Traders take many paths to reach their destination.

Can your platform get you there?

NINJATRADER® ECOSYSTEM

Search apps and services to personalize the
NinjaTrader platform to meet your requirements.
Indicators, automated strategies, free tools & more.

Explore now at ninjatraderecosystem.com

Daily technical commentary by expert analysts to help you make **smarter** investing decisions

From daily **blogs** to live **webinars**, *StockCharts.com* hosts free current market analysis and educational commentary from some of the industry's most distinguished **technical analysts**.


John Murphy


Martin Pring


Arthur Hill


Tom Bowley


Greg Schnell


Chip Anderson


Carl Swenlin


Erin Swenlin


Gatis Roze


Julius de Kempenaer

and more!

Free daily **blogs** featuring over a dozen renowned technical commentators

StockCharts.com hosts *free* daily blog content from over a dozen professional technical analysts, including prominent names such as John Murphy, Martin Pring and Arthur Hill. Thousands of online investors trust StockCharts.com to provide the unbiased expert analysis and enriching educational commentary they need to cut through the noise and make smarter investment decisions.

Live **web shows** hosted by seasoned market technicians

Our free webinars are hosted by some of the financial industry's most distinguished chartists. Join these technical titans LIVE as they put their years of experience on display and share invaluable insights into the tools and strategies they use in their own trading. Visit StockCharts.com/tv to learn more and watch our next show.

StockCharts.com

Steady As They Go

Backtesting A Mean-Reversion Strategy In Python

You hear the term "mean reversion" thrown around a lot. What does it really mean and how can you create a mean-reversion strategy you can backtest? Here's a step-by-step guide.

When prices drift too far away from the mean, there's a strong chance they will revert to the mean. To put this theory to the test, I applied a mean-reversion system to the SPDR S&P 500 ETF (SPY). The system can be applied to any ETF or stock of your choosing.

While it doesn't guarantee success, backtesting your trading ideas is essential to make sure your system has a chance of working in the real market.

WHAT IS BACKTESTING?

Backtesting involves obtaining historical price data and loading it into your backtesting harness. Your code then loops through each day of data, applies your trading signal to the data, and comes up with a profit & loss account complete with various metrics. Any trading idea that can be expressed in computer code can be backtested.

I prefer coding in Python mainly because it's a full-blown, open-source programming language. It gives me complete freedom to code and test whatever I like, at no cost to me. There are no licensing fees, no restrictions.

GATEWAY TO PYTHON

There may be several ways to approach using Python. I'll suggest two ways.

The first and easiest way is to join Quantopian, an online backtesting platform. I have loaded my system there for anyone to copy, free of charge. All you need to do is sign up and visit the post on the forum "Mean Reversion System for Stocks and Commodities magazine" (https://www.quantopian.com/posts/mean-reversion-system-for-stocks-and-commodities-magazine).

Once you sign up, you will be able to clone my notebook to your own research area in Quantopian. By doing that, you don't have to download anything onto your own computer—the notebook runs on Quantopian's own servers and uses its stock data.

The more tedious (but ultimately far more satisfying and flexible) route is to start from scratch and download everything you need onto your own laptop or computer. Daily stock data is available free of charge from several suppliers, and in recent years I have mostly used data supplied by Quandl and Yahoo. I download data programmatically using Python, but for those less versed in programming, you can download data manually from either provider. You could also look at Alpha Vantage. It is also free and I have found it to be quite satisfactory.

I chose Python because of its simplicity to learn and because it has many excellent "libraries" or add-ons such as TA Lib and Pandas. TA Lib (https://mrjbq7.github.io/ta-lib/doc_index.html) does all the hard work for you on coding indicators—it's all there for you, so why bother drafting code from scratch?

