APPLICATION NOTE

AN1940
Using the Philips Semiconductors NE5900 call-progress decoder

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INTRODUCTION

The NE5900 is a monolithic integrated circuit designed to perform detection of North American call-progress signals via cadence detection. Due to the non-standardized frequency content of the various call-progress signals, cadence detection provides a more reliable detection method due to the regularity of cadence timings. The NE5900 was primarily designed for operation in automatic dialing and call-initiation equipment. Automatic dialing requires accurate detection of the following telephone equipment signals: 1) dial tone, 2) busy, 3) ringback, and 4) reorder (equipment overloaded) signals (see Figure 1). Detection of these conditions allows a successful dialing procedure to be completed by a computer.

The NE5900 incorporates a detection scheme consisting of a front-end switched-capacitor band-pass filter (isolating the band where call-progress signals exist) and a detector stage which counts the envelope transitions in the signal during a 2.3 second timing interval (i.e., cadence detection). 2.3 seconds is the minimum time duration in which a unique envelope-transition count exists for each one of the four detected call-progress signals. At the termination of this timing window, a 3-bit TTL level port outputs a unique word corresponding to the condition detected. A fifth condition, corresponding to an “overflow”, is output if more envelope transitions were detected than exist for any of the four call-progress signals.

Input Stage

The input to the NE5900 should consist of the AC portion of the telephone line with a DC bias of 2.5V. Figure 2 shows such a circuit.

The op amp is configured as a differential amplifier with a gain of one. This stage acts simply as a buffer which extracts only the AC signal from the source, which may be the telephone handset microphone or any other point in a telephone receiver where the exchange signals are present. [Note that the input capacitors must have the appropriate DC ratings.] The 2.5V bias is accomplished by using the 2.5V reference, which appears at Pin 2, connected to the non-inverting op amp input. Capacitor C3 provides noise immunity (especially from AM radio transmissions). The 470kΩ resistor, R3, in conjunction with integrated elements, forms an anti-alias filter for the switched capacitor filter. This stage may also be configured to provide gain by increasing R4 and/or decreasing R1 and R2.

An alternate (and simpler) method is to directly couple the line to the input through a 10nF (min) capacitor in series with a 470kΩ resistor. The NE5900 will internally bias the input to the appropriate level. In this configuration (Figure 3), a capacitor of 10nF should also be connected at Pin 2 to ground for noise immunity.

The internal switched-capacitor filter provides a typical frequency response as shown in Figure 4. This filter derives its response from an integrated switched capacitor which derives its switching frequency from the externally connected 3.58MHz source. The filter typically provides rejection of greater than 40dB for frequencies below 120Hz and greater than 1.6kHz (call-progress tones typically fall between 300 and 630Hz).

Sensitivity

Sensitivity threshold as a function of input frequency is given in Figure 5. Typical sensitivity is approximately -39dBm (0dB = $0.775V_{RMS}$). The decoder will not respond to any signals below -50dBm or to tones up to 0dBm which are below 180Hz or above 800Hz. Dropouts (loss of signal) or short-duration signals which last for less than 20ms are ignored. A loss or presence of a signal lasting more than 40ms is detected.

Outputs

Outputs provided by the NE5900 consist of a 3-bit TTL-level port (Pins 10, 11, and 12), a **data-valid** flag (Pin 9), a **count-in-progress** flag (Pin 7), and an envelope output.

Data-valid starts out low (after a **clear** input) and goes high 2.3 seconds after the rising edge of the first detected energy in the call-progress band. This output signal is intended to be used as a positive edge-triggered interrupt source for interrupt-driven software. The **data-valid** output should be connected to a rising edge triggered microprocessor interrupt input. The duration of the high-state of this flag differs under different conditions, and is thus not appropriate for polling applications. (See **count-in-progress**). The appearance of the rising edge of data-valid indicates the availability of decoded data at the output port, giving the call-progress status of the last measured cadence interval. The **data-valid** flag will be reset by the clear input. After each appearance of a rising edge of **data-valid**, the NE5900 can be cleared after reading the data (by issuing a pulse of no longer than 20ms to the **clear** input). **Data-valid** is also cleared by the falling edge of the three-state enable input.

Count-in-progress is high in the period between the first detected edge of energy in the call-progress pass band and during the 2.3 second timing interval which follows. After the timing interval is through, this flag will go low until the next appearance of detectable energy in the pass band. If the end of the 2.3 second interval occurs during the detectable energy in the pass band, **count-in-progress** will go low, then return high after an approximate time delay of 4ms.

