PCIe-6346

500 kS/s/ch, 8 simultaneous AI, 24 DIO, 2 AO Multifunction I/O Device

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- *Typical* specifications describe the performance met by a majority of models.
- *Nominal* specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are *Typical* unless otherwise noted.

Conditions

Specifications are valid for 25 °C unless otherwise noted.

Analog Input

> **Note** Floating inputs can cause unnecessary power consumption and higher operating temperatures. NI recommends connecting unused analog input channels to AIGND.

Number of channels	8 differential
ADC resolution	16 bits
DNL	No missing codes, warranted
INL	Refer to the *AI Absolute Accuracy* section.
Sample rate (simultaneous sampling on all channels sampled)	
Maximum	500 kS/s
Minimum	No minimum
Timing resolution	10 ns

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Timing accuracy	50 ppm of sample rate
Input coupling	DC
Input range	±1 V, ±2 V, ±5 V, ±10 V
Maximum working voltage for all analog inputs (AI±)	
Ranges ±10 V, ±5 V	±11 V, Measurement Category I
Ranges ±2 V, ±1 V	±9 V, Measurement Category I

⚠ **Caution** Do not use for measurements within Categories II, III, and IV.

CMRR (at 60 Hz)	80 dB
Bandwidth (small signal)	2.0 MHz at ±1 V
	2.9 MHz at other ranges
Input impedance	
Device on	
AI+ to AI GND	>1 GΩ in parallel with 18 pF
AI- to AI GND	>1 GΩ in parallel with 18 pF
Device off	
AI+ to AI GND	2.37 kΩ
AI- to AI GND	2.37 kΩ
Input bias current	±6 nA
	±90 nA, maximum over full temperature range
Crosstalk (at 100 kHz)	-80 dB
Input FIFO size	4,095 samples shared among channels used
Data transfers	DMA (scatter-gather), programmed I/O
Overvoltage protection for AI<0..7>	
Device on	±30 V
Device off	±15 V
Input current during overvoltage conditions	±6.3 mA maximum/AI pin
Maximum AI channels in overvoltage	4

🛇 **Notice** Exceeding overvoltage specifications may result in data corruption on non-overvoltaged channels.

Analog Triggers

Number of triggers	1
Source	AI <0..7>, APFI 0
Functions	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Source level	
AI <0..7>	±Full scale
APFI 0	±10 V
Resolution	16 bits
Modes	Analog edge triggering, analog edge triggering with hysteresis, and analog window triggering
Bandwidth (large signal, to -3 dB)	
AI <0..7>	600 kHz
APFI 0	3.9 MHz
Accuracy	±1% of range
APFI 0 characteristics	
Input impedance	10 kΩ
Coupling	DC
Protection, power on	±30 V
Protection, power off	±15 V

AI Absolute Accuracy

Table 1. AI Absolute Accuracy

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Offset Tempco (ppm of Range/°C)	Random Noise, σ (µVrms)	Absolute Accuracy at Full Scale (µV)
10	-10	115	2	265	3,225
5	-5	115	2	148	1,613

Table 1. AI Absolute Accuracy (Continued)

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Offset Tempco (ppm of Range/°C)	Random Noise, σ (μVrms)	Absolute Accuracy at Full Scale (μV)
2	-2	117	2	74	650
1	-1	124	3	50	333

Note For more information about absolute accuracy at full scale, refer to the *AI Absolute Accuracy Example* section.

Gain tempco	16.7 ppm/°C
Reference tempco	5 ppm/°C
Residual offset error	12 ppm of range
INL error	126 ppm of range

Note Accuracies listed are warranted for up to one year from the device external calibration when the device is within 10 °C of the external calibration temperature and 1 °C of the last self calibration, when averaging 10,000 DC samples. Other accuracies may be calculated for different temperatures and sample sizes using the given equations.

AI Absolute Accuracy Equation

AbsoluteAccuracy = Reading · (GainError) + Range · (OffsetError) + NoiseUncertainty

  GainError = ResidualGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

  OffsetError = ResidualOffsetError + OffsetTempco · (TempChangeFromLastInternalCal) + INLError

  $NoiseUncertainty = \dfrac{\text{Random Noise} \cdot 3}{\sqrt{10,000}}$ for a coverage factor of 3 σ and averaging 10,000 points.