If you take the time to learn Python, you will never look back, but for nonprogrammers, it is quite a steep learning curve. But don't let that turn you off; once you have climbed the hill, you will keep on climbing. And unlike Sisyphus—the mythical Greek king who was doomed to repeatedly roll a boulder uphill

JOSE CRUZ

by Anthony Garner

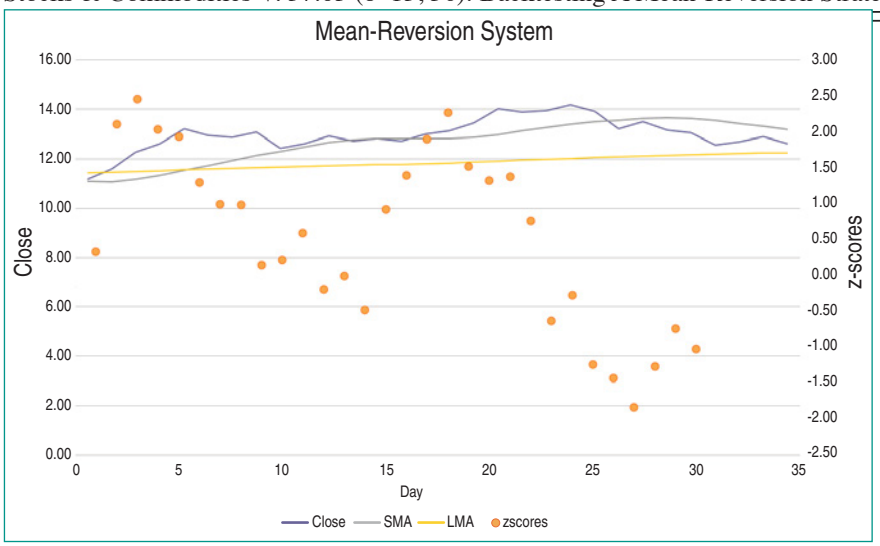


FIGURE 1: MEAN-REVERSION SYSTEM. This chart plots the close, SMA, LMA, and z-scores. A z-score greater than +1 (to indicate an overbought situation) generates a sell signal and a score less than -1 (to indicate an oversold situation) generates a buy signal.

Day	Close	Std	Z-scores	Position	SMA	LMA	Equity	Trend
0.00	11.17	0.27	0.33	Out	11.08	11.43	99.59	Downtrend
1.00	11.57	0.24	2.09	Short	11.06	11.45	99.59	Downtrend
2.00	12.26	0.45	2.45	Short	11.16	11.47	93.44	Downtrend
3.00	12.60	0.64	2.02	Short	11.31	11.50	90.37	Downtrend
4.00	13.18	0.86	1.93	Short	11.51	11.54	85.14	Downtrend
5.00	12.93	0.94	1.29	Short	11.72	11.57	87.39	Uptrend
6.00	12.86	0.95	0.99	Short	11.92	11.60	88.06	Uptrend
7.00	13.05	0.94	0.98	Short	12.13	11.63	86.31	Uptrend
8.00	12.40	0.82	0.14	Out	12.28	11.66	92.17	Uptrend
9.00	12.60	0.65	0.21	Out	12.46	11.68	92.17	Uptrend
10.00	12.91	0.47	0.59	Out	12.64	11.70	92.17	Uptrend
11.00	12.69	0.29	-0.20	Out	12.75	11.72	92.17	Uptrend
12.00	12.80	0.23	-0.01	Out	12.80	11.75	92.17	Uptrend
13.00	12.70	0.23	-0.49	Out	12.81	11.77	92.17	Uptrend
14.00	12.97	0.20	0.91	Out	12.79	11.80	92.17	Uptrend
15.00	13.11	0.22	1.39	Out	12.81	11.82	92.17	Uptrend
16.00	13.41	0.29	1.89	Out	12.86	11.85	92.17	Uptrend
17.00	14.01	0.46	2.25	Out	12.96	11.89	92.17	Uptrend
18.00	13.86	0.50	1.52	Out	13.11	11.93	92.17	Uptrend
19.00	13.93	0.52	1.32	Out	13.24	11.97	92.17	Uptrend
20.00	14.16	0.58	1.37	Out	13.36	12.01	92.17	Uptrend
21.00	13.90	0.55	0.76	Out	13.49	12.04	92.17	Uptrend
22.00	13.20	0.51	-0.64	Out	13.53	12.07	92.17	Uptrend
23.00	13.49	0.42	-0.28	Out	13.60	12.11	92.17	Uptrend
24.00	13.13	0.40	-1.24	Long	13.62	12.13	92.17	Uptrend
25.00	13.02	0.41	-1.43	Long	13.61	12.16	91.45	Uptrend
26.00	12.55	0.53	-1.84	Long	13.53	12.18	88.15	Uptrend
27.00	12.68	0.56	-1.28	Long	13.39	12.19	89.02	Uptrend
28.00	12.88	0.56	-0.74	Long	13.29	12.22	90.45	Uptrend
29.00	12.60	0.55	-1.03	Long	13.16	12.23	88.48	Uptrend

FIGURE 2: CRUNCHING THE NUMBERS. Here are some sample signals and data when the mean-reversion strategy is backtested on some randomly generated stock prices.

forever—you won't have to start all over again each time you want to draft a new trading system.

