

## SLOT MACHINE PRINCIPLES

### CHAPTER 7.4 VIRTUAL REEL - INTERNAL REEL STRIP

#### **VII VIRTUAL REEL - INTERNAL REEL STRIP:**

On May 15, 1984 patent number 4,448,419 was issued to Inge S. Telnaes of which several excerpts of the patent are listed below:

*“A gaming machine of the type utilizing rotating reels which carry on the periphery a plurality of indicia, a brake to stop the reels at a selected position and a random number generator for selecting the reel stopping position. Numbers are assigned to the reel stopping positions and entered into the random number generator with **each number being entered one or more times to control the payout odds** of each particular stopping position being selected thereby enabling any odds to be set without changing the physical characteristics of the machine.”*

*“...Slot machines are gaming devices which incorporate a plurality of reels rotatable about a common axis and on which are carried at the periphery a plurality of indicia indicating the position each reel stops. Usually the reels are set into motion by pulling a lever and upon stopping, the angular positions of the reels are detected to determine the amount of payoff to the player.*

*In the original mechanical machines the reels were stopped by actuating a brake or a tripping arm/pin which moved into grooves (cutouts) in each reel's index wheel on a random timing basis. This method was carried over to the electro mechanical machines of the 1960's and to date insofar that the basic stopping of the reels is by timewise releasing an index pin into grooves in index wheels attached to the reels with indicia displaying the game result. These varying depth grooves enabled, via physical contact closures of wipers being a part of the index arm mechanism and physical wiring to relay logic, payouts in accordance with the designed payout schedule which again was directly related to the probability of occurrence of the indicia--symbol--displayed on the reel itself.*

*Beyond the above-described slot machine devices there has followed now the electro mechanical gaming devices employing a plurality of reels rotatable about a common axis and set into rotation by the pulling of a lever. However, **in these newer devices an electronic random number generator of some type is energized which generates one number corresponding to each of the various positions at which the reels can be stopped.** As the game is played, each reel is stopped in sequence with the other reels at a position corresponding to each subsequent number generated. The angular rotational positions of the reels are detected at all times and the brake is engaged when the reel position corresponds to the random number generated for that reel. The probability for paying off on a combination of indicia on presently used machines, as described above, is dependent on the number of reels, the number of different angular rotational positions at which the reels can be stopped, and the number of winning combinations of indicia. In other words, the lowest probability for payoff that can be offered on presently used machines*

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are 1 to  $N^R$  where  $N$  is the number of angular rotational positions on each reel and  $R$  is the number of reels. Thus, for a three reel machine having 20 stop or index positions on each reel, the lowest probability that can be offered is 1:20<sup>3</sup> or 1:8000. For a machine to be commercially viable, there is a limit on the largest amount that will be paid for any such single indicia combination.

The above reasoning explains why **the slot machines which offer greatly increased payoffs are usually very large machines in terms of the number of reels and stop positions**. The large machine provides the physical size to allow an increase in the number of reel stop positions as well as number of reels to increase the probability against payoff on any one position.

It should be noted that the market demands higher and higher payoffs to maintain and increase **player appeal**, yet the casino or operator must be assured that the probability of win and payout allows for a reasonable **business profit**. Generally the profit-hold objectives before taxes and operational costs that are deducted are in the range as low as 2.7% and generally up to 15%. Hence, the higher payoff for a winning indicia combination must be counterbalanced with less probability for the high win combination of indicia.

It is therefore the purpose of this invention to increase the capability of the designer to include high payoffs without increased physical size of the machine and with uniform presentation of the games of different models to the player. It should be noted that the players perceive larger machines as being less "good" in terms of winning and payout chances. That is, large physical machines and a large number of reels develop an attitude in the player which affects the play and acceptance of the machine although this does not always coincide with the true mathematical reality and probability of payout of the machine. This attitude affects the play appeal of the device and its revenue-producing capability and this player's attitude is quite important in marketability of the slot machines both to casinos and operators as well as to the "player" slot location. Also, this attitude may be more influential on whether or not the machine is played than published figures showing the payoff odds. Thus, **it is important to make a machine that is perceived to present greater chances of payoff than it actually has within the legal limitations that games of chance must operate**.