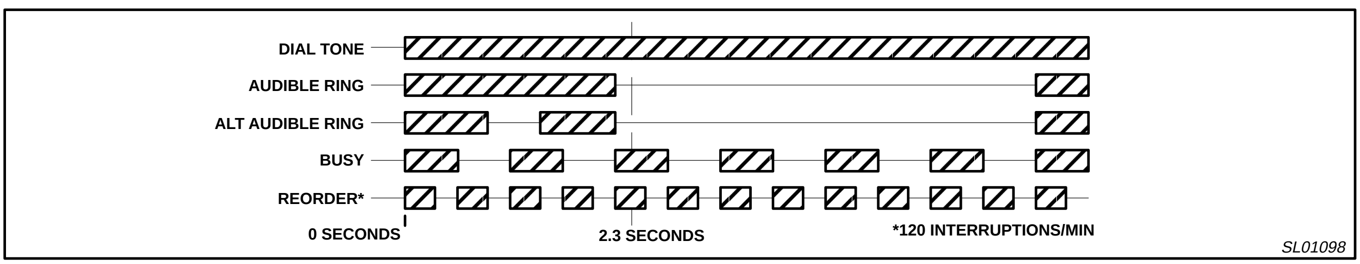

Figure 1. Detection Signals

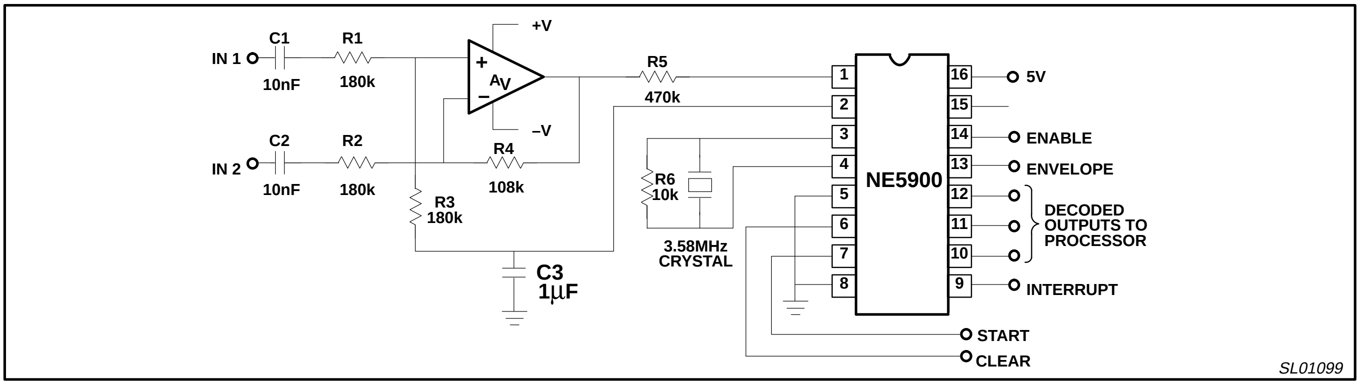

Figure 2. Typical Two-Wire Application

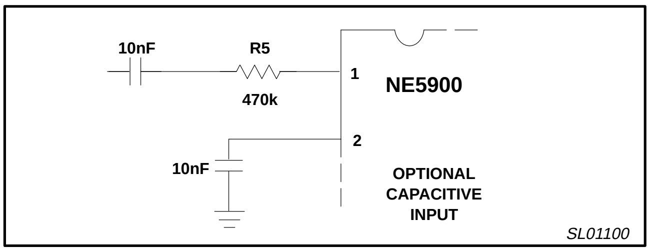

Figure 3. Direct Coupled Input

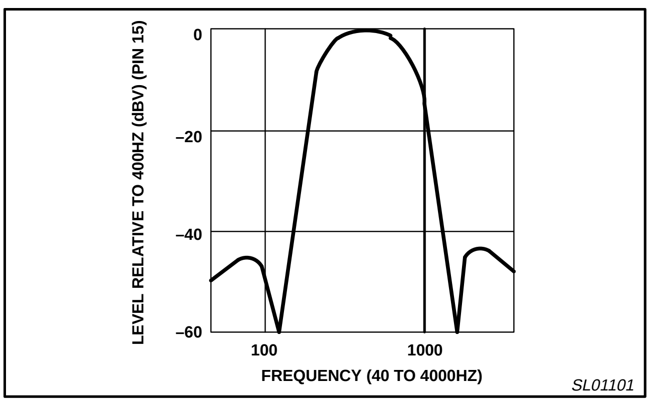

Figure 4. Filter Response

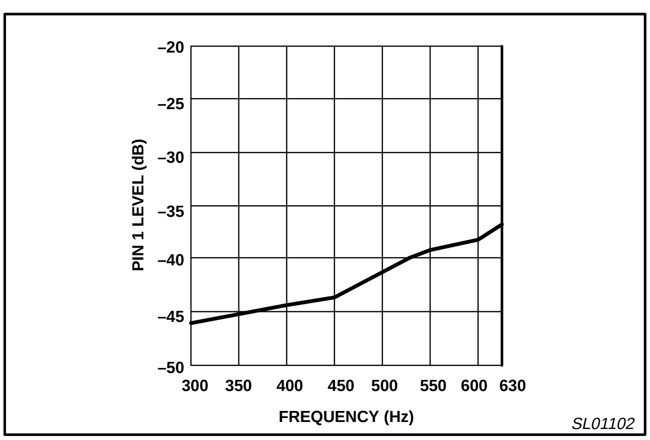

Figure 5. Input Threshold

Count-in-progress should be used in applications where the NE5900 is being polled for call-progress information. At occurrences of a high-to-low transition at this pin (and the subsequent 4ms), data is ready to be read at the port output. **Count-in-progress** is reset by a **clear** input.

Analog output provides the time-domain waveform of the input signal (post filtered). **Envelope** output provides a TTL-level envelope of the input signal (post filtered). This output can be polled by the microcontroller to implement software processing of the call-progress signals.

Clock and Input Functions

The timing source to the NE5900 consists of a clock/crystal input/output (Pins 3 and 4). The clock may be obtained by two methods: In the internal oscillator mode, the clock/crystal input/output is generally a 3.58MHz crystal connected between Pins 3 and 4. A 1MΩ resistor should be placed in parallel with the crystal to insure oscillator start-up. An alternative method is to use a CERALOCK™ brand ceramic resonator (part #CSA3.58MG). The CERALOCK™ resonator must be connected between Pins 3 and 4 in parallel with a 1MΩ resistor. Two 30pF capacitors must also be connected from Pins 3 and 4 to ground. This method will produce oscillation frequencies deviating no more than .3% on a temperature range of -50 to +120°C (assuming closely matched capacitors). With an external clock driver, Pin 3 serves as the “Clock” input, while Pin 4 can be used as a “Clock Out” (inverted). The “Clock” input can be provided by a 3.58MHz square-wave input to Pin 3. (If not CMOS level, then AC couple).

