AN3251

How to Use the SAMA5D2 RTC Under Linux®

Introduction

This application note describes how to enable the internal Real Time Clock (RTC) of the SAMA5D27 in kernel space, and how to use it in user space.

The following concepts of a clock are used in Linux systems:

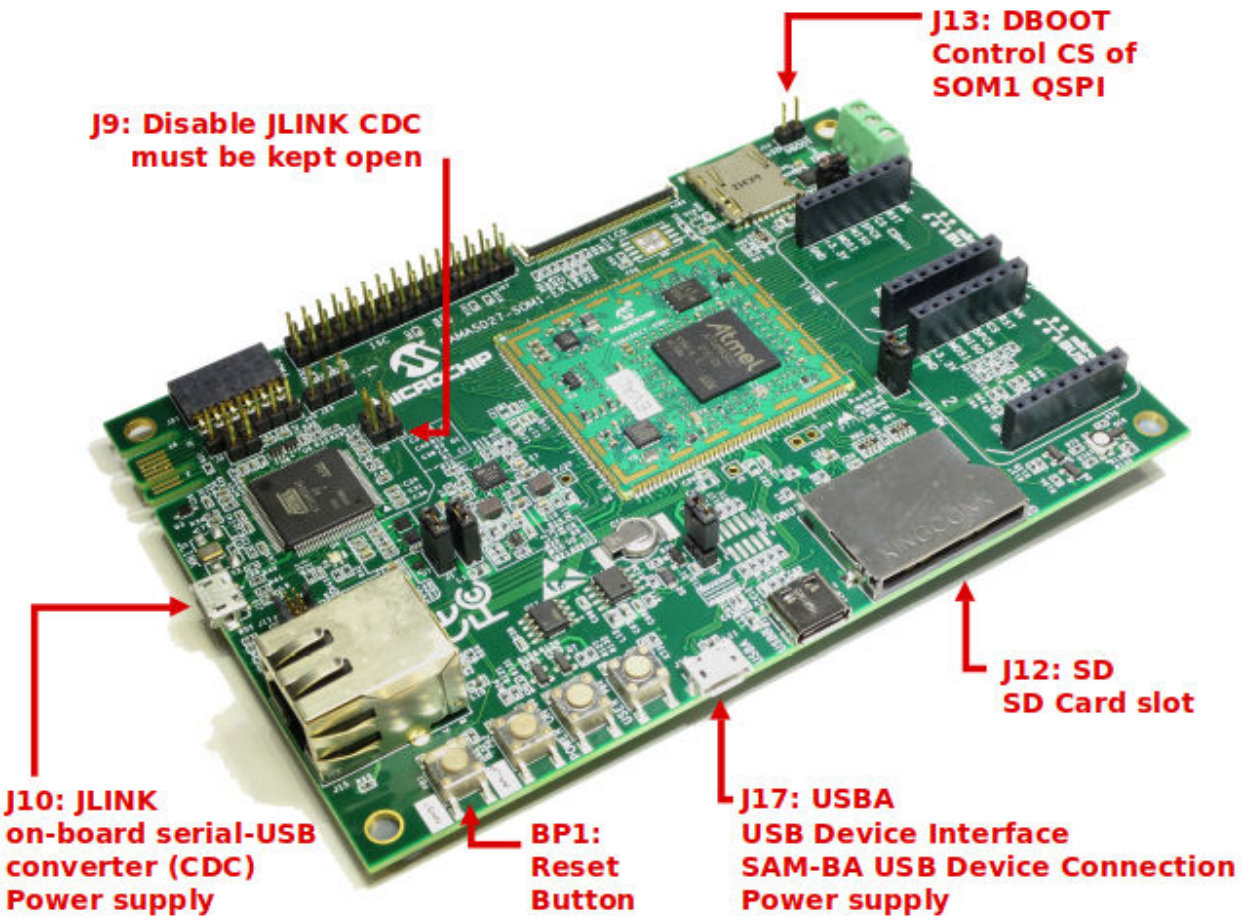
- Wall clock
  - The wall clock is the system clock. The Linux system is running based on this clock. It is hard-coded to run starting from 1970-1-1 and driven by a system tick. The wall clock starts running after a system power-on and stops running when the system powers down. It cannot be used to store real time. The wall clock is updated according to the time of the RTC at system boot.
- Real Time Clock (RTC)
  - This is an external or on-chip device dedicated to the storage of real time.

