Units, Pseudo-Units, Scaling Factors, and Units Conversion

单位、伪单位、比例因子和单位转换

Physical quantities are represented mathematically by numbers indicating their amount. Depending on whether the quantity is discrete or continuous, integers, rational numbers, or real numbers are used. Quantities such as the complex frequency, s, require complex numbers. All of these numbers, however, are incomplete in themselves in that they do not adequately represent physical quantities. The additional connection between numbers and the physical world is achieved through the use of units.

物理量用数字表示，表示它们的数量。根据数量是离散的还是连续的，使用整数、有理数或实数。诸如复数频率s这样的量需要复数。然而，所有这些数字本身都是不完整的，因为它们不能充分代表物理量。数字和物理世界之间的附加连接是通过使用单位来实现的。

A unit is the amount of a quantity that is one of it, the unity amount - hence the name for unit. A unit is something that exists in the physical world, not in mathematics as such, and is brought into math as a symbol that is attached to the number representing the amount of the quantity. For instance, through physical description, an ampere of current is a certain amount of the familiar quantity, with a standard abbreviation of A. If the amount of current in amperes is a number, n, then n A is a complete mathematical description of the value of the quantity.

一个单位是一个量的数量，它是一个单位的单位，它是一个单位。一个单位是存在于物理世界中的，而不是在数学中，它被作为一个符号连接到数学中，这个符号被表示为数量的数量。例如，通过物理描述，安培电流是已知量的一定量，具有A的标准缩写。如果安培的电流量是n，则n是对量的值的完整数学描述。



图1: Units and Computer Math

图1: 单元与计算机数学

The mathematical relationship between the amount and unit is essentially that of multiplication. Although the unit is not a number and thus cannot be multiplied, it can be treated as though it were a number, to allow mixing amounts and units in units conversion. More precisely, the amount and unit form a couple defining the value of the quantity. Computer math programs have necessitated the refinement of mathematical notation in that a more rigorous way to specify the quantity is n x A. This is n times the amount of one ampere, which has an unambiguous physical value.

数量与单位之间的数学关系本质上是乘法。虽然单位不是一个数字，因此不能相乘，它可以被视为是一个数字，允许混合单位转换的数量和单位。更确切地说，数量和单位组成一对夫妇定义数量的价值。计算机数学程序有必要改进数学符号，因为更精确的方法是指定量为n x A。这是一安培的N倍，这是一个明确的物理值。

Units are thus able to be accounted for mathematically and regarded as constants. Their actual values must come from physical interpretation and cannot be computed or derived mathematically. This does not prevent us from combining them mathematically, and even defining them using predefined units. Systems of units, such as the metric (MKS, or the present refinement, the SI) or English, reduce the number of independent units to only a few, such as length, time, mass, and charge. The metric system includes mass as a fundamental quantity and force is expressed in fundamental quantities. In the English system, force is regarded as fundamental, leading to pounds-force (lbf) as a distinct quantity from pounds-mass (lbm) or slugs.

因此，可以用数学方法计算单位，并将其视为常数。它们的实际值必须来自物理解释，不能用数学来计算或推导。这并不能阻止我们在数学上进行组合，甚至使用预定义的单元来定义它们。系统的单位，如度量（MKS，或目前的细化，Si）或英语，减少独立单元的数量很少，如长度、时间、质量和电荷。公制包括质量作为基本量，力用基本量表示。在英语中，力是根本，导致磅力（LBF）作为一种独特的数量质量（LBM）或蛞蝓。



图2: Pseudo-Units and Scaling Indicators

图2: 伪单位和标度指示器

Some mathematical constructs are sometimes made to appear as units but they are scale factors instead. The decibel (dB) is defined as

有些数学结构有时以单位形式出现，但它们是比例因子。分贝（分贝）被定义为

where x is expressed in dB. Although dB is written after the number x indicating how many dBs, dB is not really a unit. It cannot be expressed in the fundamental units of the SI system. It can only be applied to unitless quantities, or numbers; x must be unitless. Sometimes dB is written in parentheses after the symbol for the quantity to show that dB is not a unit but that the quantity is scaled (logarithmically) in dB, as defined above. It can be used with quantities that have units, such as power, p, measured in units of watts, W, but only as ratios;

其中x是用db表示的。虽然DB后数x表示多少星展写的，DB是不是真的一个单位。它不能用SI系统的基本单位来表示。它只能应用于多个数量或数字。有时DB写在括号中的数量表明DB不是一个单位但数量比例符号后（对数）dB，如上定义。它可以与单位数量，如功率，P，用单位瓦特，W，但只作为比例；

where p (dB) is power, expressed in decibels with respect to P, the reference amount of power that is 0 dB. Logarithmic scaling is used to compress quantities that range over many decades into a more convenient scale, allowing us to think of amounts in powers of ten rather than the amounts themselves.