Input functions of the NE5900 are: Signal Input (Pin 1), Test in (Pin 5, used only during manufacturing), three-state enable (Pin 14), and a clear input (Pin 6).

Signal input (Pin 1) should be configured as was covered in the section on Input Stage.

Three-state enable is a TTL-level input (active high) which produces a high-impedance state on four pins: Envelope, Bit 1, Bit 2, and Bit 3.

The **clear** input is an active high input which initializes the call-progress detection sequence. **Clear** resets **data-valid** and count-in-progress.

Operation

On the falling edge of **clear**, **count-in-progress** and **data valid** are cleared. The internal detector of the NE5900 is initialized to wait for the first appearance of energy at the appropriate level within the call-progress pass band. The IC will wait for this event before producing any output. **Data valid**, **count-in-progress**, and **Envelope** outputs will all remain low. Bits 1, 2 and 3 will retain previous states unless put into the high impedance state.

At the rising edge of the first appearance of detectable energy in the pass band, the counter will begin to count after a 38ms (typ.) delay. 2.27 seconds later, **data valid** will go high, indicating the end of the detection sequence. **Count-in-progress** will also go low at this time. The decoded data will appear at the Bits 1,2 and 3 slightly ahead of the rising edge of the **data valid** flag (approximately 4ms). A TTL-version of the signal envelope will appear at all times at the envelope output (when not put into the high impedance state). Refer to Figure 6.

The analog output provides an analog version of the signal input (post-filter). At the end of the 2.3 seconds, the decoded call-progress information should be read, and the process can be repeated by issuing a new **clear** pulse to Pin 6. If the **clear** pulse is longer than 20ms, the output condition after the **clear** pulse could be invalid. Minimum **clear** pulse width should be considered to be 150ns.