AI Absolute Accuracy Example

Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

- *TempChangeFromLastExternalCal* = 10 °C
- *TempChangeFromLastInternalCal* = 1 °C
- *number_of_readings* = 10,000
- *CoverageFactor* = 3 σ

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

$GainError$ = 115 ppm + 16.7 ppm · 1 + 5 ppm · 10 = 181.7 ppm

$OffsetError$ = 12 ppm + 2 ppm ·1 + 126 ppm = 140 ppm

$Noise\ Uncertainty = \dfrac{265\ \mu V \cdot 3}{\sqrt{10,000}} = 8\ \mu V$

$AbsoluteAccuracy$ = 10 V · ($GainError$) + 10 V · ($OffsetError$) + $NoiseUncertainty$ = 3225 μV

Analog Output

Number of channels	2
DAC resolution	16 bits
DNL	±1 LSB, maximum
Monotonicity	16 bit guaranteed
Accuracy	Refer to the *AO Absolute Accuracy* section.
Maximum update rate (simultaneous)	
1 channel	900 kS/s
2 channels	840 kS/s
Minimum update rate	No minimum
Timing accuracy	50 ppm of sample rate
Timing resolution	10 ns
Output range	±10 V
Output coupling	DC
Output impedance	0.2 Ω
Output current drive	±5 mA
Overdrive protection	±15 V
Overdrive current	15 mA
Power-on state	±20 mV
Power-on/off glitch	2 V peak for 500 ms
Output FIFO size	8,191 samples shared among channels used
Data transfers	DMA (scatter-gather), programmed I/O
AO waveform modes	Non-periodic waveform, periodic waveform regeneration mode from onboard FIFO, periodic waveform regeneration from host buffer including dynamic update

Settling time, full-scale step, 15 ppm (1 LSB)	6 µs
Slew rate	15 V/µs
Glitch energy at midscale transition	100 mV · 2.6 µs

AO Absolute Accuracy

Accuracies listed are warranted for up to one year from the device external calibration when the device is within 10 °C of the external calibration temperature and 1 °C of the last self calibration.

Table 2. AO Absolute Accuracy

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco (ppm/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/ °C)	INL Error (ppm of Range)	Absolute Accuracy at Full Scale (µV)
10	-10	130	11.3	5	52	4.8	128	3,761

AO Absolute Accuracy Equation

AbsoluteAccuracy = OutputValue · (GainError) + Range · (OffsetError)

> *GainError = ResidualGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)*
>
> *OffsetError = ResidualOffsetError + OffsetTempco · (TempChangeFromLastInternalCal) + INLError*

Digital I/O/PFI

Static Characteristics

Number of channels	24 total 8 (P0.<0..7>) 16 (PFI <0..7>/P1, PFI <8..15>/P2)
Ground reference	D GND
Direction control	Each terminal individually programmable as input or output
Pull-down resistor	50 kΩ, typical 20 kΩ, minimum
Input voltage protection	±20 V on up to two pins

⚠️ **Caution** Stresses beyond those listed under the *Input voltage protection* specification may cause permanent damage to the device.

Waveform Characteristics (Port 0 Only)

Terminals used	Port 0 (P0.<0..7>)
Port/sample size	Up to 8 bits
Waveform generation (DO) FIFO	2,047 samples
Waveform acquisition (DI) FIFO	255 samples
DI Sample Clock frequency	0 to 1 MHz, system and bus activity dependent
DO Sample Clock frequency	
Regenerate from FIFO	0 to 1 MHz
Streaming from memory	0 to 1 MHz, system and bus activity dependent
Data transfers	DMA (scatter-gather), programmed I/O
Digital line filter settings	160 ns, 10.24 μs, 5.12 ms, disable

PFI/Port 1/Port 2 Functionality

Functionality	Static digital input, static digital output, timing input, timing output
Timing output sources	Many AI, AO, counter, DI, DO timing signals
Debounce filter settings	90 ns, 5.12 μs, 2.56 ms, custom interval, disable; programmable high and low transitions; selectable per input

Recommended Operating Conditions

Input high voltage (V_{IH})	
Minimum	2.2 V
Maximum	5.25 V
Input low voltage (V_{IL})	
Minimum	0 V
Maximum	0.8 V
Output high current (I_{OH})	
P0.<0..7>	-24 mA, maximum
PFI <0..15>/P1/P2	-16 mA, maximum

Output low current (I_{OL})

