

## A Quick Tutorial in MACD: Basic Concepts

By Gerald Appel and Marvin Appel

The Moving Average Convergence-Divergence Indicator (MACD) has been a staple of technical analysis since Gerald invented it more than 30 years ago. We speculate that part of the reason why MACD has become so popular is its versatility: you can use it as an indicator with which to recognize and follow strong trends, and also as a tool for recognizing trend reversals. In this article, we will discuss how to calculate the MACD and some basic ways to interpret it. We will discuss more advanced ways of interpreting MACD readings in a later article.

### How to calculate MACD

The heart of the MACD is the difference between two moving averages: a faster one (reflecting shorter term market trends) minus a slower one (reflecting longer term trends). We frequently utilize two different sets of moving averages to calculate MACDs: a 12-day exponential moving average as the faster one paired with a 26-day exponential moving average for the slower one, or a 19-day exponential moving average paired with a 39-day average. As an example, the 12-26 day MACD is calculated each day as:

12-day exponential moving average minus 26-day exponential moving average

This so far begs the question of how to calculate N-day exponential moving averages (here, N is 12 or 26), which we now review briefly: First, find the smoothing constant  $2/(N+1)$ . In the case of the 12-day exponential moving average, the smoothing constant would be  $2/(12+1) = 2/13 = 0.154$ . In the case of the 26-day exponential moving average, the smoothing constant would be  $2/(26+1) = 2/27 = 0.074$ .

For brevity, let's call exponential moving averages by a shorter name, "expo". Having calculated the smoothing constants we use them to update the exponential moving averages for each new piece of data as follows:

New 12-day expo = Previous 12-day expo + 0.154 (new price – previous 12-day expo)

Note where the smoothing constants  
appear in these two formulas:

12-day

26-day

New 26-day expo = Previous 26-day expo + 0.074 (new price – previous 26-day expo)

Here is an example of the numerical calculations. Suppose that yesterday, the price was 265, the 12-day expo was 266 and the 26-day expo was 263. Yesterday's MACD would therefore have been 12-day expo minus 26 day expo =  $266 - 263 = 3$ . Now suppose that today's closing price rose to 270.

$$\text{New 12-day expo} = 266 + 0.154 (270 - 266) = 266 + 0.154 * 4 = 266.616$$

$$\text{New 26-day expo} = 263 + .074 (270 - 263) = 263 + 0.074 * 7 = 263.518$$

$$\text{New MACD} = 266.616 - 263.518 = 3.098$$

One last detail: These formulas are *recursive*, which means that today's reading depends on yesterday's, which does not tell you where to start. A simple approximation is to use the earliest price you have as the earliest exponential moving average reading. Following this procedure introduces a small error, but after a few weeks' of data that error becomes negligible.

### **Basic patterns**

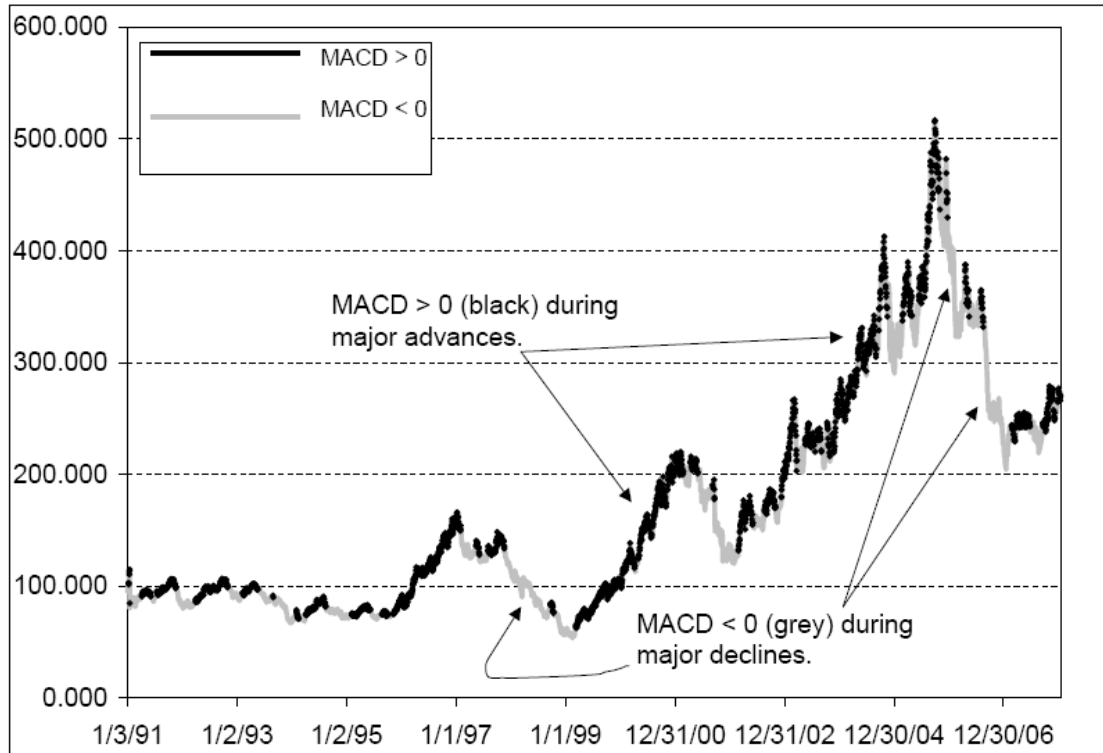
Two of the most important features of the MACD are whether it is above or below zero, and whether it is rising or falling. *As a general rule of thumb, the market climate is most unfavorable when MACD is falling and below zero*, signifying that shorter term market trends are weaker than longer term trends. This is not to imply that every day on which MACD is falling and below zero is necessarily going to be a losing day. However, in our experience, this rule of thumb has correctly identified shorter and longer market corrections.