Undefined States

Operation of the NE5900 depends on several given conditions: 1) A full 2.3 seconds of a consistent call-progress signal, 2) the absence of any alternate source of signal greater than -35dBm in the region of 300 - 630Hz (i.e., voice). The NE5900, alone, is not capable of detecting such conditions as the presence of voice, or such special signals as **call intercept**. These, and any condition other than the 4 specified call-progress signals, are not detectable through the NE5900, alone. The TTL-level envelope output is provided for software processing of these conditions.

Determining Whether Voice is Present on the Line

The NE5900 was intended for determining call-progress tones for machine-to-machine communications, and not for lines carrying voice. This presents a problem for those wanting to use the NE5900 on phone lines carrying voice, such as pay telephones and equipment that may pick up the line to dial when there might be human conversation on the line. The envelope output may be used for software determination of the line condition. The problem is simplified when it is only desired to determine whether there is voice or a dial tone on the line.

Figure 7 shows how the envelope output (Pin 13) might be used to determine whether there is a dial tone on the line or if voice signals might be present.

NAND gates A and B form an RS flip-flop and are used to determine whether there is a dial tone on the line. The other gates are used to decide, if there is no dial tone, whether there is voice on the line.

If there is a dial tone on the line after the RESET pulse is applied, the envelope output remains high and the output of gate A is high. If there is voice on the line, there will be many envelope transitions, one of which will reset the RS flip-flop and the output of gate A will go low. If there is someone on the line holding, there will be no transitions, so the output of gate A will remain high. The absence of a dial tone means that the envelope output of the NE5900 will be low, and the output of gate C will remain high, a signal that means "no dial tone". If someone is singing on the phone, they must hold a steady tone between 400 and 630Hz for the five seconds that the controller is looking at the output of gate C, something that is extremely unlikely since this is a relatively low frequency and can not be sustained at any volume for long, and, statistically, there is not very much chance that anyone will be singing on the line when a machine decides to use it.

To decide whether there is a dial tone on the line, the equipment would perform the following sequence:

1. "Pick up" the line
2. Wait a second or so to be sure there is a dial tone if one is coming
3. Apply a RESET pulse to the RS flip-flop
4. Wait about 5 seconds
5. Look at the circuit output to determine the line status
   Logic low means OK to dial
   Logic high means DO NOT dial

Another method of determining whether there is voice on the line is to use another NE5900 with a 10MHz crystal. This would cause the center of the filter pass band to be about 1300Hz, rather than the 460Hz center when using a 3.58MHz clock. Any transition of the envelope output, or any bit code other than 000, would indicate the presence of voice. Of course, you could try to switch between the two frequencies: 10MHz for voice detection and 3.58MHz for detection of call progress tones.

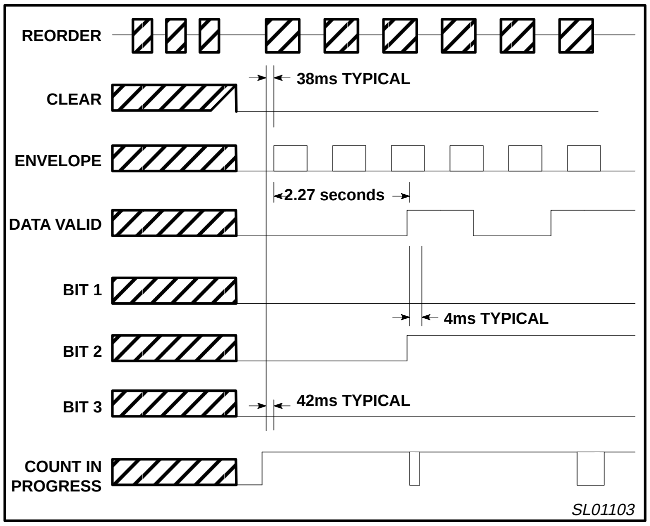

Figure 6. Typical Timing

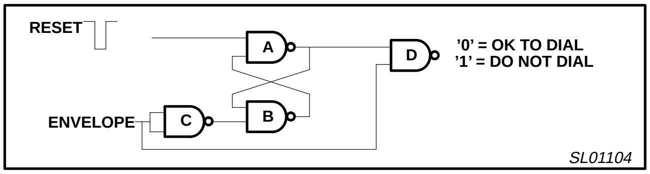

Figure 7. Looking for Dial Tone