HA16129FPJ

Single Watchdog Timer

HITACHI

Description

The HA16129FPJ is a watchdog timer IC that monitors a microprocessor for runaway. In addition to the watchdog timer function, the HA16129FPJ also provides a function for supplying a high-precision stabilized power supply to the microprocessor, a power on reset function, a power supply voltage monitoring function, and a fail-safe function that masks the microprocessor outputs if a runaway is detected.

Functions

- Watchdog timer (WDT) function
  Monitors the P-RUN signal output by the microprocessor, and issues an auto-reset ($\overline{RES}$) signal if a microprocessor runaway is detected.
- Stabilized power supply
  Provides power to the microprocessor.
- Power on and clock off functions
  The power on function outputs a low level signal to the microprocessor for a fixed period when power is first applied.
  The clock off function outputs a $\overline{RES}$ signal to the microprocessor a fixed period after a runaway occurs.
- Power supply monitoring function
  When the reference voltage (Vout) falls and becomes lower than the $\overline{NMI}$ detection voltage (4.63V, Typ) or the $\overline{STBY}$ detection voltage (3.0V Typ), this function outputs either an $\overline{NMI}$ signal or an $\overline{STBY}$ signal, respectively. Note that NMI detection can be set to monitor either V_{CC} or Vout.
- OUTE function[*1] (fail-safe function)
  Outputs a signal used to mask microprocessor outputs when a microprocessor runaway has been detected.
- $\overline{RES}$ delay function
  Sets the delay between the time the $\overline{NMI}$ signal is output and the time the $\overline{RES}$ signal is output.
- Protection functions
  The HA16129FPJ incorporates both Vout overvoltage prevention and current limiter functions.

Note: 1. OUTE function: OUTE is an abbreviation for output enable.

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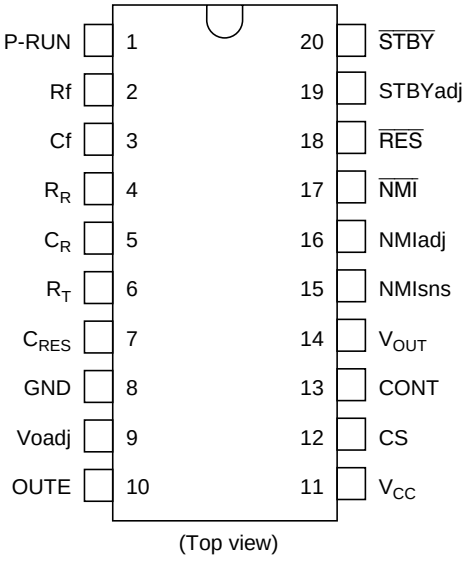
Features

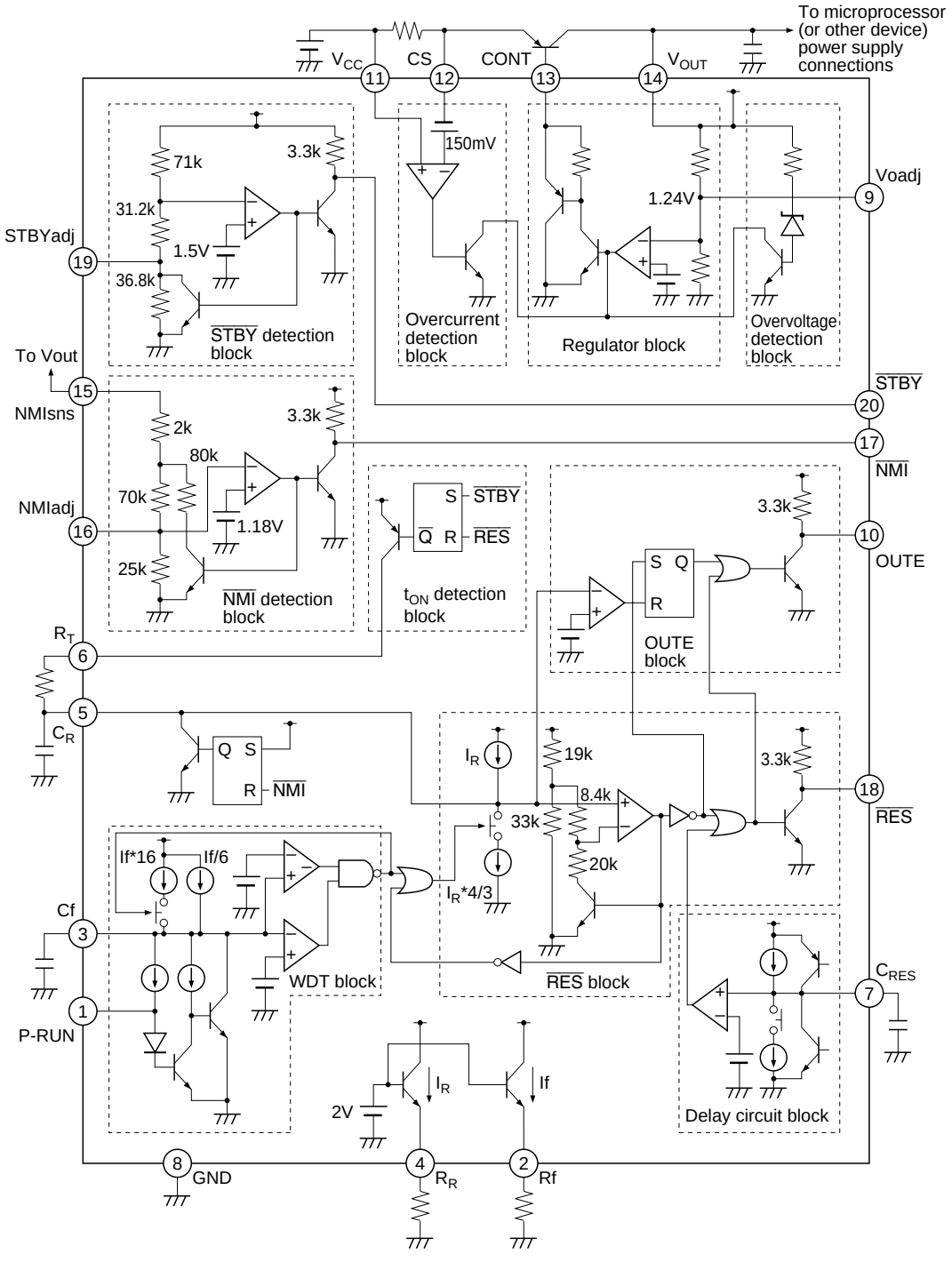
- High-precision output voltage: 5.0V ± 1.5%
- The WDT supports both frequency and duty detection schemes.
- High-precision power supply monitoring function: 4.625V ± 0.125V
- Built-in OUTE function
- All functions can be adjusted with external resistors and/or capacitors.

Pin Arrangement



(Top view)

Block Diagram



Note: The current, voltage, and resistor values listed in the diagram are reference values.
: Connect to Vout

