



[Maxim > Design Support > Technical Documents > Application Notes > 1-Wire® Devices > APP 187](#)

[Maxim > Design Support > Technical Documents > Application Notes > Battery Management > APP 187](#)

[Maxim > Design Support > Technical Documents > Application Notes > iButton® > APP 187](#)

Keywords: 1-Wire search algorithm, unique register number (ID), ROM number

APPLICATION NOTE 187

1-Wire Search Algorithm

Mar 28, 2002

Abstract: Maxim's 1-Wire® devices each have a 64-bit unique registration number in read-only memory (ROM) that is used to address them individually by a 1-Wire master in a 1-Wire network. If the ROM numbers of the slave devices on the 1-Wire network are not known, then using a search algorithm can discover them. This document explains the search algorithm in detail and provides an example implementation for rapid integration. This algorithm is valid for all current and future devices that feature a 1-Wire interface.

Introduction

Maxim's 1-Wire devices each have a 64-bit unique registration number in read-only memory (ROM) (**Figure 1**) that is used to address them individually by a 1-Wire master in a 1-Wire network. If the ROM numbers of the slave devices on the 1-Wire network are not known, then they can be discovered by using a search algorithm. This document explains the search algorithm in detail and provides an example implementation for rapid integration. This algorithm is valid for all current and future devices that feature a 1-Wire interface.

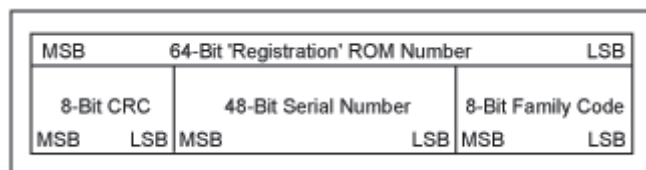


Figure 1. 64-bit unique ROM 'registration' number.

Search Algorithm

The search algorithm is a **binary tree search** where branches are followed until a device ROM number, or leaf, is found. Subsequent searches then take the other branch paths until all of the leaves present are discovered.

The search algorithm begins with the devices on the 1-Wire being reset using the reset and presence pulse sequence. If this is successful then the 1-byte search command is sent. The search command readies the 1-Wire devices to begin the search.

There are two types of search commands. The **normal search command (F0 hex)** performs a search

with all devices participating. The alarm or conditional search command (EC hex) performs a search with only the devices that are in some sort of alarm state. This reduces the search pool to quickly respond to devices that need attention.

Following the search command, the actual search begins with all participating devices simultaneously sending the first bit (least significant) in their ROM number (also called registration number). (See Figure 1.) As with all 1-Wire communication, the 1-Wire master starts every bit whether it is data to be read or written to the slave devices. Due to the characteristics of the 1-Wire, when all devices respond at the same time, this results in a logical AND of the bits sent. After the devices send the first bit of their ROM number, the master initiates the next bit and the devices then send the complement of the first bit. From these two bits, information can be derived about the first bit in the ROM numbers of the participating devices. (See Table 1.)

Table 1. Bit Search Information		
Bit (true)	Bit (complement)	Information Known
0	0	There are both 0s and 1s in the current bit position of the participating ROM numbers. This is a discrepancy.
0	1	There are only 0s in the bit of the participating ROM numbers.
1	0	There are only 1s in the bit of the participating ROM numbers.
1	1	No devices participating in search.

According to the search algorithm, the 1-Wire master must then send a bit back to the participating devices. If the participating device has that bit value, it continues participating. If it does not have the bit value, it goes into a wait state until the next 1-Wire reset is detected. This 'read two bits' and 'write one bit' pattern is then repeated for the remaining 63 bits of the ROM number (see Table 2). In this way the search algorithm forces all but one device to go into this wait state. At the end of one pass, the ROM number of this last device is known. On subsequent passes of the search, a different path (or branch) is taken to find the other device ROM numbers. Note that this document refers to the bit position in the ROM number as bit 1 (least significant) to bit 64 (most significant). This convention was used instead of bit 0 to bit 63 for convenience, to allow initialization of discrepancy counters to 0 for later comparisons.

Table 2. 1-Wire Master and Slave Search Sequence	
Master	Slave
1-Wire reset stimulus	Produce presence pulse.
Write search command (normal or alarm)	Each slave readies for search.
Read 'AND' of bit 1	Each slave sends bit 1 of its ROM number.
Read 'AND' of complement bit 1	Each slave sends complement bit 1 of its ROM number.
Write bit 1 direction (according to algorithm)	Each slave receives the bit written by master, if bit read is not the same as bit 1 of its ROM number then go into a wait state.