*When you study how MACD works with the vehicles you like to trade, it is vitally important to keep in mind that you cannot act on an MACD reading until the day after the data are in.* You can use this information only for the next day. (Here we assume daily MACDs, but you could apply the same techniques to intra-day data such as 60-minute bars, or to weekly data.) For example, if we say that periods when the MACD are falling and below zero are unfavorable, we really mean that the days *following* MACD readings that are falling and below zero have been worse than average. Let's see this in action.

### **Example: Dow-Jones AIG Energy Index**

There are two reasons to study this particular index. First, given the surge in oil prices to record highs, energy has become a hot topic. Second, there exist exchange-traded notes (similar to ETFs) that track this specific index. Although past results never guarantee what will happen to an investment in the future, we consider it an advantage to trade an investment that has extensive real time history or that tracks an index with an extensive history. Daily data on the DJ-AIG Energy Index is available back to 1991.

Figure 1 shows seventeen years of history for the DJ-AIG Energy Index (1991-2008). The gray part of the price chart represents days immediately following MACD readings below zero. The black part of the price chart represents days immediately following MACD readings above zero. Notice that all the major corrections were characterized by  $MACD < 0$ , and the major uptrends by  $MACD > 0$ .



*Figure 1: Dow Jones-AIG Energy Index, 1991-2008 in two colors: Gray when MACD was below zero the day before, and black when MACD was above zero the day before.*

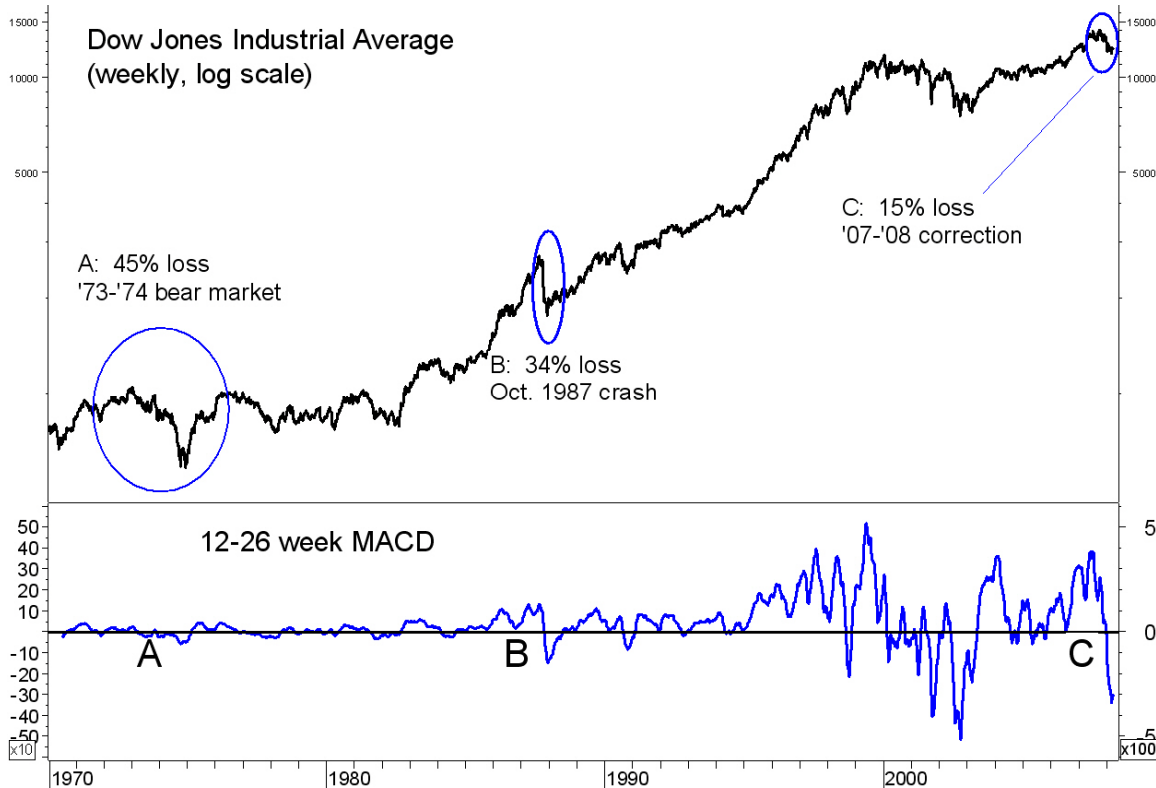
Analysis of the daily price and MACD data revealed that on days following when the 19-39 day MACD was greater than zero, the DJ-AIG Energy Index rose at a rate of 14%/year while invested. This favorable condition was in effect 55% of the time. On the other hand, on days following MACD readings below zero, this energy index fell at an annualized rate of 2%/year. Even worse, days following MACD readings that were falling and below zero saw an annualized loss rate of 11%/year. This bearish condition was in effect 22% of the time. During the entire period, the index gained 6.1%/year. It does appear that the 19-39 day MACD did an excellent job discriminating between bullish and bearish conditions in the energy market.

