National Semiconductor

January 1988

MM54HC423A/MM74HC423A Dual Retriggerable Monostable Multivibrator

General Description

The MM54/74HC423A high speed monostable multivibrators (one shots) utilize advanced silicon-gate CMOS technology. They feature speeds comparable to low power Schottky TTL circuitry while retaining the low power and high noise immunity characteristic of CMOS circuits.

Each multivibrator features both a negative, A, and a positive, B, transition triggered input, either of which can be used as an inhibit input. Also included is a clear input that when taken low resets the one shot. The 'HC423A cannot be triggered from clear.

The 'HC423A is retriggerable. That is, it may be triggered repeatedly while its outputs are generating a pulse and the pulse will be extended.

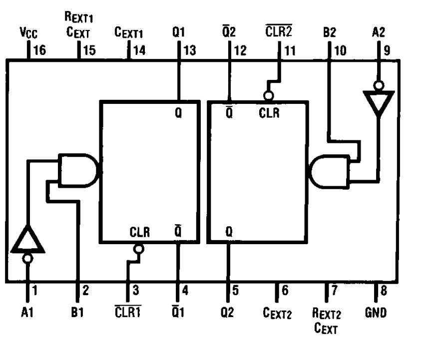
Pulse width stability over a wide range of temperature and supply is achieved using linear CMOS techniques. The output pulse equation is simply: PW = (R_{EXT}) (C_{EXT}); where PW is in seconds, R is in ohms, and C is in farads. All inputs are protected from damage due to static discharge by diodes to V_{CC} and ground.

Features

- Typical propagation delay: 40 ns
- Wide power supply range: 2V–6V
- Low quiescent current: 80 μA maximum (74HC Series)
- Low input current: 1 μA maximum
- Fanout of 10 LS-TTL loads
- Simple pulse width formula T = RC
- Wide pulse range: 400 ns to ∞ (typ)
- Part to part variation: ±5% (typ)
- Schmitt Trigger A & B inputs allow infinite rise and fall times on these inputs

Connection Diagram

Dual-In-Line Package

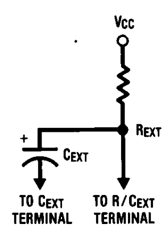


TL/F/5338–1

Top View

Order Number MM54HC423A or MM74HC423A

Timing Component



TL/F/5338–2

Note: Pin 6 and Pin 14 must be hard-wired to GND.

Truth Table

Inputs			Outputs	
$\overline{Clear}$	A	B	Q	$\overline{Q}$
L	X	X	L	H
X	H	X	L	H
X	X	L	L	H
H	L	↑	⎍	⊔
H	↓	H	⎍	⊔

H = High Level
L = Low Level
↑ = Transition from Low to High
↓ = Transition from High to Low
⎍ = One High Level Pulse
⊔ = One Low Level Pulse
X = Irrelevant

 TL/F/5338 RRD-B30M105/Printed in U. S. A.

Absolute Maximum Ratings (Notes 1 & 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage (V_{CC})	−0.5V to +7.0V
DC Input Voltage (V_{IN})	−1.5V to V_{CC}+1.5V
DC Output Voltage (V_{OUT})	−0.5V to V_{CC}+0.5V
Clamp Diode Current (I_{IK}, I_{OK})	±20 mA
DC Output Current, per pin (I_{OUT})	±25 mA
DC V_{CC} or GND Current, per pin (I_{CC})	±50 mA
Storage Temperature Range (T_{STG})	−65°C to +150°C
Power Dissipation (P_D)	
(Note 3)	600 mW
S.O. Package only	500 mW
Lead Temp. (T_L) (Soldering 10 seconds)	260°C

Operating Conditions

	Min	Max	Units
Supply Voltage (V_{CC})	2	6	V
DC Input or Output Voltage (V_{IN}, V_{OUT})	0	V_{CC}	V
Operating Temp. Range (T_A)			
MM74HC	−40	+85	°C
MM54HC	−55	+125	°C
Maximum Input Rise and Fall Time (Clear Input)			
V_{CC}=2.0V		1000	ns
V_{CC}=4.5V		500	ns
V_{CC}=6.0V		400	ns