Read 'AND' of bit 64	Each slave sends bit 64 of its ROM number.
Read 'AND' of complement bit 64	Each slave sends complement bit 64 of its ROM number.
Write bit 64 direction (according to algorithm)	Each slave receives the bit written by master, if bit read is not the same as bit 64 of its ROM number then go into a wait state.

On examination of Table 1, it is obvious that if all of the participating devices have the same value in a bit position then there is only one choice for the branch path to be taken. The condition where no devices are participating is an atypical situation that can arise if the device being discovered is removed from the 1-Wire during the search. If this situation arises then the search should be terminated and a new search could be done starting with a 1-Wire reset. A discrepancy, the condition where there are both 0s and 1s in the bit position, is the key to finding devices in the subsequent searches. The search algorithm specifies that on the first pass, when there is a discrepancy (bit/complement = 0/0), the '0' path is taken. Note that this is arbitrary for this particular algorithm. Another algorithm could be devised to use the '1' path first. The bit position for the last discrepancy is recorded for use in the next search. Table 3 describes the paths that are taken on subsequent searches when a discrepancy occurs.

Table 3. Search Path Direction	
Search Bit Position vs Last Discrepancy	Path Taken
=	Take the '1' path
<	Take the same path as last time (from last ROM number found)
>	Take the '0' path

The search algorithm also keeps track of the last discrepancy that occurs within the first eight bits of the algorithm. The first eight bits of the 64-bit registration number is a family code. As a result, the devices discovered during the search are grouped into family types. The last discrepancy within that family code can be used to selectively skip whole groups of 1-Wire devices. See the description of *ADVANCED SEARCH VARIATIONS* for doing selective searches. The 64-bit ROM number also contains an 8-bit cyclic-redundancy-check (CRC). This CRC value is verified to ensure that only correct ROM numbers are discovered. See Figure 1 for the layout of the ROM number.

The DS2480B Serial to 1-Wire Line Driver performs some of this same search algorithm in hardware. See the DS2480B data sheet and application note 192, *Using the DS2480B Serial 1-Wire Line Driver* for details. The DS2490 USB to 1-Wire bridge performs the entire search in hardware.

Figure 2 shows a flow chart of the search sequence. Note the *Reference* side bar that explains the terms used in the flow chart. These terms are also used in the source code appendix to this document.

