National Semiconductor

July 1986

DS8906 AM/FM Digital Phase-Locked Loop Synthesizer

General Description

The DS8906 is a PLL synthesizer designed specifically for use in AM/FM radios. It contains the reference oscillator, a phase comparator, a charge pump, a 120 MHz ECL/I^2L dual modulus programmable divider, and a 20-bit shift register/latch for serial data entry. The device is designed to operate with a serial data controller generating the necessary division codes for each frequency, and logic state information for radio function inputs/outputs.

The Colpitts reference oscillator for the PLL operates at 4 MHz. A chain of dividers is used to generate a 500 kHz clock signal for the external controller. Additional dividers generate a 12.5 kHz reference signal for FM and a 500 Hz reference signal for AM/SW. One of these reference signals is selected by the data from the controller for use by the phase comparator. Additional dividers are used to generate a 50 Hz timing signal used by the controller for "time-of-day".

Data is transferred between the frequency synthesizer and the controller via a 3 wire bus system. This consists of a data input line, an enable line and a clock line. When the enable line is low, data can be shifted from the controller into the frequency synthesizer. When the enable line is transitioned from low to high, data entry is disabled and data present in the shift register is latched.

From the controller 22-bit data stream, the first 2 bits address the device permitting other devices to share the same bus. Of the remaining 20-bit data word, the next 14-bits are used for the PLL divide code. The remaining 6 bits are connected via latches to output pins. These 6 bits can be used to drive radio functions such as gain, mute, FM, AM, LW and SW only. These outputs are open collector. Bit 18 is used internally to select the AM or FM local oscillator input and to select between the 500 Hz and 12.5 kHz reference. A high level at bit 18 indicates FM and a low level indicates AM.

The PLL consists of a 14-bit programmable I^2L divider, an ECL phase comparator, an ECL dual modulus (p/p + 1) prescaler, and a high speed charge pump. The programmable divider divides by (N+1), N being the number loaded into the shift register (bits 1–14 after address). It is clocked by the AM input via an ECL ÷ 7/8 prescaler, or through a ÷ 63/64 prescaler from the FM input. The AM input will work at frequencies up to 8 MHz, while the FM input works up to 120 MHz. The AM band is tuned with a frequency resolution of 500 Hz and the FM band is tuned with a resolution of 12.5 kHz. The buffered AM and FM inputs are self-biased and can be driven directly by the VCO thru a capacitor. The ECL phase comparator produces very accurate resolution of the phase difference between the input signal and the reference oscillator.

The high speed charge pump consists of a switchable constant current source (−0.3 mA) and a switchable constant current sink (+0.3 mA). If the VCO frequency is low, the charge pump will source current, and sink current if the VCO frequency is high.

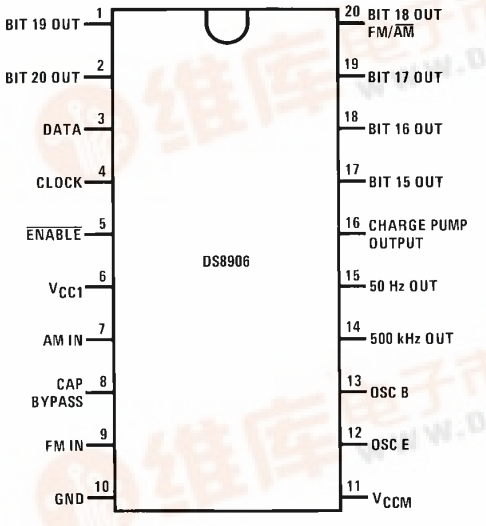
A separate V_{CCM} pin (typically drawing 1.5 mA) powers the oscillator and reference chain to provide controller clocking frequencies when the balance of the PLL is powered down.

Features

- Uses inexpensive 4 MHz reference crystal
- F_{IN} capability greater than 120 MHz allows direct synthesis at FM frequencies
- FM resolution of 12.5 kHz allows usage of 10.7 MHz ceramic filter distribution
- Serial data entry for simplified control
- 50 Hz output for "time-of-day" reference with separate low power supply (V_{CCM})
- 6-open collector buffered outputs for band switching and other radio functions
- Separate AM and FM inputs. AM input has 15 mV (typical) hysteresis

Connection Diagram

Dual-In-Line Package



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Top View

Order Number DS8906N
See NS Package Number N20A

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Absolute Maximum Ratings (Note 1)