DC Electrical Characteristics (Note 4)

Symbol	Parameter	Conditions	V_{CC}	T_A=25°C		74HC T_A=−40 to 85°C	54HC T_A=−55 to 125°C	Units
				Typ	Guaranteed Limits			
V_{IH}	Minimum High Level Input Voltage		2.0V 4.5V 6.0V		1.5 3.15 4.2	1.5 3.15 4.2	1.5 3.15 4.2	V V V
V_{IL}	Maximum Low Level Input Voltage		2.0V 4.5V 6.0V		0.3 0.9 1.2	0.3 0.9 1.2	0.3 0.9 1.2	V V V
V_{OH}	Minimum High Level Output Voltage	V_{IN}=V_{IH} or V_{IL} $\|I_{OUT}\|$≤ 20 μA	2.0V 4.5V 6.0V	2.0 4.5 6.0	1.9 4.4 5.9	1.9 4.4 5.9	1.9 4.4 5.9	V V V
		V_{IN}=V_{IH} or V_{IL} $\|I_{OUT}\|$≤ 4.0 mA $\|I_{OUT}\|$≤ 5.2 mA	4.5V 6.0V		3.96 5.46	3.84 5.34	3.7 5.2	V V V
V_{OL}	Maximum Low Level Output Voltage	V_{IN}=V_{IH} or V_{IL} $\|I_{OUT}\|$≤20 μA	2.0V 4.5V 6.0V	0 0 0	0.1 0.1 0.1	0.1 0.1 0.1	0.1 0.1 0.1	V V V
		V_{IN}=V_{IH} or V_{IL} $\|I_{OUT}\|$≤4 mA $\|I_{OUT}\|$≤5.2 mA	4.5V 6.0V		0.26 0.26	0.33 0.33	0.4 0.4	V V V
I_{IN}	Maximum Input Current (Pins 7, 15)	V_{IN}=V_{CC} or GND	5.0V		0.5	5.0	5.0	μA
I_{IN}	Maximum Input Current (all other pins)	V_{IN}=V_{CC} or GND	6.0V		±0.1	±1.0	±1.0	μA
I_{CC}	Maximum Quiescent Supply Current (standby)	V_{IN}=V_{CC} or GND I_{OUT}=0 μA	6.0V		8.0	80	160	μA
I_{CC}	Maximum Active Supply Current (per monostable)	V_{IN}=V_{CC} or GND R/C_{EXT}=0.5V_{CC}	2.0V 4.5V 6.0V	36 0.33 0.7	80 1.0 2.0	110 1.3 2.6	130 1.6 3.2	μA mA mA

Note 1: Maximum Ratings are those values beyond which damage to the device may occur.

Note 2: Unless otherwise specified all voltages are referenced to ground.

Note 3: Power Dissipation Temperature Derating: Plastic "N" Package: −12mW/°C from 65°C to 85°C Ceramic "J" Package: −12mW/°C from 100°C to 125°C

Note 4: For a power supply of 5V ±10% the worst-case output voltages (V_{OH}, V_{OL}) occur for HC at 4.5V. Thus the 4.5V values should be used when designing with this supply. Worst-case V_{IH} and V_{IL} occur at V_{CC}=5.5V and 4.5V respectively. (The V_{IH} value at 5.5V is 3.85V.) The worst-case leakage current (I_{IN}, I_{CC}, and I_{OZ}) occur for CMOS at the higher voltage and so the 6.0V values should be used.