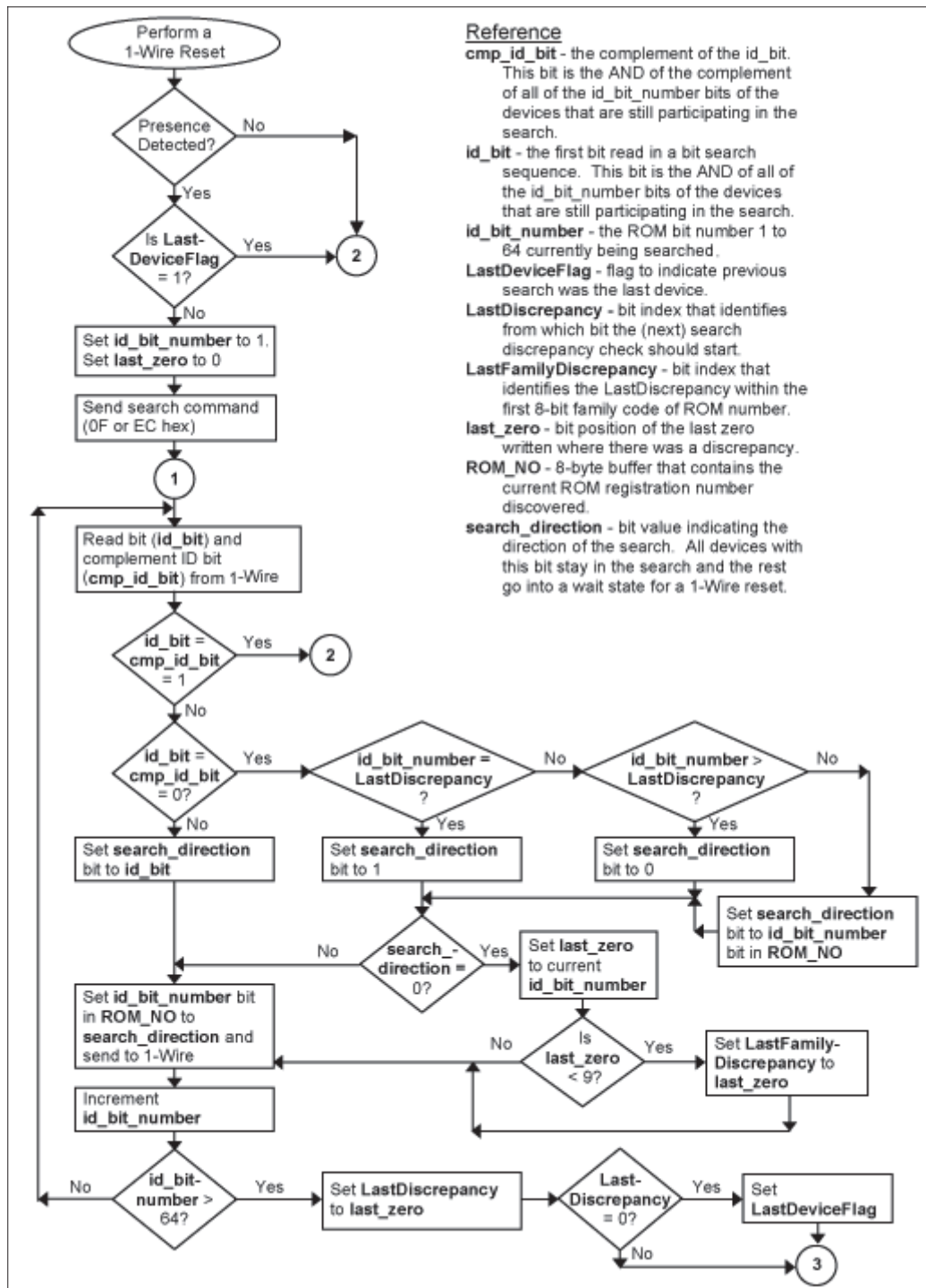


Figure 2. Search flow.

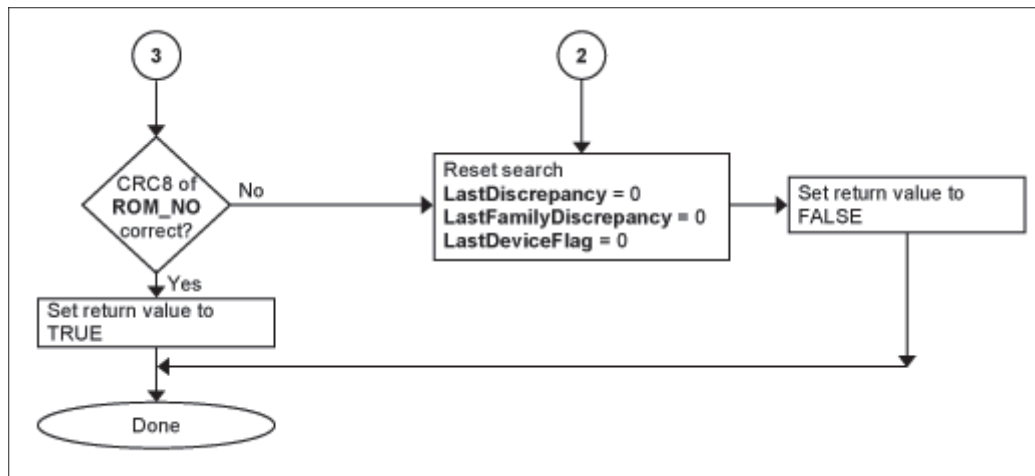


Figure 2. Search flow part II.

There are two basic types of operations that can be performed by using the search algorithm by manipulating the LastDiscrepancy, LastFamilyDiscrepancy, LastDeviceFlag, and ROM_NO register values (see **Table 4**). These operations concern basic discovery of the ROM numbers of 1-Wire devices.

First

The 'FIRST' operation is to search on the 1-Wire **for the first device**. This is performed by setting **LastDiscrepancy, LastFamilyDiscrepancy, and LastDeviceFlag to zero** and then doing the search. The resulting ROM number can then be read from the ROM_NO register. If no devices are present on the 1-Wire the reset sequence does not detect a presence and the search is aborted.

Next

The 'NEXT' operation is to search on the 1-Wire **for the next device**. This search is usually performed after a 'FIRST' operation or another 'NEXT' operation. It is performed by leaving the state unchanged from the previous search and performing another search. The resulting ROM number can then be read from the ROM_NO register. If the previous search was the last device on the 1-Wire then the result is FALSE and the condition is set to execute a 'FIRST' with the next call of the search algorithm.