Pin Function

Related Function	Pin No.	Symbol	Function
WDT.	1	P-RUN	Watchdog timer pulse input. The auto-reset function is controlled by the duty cycle or frequency of this input pulse signal.
	2	Rf	The resistor connected to this pin determines the current that flows in the Cf pin capacitor. Use the resistor value from 100 kΩ to 500 kΩ
	3	Cf	The current determined by the Rf pin charges the Cf capacitor and the potential on this pin determines the watchdog timer frequency band.
t_{RH}, t_{RL}, t_{OFF}	4	R_R	The resistor connected to this pin determines the current that flows in the C_R pin capacitor. Use the resistor value from 100 kΩ to 500 kΩ
	5	C_R	The current determined by the R_R pin charges the capacitor C_R and the potential on this pin controls the $\overline{RES}$ function (toff, t_{RH}, and t_{RL}).
t_{ON}	6	R_T	The resistor R_T, which determines only the time t_{ON} for the $\overline{RES}$ function is connected to this pin. This resistor determines the current that charges the capacitor C_R for the time t_{ON}. Use the resistor value from 100 kΩ to 500 kΩ
tr, t_{RES}	7	C_{RES}	The current determined by the Rf pin charges the capacitor C_{RES}, and the $\overline{RES}$ delay times (Tr and T_{RES}) are determined by the potential of this capacitor.
—	8	GND	Ground
Vout	9	Voadj	Insert the resistor Roadj if fine adjustment of the regulator output voltage Vout is required. Leave this pin open if Vout does not need to be changed.
Output	10	OUTE	Output for the OUTE function
Power supply	11	V_{CC}	Power supply
Current limiter	12	CS	Current limiter current detection. Connect the overcurrent detection resistor between the CS pin and the V_{CC} pin. If this function is not used, short this pin to V_{CC}. Also, connect this pin to the emitter of the external transistor. (This function can not operate when V_{OUT} < 2 V)
Vout	13	CONT	Connect this pin to the base of the external transistor.
	14	V_{OUT}	Provides the regulator output voltage and the IC internal power supply. Connect this pin to the collector of the external transistor.
$\overline{NMI}$	15	NMIsns	This pin senses the $\overline{NMI}$ detection voltage. If V_{CC} is to be detected, connect this pin to the V_{CC} pin (however, note that an external resistor is required), and if Vout is to be detected, connect this pin to the V_{OUT} pin.
	16	NMIadj	Insert a resistor if fine adjustment of the $\overline{NMI}$ detection voltage is required. Leave this pin open if fine adjustment is not required.
Output	17	$\overline{NMI}$	$\overline{NMI}$ output
Output	18	$\overline{RES}$	$\overline{RES}$ output
$\overline{STBY}$	19	STBYadj	Insert a resistor if fine adjustment of the $\overline{STBY}$ detection voltage is required. Leave this pin open if fine adjustment is not required.
Output	20	$\overline{STBY}$	$\overline{STBY}$ output

Functional Description

This section describes the functions provided by the HA16129FPJ. See the section on formulas for details on adjustment methods.

Regulator Block

Vout Voltage
This IC provides a stabilized 5V power supply by controlling the base current of an external transistor. The largest current (the maximum CONT pin current) that can be drawn by the base of this external transistor is 20mA. Also note that the Vout output is also used for the power supply for this IC's internal circuits.

Current Limiter Block

When a current detection resistor (R_{CS}) is connected between the V_{CC} pin and the CS pin, and the voltage between these pins exceeds the V_{CS} voltage (150mV Typ), the CONT pin function turns off and the output voltage supply is stopped. This function can not work when $V_{OUT} < 2V$.

Output Voltage (Vout) Adjustment

The output voltage can be adjusted by connecting an external resistor at the output voltage adjustment pin (Voadj). However, if for some reason the voltage on this Vout line increases and exceeds the voltage adjustment range (7V Max), the CONT pin function turns off and the output voltage supply is stopped.

Refer to the timing charts in conjunction with the following items.

LVI (Low Voltage Inhibit)

$\overline{\text{NMI}}$ Detection Voltage
This function monitors for drops in the power-supply voltage. This function can be set up to monitor either V_{CC} or Vout. When Vout is monitored, a low level is output from the $\overline{\text{NMI}}$ pin if that voltage falls under the detection voltage (4.63V Typ). Then, when the power-supply voltage that fell rises again, the $\overline{\text{NMI}}$ pin will output a high level. Note that this function has a fixed hysteresis of 50mV (Typ). The monitored power supply is selected by connecting the NMIsns pin either to the V_{CC} pin or to the V_{OUT} pin. When detecting V_{CC}, an external adjustment resistor is required.)

The detection voltage can also be adjusted with the NMIadj pin.

$\overline{\text{STBY}}$ Detection Voltage
This function monitors for drops in the Vout voltage. It monitors the Vout voltage, and outputs a low level from the $\overline{\text{STBY}}$ pin if that voltage drops below the detection voltage (3.0V Typ). Then, when the power-supply voltage that fell rises again, the $\overline{\text{STBY}}$ pin will output a high level. Note that this function has a fixed hysteresis of 1.35V (Typ).

The detection voltage can also be adjusted with the STBYadj pin.

Function Start Voltage

This is the minimum required Vout voltage for the $\overline{RES}$, $\overline{NMI}$, $\overline{STBY}$, and OUTE output pin functions to start operating. It is stipulated as the voltage that Vout must reach after power is first applied for these pins to output a low level.

Hysteresis

This is the difference between the LVI function detection voltage when the power-supply voltage drops, and the clear (reset) voltage when the power-supply voltage rises.

$$(V_{HYSN} = V_{NMI}' - V_{NMI};\ V_{HYSS} = V_{STBY}' - V_{STBY})$$

OUTE Function

When a microprocessor is in the runaway state, its outputs are undefined, and thus it is possible that the outputs may be driven by incorrect signals. This function is used to mask such incorrect microprocessor outputs. When the WDT function recognizes normal operation (when the $\overline{RES}$ output is high), the OUTE output will be held high. When the WDT function recognizes an abnormal state and an auto-reset pulse is output from the $\overline{RES}$ pin, the OUTE output will be held low. Thus microprocessor outputs during microprocessor runaway can be masked by taking the AND of those outputs and this signal using external AND gates.

The OUTE output will go high when the C_R pin voltage exceeds VthHcr2, and will go low when that voltage falls below VthLcr.

There are limitation that apply when the OUTE function is used. Refer to the calculation formulas item for details.

RES Function

t_{RH}
This period is the length of the high-level output period of the $\overline{RES}$ pulse when the P-RUN signal from the microprocessor stops. This is the time required for the C_R potential to reach VthLcr from VthHcr1.

t_{RL}
This period is the length of the low-level output period of the $\overline{RES}$ pulse when the P-RUN signal from the microprocessor stops. This is the time required for the C_R potential to reach VthHcr1 from VthLcr.

t_{OFF}
This is the time from the point the P-RUN signal from the microprocessor stops to the point a low level is output from the $\overline{RES}$ pin. During normal microprocessor operation, the potential on the C_R pin will be about Vout – 0.2V (although this value may change with the P-RUN signal input conditions, so it should be verified in the actual application circuit) and t_{OFF} is the time for the C_R pin potential to reach VthLcr from that potential.

t_{ON}

t_{ON} is the time from the point the $\overline{NMI}$ output goes high when power is first applied to the point the $\overline{RES}$ output goes low. t_{ON} is the time for the potential of the C_R pin to reach VthHcr1 from 0V.

tr

The time tr is the fixed delay time between the point the $\overline{NMI}$ output goes from low to high after the power-supply voltage comes up to the point $\overline{RES}$ goes from low to high. The time tr is the time for the CRES pin potential to fall from the high voltage (about 1.9V) to Vthcres.

t_{RES}

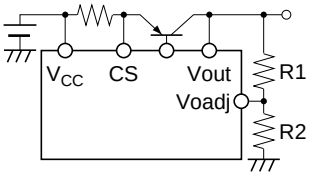
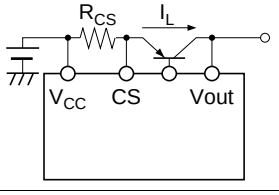
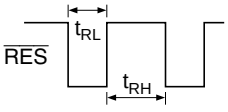
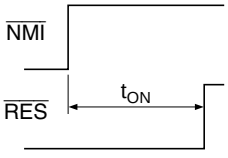
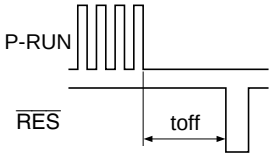
The time t_{RES} is the fixed delay time between the point the $\overline{NMI}$ output goes from high to low when the power-supply voltage falls to the point $\overline{RES}$ goes from high to low. The time t_{RES} is the time for the C_{RES} pin potential to rise from 0V to Vthcres.