AC Electrical Characteristics $V_{CC}=5V$, $T_A=25°C$, $C_L=15$ pF, $t_r=t_f=6$ ns

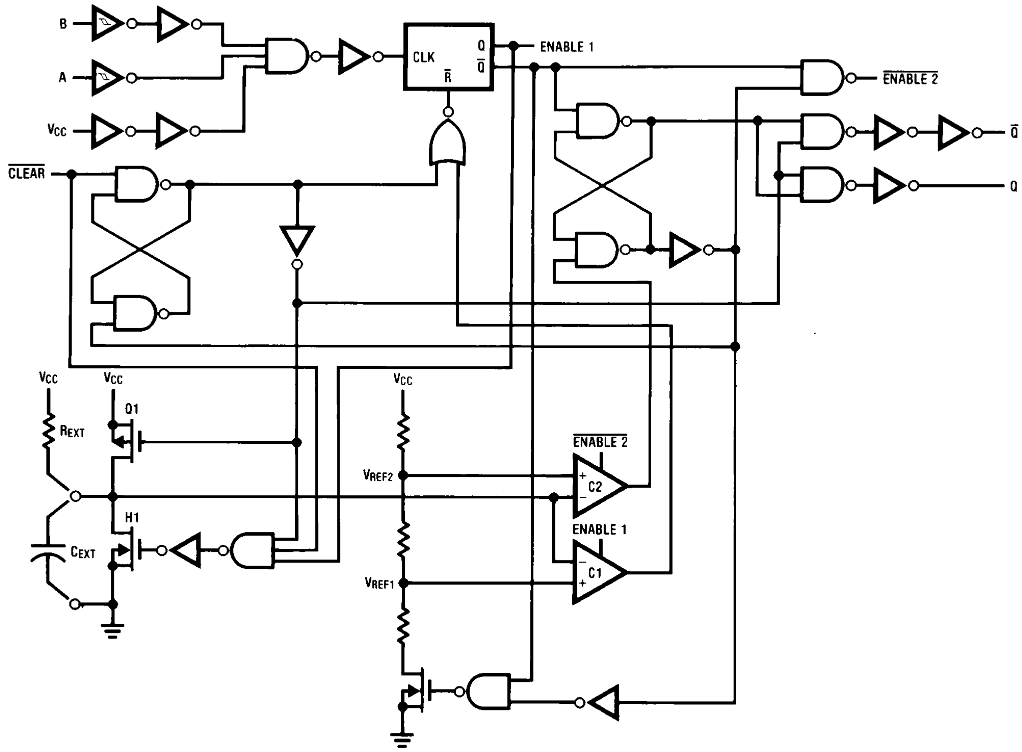
Symbol	Parameter	Conditions	Typ	Limit	Units
t_{PLH}	Maximum Trigger Propagation Delay, A, B to Q		22	33	ns
t_{PHL}	Maximum Trigger Propagation Delay, A, B to $\overline{Q}$		25	42	ns
t_{PHL}	Maximum Propagation Delay, Clear to Q		20	27	ns
t_{PLH}	Maximum Propagation Delay, Clear to $\overline{Q}$		22	33	ns
t_W	Minimum Pulse Width, A, B or Clear		14	26	ns
t_{REM}	Minimum Clear Removal Time			0	ns
$t_{WQ(MIN)}$	Minimum Output Pulse Width	$C_{EXT}=28$ pF $R_{EXT}=2$ kΩ	400		ns
t_{WQ}	Output Pulse Width	$C_{EXT}=1000$ pF $R_{EXT}=10$ kΩ	10		μs

AC Electrical Characteristics $C_L=50$ pF $t_r=t_f=6$ ns (Unless otherwise specified)