Figure 3 (a, b, c) goes through a **simple search example with three devices**. For illustration, this example assumes devices with a **2-bit ROM number only**.

Devices

A = 01 (binary: bit 2, bit 1)
B = 00
C = 11

FIRST

bit 1	Read bit	Read complement-bit	Write direction
A	1	0	
B	0	1	
C	1	0	
	0	0	0 (bit position > LastDiscrepancy)
bit 2	Read bit	Read complement-bit	Write direction
A	(wait state)		
B	0	1	
C	(wait state)		
	0	1	0 (only one path available)

Device B is found 00, LastDiscrepancy is now 1

NEXT

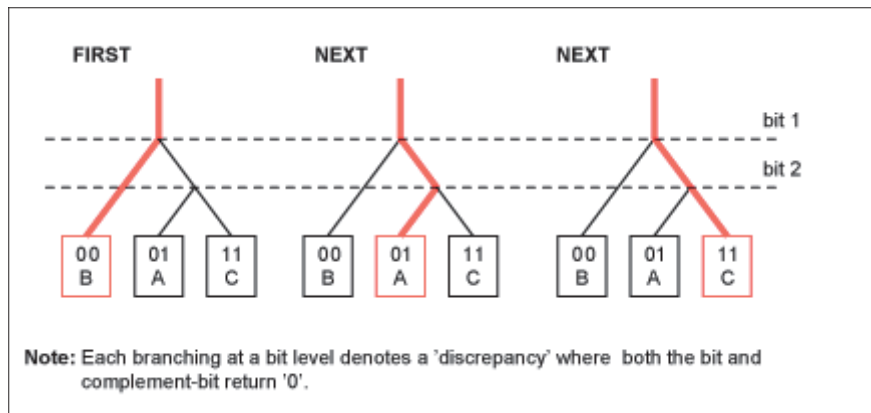
bit 1	Read bit	Read complement-bit	Write direction
A	1	0	
B	0	1	
C	1	0	
	0	0	1 (bit position = LastDiscrepancy)
bit 2	Read bit	Read complement-bit	Write direction
A	0	1	
B	(wait state)		
C	1	0	
	0	0	0 (bit position > LastDiscrepancy)

Device A is found 01, LastDiscrepancy is now 2

NEXT

bit 1	Read bit	Read complement-bit	Write direction
A	1	0	
B	0	1	
C	1	0	(bit position < LastDiscrepancy)
	0	0	1
bit 2	Read bit	Read complement-bit	Write direction
A	0	1	
B	(wait state)		
C	1	0	(bit position = LastDiscrepancy)
	0	0	1

Device C is found 11, LastDeviceFlag is TRUE



(for simplicity the family discrepancy register and tracking has been left out of this example)

FIRST

- ◆ **LastDiscrepancy = LastDeviceFlag = 0**
- ◆ Do 1-Wire reset and wait for presence pulse, if no presence pulse then done
- ◆ **id_bit_number = 1, last_zero = 0**
- ◆ Send search command, 0F hex
- ◆ Read first bit **id_bit**: 1 (Device A) AND 0 (Device B) AND 1 (Device C) = 0
- ◆ Read complement of first bit **cmp_id_bit**: 0 (Device A) AND 1 (Device B) AND 0 (Device C) = 0
- ◆ Since **id_bit_number > LastDiscrepancy** then **search_direction = 0, last_zero = 1**
- ◆ **Send search_direction bit of 0**, both Devices A and C go into wait state
- ◆ Increment **id_bit_number** to 2
- ◆ Read second bit **id_bit**: 0 (Device B) = 0
- ◆ Read complement of second bit **cmp_id_bit**: 1 (Device B) = 1
- ◆ Since bit and complement are different then **search_direction = id_bit**
- ◆ **Send search_direction bit of 0**, Device B is discovered with **ROM_NO** of '00' and is now selected
- ◆ **LastDiscrepancy = last_zero**