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

Supply Voltage	
(V_{CC1})	7V
(V_{CCM})	7V
Input Voltage	7V
Output Voltage	7V
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 4 seconds)	260°C

Operating Conditions

	Min	Max	Units
Supply Voltage, V_{CC}			
V_{CC1}	4.75	5.25	V
V_{CCM}	4.5	6.0	V
Temperature, T_A	0	70	°C

DC Electrical Characteristics (Notes 2 and 3)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{IH}	Logical "1" Input Voltage			2.1			V
I_{IH}	Logical "1" Input Current	$V_{IN} = V_{CC1}$			0	10	μA
V_{IL}	Logical "0" Input Voltage					0.7	V
I_{IL}	Logical "0" Input Current	Data, Clock and $\overline{\text{ENABLE}}$ INPUTS, $V_{IN} = 0V$			−5	−25	μA
I_{OH}	Logical "1" Output Current All Bit Outputs, 50 Hz Output	$V_{OH} = 5.25V$				50	μA
	500 kHz Output	$V_{OH} = 2.4V$, $V_{CCM} = 4.5V$				−250	μA
V_{OL}	Logical "0" Output Voltage All Bit Outputs	$I_{OL} = 5$ mA				0.5	V
	50 Hz Output, 500 kHz Output	$I_{OL} = 250$ μA				−0.5	V
I_{CC1}	Supply Current (V_{CC1})	All Bit Outputs High			90	160	mA
$I_{CCM(STANDBY)}$	V_{CCM} Supply Current	$V_{CCM} = 6.0V$, All Other Pins Open			1.5	4.0	mA
I_{OUT}	Charge Pump Output Current	$1.2V \le V_{OUT} \le V_{CCM} - 1.2V$, $V_{CCM} \le 6.0V$	Pump Up	−0.10	−0.30	−0.6	mA
			Pump Down	0.10	0.30	0.6	mA
			TRI-STATE®		0	±100	nA
$I_{CCM(OPERATE)}$	V_{CCM} Supply Current	$V_{CCM} = 6.0V$, $V_{CC1} = 5.25V$, All Other Pins Open			2.5	6.0	mA

AC Electrical Characteristics $V_{CC} = 5V$, $T_A = 25°C$, $t_r \le 10$ ns, $t_f \le 10$ ns

Symbol	Parameter	Conditions		Min	Typ	Max	Units
$V_{IN(MIN)(F)}$	F_{IN} Minimum Signal Input	AM and FM Inputs, $0°C \le T_A \le 70°C$			20	100	mV (rms)
$V_{IN(MAX)(F)}$	F_{IN} Maximum Signal Input	AM and FM Inputs, $0°C \le T_A \le 70°C$		1000	1500		mV (rms)
$F_{OPERATE}$	Operating Frequency Range (Sine Wave Input)	V_{IN} = 100 mV rms, $0°C \le T_A \le 70°C$	AM	0.4		8	MHz
			FM	60		120	MHz
R_{IN} (FM)	AC Input Resistance, FM	120 MHz, V_{IN} = 100 mV rms		300			Ω
R_{IN} (AM)	AC Input Resistance, AM	2 MHz, V_{IN} = 100 mV rms		1000			Ω
C_{IN}	Input Capacitance, FM and AM	V_{IN} = 120 MHz		3	6	10	pF
$t_{\overline{EN}1}$	Minimum $\overline{\text{ENABLE}}$ High Pulse Width				625	1250	ns
$t_{\overline{EN}0}$	Minimum $\overline{\text{ENABLE}}$ Low Pulse Width				375	750	ns
$t_{CLK\overline{EN}0}$	Minimum Time before ENABLE Goes Low that CLOCK must be Low				−50	0	ns
$t_{\overline{EN}0CLK}$	Minimum Time after ENABLE Goes Low that CLOCK must Remain Low				275	550	ns
$t_{CLK\overline{EN}1}$	Minimum Time before $\overline{\text{ENABLE}}$ Goes High that Last Positive CLOCK Edge May Occur				300	600	ns

AC Electrical Characteristics $V_{CC} = 5V, T_A = 25°C, t_r \leq 10$ ns, $t_f \leq 10$ ns (Continued)