Reference Documents

Title	Reference	Available
SAMA5D2 Series Datasheet	DS60001476	https://www.microchip.com/design-centers/32-bit-mpus
SAMA5D27 SOM1 Kit1 User Guide	DS50002667	https://www.microchip.com/DevelopmentTools/ProductDetails/PartNO/ATSAMA5D27-SOM1-EK1

Prerequisites

- Hardware
  - PC
  - SAMA5D27 SOM1 Evaluation Kit (Part Number: ATSAMA5D27-SOM1-EK1)
  - SDCard
- Software
  This demo runs on the AT91 Linux platform built by Buildroot. The first step is to set up the AT91 Buildroot development environment. Refer to the web site: http://www.at91.com/linux4sam/bin/view/Linux4SAM/BuildRoot


J13: DBOOT
Control CS of
SOM1 QSPI
J9: Disable JLINK CDC
must be kept open
J12: SD
SD Card slot
J10: JLINK
on-board serial-USB
converter (CDC)
Power supply
BP1:
Reset
Button
J17: USBA
USB Device Interface
SAM-BA USB Device Connection
Power supply

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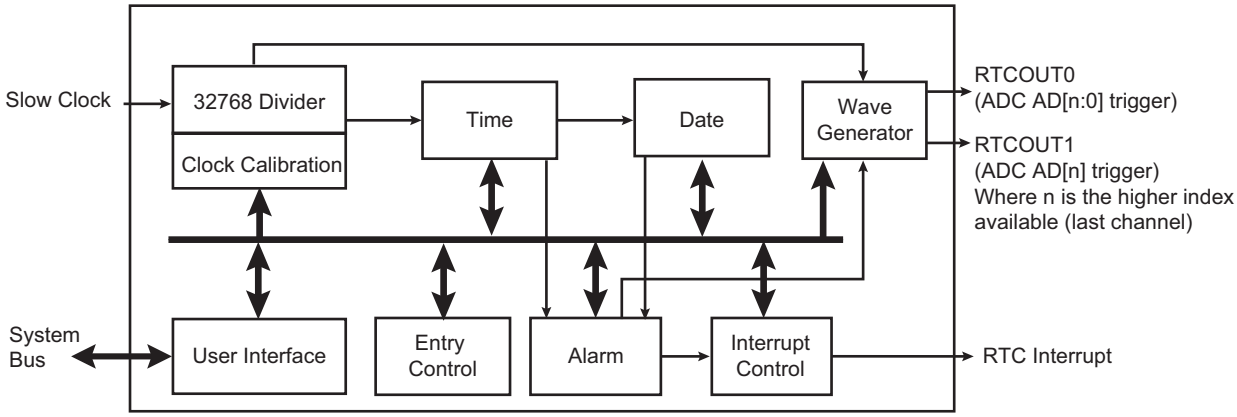
1. Hardware Design

The SAMA5D2 MPU integrates an RTC with the characteristics listed below:

- Full Asynchronous Design for Ultra-Low Power Consumption
- Gregorian, UTC and Persian Modes Supported
- Programmable Periodic Interrupt
- Safety/security Features:
  - Valid Time and Date Programming Check
  - On-The-Fly Time and Date Validity Check
- Counters Calibration Circuitry to Compensate for Crystal Oscillator Variations
- Waveform Generation for Trigger Event
- Tamper Timestamping Registers
- Register Write Protection

Figure 1-1. RTC Block Diagram



2. Software Design

The Microchip Linux platform was built using Buildroot with the following configuration:

atmel_sama5d27_som1_ek_mmc_dev_defconfig

All necessary features for the RTC have been selected in this configuration.