Symbol	Parameter	Conditions		V_{CC}	$T_A=25°C$		74HC $T_A=-40$ to 85°C	54HC $T_A=-55$ to 125°C	Units
					Typ	Guaranteed Limits			
t_{PLH}	Maximum Trigger Propagation Delay, A or B to Q			2.0V 4.5V 6.0V	77 26 21	169 42 32	194 51 39	210 57 44	ns ns ns
t_{PHL}	Maximum Trigger Propagation Delay, A or B to $\overline{Q}$			2.0V 4.5V 6.0V	88 29 24	197 48 38	229 60 46	250 67 51	ns ns ns
t_{PHL}	Maximum Propagation Delay, Clear to Q			2.0V 4.5V 6.0V	54 23 19	114 34 28	132 41 33	143 45 36	ns ns ns
t_{PLH}	Maximum Propagation Delay, Clear to $\overline{Q}$			2.0V 4.5V 6.0V	56 25 20	116 36 29	135 42 34	147 46 37	ns ns ns
t_W	Minimum Pulse Width A, B, Clear			2.0V 4.5V 6.0V	57 17 12	123 30 21	144 37 27	157 42 30	ns ns ns
t_{REM}	Minimum Clear Removal Time			2.0V 4.5V 6.0V	0 0 0	0 0 0	0 0 0	0 0 0	ns ns ns
t_{WQ}	Output Pulse Width	$C_{EXT}=0.1$ μF $R_{EXT}=10$ kΩ	Min	5.0V	1	0.9	0.86	0.85	ms
			Max	5.0V	1	1.1	1.14	1.15	ms
t_{TLH}, t_{THL}	Maximum Output Rise and Fall Time			2.0V 4.5V 6.0V	30 8 7	75 15 13	95 19 16	110 22 19	ns ns ns
C_{PD}	Power Dissipation Capacitance (Note 5)				83				pF
C_{IN}	Maximum Input Capacitance (Pins 7 & 15)				12	20	20	20	pF
C_{IN}	Maximum Input Capacitance (other inputs)				6	10	10	10	pF

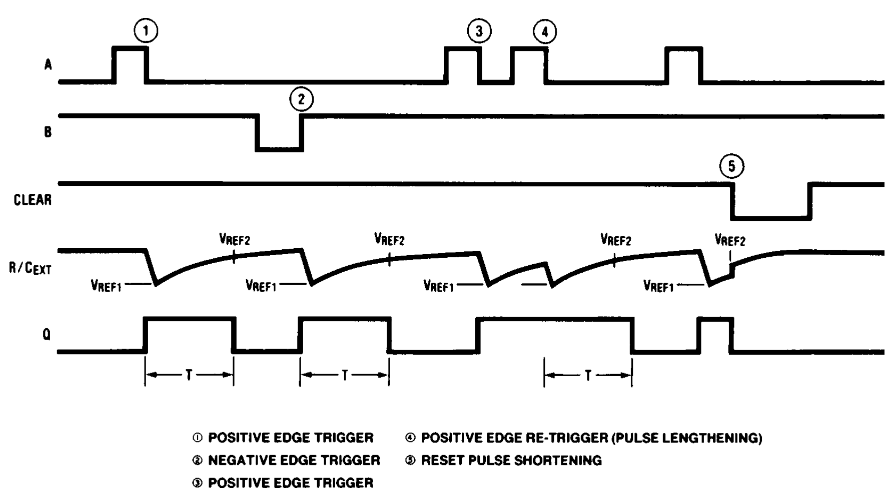
Note 5: C_{PD} determines the no load dynamic power consumption, $P_D = C_{PD} V_{CC}^2 f + I_{CC} V_{CC}$, and the no load dynamic current consumption, $I_S = C_{PD} V_{CC} f + I_{CC}$.

Logic Diagram



TL/F/5338–5

Theory of Operation



TL/F/5338–6

FIGURE 1

Theory of Operation (Continued)

TRIGGER OPERATION

As shown in *Figure 1* and the logic diagram before an input trigger occurs, the one-shot is in the quiescent state with the Q output low, and the timing capacitor C_{EXT} completely charged to V_{CC}. When the trigger input A goes from V_{CC} to GND (while inputs B and clear are held to V_{CC}) a valid trigger is recognized, which turns on comparator C1 and N-Channel transistor N1 ①. At the same time the output latch is set. With transistor N1 on, the capacitor C_{EXT} rapidly discharges toward GND until V_{REF1} is reached. At this point the output of comparator C1 changes state and transistor N1 turns off. Comparator C1 then turns off while at the same time comparator C2 turns on. With transistor N1 off, the capacitor C_{EXT} begins to charge through the timing resistor, R_{EXT}, toward V_{CC}. When the voltage across C_{EXT} equals V_{REF2}, comparator C2 changes state causing the output latch to reset (Q goes low) while at the same time disabling comparator C2. This ends the timing cycle with the one-shot in the quiescent state, waiting for the next trigger.