WDT Function

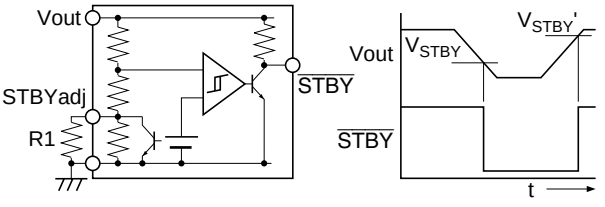
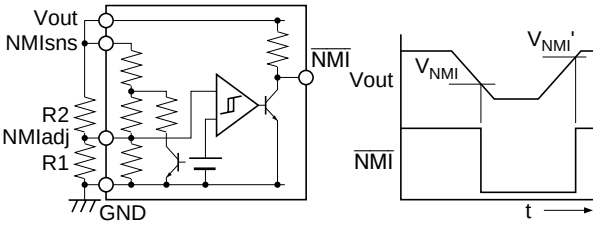
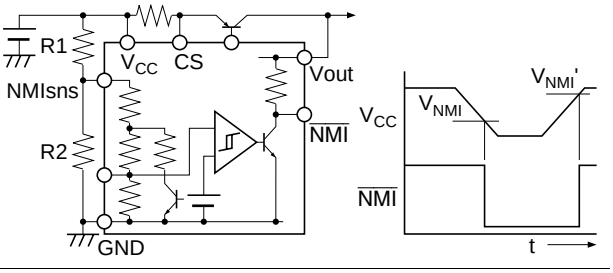
This function determines whether the microprocessor is operating normally or has entered a runaway state by monitoring the duty or frequency of the P-RUN signal. When this function recognizes a runaway state, it outputs a reset pulse from the $\overline{RES}$ pin and sets the OUTE pin to low from high. It holds the $\overline{RES}$ and OUTE pins fixed at high as long as it recognizes normal microprocessor operation.

In this function, the potential of the Cf capacitor is controlled by the P-RUN signal. This Cf pin potential charges the capacitor C_R that controls the reset pulse to be between VthLcf and VthHcf. The judgment as to whether or not the microprocessor is operating normally, is determined by the balance between the charge and discharge voltage on the capacitor C_R at this time.

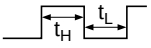
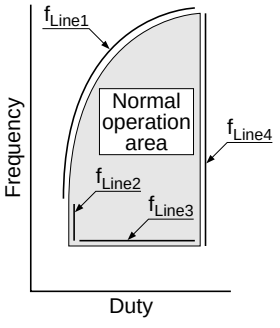
Calculation Formulas

Item	Formula	Notes
Reference voltage	$Vout = 1.225 \left(1 + \frac{37 // R1}{12 // R2}\right)$ R1, R2; kΩ	While the Vout voltage will be 5 V ±1.5% when the Voadj pin is open, the circuit shown here should be used to change the Vout voltage externally. 
Current limiter voltage	V_{CS} (150 mV Typ) < $I_L \cdot R_{CS}$	When this function operates, the base current to the external transistor connected to the CS pin stops and the Vout output is lowered. 
OVP	—	This function prevents the microprocessor from being damaged if the Vout voltage is inadvertently increased to too high a level. The OVP detection voltage is fixed.
t_{RH}, t_{RL}	$t_{RH} = 3.3 \times C_R \cdot R_R$ $t_{RL} = 1.1 \times C_R \cdot R_R$	These determine the reset pulse frequency and duty. 
t_{ON}	$t_{ON} = 1.1 \times C_R \cdot R_T$	Sets the time from the rise of the $\overline{NMI}$ signal to the point the $\overline{RES}$ output is cleared. 
t_{OFF}	$t_{OFF} = 6.5 \times C_R \cdot R_R$	Sets the time from the point the P-RUN pulse stops to the point a reset pulse is output. 

Calculation Formulas (cont)

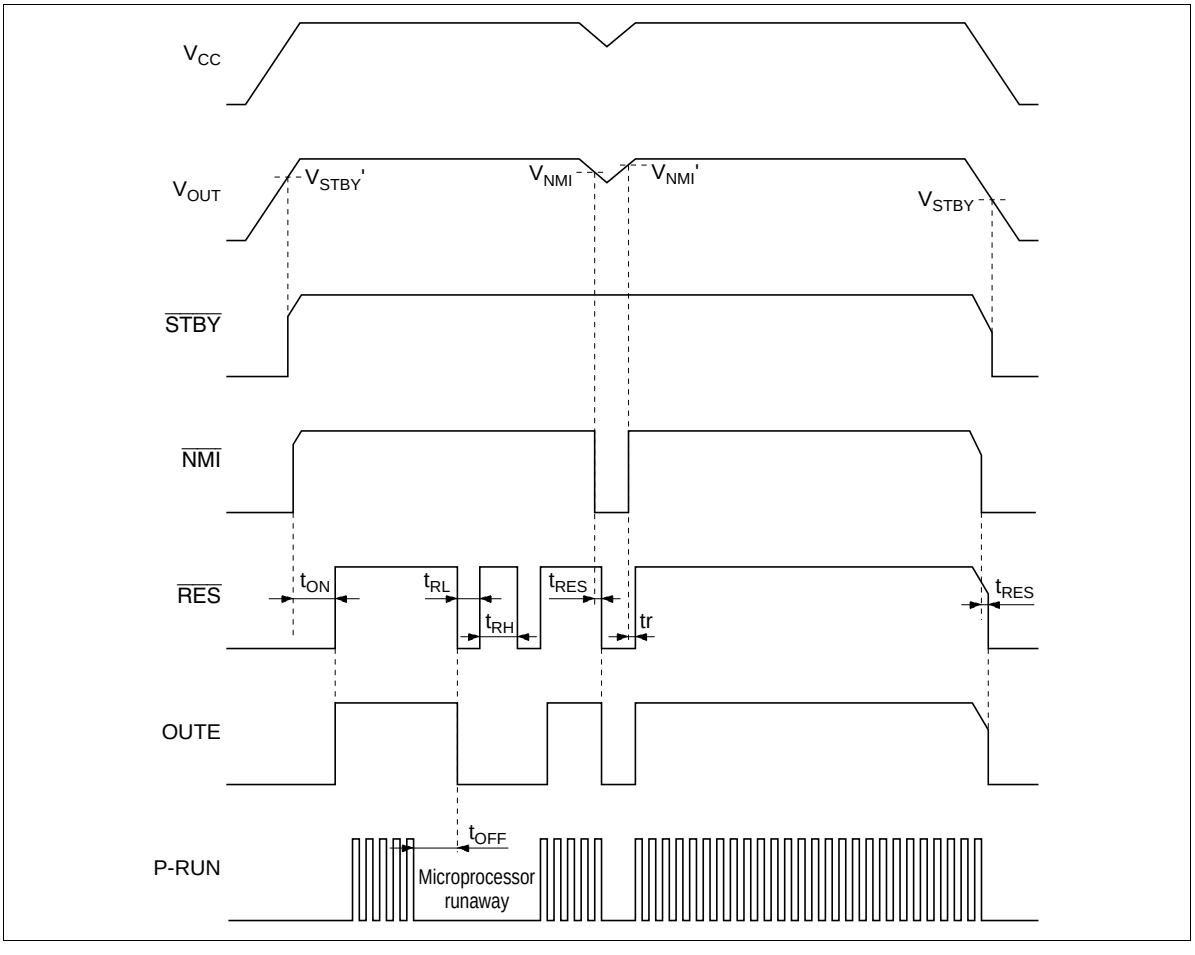
Item	Formula	Notes
V_{STBY}	$V_{STBY} = 1.48 \times \left(\frac{67.6}{29.5 + 36.2 // R1} + 1 \right)$	The voltage at which the $\overline{STBY}$ signal is output when Vout falls. The $\overline{STBY}$ detection voltage can be adjusted by connecting a resistor between the STBYadj pin and ground (R3). However, the $\overline{STBY}$ recovery voltage cannot be adjusted. 
V_{NMI} (Vout detection)	$V_{NMI} = 1.2 \times \left(1 + \frac{R1 // 73}{R2 // 25} \right)$ R1, R2; kΩ	The voltage at which the $\overline{NMI}$ signal is output when Vout falls. (When NMIsns is connected to Vout.) The $\overline{NMI}$ detection voltage can be adjusted by connecting resistors between the NMIadj pin and Vout (R1), and between the NMIadj pin and ground (R2). 
V_{NMI} (V_{CC} detection)	$V_{NMI} = 4.62 \times \left(\frac{R1}{R2 // 97.1} + 1 \right)$ Recovery voltage $V_{NMI} = 4.68 \times \left(\frac{R1}{R2 // 45.5} + 1 \right)$ R1, R2; kΩ	The voltage at which the $\overline{NMI}$ signal is output when V_{CC} falls. (When NMIsns is connected to V_{CC}.) The $\overline{NMI}$ detection voltage can be adjusted by connecting resistors between the NMIsns pin and V_{CC} (R1), and between the NMIsns pin and ground (R2). 
OUTE	$C_R \times R_R > 19.3 \times Cf \times Rf$	If the OUTE function is used, the relationship shown at the left must be fulfilled to assure that pulses are not incorrectly generated in this output when a microprocessor runaway state is detected.