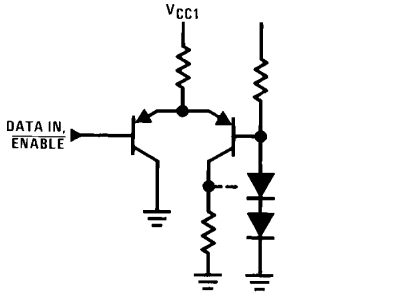
Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{EN1CLK}	Minimum Time After ENABLE Goes High Before an Unused Positive CLOCK Edge May Occur			175	350	ns
t_{CLKH}	Minimum CLOCK High Pulse Width			275	550	ns
t_{CLKL}	Minimum CLOCK Low Pulse Width			400	800	ns
t_{DS}	Minimum DATA Setup Time, Minimum Time Before CLOCK that DATA Must be Valid			150	300	ns
t_{DH}	Minimum DATA Hold Time, Minimum Time After CLOCK that DATA Must Remain Valid			400	800	ns

Note 1: ''Absolute Maximum Ratings'' are those values beyond which the safety of the device cannot be guaranteed. Except for ''Operating Temperature Range'' they are not meant to imply that the devices should be operated at these limits. The table of ''Electrical Characteristics'' provides conditions for actual device operation.

Note 2: Unless otherwise specified min/max limits apply across the 0°C to +70°C temperature range for the DS8906.

Note 3: All currents into device pins shown as positive, out of device pins as negative, all voltages referenced to ground unless otherwise noted. All values shown as max or min on absolute value basis.

Schematic Diagrams (DS8906 AM/FM PLL Typical Input/Output Schematics)



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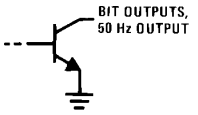

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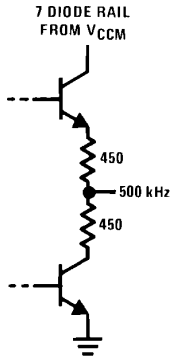

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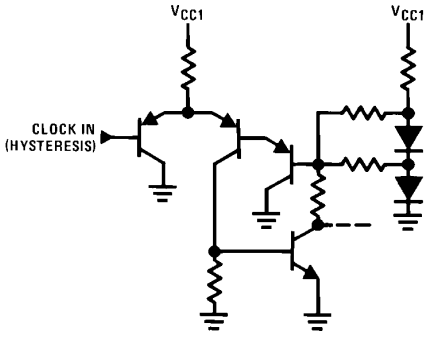

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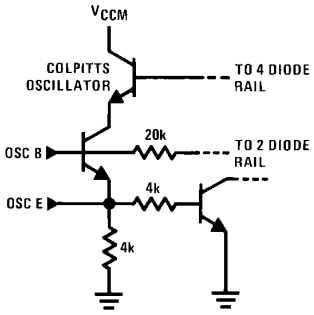

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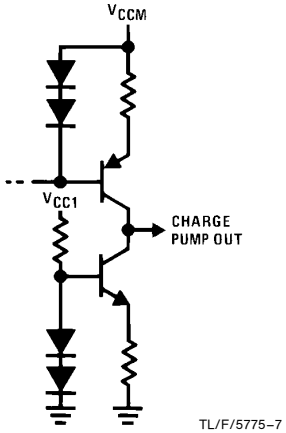
Schematic Diagrams (DS8906 AM/FM PLL Typical Input/Output Schematics) (Continued)



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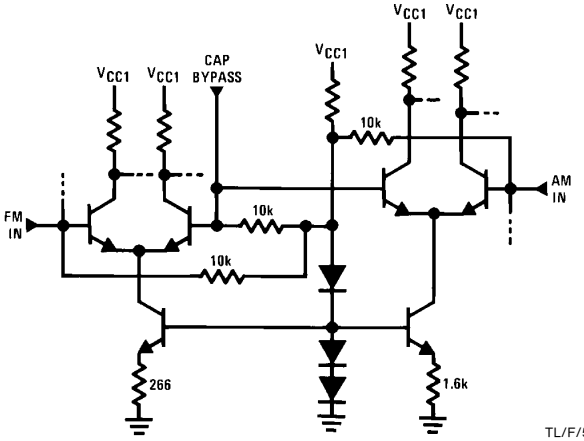