A valid trigger is also recognized when trigger input B goes from GND to V_{CC} (while input A is at GND and input clear is at V_{CC} ②.)

It should be noted that in the quiescent state C_{EXT} is fully charged to V_{CC} causing the current through resistor R_{EXT} to be zero. Both comparators are "off" with the total device current due only to reverse junction leakages. An added feature of the 'HC423A is that the output latch is set via the input trigger without regard to the capacitor voltage. Thus, propagation delay from trigger to Q is independent of the value of C_{EXT}, R_{EXT}, or the duty cycle of the input waveform.

RETRIGGER OPERATION

The 'HC423A is retriggered if a valid trigger occurs ③ followed by another trigger ④ before the Q output has returned to the quiescent (zero) state. Any retrigger, after the timing node voltage at pin or has begun to rise from V_{REF1}, but has not yet reached V_{REF2}, will cause an increase in output pulse width T. When a valid retrigger is initiated ④, the voltage at the R/C_{EXT} pin will again drop to V_{REF1} before progressing along the RC charging curve toward V_{CC}. The Q output will remain high until time T, after the last valid retrigger.

Because the trigger-control circuit flip-flop resets shortly after C_X has discharged to the reference voltage of the lower reference circuit, the minimum retrigger time, t_{rr} is a function of internal propagation delays and the discharge time of C_X:

$$t_{rr} = 20 + \frac{187}{V_{CC} - 0.7} + \frac{565 + (0.256\ V_{CC})\ C_X}{(V_{CC} - 0.7)^2}\ \text{ns}$$

Another removal/retrigger time occurs when a short clear pulse is used. Upon receipt of a clear, the one shot must charge the capacitor up to the upper trip point before the one shot is ready to receive the next trigger. This time is dependent on the capacitor used and is approximately:

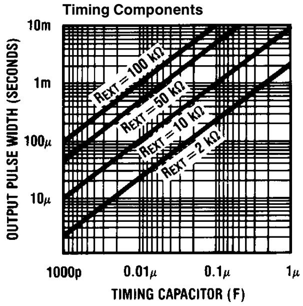
$$t_{rr} = 196 + \frac{640}{V_{CC} - 0.7} + \frac{522 + (0.3\ V_{CC})\ C_X}{(V_{CC} - 0.7)^2}\ \text{ns}$$

RESET OPERATION

These one shots may be reset during the generation of the output pulse. In the reset mode of operation, an input pulse on clear sets the reset latch and causes the capacitor to be fast charged to V_{CC} by turning on transistor Q1 ⑤. When the voltage on the capacitor reaches V_{REF2}, the reset latch will clear and then be ready to accept another pulse. If the clear input is held low, any trigger inputs that occur will be inhibited and the Q and $\overline{Q}$ outputs of the output latch will not change. Since the Q output is reset when an input low level is detected on the Clear input, the output pulse T can be made significantly shorter than the minimum pulse width specification.

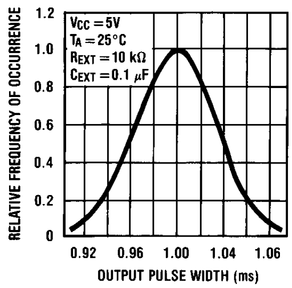
Theory of Operation (Continued)

