During normal operation, an electronic system generates wasted heat that can cause malfunctions and damage components unless you remove it. In an ideal world, you would have the time and resources to perform a rigorous evaluation of an electronic system's cooling requirements early in the design phase and thus avoid the cooling errors others have made in the past (Reference 1). However, circumstances often demand a diagnostic evaluation of a system's cooling methods or a rapid estimate of a proposed system's cooling requirements. For these purposes, you don't need an advanced degree in computational fluid dynamics; this Design Idea outlines a method that may be all that's necessary.

**Figure 1** shows a typical cabinet-mounted electronic system that includes two power supplies, a pc board, and a display. For simple products, you can assume that all of the power entering the cabinet from the ac power line ultimately converts into heat that dissipates within the cabinet. After you calculate the system's ac and dc power requirements, you can estimate the amount of power that the cooling method must dissipate. As a rule of thumb, the thermal capacity of air is 0.569W-minute/°C/ft$^3$ (Reference 2). That is, one cubic foot per minute of moving air can transfer 0.569W of dissipated heat for a 1°C temperature change. You can also express this rule as its reciprocal: To dissipate the heat 1W of power produces and maintain a 1°C temperature change, you need to provide an air stream of 1.757 cfm (cubic feet/minute). Thus, once you determine the wattage dissipated within a system and specify an allowable internal temperature rise, you can estimate a cooling fan's required air-movement capacity rating in cubic feet/minute.
To estimate a system's cooling requirements, you can simplify the thermal model to comprise an ac-power input and a dissipated-heat output.

However, a cooling fan's maximum rating in cubic feet/minute occurs only at zero static pressure, or back pressure, an operating condition that you don't realize in practice. You derate the fan's air-movement ability based on either measurements or estimates of the back pressure in the system's cabinet. (A manometer-style gauge measures air-pressure differentials in units of inches of water—that is, the height in inches of a column of water supported by the difference between ambient air and pressurized air within an enclosure.) For example, a manometer might display a pressure differential of 0.10 to 0.15 in. of water across a mostly clogged dust filter. When you plot the pressure versus airflow-volume curve for a typical 100-cfm fan, this pressure differential might reduce the fan's airflow volume to only 50 cfm.

In a sample calculation, a system uses 70% of a single ac/dc 400W power supply's output that operates at 75% efficiency—that is, the supply contributes 25% of its output as heat. The system's fan or fans must remove all of the resultant waste heat, as follows: \( P_{\text{DISS}} = 125\% \times 400\text{W} = 500\text{W}; 70\% \times 500\text{W} = 350\text{W}. \) Design the system for operation in ambient air that's no hotter than 35°C (95°F). The system's heated exhaust air must not exceed a worst-case temperature of 50°C (122°F), producing a temperature difference, \( T_D \), of 15°C. Next, calculate \( n \), the effective airflow required, in units of cubic feet/minute: \( n(\text{cfm}) = k \times P_{\text{DISS}} / T_D \), where \( k = 1.757 \text{ cfm} \times ^\circ \text{C}/\text{W}. \) Solving for \( n \) yields: \( n = 1.757 \text{ cfm} \times ^\circ \text{C}/\text{W} \times 350\text{W}/15^\circ \text{C} = 40.99 \text{ cfm}. \)

Select a fan and examine its pressure versus-airflow-volume curve (Figure 2). At an airflow of 41 cfm, the fan's static pressure curve shows 0.1 in. of water within the fan's normal operating range. (For additional information on fans and their characteristics, see Reference 3.)
You can use a fan’s airflow-versus-pressure difference curve to determine whether the fan
will provide adequate cooling in your application.

References
1. Kordyban, Tony, "Ten stupid things engineers do to mess their cooling," Electronics Cooling,
   January 2000.