其中p（DB）是功率，以分贝表示，p，参考功率为0分贝。对数标度被用来压缩几十年的数量，使之更为方便，使我们能够考虑十的幂，而不是数量本身。

To be consistent with the above use of the dB scale to scale power, then voltage or current, x, both of which vary as the square with respect to power are expressed in a consistent logarithmic scale as

为了符合上述分贝刻度的使用功率，那么电压或电流，X，这两个随着功率的平方不同，以一致的对数刻度表示。

where X is the reference (0 dB) value of x. In all cases, x and X must be in the same (or convertible) units so that their ratio is unitless.

其中x是参考（0分贝），在所有情况下的值，x和x必须在同一单位（或转换），比无单位。

It is not necessary to use dB for logarithmic scaling. In electrical engineering, it has become commonplace, but logarithmic scaling of quantities can be presented in the more natural scale of octaves or decades. This avoids confusion with reference quantities. (Is it 10 or 20 dB per decade?) I have quit using dB and have reverted to the less cumbersome decade (dec) or octave (oct) for logarithmic scaling, where orders of magnitude are decades. Please join me in reviving the decade as the logarithmic scale factor in preference to dB.

没有必要使用DB进行对数标度。在电气工程，这已经司空见惯，但数量对数缩放可以在八度或几十年的更自然的尺度。这避免了参考量的混淆。（每十年10或20分贝？）我已经放弃使用DB已经恢复到较繁琐的十年（DEC）或倍频程（OCT）对数标度，在量级几十年。请和我一起，把十年作为对数比例因子恢复到db。

Another quantity that is not really a unit either is the radian (rad). There are 2&#960; radians per revolution or cycle of a circle. In trigonometry, the measure of angle is defined based on the unit circle, a circle of radius one with center at the origin, (x, y) = (0, 0) of the coordinate system. Then the definition of sine and cosine of angle &#952; is: x = cos&#952; and y = sin&#952;. This is basic trigonometry and does not involve physical quantities directly. The distance along the circumference of the circle equal to the radius is subtended by an arc having an angle of 1 radian, by definition. Yet there is nothing requiring that a unit of angular measure be introduced. The angle subtended is a ratio of lengths, of that along the circumference over the radius.

另一个不是单位的量也就是弧度（RAD）。有2 # 960；每一个圆弧度的革命或周期。在三角法中，角的度量是以单位圆为基础的，圆半径为原点的圆，坐标系的（x，y）＝（0, 0）。然后，正弦和余弦角# 952定义；是：x = COS和# 952；y =罪与# 952；。这是基本三角，不直接涉及物理量。沿圆等于半径的圆周的距离是以具有1弧度角弧形，由定义。然而，没有什么要求引入角量单位。角是长度比，即沿圆周的半径。

The motivation to call this ratio a unit arises because of other angular measures. I know of three. Besides the grad, which is a kind of decimal degree and a European measure that divides the circle into 400 parts (an even 100 per quadrant), there are revolutions (or cycles) and degrees. The degree is an angular measure shrouded in ancient history, going back to the Chaldeans, with their dual base-6, base-10 mathematics and 360-day year. The year is, of course, associated with the earth going around the sun in the circle of its orbit, and it is not unexpected that the circle would be divided into 360 degrees of angle. This is more of a physically derived unit of angle - indeed, a geocentric measure - than purely mathematical. Consequently, the degree as an angular scaling indicator, despite how deeply entrenched it is in engineering and science, is an artificial and somewhat arbitrary measure. I have begun to disabuse myself of it, preferring instead the more natural measures of radian and revolution.