### **A refinement: Using MACD to Find Overbought/oversold areas**

You are not limited to checking whether MACD is above or below zero—the actual level can be important as well, particularly at historical extremes. For example, if you calculate that MACD

has gotten unusually far below zero, down to areas seen only at previous major market bottoms, it would be reasonable to use that observation as the basis for predicting that the market was due to turn back up. We will see how that has worked with Dow Jones Industrial Average, but first we need to digress to cover one more fine point.

When analyzing multi-year charts, prices can cover a very wide range. For example, if you use the formulas presented so far on a long-term chart of the Dow Industrials, you might get a result like what appears in Figure 2:



*Figure 2: Dow Jones Industrial Average weekly, and three market declines, 1970-2008, along with the 12-26 week MACD expressed in points.*

The three events shown in Figure 2 are the 1973-1974 bear market, the stock market crash of October 1987, and the recent (October 2007-March 2008) market correction. The worst extent of the price declines (based on weekly closes) is labeled. Clearly, in terms of price decline, the recent correction is far milder than the other two historical events.

However, the decline in MACD was far more dramatic in 2008 than in 1987 or 1974. The reason is that the moving average formulas use price data, so a 100-point decline in the Dow Industrials can produce roughly the same point change in an exponential moving average regardless of whether the starting price is 1000 or 10,000—What matters is not the general level

of stock prices, but only the number of points that separate the stock price and its moving average. However, as equity investors, we are usually more interested in *percentage* changes than in point changes. (Futures traders may not agree.) Fortunately, a simple additional calculation can create an MACD that reflects percentage changes, so that the market action that occurred in disparate price ranges can be compared.

In order to normalize MACD, simply divide the original reading by the slower moving average. To wit: The formula used to calculate the MACD in Figure 2 is

$$\text{faster expo} - \text{slower expo} = \text{MACD in \$ or points} \quad (\text{equation 1})$$

The normalized formula that converts MACD into a percentage is

$$(\text{faster expo} - \text{slower expo}) / (\text{slower expo}) = \text{MACD in \%} \quad (\text{equation 2})$$

In order to avoid confusion between the two different formulas, we will refer to the MACD in % calculated by equation 2 as “MACD%”. If we utilize the formula for MACD% on the price history in Figure 2, we get the more consistent result that appears in Figure 3 (next page), where the magnitude of the moves in MACD% parallels the *percentage* changes in price.

### **Signals that have been correct 85% of the time**

Now that we are in a position to compare MACD% readings from the 1970s (when the Dow Industrials peaked around 1000) and the current decade (where the Dow peaked at 14,000) we can see in Figure 3 (next page) that the 12-26 week MACD% reached a major long-term oversold level when it got down to -3% or below. That has occurred just seven times in the past 38 years. When MACD subsequently climbed back above -3%, it was a good time to enter the market on all but one of these occasions (November 2001). The market correction that has carried into 2008 has not brought the 12-26 week MACD% of the Dow Industrials down as far as -3%. If it does, we would consider the subsequent recovery to be a good time to take new positions.

