Mobile Workstation MW-520
Unit Operation During Excessive Temperature Conditions
05 April 2000

1. INTRODUCTION

As a mobile computing device, the MW-520 employs several hardware components whose proper performance and reliability depend on the ambient temperature in which the MW-520 can be operated. We have found that many of our customers have had questions concerning the MW-520 and its operation within environments of excessive heat. This paper identifies the operating temperature range, discusses the thermal monitoring control system and power management system designed to reduce excessive heat conditions, and provides suggestions on how to maximize the benefit provided by these features. It is hoped that this information addresses the questions concerning the unit and provides a basis for further discussions, should any other questions or concerns arise.

2. OPERATING TEMPERATURE RANGE

The ambient operating temperature range of the MW-520 has been set at 0° to 50°C (32° to 122°F) in order to prevent the unit from operating improperly as well as to protect sensitive components from potential wear or even permanent damage. This range refers to the environmental temperature conditions of the vehicle containing the MW-520. It represents the widest range available that still maintains the level of protection necessary to allow the MW-520 to meet all of Motorola's strict performance and quality standards. The limits were set based on the results of extensive long-term testing on the performance and durability of key components, such as the hard drive, CPU, and active matrix thin-film transistor (TFT) LCD at a variety of different operating temperatures and conditions.

Beyond stating an environmental operating temperature range specification, Motorola, unlike laptop manufacturers, has designed thermal protection into the MW-520 that will prevent the unit from being operated in temperatures that would compromise performance or reliability.

3. ADVANCED POWER MANAGEMENT FUNCTIONALITY

The MW-520 supports Advanced Power Management functionality in order to provide optimum power conservation. This functionality provides heat dissipation within the MW-520 and efficient battery usage within the vehicle.

The MW-520 Advanced Power Management function has three modes of operation: 1) "Full On" state which produces maximum power consumption; 2) "Idle and Standby" state which provides partial power reduction, and 3) "Suspend" state which provides full power reduction. The "Full On" state occurs when there is user activity such as typing text messages, report writing or applications are processing information. The "Idle or Standby" state occurs during brief periods of inactivity in which there is no user input (typing on keyboard) or applications processing information. The "Suspend" state occurs after longer periods of inactivity. The partial power savings of the "Idle and Standby" state are achieved by controlling the Central Processor Unit clock speed and turning off of the hard disk. The "Suspend" state achieves full power reduction by turning off the microprocessor and DMA clocks, video (including backlight), and all controllable peripheral devices. Configuration settings in the MW-520 BIOS and Operating System determine the inactivity periods required to enter the power management modes.

The MW-520 can be automatically or manually put into suspend mode. Automatic suspend activation is enabled in the BIOS setting of the MW-520. This setting is adjustable from 5 to 60 minutes with a 10-minute default value. The MW-520 is manually put into suspend by depressing the suspend button located on the MW-520 display panel.

Power management benefits ignition-sensed as well as non-ignition-sensed installations. An ignition-sensed installation allows operation of the MW-520 only when the vehicle ignition is on. A non-ignition-sensed installation allows operation of the MW-520 regardless of the ignition state.. If the installation is

configured so that the MW-520 is operational only when the vehicle ignition is on, the operator may choose to engage power management manually or allow it to be engaged automatically.

The power management function, initialized when the unit is in a suspend state, reduces power consumption and heat generation within the unit. Therefore, it minimizes the risk that the high temperature shutdown timer will be engaged (as explained in Section 4) when maximum temperature thresholds are reached. Appendix A.1 contains a flow chart that shows how the suspend state and power management function work together.

4. TEMPERATURE MONITORING AND CONTROL SYSTEM

In addition to the power management functionality, the MW-520 also contains a software-based and a hardware-based temperature monitoring and control system. This system is responsible for sensing the temperature in the CPU and display units, and determining if it is safe for the unit to continue operating. Since temporary operation of the MW-520 at environmental temperatures above 122°F does not cause any wear or damage to the internal components of the MW-520, the temperature monitoring and control system has been programmed to allow start-up and operation at environmental temperatures above 122°F. As a result, the MW-520 is allowed to begin operating when the vehicle is first started, even if environmental conditions exceed 122°F, providing an opportunity for the vehicle's air-conditioner to bring the temperature down below 122°F. A description of this system is contained in the following sections. Appendices A.2 and A.3 contain flow charts that show how this system works for the CPU and display.