将这个比率称为单位的动机是因为其他的角度度量。我知道三个。除了毕业，这是一种十进制度和一个欧洲的措施，分为400个部分（每100甚至象限），有革命（或周期）和学位。度角测量笼罩在古老的历史，追溯到迦勒底人，用他们的双重基底-6、10数学和360天的一年。当然，这一年与围绕太阳轨道运行的地球相联系，这一点也不出人意料，这个循环将被分成360个角度。这是一个物理导角的单位-事实上，地心的措施比纯粹的数学。因此，作为一个角标度指示器，尽管它在工程和科学上有多么根深蒂固，但它是一种人为的、有点武断的度量。我已经开始纠正自己，而是弧度和革命更自然的措施。

In electrical engineering, frequency is expressed in inverse seconds, s&#8722;1, though sometimes rad/s is used for radians per second. However, in carrying out math on units, there is often nothing to cancel the radians unit. It is a pseudo-unit, a scaling factor given a name to distinguish it from degrees and revolutions. In this use, it functions well, but to apply it as a unit can lead to puzzlement and confusion. It is better to not introduce it as a unit into engineering calculations. It functions as a scale factor for angles. Hence, natural frequency is expressed in units of s&#8722;1.

在电气工程，频率是秒的倒数表示，标# 8722；1，尽管有时rad/s用于弧度/秒。然而，在进行数学上的单位，往往有没有取消弧度单位。它是一个伪单位，一个比例因子，给出一个名称来区分它的度数和转数。在这种用法中，它起着很好的作用，但是把它作为一个单元来应用可能会导致困惑和困惑。最好不要把它作为一个单元引入工程计算。它用作角的比例因子。因此，固有频率在8722的#单位表示；1。

As a scaling factor, the relationship between radians and revolutions is simply that there are &#960; rad/rev and

作为一个缩放因子，弧度与革命之间的关系很简单，有# 960弧度/转速；

where a revolution (rev), as used more commonly in mechanical engineering, is the same as a cycle in electrical engineering.

在机械工程中，更常用的一种革命是与电气工程中的循环一样。

One occurrence of the need to resolve angular units (again, involving frequency) are in transfer functions in the s-domain. In normalized form, however, transfer functions are written as a ratio of frequencies. For instance,

最需要解决角单元发生（再次，涉及频率）在传递函数在s域。然而，在规范形式下，传递函数被写成频率比。例如,

has a zero at &#969;z and a pole at the origin. The origin pole crosses the unity-gain (0 dec) axis at a frequency of &#969;0. Although &#969;0 is not a break frequency, it is the frequency to use in the ratio of the pole at the origin because at s = &#969;0 (or more properly, at s = j&#969; = j&#969;0), ||s/ &#969;|| = 1 just as the zero is at s = &#969;z. The s-dependent factor of G(s) (the rational function in parentheses) is thereby reduced to one at zero frequency (s = 0 s&#8722;1) whenever there are no poles or zeros at the origin. Poles at the origin make the value of the transfer function magnitude infinite at 0 Hz or 0 s&#8722;1, and it makes no sense in that case to talk of the static (dc) gain. It is not G0; it is infinite. However, by setting the value of the static gain, G0, as the value at G(&#969;0), the transfer function in its normalized form still has a useful meaning when the s-dependent factor is equal to one.

有一个零和# 969；Z和一个在原点的极点。源极穿过单位增益（0月）在频率和# 969轴；0。虽然与# 969；0是没有休息的频率，它的频率使用在原点的极点比因为在S =和# 969；0（或更确切地说，在S =该# 969；=该# 969；0），| | /与# 969；| | = 1只为零是在s = 969和#；Z G的S-依赖的因素（S）（括号中的有理函数）从而减少到一个在零频率（S = 0的# 8722；1）当有在原产地没有极点或零点。极点在原点使传递函数的幅度无限的价值在0赫兹或0标# 8722；1，它是没有意义的，说话的静态（直流）增益。它不是G0；它是无穷的。然而，通过设置的静态增益，G0值，在G值（与# 969；0），在其标准形式的传递函数仍在依赖于S-因子等于一个有用的意义。

With frequency ratios in use, the convention of using &#969; to represent frequency in s&#8722;1and f in Hz (&#8801; rev/s) is somewhat of an artifice of convenience and not really a necessity. &#969; and f represent the same quantity, though the different symbols indicate which scaled unit for frequency is used. In any engineering equation, units must be reconciled, and in transfer functions for which quantities of frequency always occur in ratios, they can be either in s&#8722;1 or Hz (or even degrees/second), as long as both quantities of the ratio have the same scale factors which cancel.

随着使用频率的比率，使用与# 969大会；代表的#频率8722 Hz；1和F（与# 8801；转/秒）是很方便的手段，而不是一个真正的必要性。与# 969；F代表数量相同，但不同的符号表示，单位为频率的使用比例。在任何工程方程，单位必须调和，在传递函数的数量的频率总是发生在比，他们可以在# 8722；1 Hz（或均匀度/秒），只要比值的量有相同的规模因素，取消。