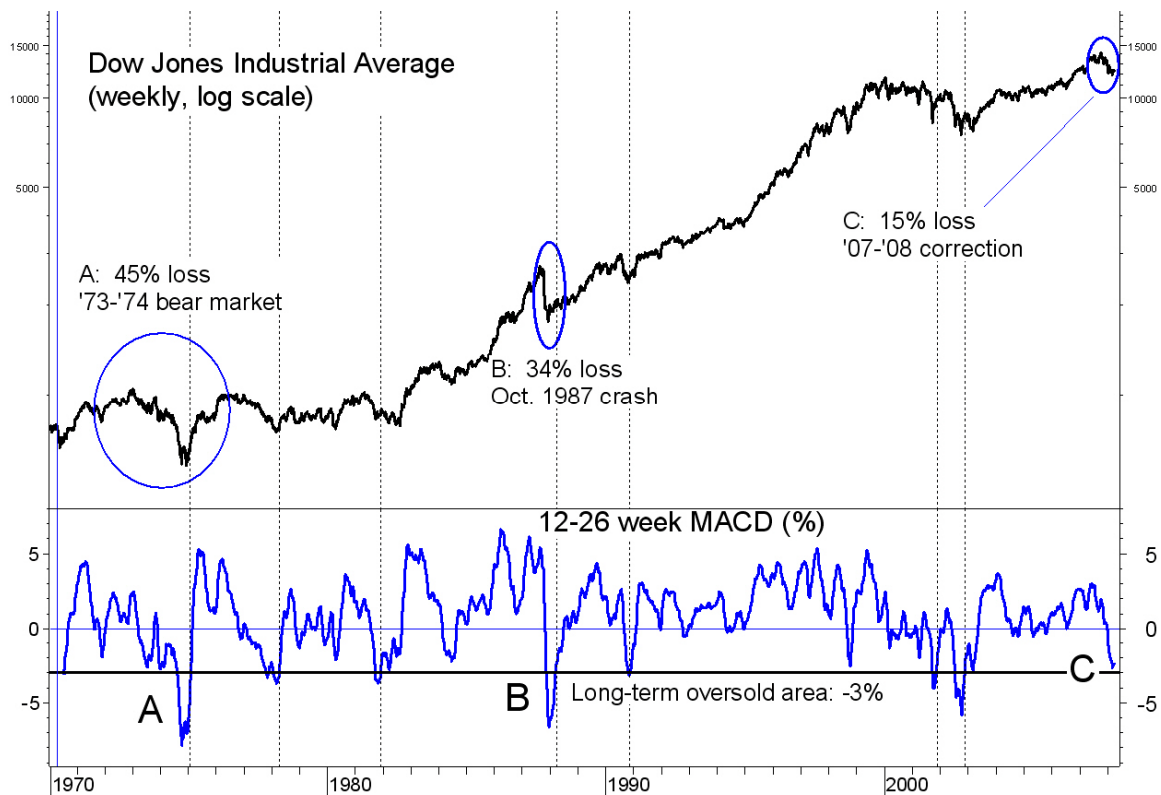


Figure 3: Dow Jones Industrial Average (1970-2008) with the 12-26 week MACD expressed as %. Vertical dashed lines indicate the seven occasions when MACD% climbed from below to above  $-3\%$ . The 1973-1974 bear market, crash of 1987 and 2007-2008 market correction are labeled A,B,C (respectively) as in Figure 2.

## Conclusion

We have seen how to calculate the MACD, although many of you may be using software packages that do this for you. The first bits of information to glean are whether the MACD is above or below zero, and whether it is rising or falling. Generally, market conditions are unfavorable when the MACD is falling and below zero.

Next we saw that by converting MACD from units of price (or points) to units of %, it is possible to compare market conditions from periods when prices varied widely. In the case of the Dow Jones Industrial Average, we saw that  $-3\%$  has historically been a long-term oversold level for the 12-26 week MACD%, and frequently a prelude to excellent market entries.

We cannot emphasize enough that you need to experiment with whatever vehicle you are trading to determine whether the MACD patterns presented here might also be relevant to your own investment, because that will often not be the case. Also, you should take potential transaction costs into account when deciding how you might want to apply the MACD to your own investing strategies.

In sum, we have discussed examples of how to use MACD as an indicator of the overall investment climate. The concepts discussed here are covered in more detail in Gerald Appel's book, "Technical Analysis: Power Tools for Active Investors" (Prentice-Hall 2005).

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