Calculation Formulas (cont)

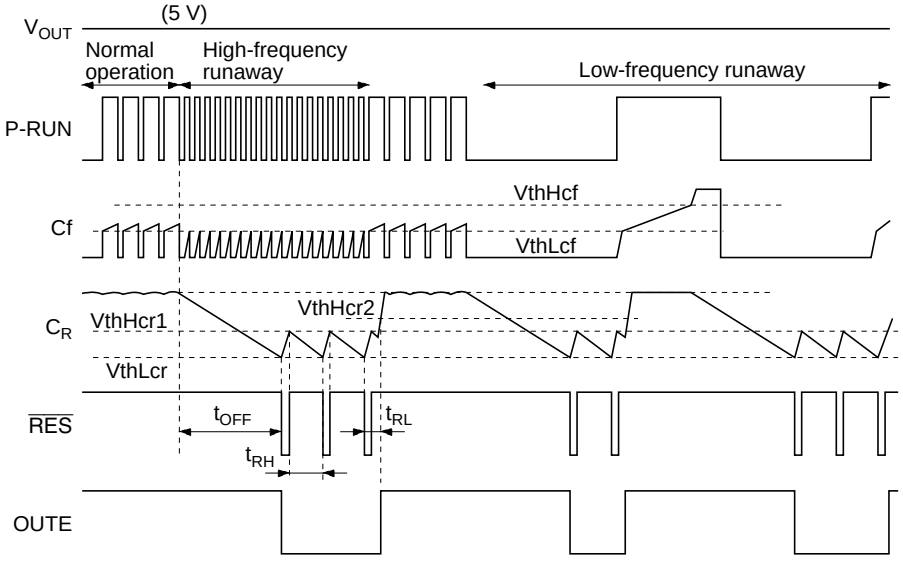
Item	Formula	Notes
WDT.	$f_{Line1} = \frac{0.31 \times (Du - 24)}{Cf \cdot Rf}$ f_{Line2} = 24% (fixed) $f_{Line3} = \frac{0.024}{Cf \cdot Rf}$ f_{Line4} = 99% The relationship between f_{Line1} and f_{Line3} $f_{Line1} = f_{Line3} \times 12.9\ (Du - 24)$ Du: The P-RUN signal duty cycle  $Du = \frac{t_H}{t_H + t_L} \times 100$	The WDT function judges whether the P-RUN pulse signal is normal or not. If the WDT function judges the P-RUN pulse signal to be abnormal, it outputs a reset signal. The normal range is the area enclosed by f_{Line1} to f_{Line4} in the figure. 

Timing Charts

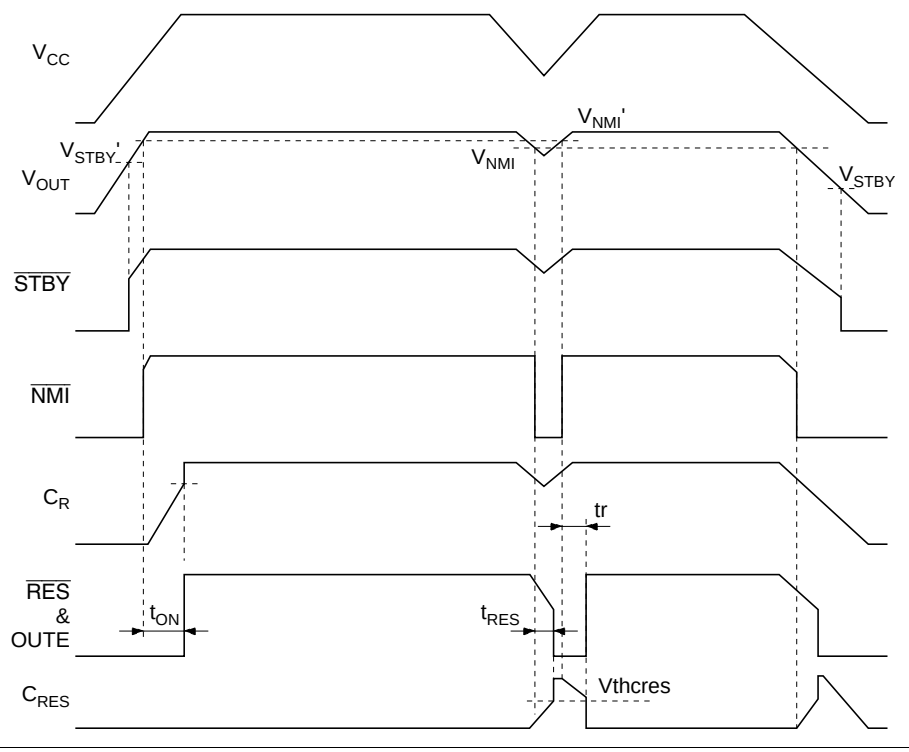
Whole system timing chart



WDT. timing chart



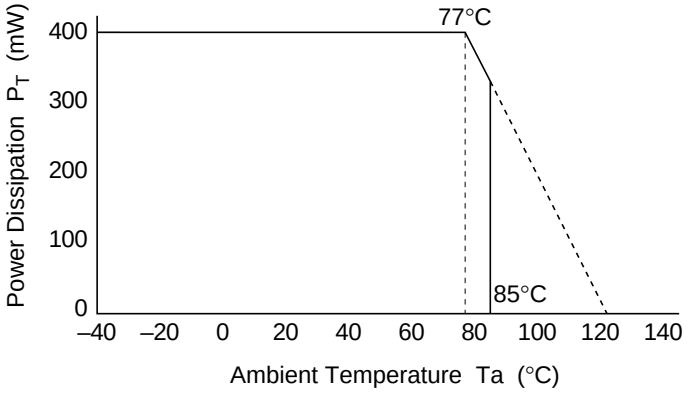
LVI timing chart



Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating	Unit
Power supply voltage	V_{CC}	40	V
CS pin voltage	V_{CS}	V_{CC}	V
CONT pin current	Icont	20	mA
CONT pin voltage	Vcont	V_{CC}	V
Vout pin voltage	Vout	12	V
P-RUN pin voltage	V_{PRUN}	Vout	V
NMIsns pin voltage	V_{NMIsns}	V_{CC}	V
$\overline{\text{NMI}}$ pin voltage	V_{NMI}	Vout	V
$\overline{\text{STBY}}$ pin voltage	V_{STBY}	Vout	V
$\overline{\text{RES}}$ pin voltage	V_{RES}	Vout	V
OUTE pin voltage	V_{OUTE}	Vout	V
Power dissipation[*1]	P_T	400	mW
Operating temperature	Topr	–40 to +85	°C
Storage temperature	Tstg	–50 to +125	°C

Note: 1. This is the allowable value when mounted on a 40 × 40 × 1.6 mm glass-epoxy printed circuit board with a mounting density of 10% at ambient temperatures up to Ta = 77°C. This value must be derated by 8.3 mW/°C above that temperature.