It is a further purpose of the present invention to provide a machine on which the **probability is easily designed and on which high value payoffs can be offered on a standard three or four reel machine** with correct probability that makes the high value payoffs feasible. The major benefits of such a machine besides the marketability and competitiveness to other slot machines and pure electronic or video games and gaming devices are:

(1) Prevention of **tampering** of the game to create illegal wins and payoffs.

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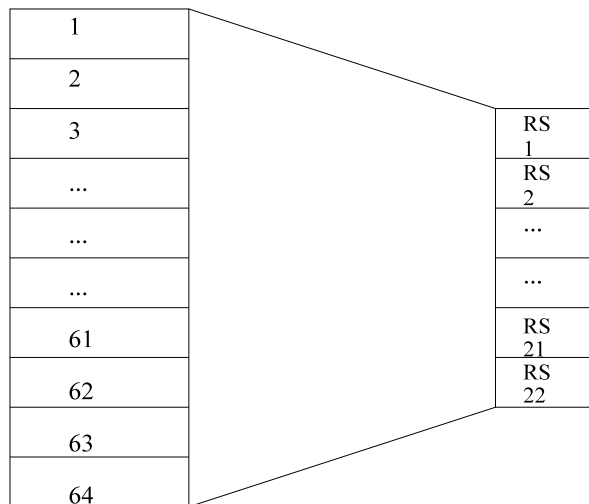
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*Note that this feature of the invention protects both the operator and more importantly, the public or player as well as the licensing agency.*

*(2) **Standardization in design and production** by cost effectiveness of the product line across all conceivable product models and payoff probabilities and odds, i.e. payback of a win for a given coin insert.”*

*“...A random number generator is provided with electronic circuitry which computes the random stop position at which the reel should be stopped by the physical brake. This is done with an electronically random number selected from **a group of numbers which exceeds the number of physical reel positions such that one physical reel position is represented by one or several positions on the virtual or electronically generated reel** which is in affect, randomly stopped by the random number generator. In this invention the physical reels are only used as a display of the random number generated result and are not the game itself as in standard slot machines. In this manner, a standard slot machine or gaming apparatus can be made to **function at payout odds, independent of the limits set by the number of physical reels and their physical stop positions, by changing the random number generator.**”*

This invention was a major breakthrough in the evolution of the slot machine. Now manufacturers could design machines that looked identical but had their payout percentage determined by software (firmware). Allowing virtual reel positions (real in software) to be mapped to real world reel strip positions.



**SIXTY FOUR VIRTUAL REEL POSITIONS MAPPED TO TWENTY TWO REEL POSITIONS**

Reel strip Number 3441 HOLD % 4.988 Denomination:

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MODEL # : ##36X PAYTABLE:126A533

99% Confidence value; 10,000,000 pulls- LOW % 94.5

HIGH % 95.53

COIN #	PERCENT PAYBACK	HIT FREQ	TOTAL HITS	TOTAL PAYS
1	95.012%	14.546%	54292	354632
2	95.012%	14.546%	54292	709264

SYM	NUMBER / REEL		
	R1	R2	R3
~	30	36	42
CH	2	1	1
1B	26	6	20
2B	7	15	3
3B	3	10	2
7	2	2	2
DD	2	2	2

PAY COMBO	# PER REEL	HITS	PULLS/HIT	PAYS	TOTAL PAYS
CH XX XX	2 71 71	9522	39	2	19044
XX CH XX	70 1 71	4692	80	2	9384
XX XX CH	70 71 1	4692	80	2	9384
CH CH XX	2 1 71	138	2705	5	690
CH XX CH	2 71 1	138	2705	5	690
XX CH CH	70 1 1	68	5489	5	340
AB AB AB	36 31 25	24405	15	5	122025
CH DD XX	2 2 71	276	1352	10	2760
DD CH XX	2 1 71	138	2705	10	1380
CH XX DD	2 71 2	276	1352	10	2760
DD XX CH	2 71 1	138	2705	10	1380
XX CH DD	70 1 2	136	2744	10	1360
XX DD CH	70 2 1	136	2744	10	1360
AB AB DD	36 31 2	1650	226	10	16500
AB DD AB	36 2 25	706	529	10	7060
DD AB AB	2 31 25	1180	316	10	11800
1B 1B 1B	26 6 20	3120	120	10	31200
CH CH CH	2 1 1	2	186624	10	20
1B 1B DD	26 6 2	312	1196	20	6240
1B DD 1B	26 2 20	1040	359	20	20800

### Simple Slot Math

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A vital element to maximizing revenue on the slot floor is knowing how reel and video slot games should perform. Many information collection and analysis tools are available to help survey operating results and increase revenues, but using them requires a basic understanding of the economics of game machine yields, holds, payback, returns, etc.