There are some excellent beginners' resources available, but the easiest way is probably just to dig in. Start by downloading Anaconda for Python version 3.7. That is what I am currently using.

Anaconda loads Python itself together with a great number of the libraries you will need to get started, such as Numpy for number-crunching, Pandas for time series manipulation, and Matplotlib for charting.

Once you have done that, go to my Gist page (https://gist.github.com/AnthonyFJGarner/ccd23f0e9d46214612f59c7b92a82149) and you can download the system at no cost. Load the notebook into the file location used by your Anaconda installation. Then load "Jupyter Notebook" and open the notebook.

Numpy, Matlibplot, and Pandas come preloaded but you will have to load Alpha Vantage, Yahoo Finance, and FFN if you want to use them. There is also a Python Quandl library you can load if you want to access Quandl data. Installing third-party libraries will usually take the form of "pip install quandl" from the Windows command line.

THE MEAN-REVERSION SYSTEM

The system sells stocks that have become overbought and buys stocks that have become oversold in relation to a 10-day moving average of the stock price. The trigger is a move up or down by more than one standard deviation from the 10-day average price: a z-score of over +1 triggers a sell and a z-score of less than -1 triggers a buy.

In Figures 1 and 2, I provide a chart (Figure 1) and data (Figure 2) illustrating the system's operation on some randomly generated stock prices.

THE CODE

Most of the code contained in the notebook is concerned with obtaining and preparing data for the test, and with displaying the results of the test.

The system itself is contained in a function, which takes the data, loops through it applying the trading signal, and then returns a Pandas DataFrame with the results. A DataFrame is similar, conceptually, to an Excel spreadsheet and can be downloaded onto your computer for further analysis.

The function that runs the test is shown in the sidebar "Python Code For Backtest Of Mean-Reversion Strategy." This sidebar also shows the cell that calls the function.

PYTHON CODE FOR BACKTEST OF MEAN-REVERSION STRATEGY

```
# Trade using a simple mean-reversion strategy

def trade(stock, length):

    temp_dict = {}
    # If window length is 0, algorithm doesn't make sense,
    # so exit
    if length == 0:
        return 0

    # Compute rolling means and rolling standard
    # deviation
    # sma and lma are filters to prevent taking long or
    # short positions against the longer term trend
    rolling_window = stock.Adj_Close.
rolling(window=length)
    mu = rolling_window.mean()
    sma = stock.Adj_Close.rolling(window=length*1).
mean()
    lma = stock.Adj_Close.rolling(window=length * 10).
mean()
    std = rolling_window.std()

    # If you don't use a maximum position size the
    # positions will keep on pyramidding.
    # Set max_position to a high number (1000?) to
    # disable this parameter
    # Need to beware of unintended leverage
    max_position = 1
    percent_per_trade = 1.0

    # Slippage and commission adjustment - simply
    # reduces equity by a percentage guess
    # a setting of 1 means no slippage, a setting of
    # 0.999 gives 0.1% slippage
    slippage_adj = 1

    # Compute the z-scores for each day using the
    # historical data up to that day
    zscores = (stock.Adj_Close - mu) / std

    # Simulate trading
    # Start with your chosen starting capital and no
    # positions
    money = 1000.00
    position_count = 0

    for i, row in enumerate(stock.itertuples(), 0):

        # set up position size so that each position is a fixed
        # position of your account equity
        equity = money + (stock.Adj_Close[i] * position_
count)
        if equity > 0:
            fixed_frac = (equity * percent_per_trade) / stock.
Adj_Close[i]
        else:
            fixed_frac = 0
        fixed_frac = int(round(fixed_frac))

        # exit all positions if zscore flips from positive to
        # negative or vice versa without going through
        # the neutral zone
        if i > 0:
            if (zscores[i - 1] > 0.5
                    and zscores[i] < -0.5) or (zscores[i - 1] < -0.5
                                               and zscores[i] > 0.5):

                if position_count > 0:
                    money += position_count * stock.Adj_Close[i]
* slippage_adj
                elif position_count < 0:
                    money += position_count * stock.Adj_Close[i]
* (
                        1 / slippage_adj)
                position_count = 0

        # Sell short if the z-score is > 1 and if the longer
        # term trend is negative
        if (zscores[i] > 1) & (position_count > max_position *
-1) & (sma[i] <
                                                    lma[i]):

            position_count -= fixed_frac
            money += fixed_frac * stock.Adj_Close[i] * slip-
page_adj

        # Buy long if the z-score is < 1 and the longer
        # term trend is positive
        elif zscores[i] < -1 and position_count < max_position
and sma[i] > lma[i]:

            position_count += fixed_frac
            money -= fixed_frac * stock.Adj_Close[i] * (1 / slip-
page_adj)

        # Clear positions if the z-score between -.5 and .5
        elif abs(zscores[i]) < 0.5:
            #money += position_count * stock.Adj_Close[i]
            if position_count > 0:
                money += position_count * stock.Adj_Close[i] *
slippage_adj
            elif position_count < 0:
                money += position_count * stock.Adj_Close[i] * (
                    1 / slippage_adj)
            position_count = 0

        # fill dictionary with the trading results.
        temp_dict[stock.Date[i]] = [
            stock.Adj_Open[i], stock.Adj_Close[i], mu[i], std[i],
zscores[i],
            money, position_count, fixed_frac, sma[i], lma[i]
        ]
    # create a dataframe to return for use in calculating
    # and charting the trading results
    pr = pd.DataFrame(data=temp_dict).T
    pr.index.name = 'Date'
    pr.index = pd.to_datetime(pr.index)
    pr.columns = [
        'Open', 'Close', 'mu', 'std', 'zscores', 'money', 'posi-
tion_count',
        'fixed_frac', 'sma', 'lma'
    ]
    pr['equity'] = pr.money + (pr.Close * pr.position_count)
    #
    return pr

moving_average=10
profit = trade(stock, moving_average)
profit.to_csv('../data/mean_reversion_profit.csv')
```

