on this and other products, contact your local rep or visit our Web site at http://www.teledynedalsa.com/sensors/products/products.asp.

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This information is subject to change without notice.

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