4.1 CPU Thermal Protection

The MW-520 startup routine includes a check of the internal temperature of the CPU and is continuously monitored during operation. The action of the CPU thermal protection mechanism is based on whether the measured internal temperature is below 60°C (140°F), between 60°C (140°F) and 80°C (176°F), or above 80°C(176°F). The CPU thermal protection mechanism operates as follows:

If the internal temperature is below 140°F, the device starts up and operates normally. No thermal protection timers are initialized.

If the internal temperature is above 140°F and below 176°F on power up, the device will start normally and activate the first 30-minute thermal protection timer. No notification is given to the user at this time since it is assumed that the user will take action to cool the passenger compartment. If the temperature has not cooled to below the threshold before the 30-minute timer expires, the user will receive a high temperature notification warning and the temperature LED will start blinking red. The user should select the OK button to confirm this message and take actions to cool the unit and continue operations. If the internal temperature continues to exceed 140°F, a second 10-minute thermal protection timer will be initiated. If this 10-minute timer expires, the user receives a second high temperature notification warning. The user should select the OK button, close the applications, and turn-off the MW-520. If the user does not shutdown the MW-520, it will automatically perform an orderly shutdown after the 3-minute timer expires. If the internal temperature drops below 60°C (140°F) at any point after the first user message, a dialogue box stating that the internal temperature is within operating range appears. The thermal protection mechanism timers are reset and operation of the MW-520 can resume.

At any time during the high temperature shutdown process, the user may clear the notifications manually by closing the dialogue box. However, if the user chooses not to clear the notifications, upon receipt of a radio transmission, all the high temperature notifications will be placed in the background of the application that is currently running while the temperature light continues to flash. The flashing LED serves as an indication that the unit needs to be cooled while allowing the operator continued use of the MDT application.

If the internal temperature is above 80°C (176°F), the MW-520 will not power on until the temperature is reduced. This condition is indicated by the lighting up off all display LED's for one second and then turning off.

4.2 Display Thermal Protection

The MW520 startup routine includes a check of the internal temperature of the display and is measured continuously during operation. If the internal display temperature rises above 68°C (154°F), the thermal protection mechanism disables the backlight to prevent damage to the liquid crystal display. The temperature LED on the display will flash when the internal display temperature is above 68°C (154°F).

5. SUMMARY

Motorola, unlike laptop manufacturers, has designed thermal protection into the MW-520 that will prevent the unit from being operated in temperatures that would compromise performance or reliability. This approach to effective thermal management in the MW-520 comes at a time when most manufacturers of competing mobile computer products publish an operating temperature specification, but offer no means of actual protection for their equipment from temperatures outside the specified range. The thermal shutdown timer and power management values were designed to give the user the greatest operational flexibility while still providing the maximum level of protection for the MW-520 components. Extensive testing has proven that this mechanism is safe and effective for regular and repeated MW-520 operation.

These systems remove the burden on the user to measure and monitor the vehicle temperature or risk damage to their equipment.

6. APPENDIX

The following sections contain additional information that may aid users in their understanding of the power management feature and thermal protection system.