THE PARAMETERS

I won't comment in detail on the function since I have already described the operation of the system conceptually. If you are interested in the system, you will need to work through the function line by line and experiment by changing the parameters. The default settings I have used are as follows:

- **SMA**—The same length as the moving average passed to the function when it is called. You can change this by changing "*1" to "*2" for example.
- **LMA**—10 times the length of the moving average passed to the function. Thus, it is currently set to 100 days. You can change this multiple as you choose.
- **Max_position** is currently set to 1. Increase it if you want to pyramid trades but watch out for leverage.
- **Percent_per_trade** is currently set to 100%. You will need to reduce this if you want to pyramid without incurring leverage. This is fixed-fractional position sizing, used to promote compound growth in the equity curve. Some prefer to test on single contracts/shares but this is not the way I have drafted the system.
- **Slippage** is currently set at 1, which equates to no slippage being charged. Setting it to 0.999 would result in slippage of 0.1%.
- **Money**—I have assumed starting capital of $1,000 but you can experiment with different amounts.
- **Z-score signals**—I have set an initial parameter of +1 for an overbought signal and -1 for an oversold signal. You can experiment with different levels.
- **Neutral zone**—I have set +0.5 and -0.5 as the z-scores that will trigger position exits. You can experiment with different zones.

THE RESULTS

The notebook you will find on my Gist and Quantopian shows a backtest of this strategy on SPY (the S&P 500 ETF) from 1993 to December 2018. You can try it out on different stocks.

In Figures 3, 4, and 5, I show the various statistics and charts produced by the test. Figure 3 shows the equity curve produced by the system test. Figure 4 plots the drawdown. Figure 5 shows

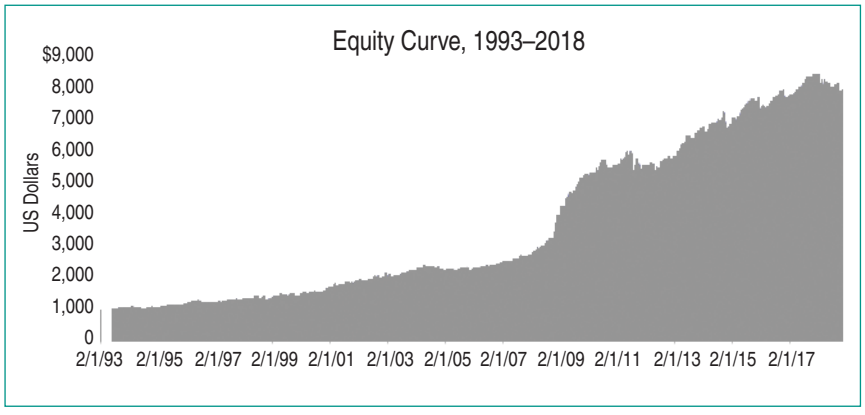


FIGURE 3: EQUITY CURVE (2/1/1993–12/7/2018). Overall, the equity curve has a positive slope.