Typical Output Pulse Width vs. Timing Components



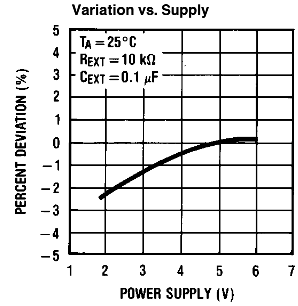
TL/F/5338–7

Typical Distribution of Output Pulse Width, Part to Part



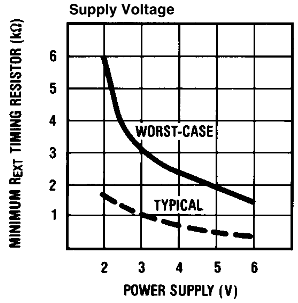
TL/F/5338–8

Typical 1ms Pulse Width Variation vs. Supply



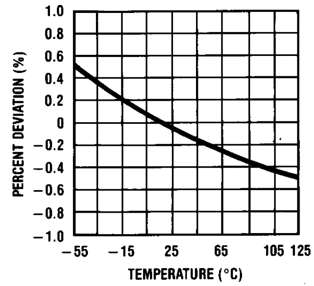
TL/F/5338–9

Minimum R_{EXT} vs. Supply Voltage



TL/F/5338–10

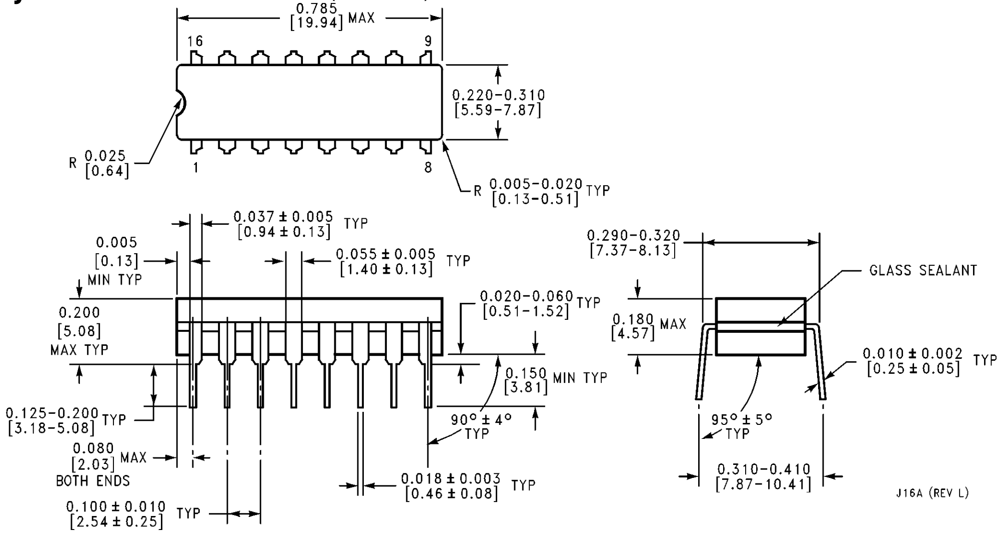
Typical 1ms Pulse Width Variation vs. Temperature



TL/F/5338–11

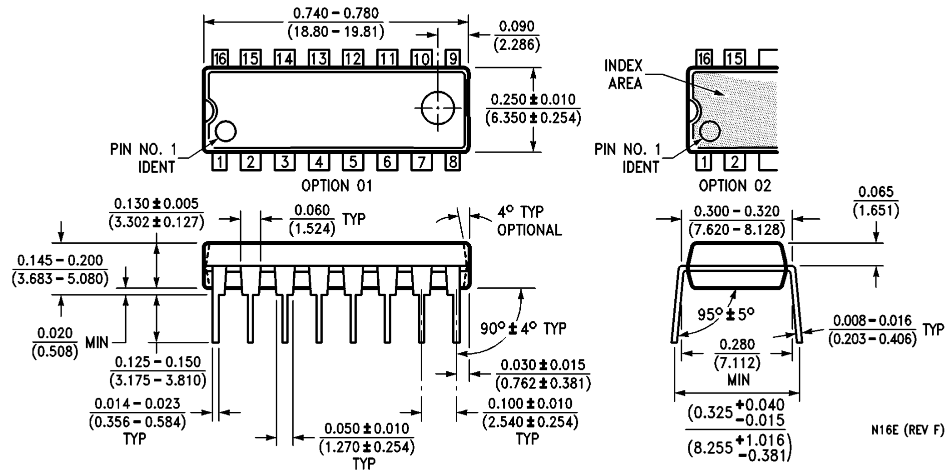
Note: R and C are not subjected to temperature. The C is polypropylene.

Physical Dimensions inches (millimeters)



Order Number MM54HC423AJ or MM74HC423AJ
NS Package J16A

Physical Dimensions inches (millimeters) (Continued)



Order Number MM74HC423AN
NS Package N16E

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408