P0.<0..7>	24 mA, maximum
PFI <0..15>/P1/P2	16 mA, maximum

Digital I/O Characteristics

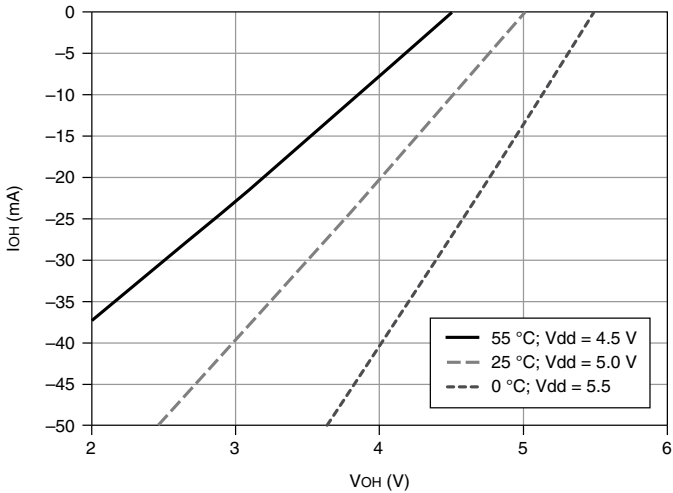|	
Positive-going threshold (VT+)	2.2 V, maximum
Negative-going threshold (VT-)	0.8 V, minimum
Delta VT hysteresis (VT+ - VT-)	0.2 V , minimum
I_{IL} input low current (V_{IN} = 0 V)	-10 μA, maximum
I_{IH} input high current (V_{IN} = 5 V)	250 μA, maximum

Figure 1. P0.<0..7>: I_{OH} versus V_{OH}
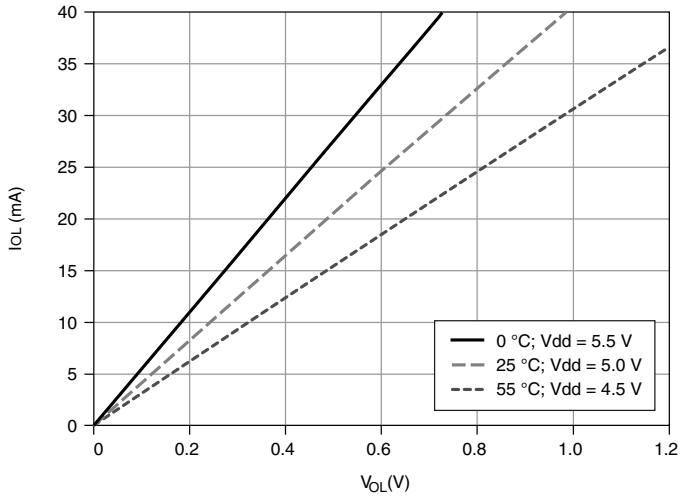
Figure 2. P0.<0..7>: I_{OL} versus V_{OL}

IOL (mA)

40
35
30
25
20
15
10
5
0

0   0.2   0.4   0.6   0.8   1.0   1.2

V_{OL}(V)

—— 0 °C; Vdd = 5.5 V
– – 25 °C; Vdd = 5.0 V
- - - 55 °C; Vdd = 4.5 V

Figure 3. PFI <0..15>/P1/P2: I_{OH} versus V_{OH}

IOH (mA)

0
−5
−10
−15
−20
−25
−30
−35
−40
−45
−50

2   3   4   5   6

V_{OH} (V)

—— 55 °C; Vdd = 4.5 V
– – 25 °C; Vdd = 5.0 V
- - - 0 °C; Vdd = 5.5
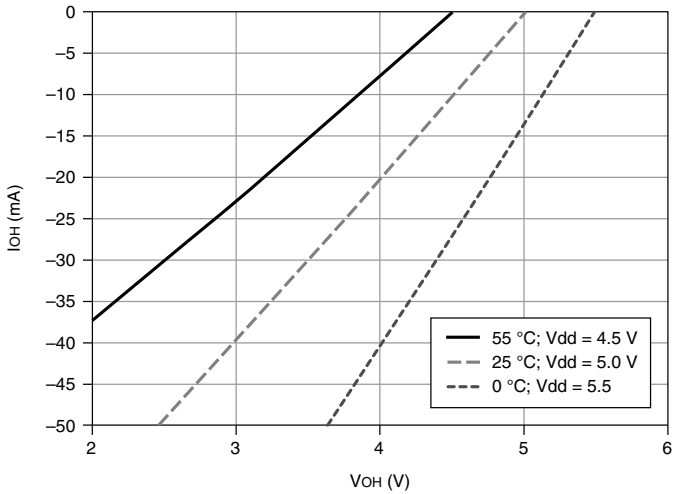
Figure 4. PFI <0..15>/P1/P2: I_{OL} versus V_{OL}
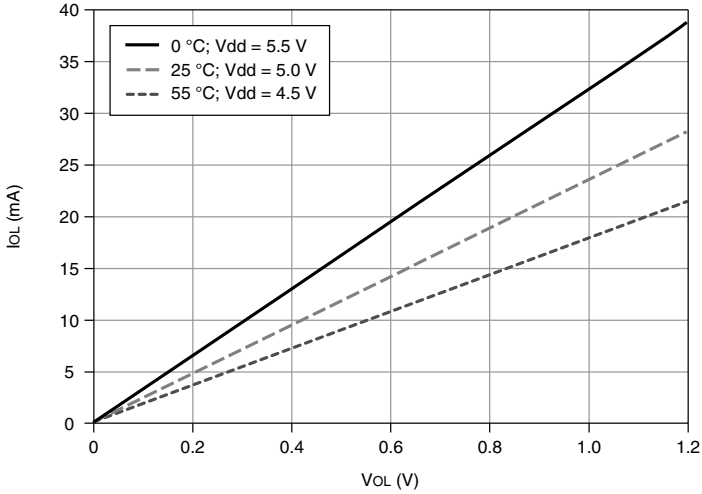
General-Purpose Counters