Electrical Characteristics (Ta = 25°C, V_{CC} = 12V, Vout = 5.0V, Rf = R_R = 180kΩ, Cf = 3300pF, C_R = 0.1µF, R_T = 390kΩ, C_{RES} = 1500pF, R_{CS} = 0.2Ω)

Item		Symbol	Min	Typ	Max	Unit	Test conditions
Power supply current		I_{CC}	—	10	15	mA	
Current limiter voltage		V_{CS}	100	150	200	mV	V_{CS} = (V_{CC} pin voltage – CS pin voltage)
Regulator block	Output voltage	Vout	4.925	5.00	5.075	V	V_{CC} = 12V, Icont = 5mA
	Input voltage stabilization	Volin	–30	—	30	mV	V_{CC} = 6 to 17.5V, Icont = 10mA
	Load current stabilization	Voload	–30	—	30	mV	Icont = 0.1 to 15mA
	Ripple exclusion ratio	R_{REJ}	(45)	75	—	dB	Vi = 0.5Vrms, fi = 1kHz
	Output voltage temperature coefficient	| δVout/δT |	—	40	(200)	ppm/°C	Icont = 5mA
	Output voltage adjustment range	V_{oMAX}	—	—	7.0	V	
P-RUN input block	Input high-level voltage	V_{iH}	2.0	—	—	V	
	Input low-level voltage	V_{iL}	—	—	0.8	V	
	Input high-level current	I_{iH}	—	300	500	µA	V_{iH} = 5.0V
	Input low-level current	I_{iL}	–5	0	5	µA	V_{iL} = 0.0V
$\overline{\text{NMI}}$ output block	High level	V_{OHN}	Vout – 0.2	Vout	Vout + 0.2	V	I_{OHN} = 0mA
	Low level	V_{OLN}	—	—	0.4	V	I_{OLN} = 2.0mA
	Function start voltage	V_{STN}	—	0.7	1.4	V	
$\overline{\text{STBY}}$ output block	High level	V_{OHS}	Vout – 0.2	Vout	Vout + 0.2	V	I_{OHS} = 0mA
	Low level	V_{OLS}	—	—	0.4	V	I_{OLS} = 2.0mA
	Function start voltage	V_{STS}	—	0.7	1.4	V	

Note: Values in parentheses are design reference values.

Electrical Characteristics (Ta = 25°C, V_{CC} = 12V, Vout = 5.0V, Rf = R_R = 180kΩ, Cf = 3300pF, C_R = 0.1µF, R_T = 390kΩ, C_{RES} = 1500pF, R_{CS} = 0.2Ω) (cont)

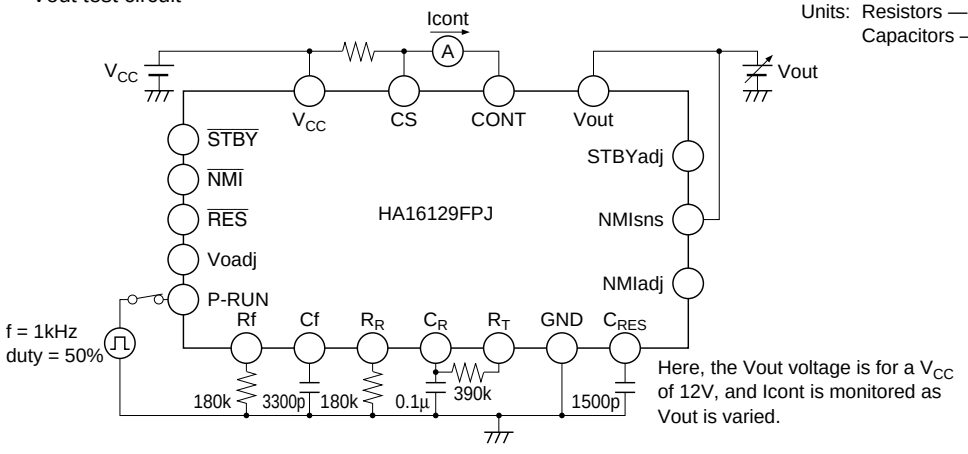
Item			Symbol	Min	Typ	Max	Unit	Test conditions
$\overline{RES}$ output block	High level		V_{OHR}	Vout – 0.2	Vout	Vout + 0.2	V	I_{OHR} = 0mA
	Low level		V_{OLR}	—	—	0.4	V	I_{OLR} = 2.0mA
	Function start voltage		V_{STR}	—	0.7	1.4	V	
OUTE output block	High level		V_{OHE}	Vout – 0.2	Vout	Vout + 0.2	V	I_{OHE} = 0mA
	Low level		V_{OLE}	—	—	0.4	V	I_{OLE} = 2.0mA
	Function start voltage		V_{STE}	—	0.7	1.4	V	
$\overline{RES}$ function	Power on time		ton	25	40	60	ms	
	Clock off time		toff	80	130	190	ms	
	Reset pulse high time		t_{RH}	40	60	90	ms	
	Reset pulse low time		t_{RL}	15	20	30	ms	
LVI function	$\overline{NMI}$ function (Vout detection)	Detection voltage 1	V_{NMI1}	4.5	4.63	4.75	V	
		Hysteresis 1	V_{HYSN1}	—	50	100	mV	
		Temperature coefficient	$\lvert \delta V_{NMI}/\delta T \rvert$	—	100	(400)	ppm/°C	
	$\overline{NMI}$ function (V_{CC} detection)	Detection voltage 2	V_{NMI2}	5.0	5.4	5.7	V	R1 = 13kΩ, R2 = 390kΩ
		Hysteresis 2	V_{HYSN2}	0.5	0.8	1.3	V	R1 = 13kΩ, R2 = 390kΩ
	$\overline{STBY}$ function	Detection voltage	V_{STBY}	2.70	3.00	3.30	V	
		Hysteresis	V_{HYSS}	1.20	1.35	1.50	V	
		Temperature coefficient	$\lvert \delta V_{STBY}/\delta T \rvert$	—	100	(400)	ppm/°C	
$\overline{RES}$ delay time	Disable time		t_{RES}	(100)	200	(300)	µs	
	Recovery time		tr	(100)	200	(300)	µs	

Note: Values in parentheses are design reference values.