2.1 Device Tree

- Action: no need to change
- Location: buildroot-at91/output/build/linux-linux4sam_6.0/arch/arm/boot/dts
- Sources: sama5d2.dtsi

Device tree for RTC in sama5d2.dtsi:

```
rtc@f80480b0 {
    compatible = "atmel,at91rm9200-rtc";
// specify which driver will be used for this RTC device
    reg = <0xf80480b0 0x30>; // RTC base address is 0xf80480b0, size of register block is 0x30
    interrupts = <74 IRQ_TYPE_LEVEL_HIGH 7>;
// PID of RTC is 74, high level triggered, priority is 7
    clocks = <&clk32k>; // slow clock was used by RTC
};

clk32k: sckc@f8048050 {
    compatible = "atmel,sama5d4-sckc";
// specify which driver will be used for this slow clock device
    reg = <0xf8048050 0x4>;
// slow clock controller base address is 0xf8048050, size of register block is 0x4

    clocks = <&slow_xtal>;
// two clock sources for slow clock controller, external 32.768KHz crystal or internal 64KHz
RC
// here we use the external 32.768 kHz crystal oscillator.
    #clock-cells = <0>;
};
```

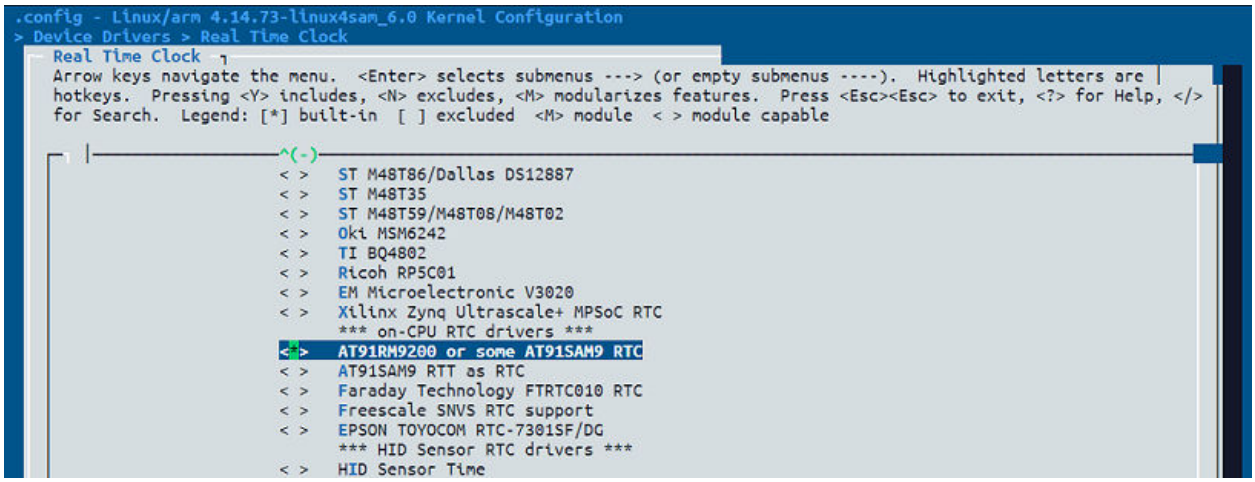
2.2 Kernel

- Action: no need to change
- Location: buildroot-at91/output/build/linux-linux4sam_6.0/
- Defconfig: sama5_defconfig
- Driver files: drivers/rtc/rtc-at91rm9200.c

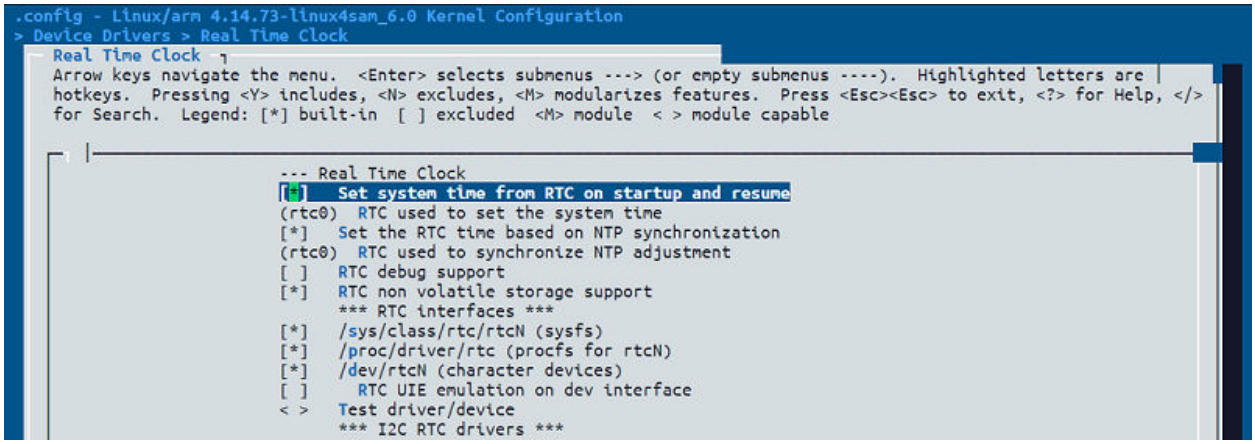
Check the kernel configuration for the RTC function:

```
user@at91:~/buildroot-at91$ make linux-menuconfig
```