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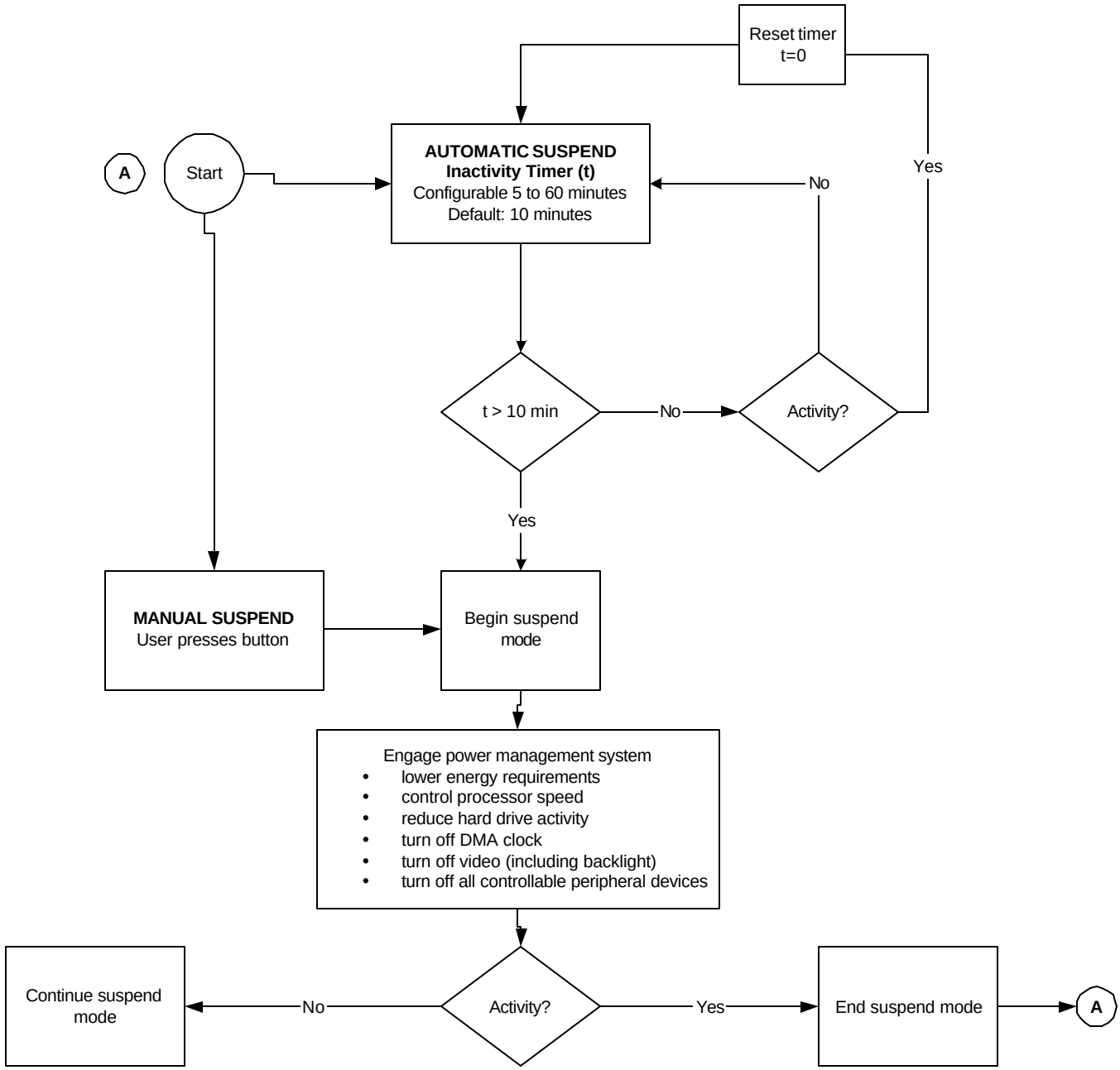
Appendix A.1 – Suspend State and Power Management Flow Chart