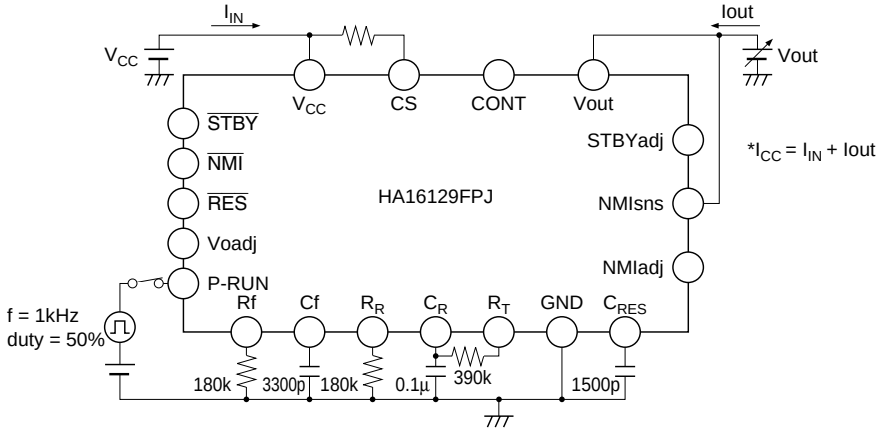
Test Circuits

- Vout test circuit

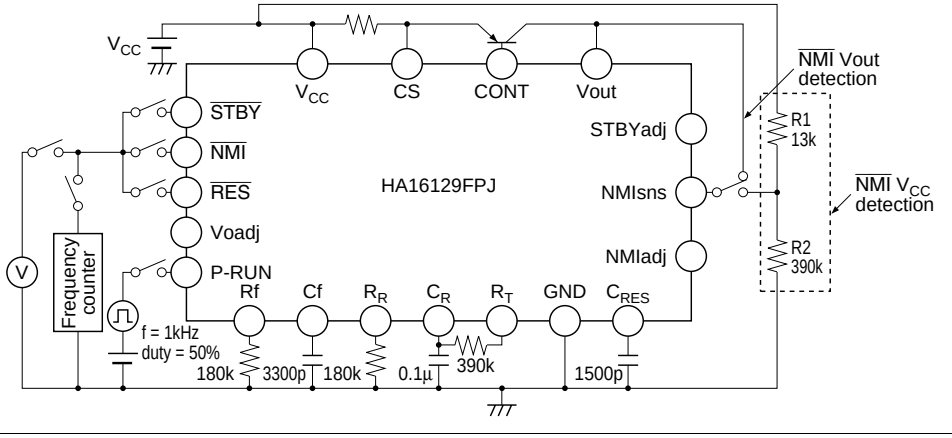
Units: Resistors — Ω
Capacitors — F



- I_{CC} test circuit

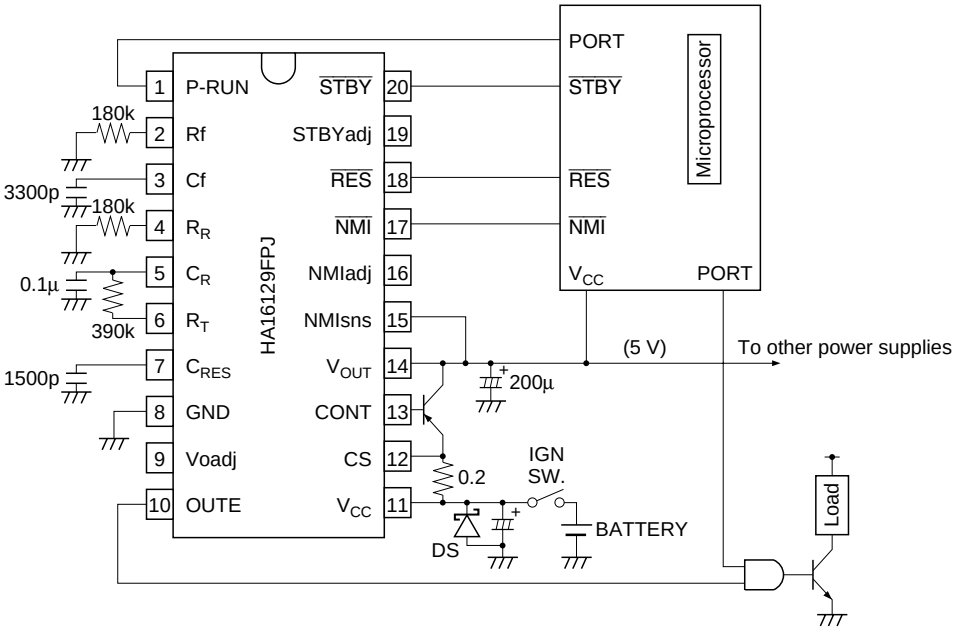


- Test circuit for other parameters

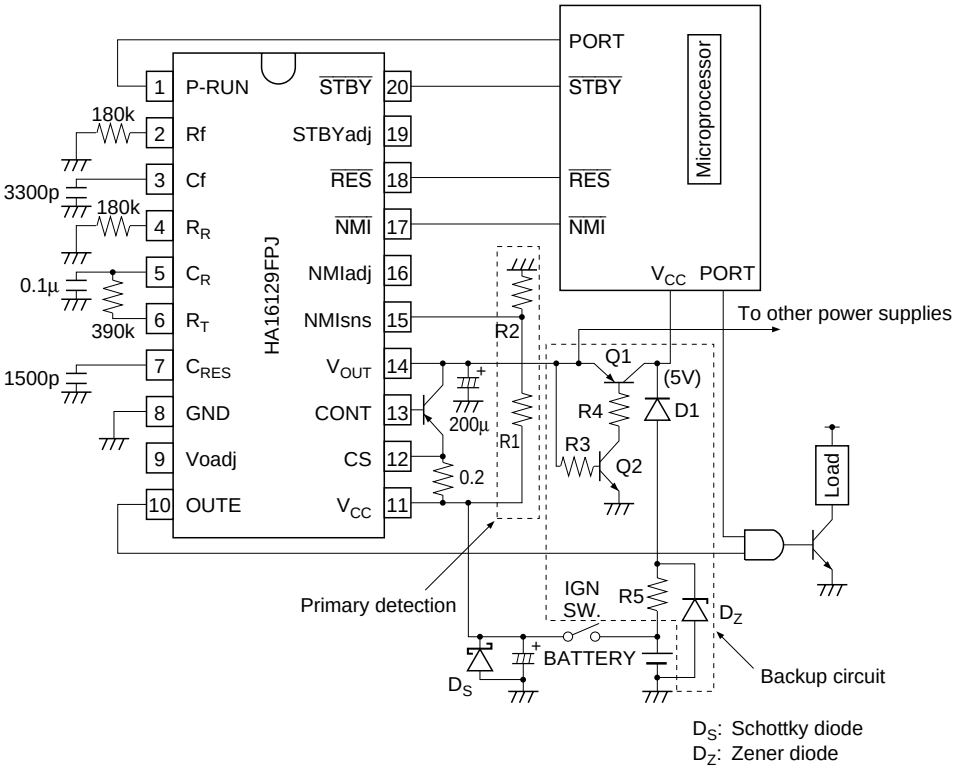


System Circuit Examples

- Example of a basic system

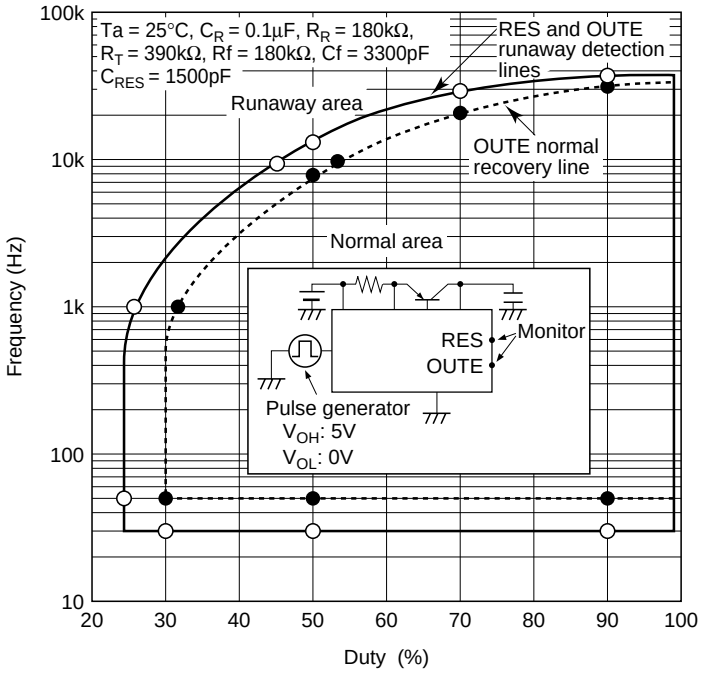


- Example of a system using a backup circuit and a primary voltage monitoring circuit