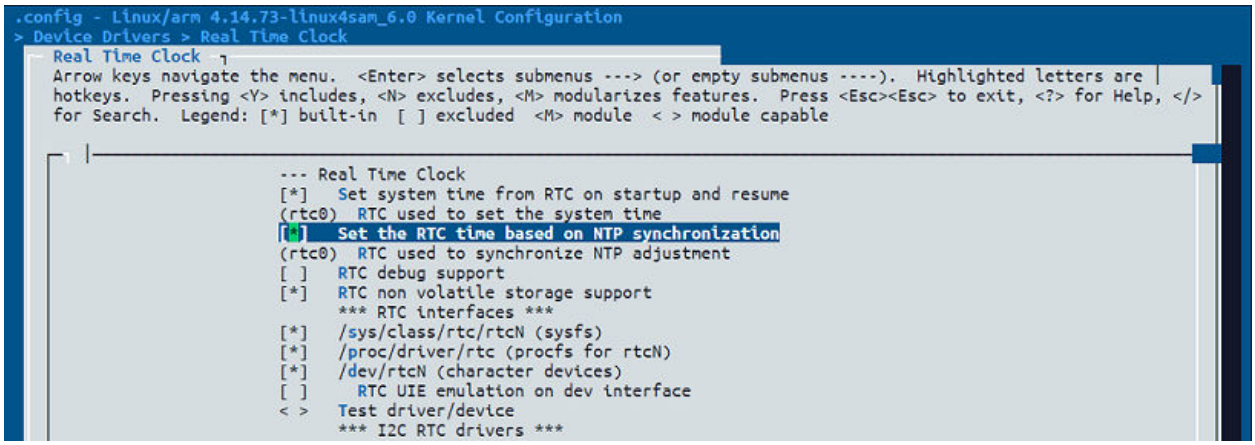
Device Drivers > Real Time Clock >AT91RM9200 or some AT91SAM9 RTC
With this default setting, the RTC driver has been selected.



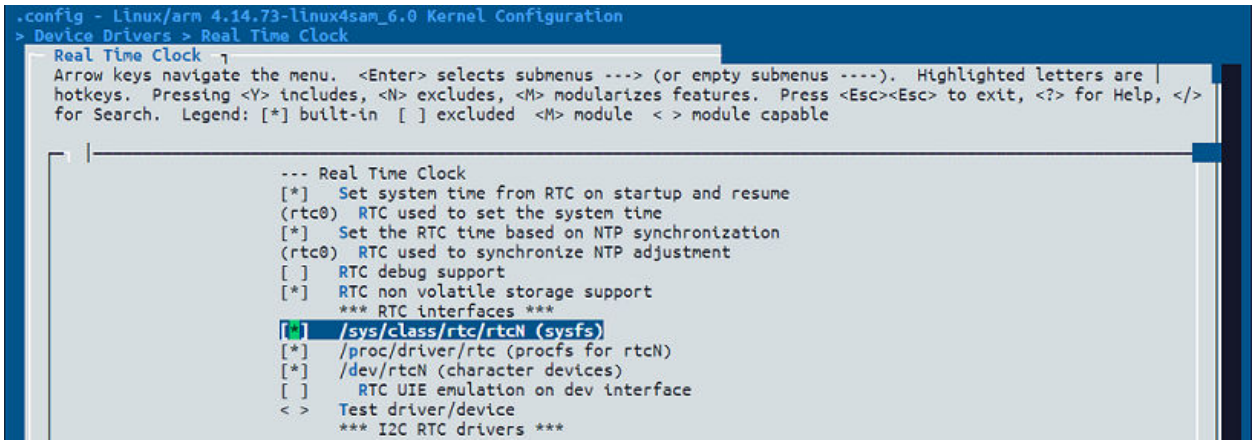
Device Drivers > Real Time Clock >Set system time from RTC on startup and resume
With this feature selected, the system time (wall clock) will be set to use the value read from a specified RTC device.