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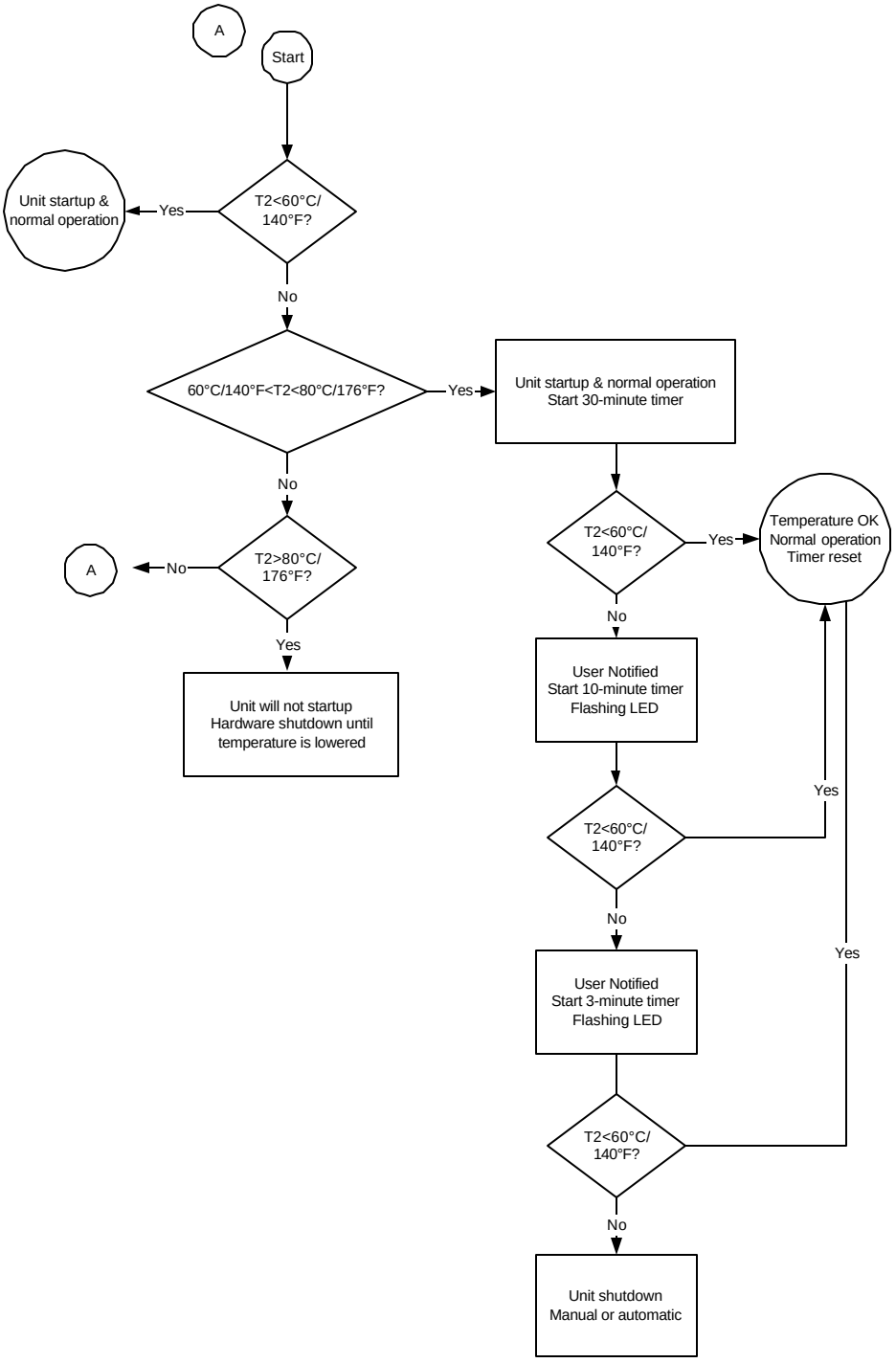
Appendix A.2 – CPU Temperature Monitoring and Control System Flow Chart



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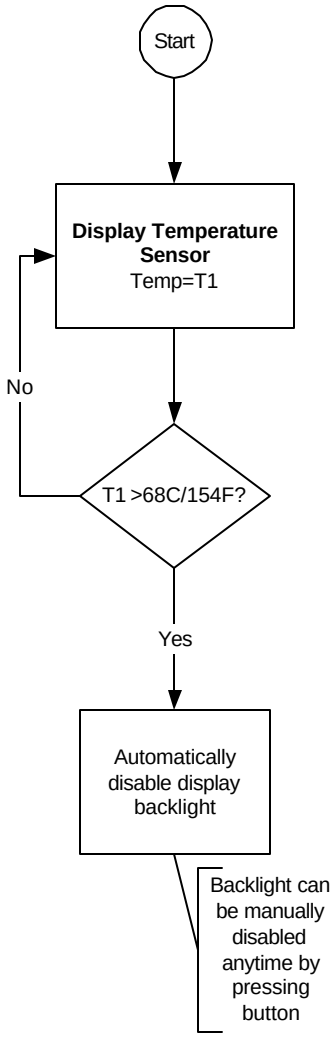
Appendix A.3 – Display Temperature Monitoring and Control System Flow Chart