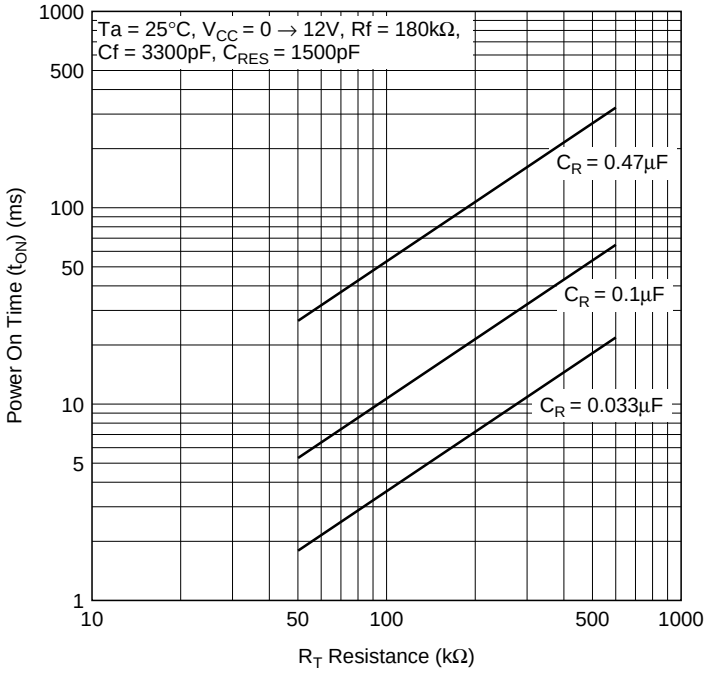


Operating Waveforms

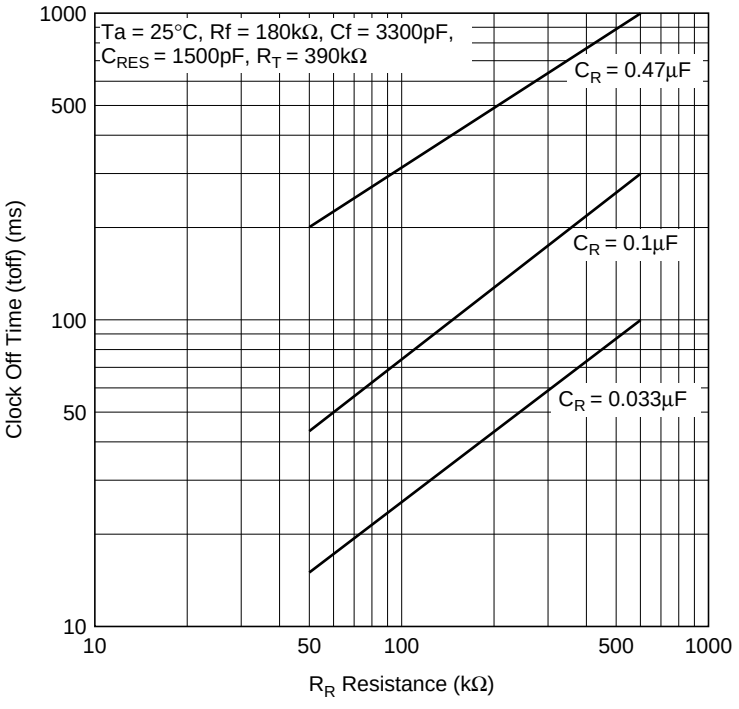
Frequency vs. Duty Characteristics



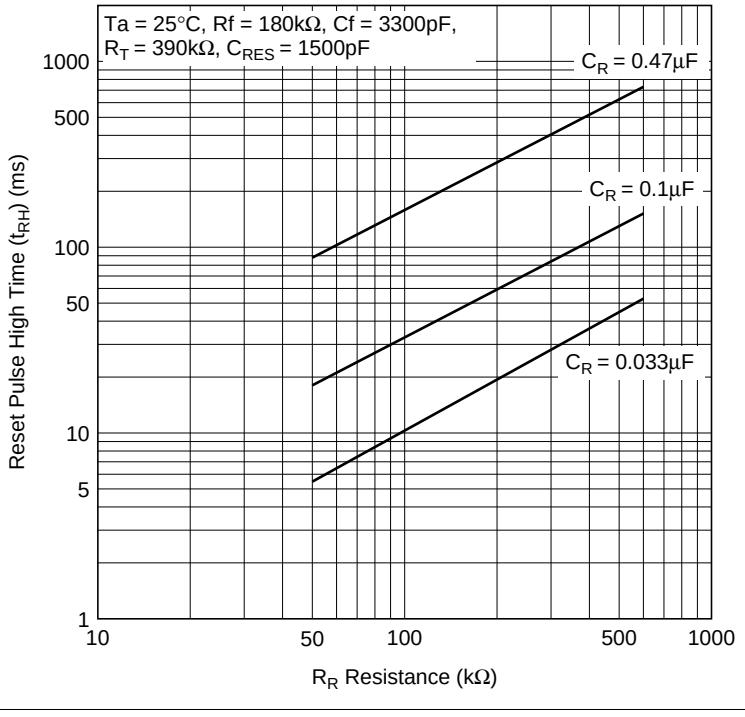
Power On Time (t_{ON}) vs. R_T Resistance Characteristics



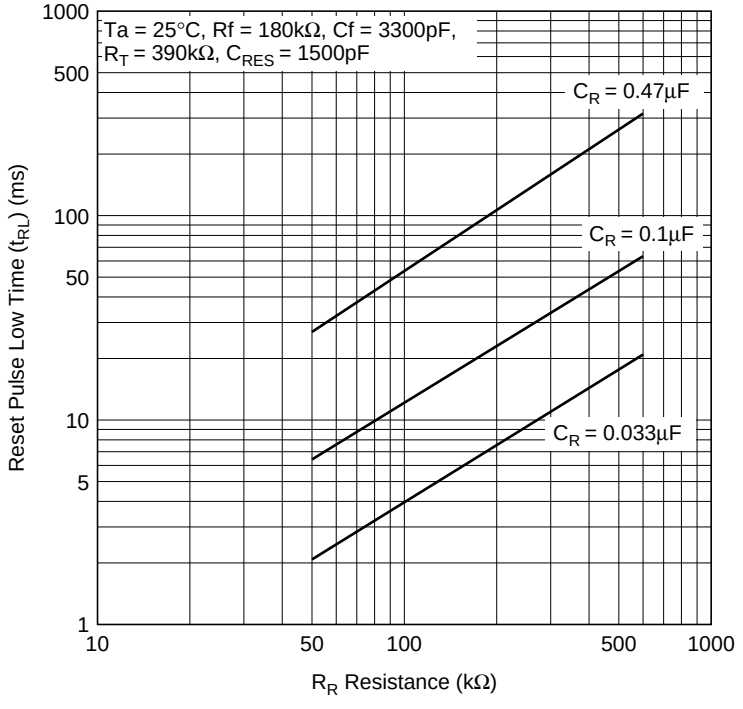
Clock Off Time (toff) vs. R_R Resistance Characteristics



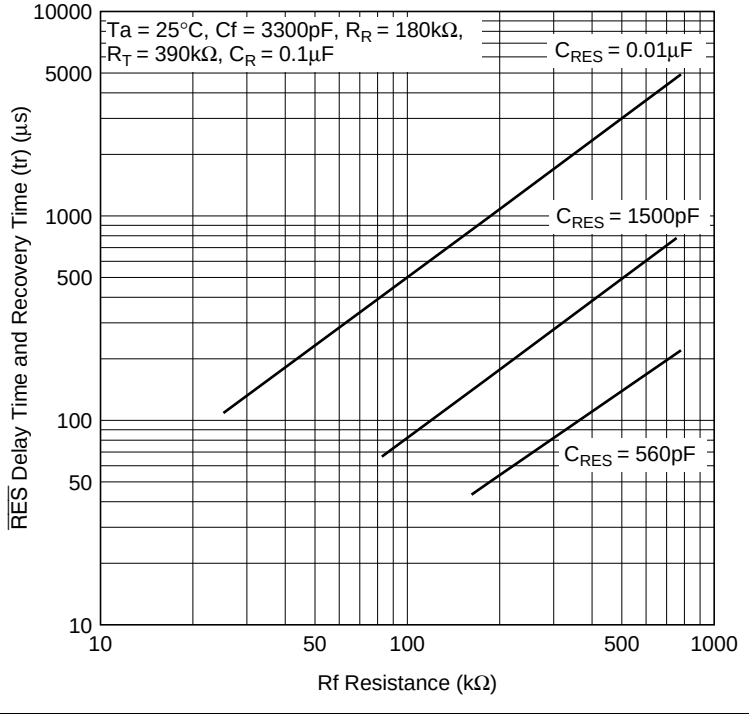
Reset Pulse High Time (t_{RH}) vs. R_R Resistance Characteristics



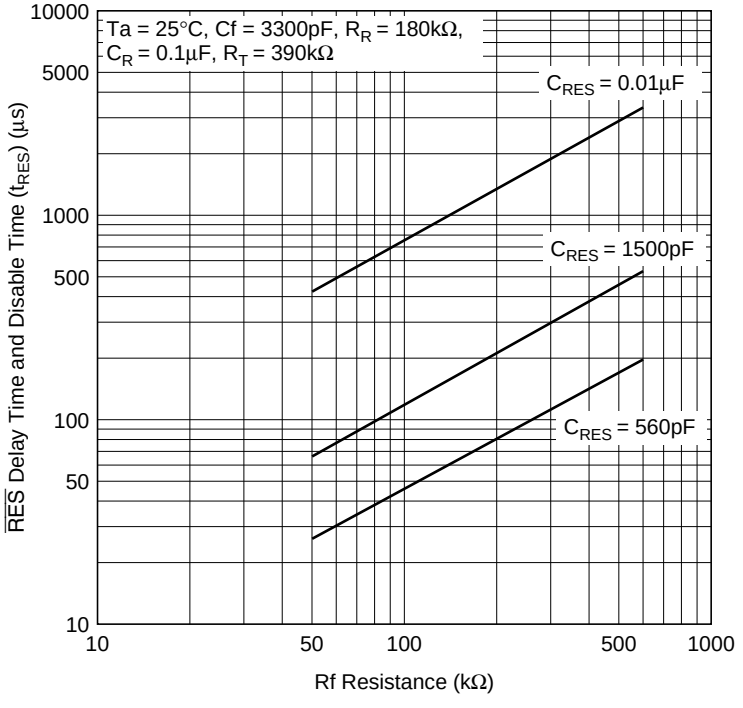
Reset Pulse Low Time (t_{RL}) vs.
R_R Resistance Characteristics