NEXT

- ◆ Do 1-Wire reset and wait for presence pulse, if no presence pulse then done
- ◆ **id_bit_number = 1, last_zero = 0**
- ◆ Send search command, 0F hex
- ◆ Read first bit **id_bit**: 1 (Device A) AND 0 (Device B) AND 1 (Device C) = 0
- ◆ Read complement of first bit **cmp_id_bit**: 0 (Device A) AND 1 (Device B) AND 0 (Device C) = 0
- ◆ Since **id_bit_number = LastDiscrepancy** then **search_direction = 1**
- ◆ **Send search_direction bit of 1**, Devices B goes into wait state
- ◆ Increment **id_bit_number** to 2
- ◆ Read second bit **id_bit**: 0 (Device A) AND 1 (Device C) = 0
- ◆ Read complement of second bit **cmp_id_bit**: 1 (Device A) AND 0 (Device C) = 0
- ◆ Since **id_bit_number > LastDiscrepancy** then **search_direction = 0, last_zero = 2**
- ◆ **Send search_direction bit of 0**, Devices C goes into wait state
- ◆ **Device A is discovered with ROM_NO of '01'** and is now selected
- ◆ **LastDiscrepancy = last_zero**

NEXT

- ◆ Do 1-Wire reset and wait for presence pulse, if no presence pulse then done
- ◆ **id_bit_number = 1, last_zero = 0**
- ◆ Send search command, 0F hex
- ◆ Read first bit **id_bit**: 1 (Device A) AND 0 (Device B) AND 1 (Device C) = 0
- ◆ Read complement of first bit **cmp_id_bit**: 0 (Device A) AND 1 (Device B) AND 0 (Device C) = 0
- ◆ Since **id_bit_number < LastDiscrepancy** then **search_direction = ROM_NO (first bit) = 1**
- ◆ **Send search_direction bit of 1**, Devices B goes into wait state
- ◆ Increment **id_bit_number** to 2
- ◆ Read second bit **id_bit**: 0 (Device A) AND 1 (Device C) = 0
- ◆ Read complement of second bit **cmp_id_bit**: 1 (Device A) AND 0 (Device C) = 0
- ◆ Since **id_bit_number = LastDiscrepancy** then **search_direction = 1**
- ◆ **Send search_direction bit of 1**, Devices A goes into wait state
- ◆ **Device C is discovered with ROM_NO of '11'** and is now selected
- ◆ **LastDiscrepancy = last_zero** which is 0 so **LastDeviceFlag = TRUE**

NEXT

- ◆ **LastDeviceFlag** is true so return FALSE
- ◆ **LastDiscrepancy = LastDeviceFlag = 0**

Figure 3. Search Example.

Advanced Search Variations

There are three advanced search variations using the same state information, namely LastDiscrepancy, LastFamilyDiscrepancy, LastDeviceFlag, and ROM_NO. These variations allow specific family types to be

targeted or skipped and device present verification (see **Table 4**).

Verify

The 'VERIFY' operation verifies if a device with a known ROM number is currently connected to the 1-Wire. It is accomplished by supplying the ROM number and doing a targeted search on that number to verify it is present. First, set the ROM_NO register to the known ROM number. Then set the LastDiscrepancy to 64 (40 hex) and the LastDeviceFlag to 0. Perform the search operation and then read the ROM_NO result. If the search was successful and the ROM_NO remains the ROM number that was being searched for, then the device is currently on the 1-Wire.

Target Setup

The 'TARGET SETUP' operation is a way to preset the search state to first find a particular family type. Each 1-Wire device has a one byte *family* code embedded within the ROM number (see Figure 1). This family code allows the 1-Wire master to know what operations this device is capable of. If there are multiple devices on the 1-Wire it is common practice to target a search to only the family of devices that are of interest. To target a particular family, set the desired family code byte into the first byte of the ROM_NO register and fill the rest of the ROM_NO register with zeros. Then set the LastDiscrepancy to 64 (40 hex) and both LastDeviceFlag and LastFamilyDiscrepancy to 0. When the search algorithm is next performed the first device of the desired family type is discovered and placed in the ROM_NO register. Note that if no devices of the desired family are currently on the 1-Wire, then another type will be found, so the family code in the resulting ROM_NO must be verified after the search.

Family Skip Setup

The 'FAMILY SKIP SETUP' operation sets the search state to skip all of the devices that have the family code that was found in the previous search. This operation can only be performed after a search. It is accomplished by copying the LastFamilyDiscrepancy into the LastDiscrepancy and clearing out the LastDeviceFlag. The next search then finds devices that come after the current family code. If the current family code group is the last group in the search then the search returns with the LastDeviceFlag set.

Table 4. Search Variations State Setup				
	LastDiscrepancy	LastFamily-Discrepancy	LastDeviceFlag	ROM_NO
FIRST	0	0	0	Result
NEXT	Leave unchanged	Leave unchanged	Leave unchanged	Result
VERIFY	64	0	0	Set with ROM to verify, check if same after search
TARGET SETUP	64	0	0	Set first byte to family code, set rest to zeros