Number of counter/timers	4
Resolution	32 bits
Counter measurements	Edge counting, pulse, pulse width, semi-period, period, two-edge separation
Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks	100 MHz, 20 MHz, 100 kHz
External base clock frequency	0 MHz to 25 MHz
Base clock accuracy	50 ppm
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down, Sample Clock
Routing options for inputs	Any PFI, RTSI, analog trigger, many internal triggers
FIFO	127 samples per counter
Data transfers	Dedicated scatter-gather DMA controller for each counter/timer, programmed I/O

Frequency Generator

Number of channels	1
Base clocks	20 MHz, 10 MHz, 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any PFI or RTSI terminal.

Phase-Locked Loop (PLL)

Number of PLLs	1

Table 3. Reference Clock Locking Frequencies

Reference Signal	PCI Express Locking Input Frequency (MHz)
RTSI <0..7>	10, 20
PFI <0..15>	10, 20

Output of PLL	100 MHz Timebase; other signals derived from 100 MHz Timebase including 20 MHz and 100 kHz Timebases

External Digital Triggers

Source	Any PFI, RTSI
Polarity	Software-selectable for most signals
Analog input function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase
Analog output function	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer functions	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down, Sample Clock

Digital waveform generation (DO) function	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Digital waveform acquisition (DI) function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase

Device-to-Device Trigger Bus

Input source	RTSI <0..7>
Output destination	RTSI <0..7>

Note All instances of RTSI in this document refer to RTSI <0..7>.

Output selections	10 MHz Clock, frequency generator output; many internal signals
Debounce filter settings	90 ns, 5.12 μs, 2.56 ms, custom interval, disable; programmable high and low transitions; selectable per input

Bus Interface

Form factor	x4 PCI Express, specification v1.1 compliant
Slot compatibility[1]	x4, x8, and x16 PCI Express or PCI Express hybrid slots
DMA channels	8 (can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1, counter/timer 2, counter/timer 3)

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[1] Some motherboard reserve the x16 slot for graphics use. For PCI Express guidelines, refer to *ni.com/pciexpress*.

Power Requirements

⚠️ **Caution** The protection provided by the PCIe-6346 can be impaired if it is used in a manner not described in the user documentation.

⚠️ **Attention** La protection apportée par le PCIe-6346 risque d'être endommagée s'il est utilisé d'une autre façon que celle décrite dans la documentation utilisateur.

+3.3 V	2.1 W
+12 V	17.1 W

Current Limits

⚠️ **Caution** Exceeding the current limits may cause unpredictable device behavior.

+5 V terminal (connector 0)	1 A, maximum

📝 **Note** Connector 0 has a self-resetting fuse that opens when current exceeds this specification.

P0/PFI/P1/P2 and +5 V terminals combined	1.2 A, maximum

Physical Characteristics

Printed circuit board dimensions	16.8 cm × 11.1 cm (6.60 × 4.38 in.)
PCI Express mechanical form factor	Standard height, half length, single slot
Integrated air mover (fan)	No
Weight	100 g (3.6 oz)
I/O connectors	
PCIe device connector	68-Pos Right Angle Single Stack PCB-Mount VHDCI (Receptacle)
Cable connector	68-Pos Offset IDC Cable Connector (Plug) (SHC68-*)

📝 **Note** For more information about the connectors used for DAQ devices, refer to the document, *NI DAQ Device Custom Cables, Replacement Connectors, and Screws*, by going to *ni.com/info* and entering the Info Code `rdspmb`.

Calibration

Recommended warm-up time	15 minutes
Calibration interval	1 year

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel to earth	11 V, Measurement Category I

⚠ **Caution** Do not connect the PCIe-6346 to signals or use for measurements within Measurement Categories II, III, or IV.