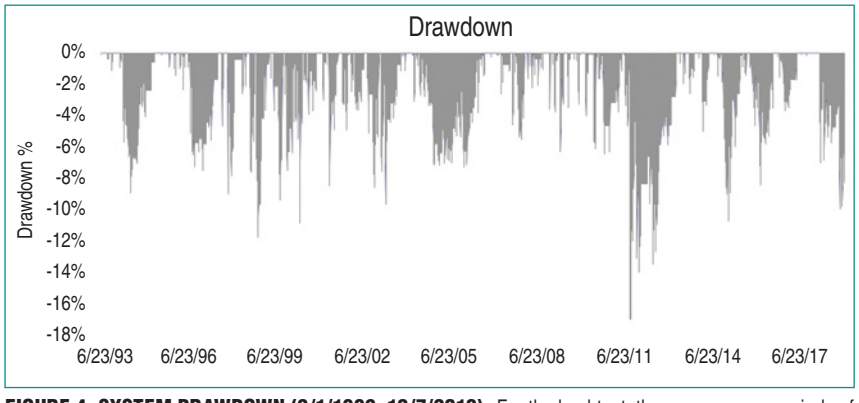


FIGURE 4: SYSTEM DRAWDOWN (2/1/1993–12/7/2018). For the backtest, there were some periods of drawdowns with the most significant being -13% on 6/20/2012.

System Performance Statistics	
Start	1993-02-01
End	2018-12-07
Risk-free rate	0.00%
Total Return	704.95%
Daily Sharpe	0.85
Daily Sortino	1.33
CAGR	8.40%
Max Drawdown	-14.44%
Calmar Ratio	0.58
MTD	1.36%
3m	-0.78%
6m	-1.30%
YTD	-4.45%
1Y	-4.45%
3Y (ann.)	1.78%
5Y (ann.)	3.69%
10Y (ann.)	7.96%
Since Incep. (ann.)	8.40%
Daily Sharpe	0.85
Daily Sortino	1.33
Daily Mean (ann.)	8.58%
Daily Vol (ann.)	10.10%
Daily Skew	0.42
Daily Kurt	24.86
Best Day	8.87%
Worst Day	-7.28%
Monthly Sharpe	1.06
Monthly Sortino	1.96
Monthly Mean (ann.)	8.41%
Monthly Vol (ann.)	7.93%
Monthly Skew	0.31
Monthly Kurt	7.35
Best Month	15.75%
Worst Month	-9.52%
Yearly Sharpe	0.83
Yearly Sortino	9.86
Yearly Mean	8.82%
Yearly Vol	10.69%
Yearly Skew	1.97
Yearly Kurt	4.80
Best Year	44.31%
Worst Year	-4.45%
Avg. Drawdown	-2.37%
Avg. Drawdown Days	45.15
Avg. Up Month	1.86%
Avg. Down Month	-1.36%
Win Year %	84.00%
Win 12m %	87.33%

FIGURE 5: TRADING SYSTEM PERFORMANCE RESULTS. You can see various performance metrics for the system produced by the backtest. .

performance statistics for the test.

This article doesn't represent investment advice. I have spent many years backtesting and trading systems on both stocks and futures, and one thing I am clear about is that returns will always be lower, and drawdowns greater, than what the backtesting results suggest.

By way of example, trend-following in the futures markets was extremely profitable for many years but now seems to have died a death, thanks to too many participants. Firms that built their entire fortune on trend-following have gone bust or reduced their exposure to the strategy.

The best-laid plans have a habit of going awry. Trade small enough not to blow yourself out of the water or cause too much stress. Don't use too much leverage (if any), and recognize that markets never remain the same. Constant evolution is necessary for survival.