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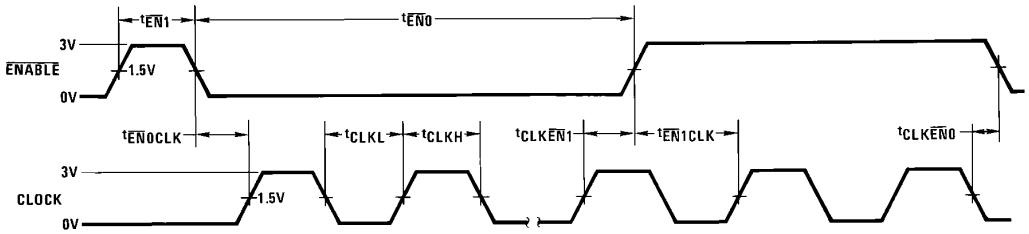
Timing Diagrams*

$\overline{\text{ENABLE}}$ vs CLOCK



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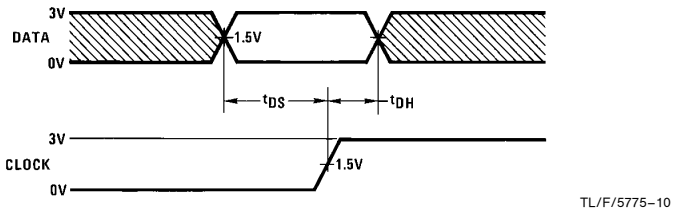
CLOCK vs DATA



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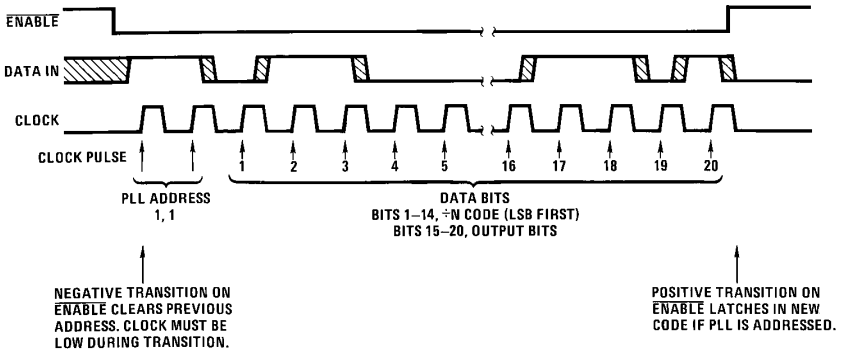
AM/FM Frequency Synthesizer (Scan Mode)



*Timing diagrams are not drawn to scale. Scale within any one drawing may not be consistent, and intervals are defined positive as drawn.

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Applications Information

SERIAL DATA ENTRY INTO THE DS8906

Serial information entry into the DS8906 is enabled by a low level on the $\overline{\text{ENABLE}}$ input. One binary bit is then accepted from the DATA input with each positive transition of the CLOCK input. The CLOCK input must be low for the specified time preceding and following the negative transition of the $\overline{\text{ENABLE}}$ input.

The first 2 bits accepted following the negative transition of the $\overline{\text{ENABLE}}$ input are interpreted as address. If these address bits are *not* 1,1, *no* further information will be accepted from the DATA inputs, and the internal data latches *will not* be changed when $\overline{\text{ENABLE}}$ returns high.

If these first 2 bits *are* 1,1, then all succeeding bits are *accepted* as data, and are shifted successively into the internal shift register as long as $\overline{\text{ENABLE}}$ remains low.

Any *data* bits preceding the 20th to last bit will be shifted out, and are thus irrelevant. Data bits are counted as any bits following 2 valid (1,1) address bits with the $\overline{\text{ENABLE}}$ low.

When the $\overline{\text{ENABLE}}$ input returns high, any further serial data input is inhibited. Upon this positive transition of the $\overline{\text{ENABLE}}$, the data in the internal shift register is transferred into the internal data latches.

Note that until this time, the states of the internal data latches have remained unchanged.