⚠ **Attention** Ne connectez pas le PCIe-6346 à des signaux et ne l'utilisez pas pour effectuer des mesures dans les catégories de mesure II, III ou IV.

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

📝 **Note** Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are for other circuits not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Environmental Characteristics

Temperature and Humidity

Temperature	
Operating (local operational ambient environment[2])	0 °C to 50 °C
Storage	-40 °C to 70 °C

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[2] For PCI Express adapter cards with integrated air movers, NI defines the local operational ambient environment to be at the fan inlet. For cards without integrated air movers, NI defines the local operational ambient environment to be 25 mm (1 in.) upstream of the leading edge of the card. For more information about the local operational ambient environment definition for PCI Express adapter cards, visit *ni.com/info* and enter the Info Code pcielocalambient.

Humidity

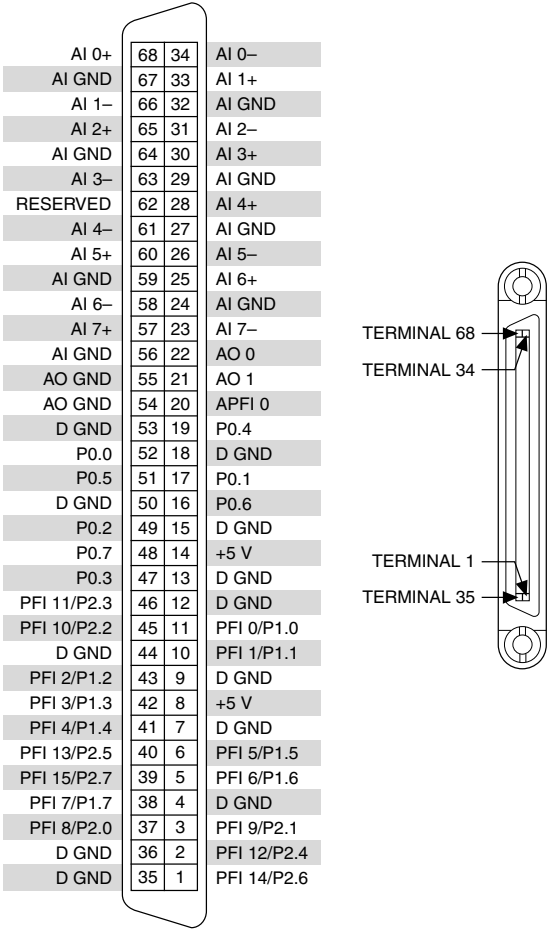|	
Operating	10% to 90% RH, noncondensing
Storage	5% to 95% RH, noncondensing
System slot airflow	0.4 m/s (80 LFM)
Pollution Degree	2
Maximum altitude	2,000 m (800 mbar) (at 25 °C ambient temperature)

Shock and Vibration

Random vibration

Operating	5 Hz to 500 Hz, 0.3 g RMS
Non-operating	5 Hz to 500 Hz, 2.4 g RMS
Operating shock	30 g, half-sine, 11 ms pulse

PCIe-6346 Device Pinout

Figure 5. PCIe-6346 Pinout

AI 0+	68	34	AI 0–
AI GND	67	33	AI 1+
AI 1–	66	32	AI GND
AI 2+	65	31	AI 2–
AI GND	64	30	AI 3+
AI 3–	63	29	AI GND
RESERVED	62	28	AI 4+
AI 4–	61	27	AI GND
AI 5+	60	26	AI 5–
AI GND	59	25	AI 6+
AI 6–	58	24	AI GND
AI 7+	57	23	AI 7–
AI GND	56	22	AO 0
AO GND	55	21	AO 1
AO GND	54	20	APFI 0
D GND	53	19	P0.4
P0.0	52	18	D GND
P0.5	51	17	P0.1
D GND	50	16	P0.6
P0.2	49	15	D GND
P0.7	48	14	+5 V
P0.3	47	13	D GND
PFI 11/P2.3	46	12	D GND
PFI 10/P2.2	45	11	PFI 0/P1.0
D GND	44	10	PFI 1/P1.1
PFI 2/P1.2	43	9	D GND
PFI 3/P1.3	42	8	+5 V
PFI 4/P1.4	41	7	D GND
PFI 13/P2.5	40	6	PFI 5/P1.5
PFI 15/P2.7	39	5	PFI 6/P1.6
PFI 7/P1.7	38	4	D GND
PFI 8/P2.0	37	3	PFI 9/P2.1
D GND	36	2	PFI 12/P2.4
D GND	35	1	PFI 14/P2.6

TERMINAL 68

TERMINAL 34

TERMINAL 1

TERMINAL 35