Anthony Garner started his career in 1979 as a lawyer in London, UK, with Slaughter And May, specializing in commercial and financial work. In 1984 he moved to what is now UBS and spent some years as an analyst and stockbroker with postings in London, Tokyo, Hong Kong, Singapore, and Zurich. In 1992 he branched out on his own and since then he has been engaged in managing and trading his own investments. He can be contacted via his website at https://anthonygarnerinvestments.com/about/.

*The code given in this article is available in the **Article Code** section of our website, Traders.com.*

The system sells stocks that have become overbought and buys stocks that have become oversold in relation to a 10-day moving average of the stock price.

*See our **Traders' Tips** section beginning on page 48 for commentary and implementation of Anthony Garner's technique in various technical analysis programs. Accompanying program code can be found in the Traders' Tips area at Traders.com.*

READING & RESOURCES

- Quantopian, https://www.quantopian.com/posts/mean-reversion-system-for-stocks-and-commodities-magazine
- Quandl, https://www.quandl.com
- Yahoo.com
- Alpha Vantage, https://www.alphavantage.co (not .com)
- Python.org
- TA Lib, https://mrjbq7.github.io/ta-lib/doc_index.html
- Anaconda, https://www.anaconda.com/distribution
- Gist, https://gist.github.com/AnthonyFJGarner/ccd23f0e9d46214612f59c7b92a82149

How much is your broker **charging you?**

	US Margin Loan Rates Comparison	Commission Rates Comparison	
	$300K	**Equity Trades**	**Options[1] Base per contract**
● **Interactive Brokers[2]**	**3.56%[3]**	**$2.34**	**no base cost** $**0.69** per contract[4]
○ **E-Trade**	9.00%	$6.95	$6.95 base + $0.75 per contract
○ **Fidelity**	8.07%	$4.95	$4.95 base + $0.65 per contract
○ **Schwab**	8.07%	$4.95	$4.95 base + $0.65 per contract
○ **TD Ameritrade**	8.75%	$6.95	$6.95 base + $0.75 per contract

Each firm's information reflects the standard online trades pricing obtained from the respective firm's websites as of 3/4/19. Pricing and offers subject to change without notice.

To see the full comparison visit:
ibkr.com/**iwantmore**

Interactive Brokers **Rated #1**
Best Online Broker 2019 by Barron's*

InteractiveBrokers

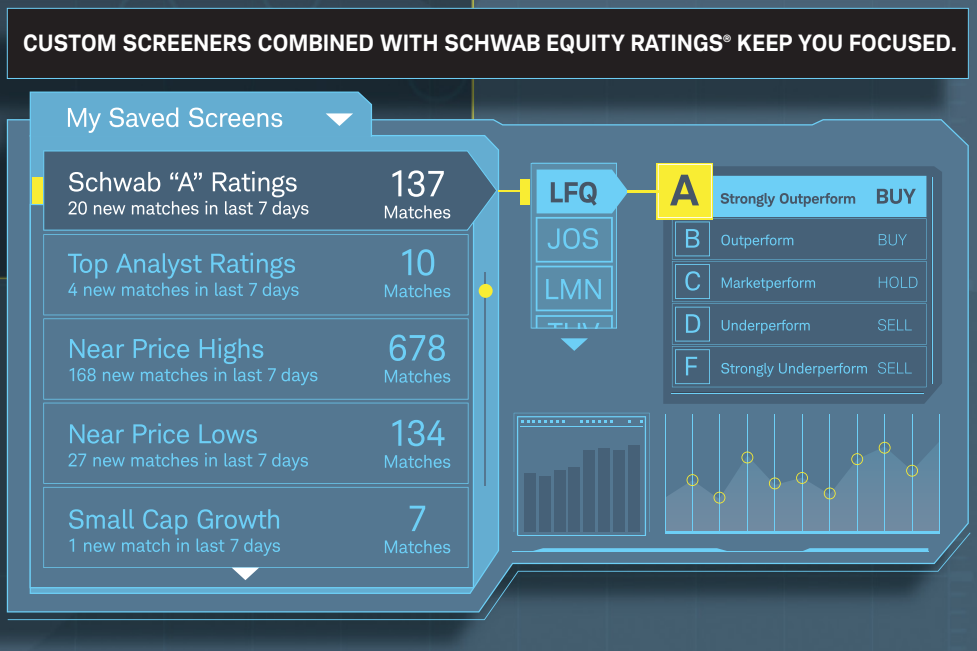
Trading on margin is **only for sophisticated investors** with **high risk tolerance**. You may lose more than your initial investment.