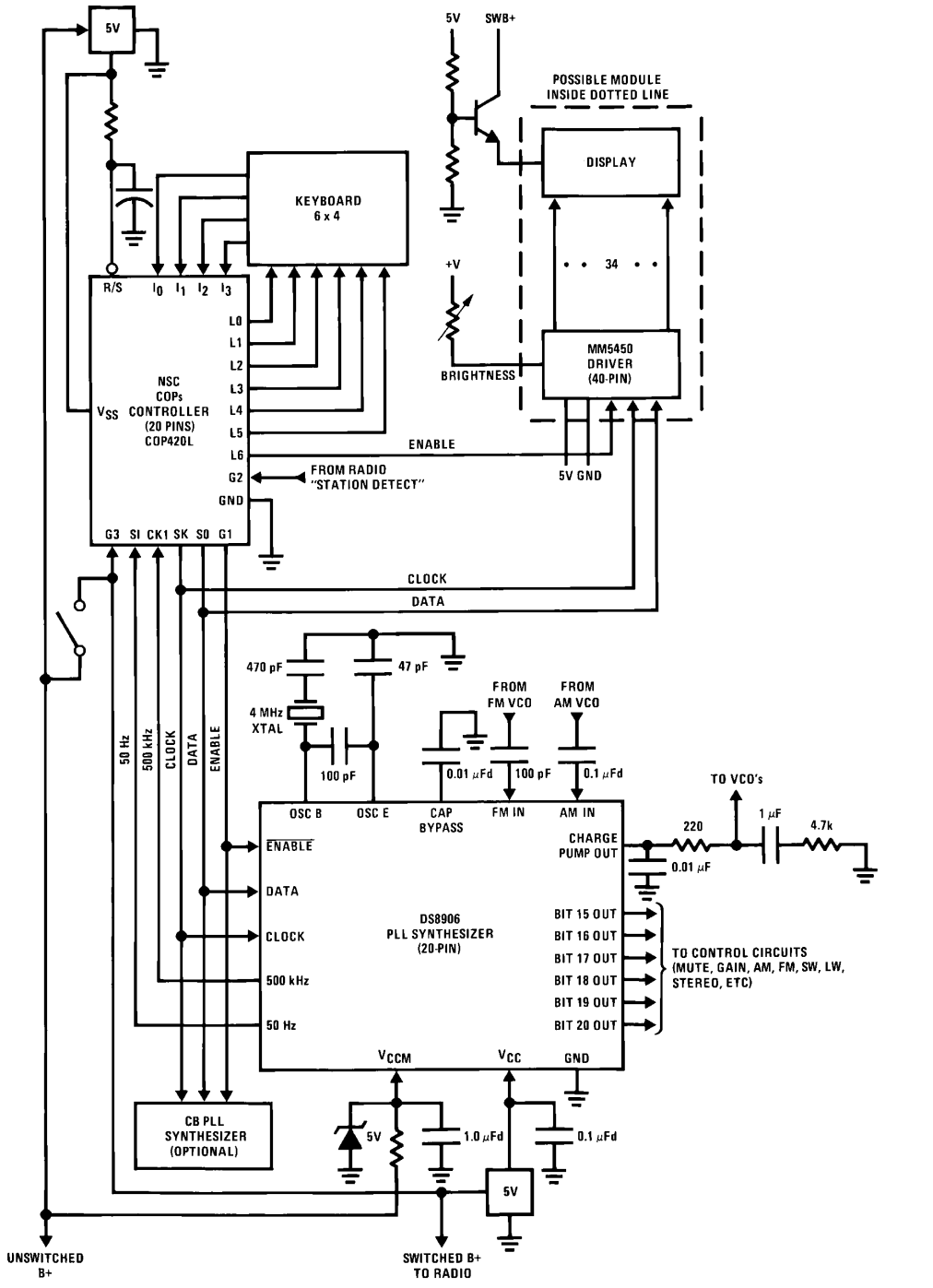
These data bits are interpreted as follows:

DATA BIT POSITION	DATA INTERPRETATION		
Last	Bit 20 Output (Pin 2)		
2nd to Last	Bit 19 Output (Pin 1)		
3rd to Last	Bit 18 Output (FM/$\overline{\text{AM}}$) (Pin 20)		
4th to Last	Bit 17 Output (Pin 19)		
5th to Last	Bit 16 Output (Pin 18)		
6th to Last	Bit 15 Output (Pin 17)		
7th to Last	MSB of N	(2^{13})	÷N
8th to Last		(2^{12})	
9th to Last		(2^{11})	
10th to Last		(2^{10})	
11th to Last		(2^{9})	
12th to Last		(2^{8})	
13th to Last		(2^{7})	
14th to Last		(2^{6})	
15th to Last		(2^{5})	
16th to Last		(2^{4})	
17th to Last		(2^{3})	
18th to Last		(2^{2})	
19th to Last		(2^{1})	
20th to Last	LSB of N	(2^{0})	

Note. The actual divide code is N + 1, i.e., the number loaded plus 1.