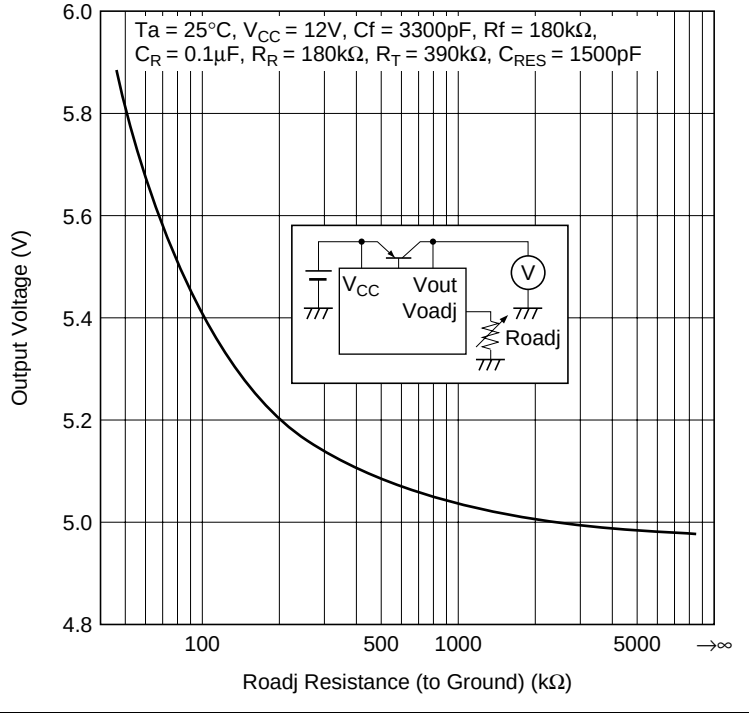
$\overline{RES}$ Delay Time and Recovery Time (tr) vs.
Rf Resistance Characteristics



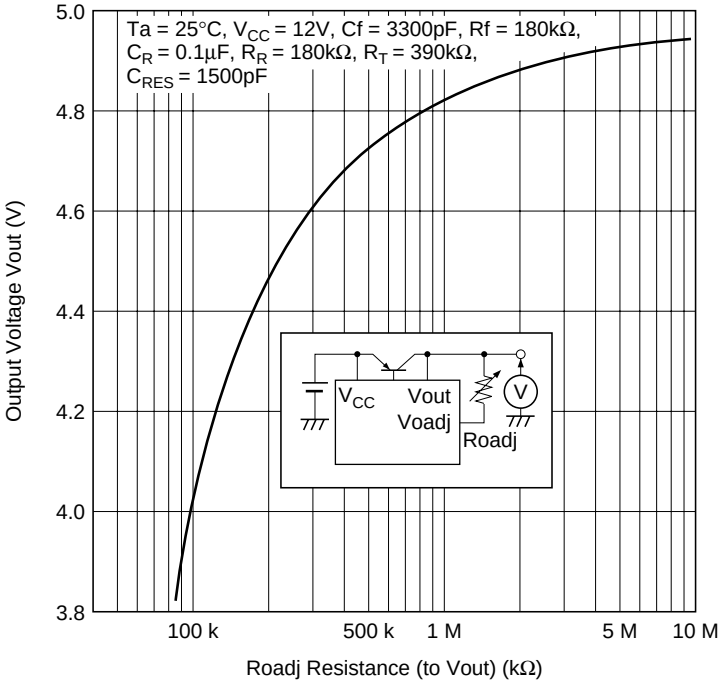
$\overline{RES}$ Delay Time and Disable Time (t_{RES}) vs.
Rf Resistance Characteristics



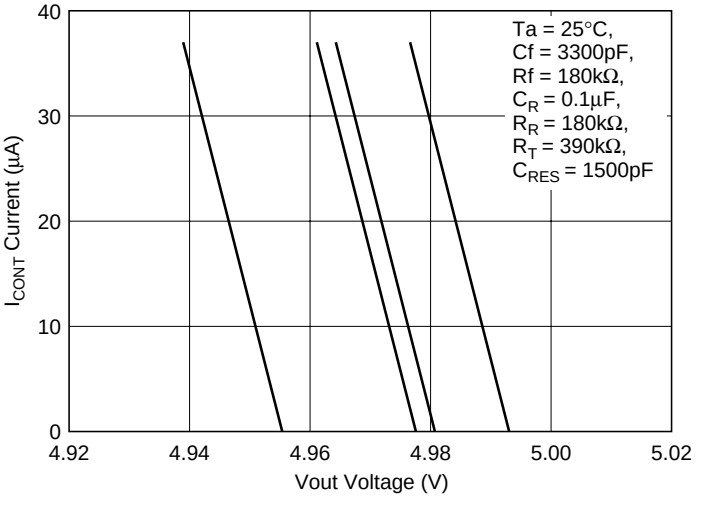
Output Voltage vs.
Roadj Resistance (to Ground) Characteristics

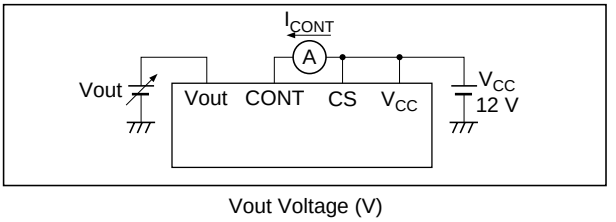


Output Voltage vs.
Roadj Resistance (to Vout) Characteristics



I_{CONT} Current vs. Vout Voltage Characteristics

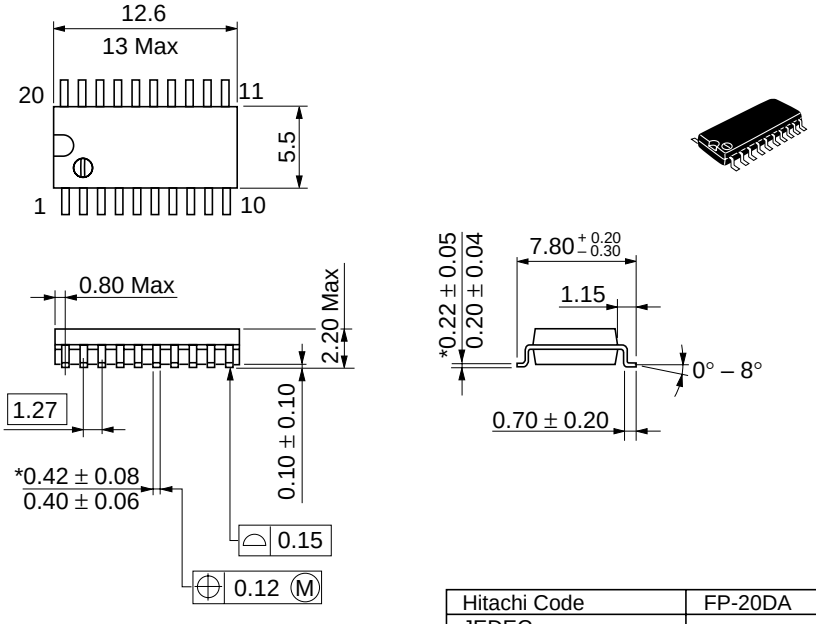




Vout Voltage (V)

Package Dimensions

Unit: mm



*Dimension including the plating thickness
Base material dimension

Hitachi Code	FP-20DA
JEDEC	—
EIAJ	Conforms
Mass (reference value)	0.31 g

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