Learning to read percentage sheets for slots can be complicated. However, an investment of time and effort is important to optimizing the revenue for each machine.

The following are examples of simple slot math for a reel stop program, a video poker program and a bonus game. These equations represent the most basic operations only.

### Spinning Reel Slot

#### *Number of Stops/Combination/Machine Cycle*

**Stops** = Reel positions, positions at which the reel can stop

**Machine Cycle** = Total number of possible combinations, calculated by multiplying the total number of stops of all the reel positions: Reel 1 positions x Reel 2 positions x Reel 3 positions, and so on

**Example 1 - 32-stop, 3-reel game:**  
 $32 \times 32 \times 32 = 32,768$  combinations

**Example 2 - 64-stop, 4-reel game:**  
 $64 \times 64 \times 64 \times 64 = 16,777,216$  combinations

#### *Hits Per Cycle and Jackpot Odds*

**Hits/Cycle** = Number of times a certain jackpot combination theoretically lines up during one machine cycle

**Jackpot Odds** = Theoretical odds of hitting a certain jackpot on any given handle pull

**Example 1 - 32-stop, 3-reel slot game:**

*What are the odds of hitting the top jackpot of three 7s when the number of 7s per reel are: Reel 1 = 2; Reel 2 = 2, and Reel 3 = 1?*

**Step 1:** Determine the total possible jackpot combinations.

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The # of jackpot combinations = Reel 1 # of winning symbols x Reel 2 # of winning symbols x Reel 3 # of winning symbols. In this case,  $2 \times 2 \times 1 = 4$  hits/cycle.

**Step 2:** Jackpot odds = (machine cycle  $\div$  hits/cycle).

In this case,  $32,768 \div 4 = 8,192:1$  (which means the jackpot should hit every 8,192 pulls).

#### **Example 2 - 64-stop, 4-reel slot game:**

*What are the odds of hitting the top jackpot of four Jokers when the number of Jokers per reel are: Reel 1 = 2, Reel 2 = 2, Reel 3 = 2, and Reel 4 = 2?*

**Step 1:** Compute the possible jackpot combinations.

$2 \times 2 \times 2 \times 2 = 16$  jackpot combinations, or hits/cycle

**Step 2:** Compute the jackpot odds.  $16,777,216 \div 16 = 1,048,576:1$  (which means the jackpot should hit every 1,048,576 pulls).

#### ***Hit Frequency and Win Frequency***

**Hit Frequency** = Theoretical percentage of plays involving a pay. The number of combinations involving a pay  $\div$  cycle = hit frequency

**Win Frequency** = Theoretical number of plays between pays. Cycle  $\div$  number of combinations involving a pay = win frequency

#### **Example 1 - 3-reel, 32-stop game that has 3,277 pay combinations:**

*What is the hit frequency?*  $3,277 / 32,768 = 10\%$  hit frequency

*What is the win frequency?*  $32,768 / 3,277 = 10$  games between pays

#### **Example 2 - 64-stop, 4-reel game has a 15% hit frequency:**

*How many pay combinations are there?*  $16,777,216 \times 15\% = 2,516,582$  pay combinations

*What is the win frequency?* Win frequency =  $1 / \text{hit frequency} = 1 / 15\% = 6.67$  games between pays