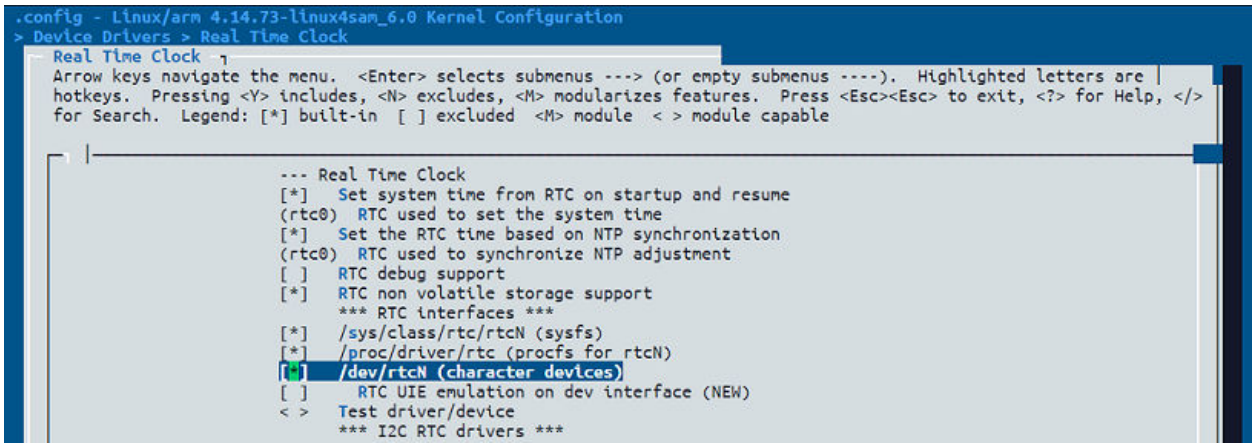
Device Drivers > Real Time Clock >Set the RTC time based on NTP synchronization
With this feature selected, the system time (wall clock) is stored in the RTC specified by RTC_SYSTOHC_DEVICE approximately every 11 minutes if user space reports a synchronized NTP status.



Device Drivers > Real Time Clock >/sys/class/rtc/rtcN (sysfs)
With this feature selected, the RTC driver is easily accessed in command line via sysfs.



Device Drivers > Real Time Clock > /dev/rtcN (character devices)
With this feature selected, the RTC driver can be accessed using standard Linux C language API via the device node of the RTC.



2.3 Rootfs

- Action: no need to change
- Location: buildroot-at91/output/images/rootfs.tar
  (This is not the run time root filesystem)

Three methods (file nodes) can be used to access the RTC driver:

1. /dev/rtc0
   The dev node interface can only be accessed by C language because most of operations must be done by ioctl().
2. /sys/class/rtc
   The sysfs interface is easier to access because all necessary operations can be done by read() and write(). Normally this interface is used in a Scripts program or in command line.
3. /proc/driver/rtc
   The proc interface is used to check the status of the RTC device.

3. Hands-On

3.1 Access with /dev/rtc0

1. hwclock is a Linux command for accessing RTC via /dev/rtcX device node:

```
# hwclock --help
BusyBox v1.27.2 (2019-04-26 11:28:56 CST) multi-call binary.

Usage: hwclock [-r|--show] [-s|--hctosys] [-w|--systohc] [-t|--systz] [-l|--localtime] [-
u|--utc] [-f|--rtc FILE]

Query and set hardware clock (RTC)

        -r      Show hardware clock time
        -s      Set system time from hardware clock
        -w      Set hardware clock from system time
        -t      Set in-kernel timezone, correct system time
                if hardware clock is in local time
        -u      Assume hardware clock is kept in UTC
        -l      Assume hardware clock is kept in local time
        -f FILE Use specified device (e.g. /dev/rtc2)
```