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Appendix A.3 - Frequently Asked Questions

a) Are there ways to optimize the benefits that are derived from the power management functionality so that less heat is generated in the MW-520?
Yes. As stated in the write-up, power management is implemented when the MW-520 is allowed to enter a "suspend" state, whether that state occurs automatically or manually. In a "suspend" state, the energy demands of the vehicle battery are reduced and the production of heat is lowered. Therefore, ensuring that the unit is placed in a "suspend" state when not in use is one way to reduce heat generation and avoid excessive heat conditions.

b) Can the automatic suspend time interval be adjusted to increase the frequency of a unit entering a suspend state and thus minimizing the heat generated within the MW-520?
Yes. The factory default "Auto Suspend Timeout" interval is ten (10) minutes. If a system makes extensive use of broadcast messaging (or "all call" messages to the mobile devices) or other features that may keep the unit active, it is possible that the unit is never inactive long enough to enter a suspend state where power consumption and heat production is minimized. Therefore, adjusting the BIOS "Auto Suspend Timeout" to five (5) minutes increases the possibility of the MW-520 to enter the low power consumption mode associated with a suspend state. This can help reduce the overall temperature of the unit.

c) When the unit enters a "suspend" state, can messages still be delivered?
The answer to this question depends on the configuration of the modem. The MW-520 RF modem can be configured in a manner that does not allow message delivery from the modem to the mobile messaging application while in suspend state, interfering with the delivery of messages to the user in the field. Therefore, when the modem is configured in this manner and the MW-520 is in a suspend state, messages will not be delivered to the messaging application. This situation occurs when the modem DTE parameter "On-line Deliver Style" is set to "Deliver Immediately".

To prevent this situation from happening, , it is recommended that the modem DTE parameter "On-line Deliver Style" be set to "Wait for DTR". This parameter change will allow the MW-520 to wake from a suspend state when an outbound message is received by the modem. The modem will then deliver the message to the messaging application. The user is then notified that a new message has been received by the messaging application.

d) Given that the ambient temperature inside a closed vehicle without the air conditioner running can frequently rise above 50°C (122°F), especially in warmer climates, is there a way to reduce the cases when the display screen enters a thermal protection mode?
While warmer climates have longer periods where the temperature in closed car conditions can rise above 122°F, these conditions also occur in northern states during the summer months. If the MW-520 is in an environment above the operational temperature, it is recommended that it is either turned off or allowed to be in suspend mode to keep internal heat production minimized.

The display is not capable of remaining in a full power consumption mode in environments above the operating temperature range of 122°F and does not enter the thermal protection mode until the internal temperature of the display exceeds 154°F. Once the temperature exceeds this maximum limit, the display backlight is turned off, and can not be enabled until measures are taken to cool down the display. End users may not have the time to cool down the display, and therefore a method to reduce the occurrence of a shutdown condition is required. There are several ways to accomplish this.

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The simplest way to reduce the occurrence of thermal protection and prevent shutdown is to reduce the overall ambient temperature of the operating environment. Slightly opening a window on both sides of the vehicle prior to leaving the vehicle should provide enough cross ventilation and air circulation to reduce the ambient operating temperature within the vehicle.

Another way to prevent the shutdown is to turn-off the display backlight prior to leaving the vehicle unattended for extended periods of time. The backlight is the primary source of internal heat build up in the display and is active whenever the MW-520 is not in suspend state unless it is turned off manually by the user. Manually turning off the backlight ensures that it is turned off, reducing the amount of heat generated in the display. Upon returning to the vehicle, the display backlight can be turned back on by pressing the backlight button on the display. The air temperature inside the car starts to cool as soon at the door is opened, and if necessary, continues to cool with the windows rolled down or the use of the air conditioner until the user is comfortable. This is an alternative to the user having to take the time to cool the display after returning to the vehicle in the conditions listed above.

e) The thermal monitoring and control system uses three timers – 30-minute, 10-minute, and 3-minute to provide the user with three opportunities to cool down the unit prior to automatic shutdown. Can the duration of these timers be modified?

No. The timer values are manufacturers' settings, not configurable parameters. Therefore, these settings can not be changed.