Member - NYSE, FINRA, SIPC – Supporting documentation for any claims and statistical information will be provided upon request. Services vary by firm. *Interactive Brokers rated #1, Best Online Broker according to Barron's Best Online Brokers Survey of 2019: February 25, 2019. For more information see, ibkr.com/ info - Barron's is a registered trademark of Dow Jones & Co. Inc. [1] Options involve risk and are not suitable for all investors. For more information read the "Characteristics and Risks of Standardized Options". For a copy, call 312 542-6901. [2] The IB commission rates shown are the average of the client commissions for trades executed in February 2019 and are subject to minimums and maximums as shown on the IB website. Some of the firms listed may have additional fees and some firms may reduce or waive commissions or fees, depending on account activity or total account value. Under some commission plans, overnight carrying fees may apply. [3] IB calculates the interest charged on margin loans using the applicable rates for each interest rate tier listed on its website. For additional information on margin loan rates, see ibkr.com/interest. [4] $1.00 commission minimum.

05-IB19-1167CH1165

Schwab Trading Services

You could waste time sifting through random trade ideas.
But you know better.



PLUS EARN **500** commission-free online trades **for two years**

Schwab is the better place for traders.

charles SCHWAB

schwab.com/trading

Own your tomorrow.®

Enroll in the offer and make a qualifying net deposit of $100,000 to earn 500 commission-free online trades. Limited to one account per client. Trades are good for two years and include only base equity, ETF, and options commissions and option per contract fees up to 20 contracts. Restrictions apply. See schwab.com/trading or call us for terms and conditions. Offer may be changed or terminated at any time without notice.

Schwab Equity Ratings are not personal recommendations for any particular investor or client and do not take into account your individual circumstances, financial situation, investments, or other objectives or needs.

SUBSCRIBE OR RENEW TODAY!

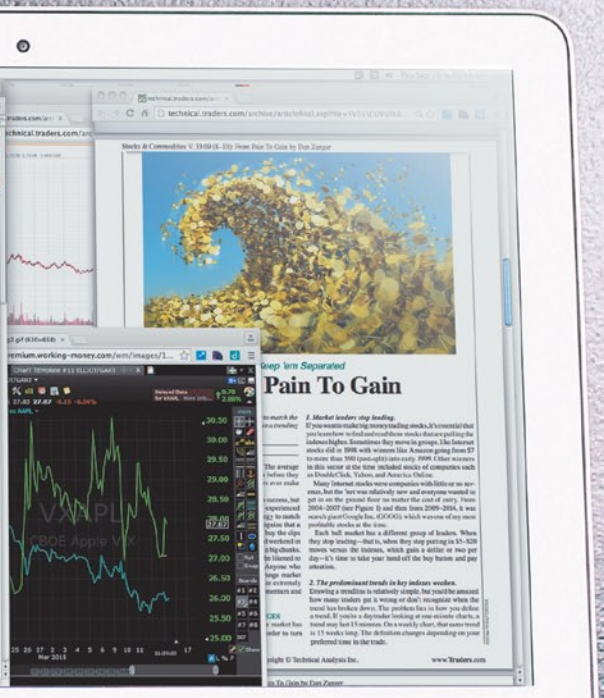
Every Stocks & Commodities subscription (regular and digital) includes:

- **Full access to our Digital Edition**
  The complete magazine as a PDF you can download.
- **Full access to our Digital Archives**
  That's 35 years' worth of content!
- **Complete access to WorkingMoney.com**
  The information you need to invest smartly and successfully.
- **Access to Traders.com Advantage**
  Insights, tips and techniques that can help you trade smarter.

1 year $89.99

2 years..... $149.99

3 years..... $199.99



PROFESSIONAL TRADERS' STARTER KIT

A 5-year subscription to S&C magazine that includes everything above PLUS a free* book, Charting The Stock Market: The Wyckoff Method, all for a price that saves you $150 off the year-by-year price! *Shipping & handling charges apply for foreign orders.

5 years..... $299.99

That's around $5 a month!

Visit **www.Traders.com** to find out more!

Email: Circ@Traders.com • Phone: 206-938-0570 facebook.com/STOCKSandCOMMODITIES @STOCKSandCOMM