2. Read the RTC time:

```
# hwclock
Wed Jul 24 13:47:14 2019  0.000000 seconds
```

3. Read the time of the wall clock:

```
# date
Wed Jul 24 13:47:54 UTC 2019
```

4. Set the system time from the hardware clock:

```
# hwclock -s
```

5. Set the hardware clock from the system time:

```
# hwclock -w
```

3.2 Access with /sys/class/rtc

1. Read the RTC time and date:

```
# cat /sys/class/rtc/rtc0/time
14:55:22
# cat /sys/class/rtc/rtc0/date
2019-07-24
```

2. Use the RTC alarm to wake up the system:
   2.1. The alarm signal is asserted after 20 seconds:

```
# echo +20 > /sys/class/rtc/rtc0/wakealarm
```

   2.2. Check the current time:

```
# date
Wed Jul 24 23:01:21 CST 2019
```

   2.3. Set the system to standby:

```

# echo standby > /sys/power/state
PM: suspend entry (shallow)
PM: Syncing filesystems ... done.
Freezing user space processes ... (elapsed 0.001 seconds) done.
OOM killer disabled.
Freezing remaining freezable tasks ... (elapsed 0.001 seconds) done.
```

```
Suspending console(s) (use no_console_suspend to debug)
atmel_usart_serial atmel_usart_serial.0.auto: using dma0chan5 for rx DMA
transfers
atmel_usart_serial atmel_usart_serial.0.auto: using dma0chan6 for tx DMA
transfers
OOM killer enabled.
Restarting tasks ... done.
PM: suspend exit
```

2.4. Check the wake-up time:

```
# date
Wed Jul 24 23:01:42 CST 2019
```

3.3 Access with /proc/driver/rtc

1. Check the status of the RTC device:

```
user@at91:~$ cat /proc/driver/rtc
rtc_time        : 07:08:08
rtc_date        : 2019-07-24
alrm_time       : 06:24:45
alrm_date       : 2019-07-10
alarm_IRQ       : no
alrm_pending    : no
update IRQ enabled      : no
periodic IRQ enabled    : no
periodic IRQ frequency  : 1024
max user IRQ frequency  : 64
24hr            : yes
periodic_IRQ    : no
update_IRQ      : no
HPET_emulated   : yes
BCD             : yes
DST_enable      : no
periodic_freq   : 1024
batt_status     : okay
```

4. Time Zone

The time zone feature is supported by Buildroot and can be selected using the following path:

user@at91:~/buildroot-at91$ make menuconfig

The dates and times in the following lines are examples.

1. System configuration >

```
[*] Install timezone info
                    (default) timezone list
                    (Etc/UTC) default local time
```

2. Rebuild your Buildroot and burn with the updated sdcard.img: **user@at91:~/buildroot-at91$ make**
3. Check the time zone information on the target board. UTC was used as the default setting:

```
# ls -l /etc/TZ
lrwxrwxrwx  1 root  root  32 Jul 23 18:17 /etc/TZ -> ../usr/share/zoneinfo/uclibc/UTC
```

4. The following log shows how many time zones have been predefined on the target:

```
# ls /usr/share/zoneinfo/uclibc/
Africa      Chile       GB-Eire     Israel      Navajo      US
America     Cuba        GMT         Jamaica     PRC         UTC
Antarctica  EET         GMT+0       Japan       PST8PDT     Universal
Arctic      EST         GMT-0       Kwajalein   Pacific     W-SU
Asia        EST5EDT     GMT0        Libya       Poland      WET
Atlantic    Egypt       Greenwich   MET         Portugal    Zulu
Australia   Eire        HST         MST         ROC
Brazil      Etc         Hongkong    MST7MDT     ROK
CET         Europe      Iceland     Mexico      Singapore
CST6CDT     Factory     Indian      NZ          Turkey
Canada      GB          Iran        NZ-CHAT     UCT
```

5. The default time zone is UTC, local time is 13:52:41:

```
# date
Wed Jul 24 13:52:41 UTC 2019
```

6. Now let's change the time zone to Asia Shanghai. The modified time zone is CST, local time is changed to 21:53:46 (+8 hours):

```
# ln -s -f /usr/share/zoneinfo/uclibc/Asia/Shanghai /etc/TZ
# ls -l /etc/TZ
lrwxrwxrwx 1 root root 40 Jul 24 21:53 /etc/TZ -> /usr/share/zoneinfo/uclibc/Asia/
Shanghai
# date
Wed Jul 24 21:53:46 CST 2019
```

5. Revision History

5.1 Rev. A - 09/2019

First issue.

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