Typical Application

Electronically Tuned Radio Controller System; Direct Drive LED



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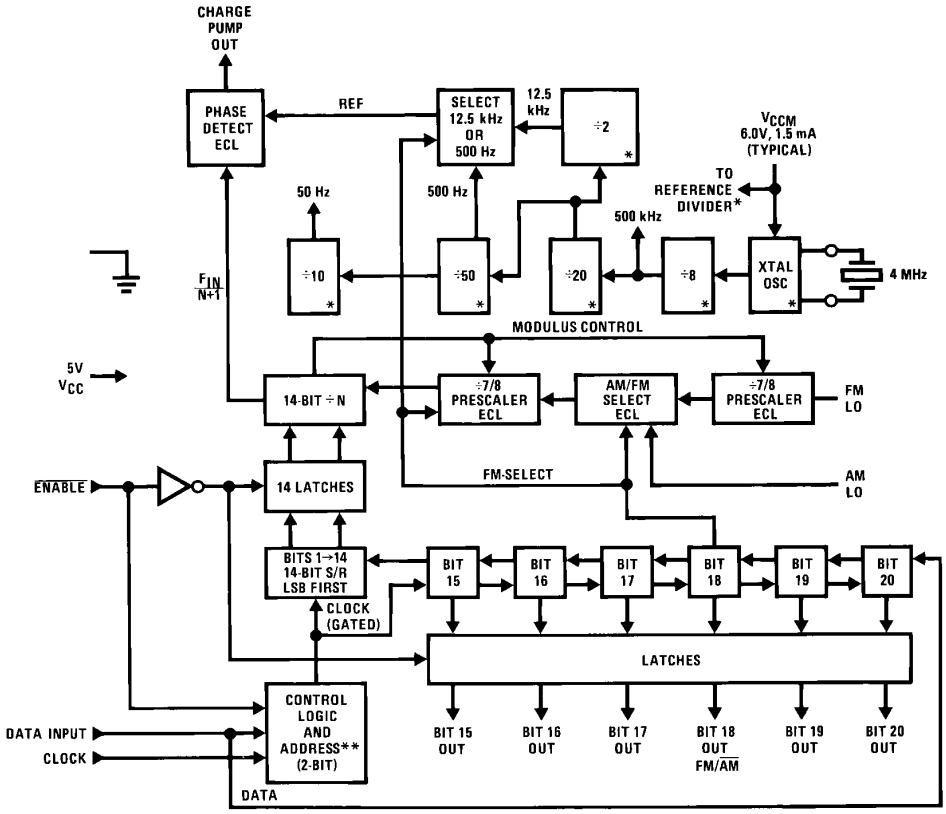
Logic Diagram

AM/FM PLL Synthesizer



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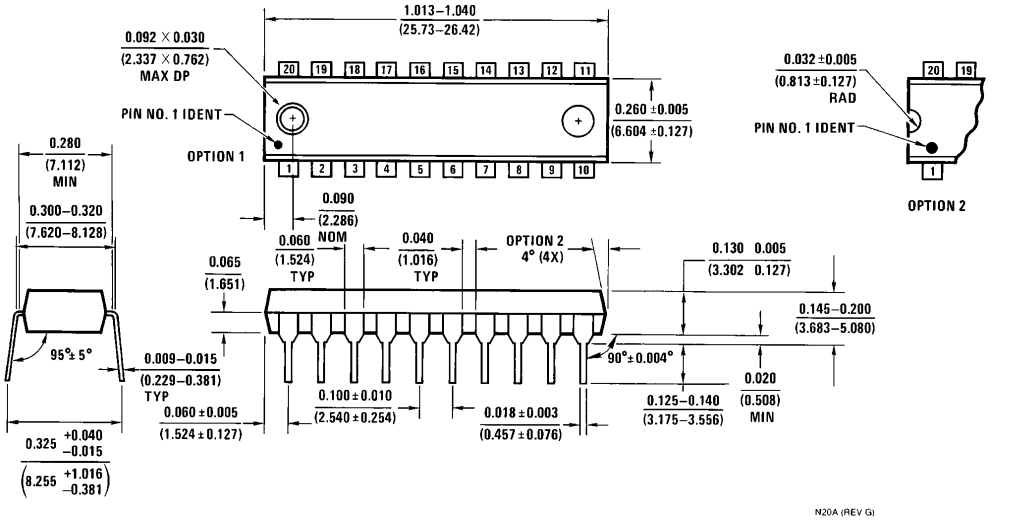
*Sections operating from V_{CCM} supply

**Address (1, 1)

Physical Dimensions inches (millimeters)



Molded Dual-In-Line Package (N)
Order Number DS8906N
NS Package Number N20A

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