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Sample Reel Slot Percentage Sheet									
Hold %: 5.325		90% Confidence Value		10,000,000 Pulls		Low %: 94.35		High %: 95.00	
Coin#	Percent Payback	Hit Freq	Total Hits	Total Pays	Symbols	Number Per Reel			
						R1	R2	R3	
1	94.370%	16.335%	42820	247384	~~	24	28	29	
2	94.675%	16.335%	42820	496368	B7	8	2	2	
					HB	12	4	9	
					RB	4	12	12	
					BB	12	12	4	
					H7	2	2	6	
					R7	2	4	2	
Pay Combo	#Per Reel			Hits	Pulls/Hits	Pays	Total Pay		
~~ ~~~	24	28	29	19488	13	1	19488		
AL AL AL	20	14	6	1072	245	2	2144		
AW AW AW	14	6	15	804	326	2	1608		
AR AR AR	6	16	14	752	349	2	1504		
AB AB AB	28	28	25	17952	15	5	89760		
RB RB RB	4	12	12	576	455	10	5760		
AR AW AL	6	6	6	144	1820	20	2880		
HB HB HB	12	4	9	432	607	25	10800		
BB BB BB	12	12	4	576	455	40	23040		
RB HB BB	4	4	4	64	4096	50	3200		
A7 A7 A7	12	8	10	880	298	80	70400		
B7 B7 B7	8	2	2	32	8192	150	4800		
H7 H7 H7	2	2	6	24	10923	200	4800		
R7 R7 R7	2	4	2	16	16384	250	4000		
					(coin #2)	(500p)			
R7 H7 B7	2	2	2	8	32768	400	3200		
					(coin #2)	(1000p)			

This is a 3-reel, 2-coin, 64-stop machine. Reel combinations: 262,144.  
Total Hits 42,820. Total Coins Paid 247,384.

### Video Poker

The video poker percentage sheet differs from a spinning reel percentage sheet in two important ways:

**The percentage is calculated and clearly stated** - A percentage sheet for a spinning reel slot game is made up of a matrix of possible variations, such that some calculation is necessary to arrive at hold and payback percentages.

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The video poker percentage sheet, however, lists probabilities and odds for different hand combinations. The parameters of the standard video poker game are static, in that the game must be played with a 52-card deck. The only way to alter the economics of the game is to change the value assigned to various winning combinations - change the payable.

Sample Video Poker Percentage Sheet (5/8 Jacks or Better Poker)				
	<i>Pay</i>	<i>Max Pay</i>	<i>Probability</i>	<i>Contribution</i>
<b>Royal Flush</b>	250	800	.0000249	2.0%
<b>Straight Flush</b>	50	50	.0001077	.5%
<b>4 Of A Kind</b>	25	25	.00236629	5.9%
<b>FullHouse</b>	8	8	.0115137	9.2%
<b>Flush</b>	5	5	.0109076	5.5%
<b>Straight</b>	4	4	.0112351	4.5%
<b>3 Of A Kind</b>	3	3	.0744627	22.3%
<b>2 Pair</b>	2	2	.1292984	25.9%
<b>Jacks Or Better</b>	1	1	.2150706	21.5%

# of paid to player for one (1) coin wagered

Maximum # of coins x maximum pay equals number of coins available to win with maximum coins wagered

Probability of hand occurring

Hit Frequency = 45.5%  
 Optimum Player Return = 97.3%  
 Expected Field Return = 93.3%-95.3%  
 Note: Percentages are based on max coin play.

**The percentage is expressed as a range of player returns** - The video poker percentage sheet essentially offers three levels of player returns.

- The optimum return is achieved when the player plays the game most efficiently, or "*computer perfect*."
- The high expected field return is the upper limit of a range of performance expected when *experienced players* are actually playing the game. This represents the highest average performance expected in real-life on-site play
- The low expected field return represents the type of performance anticipated for *inexperienced players* or those encountering a new game for the first time.

Why is poker performance expressed as a range? The game odds assigned to winning combinations actually account for player skill. Poker differs from slot games in that the outcome involves player choices and skill, and players get better at playing the game over time.

#### Video Poker Cycles

- Number of possible dealt hands:



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- 2,598,960
- Number of possible deal/draw hands:  
6,754,593,081,000
- Number of hands between dealt Royal Flushes  
649,740
- Number of hands between drawn Royal Flushes:  
20,000 - 50,000
- Odds of a Royal Flush in a particular suit:  
1 in 160,000

#### Bonus Games

There are two primary-bonus game categories - pre-programmed and programmable.

Pre-programmed machines a bonus game as integral part of the basic machine software.

The percentage sheets received with the game show the bonus game payouts in an auxiliary table and in combination with the base game.

The pre-programmed bonus game percentage sheet is similar to the video poker percentage sheet in that it shows the probability of hitting a specific bonus amount rather than a matrix of possible combinations like the spinning reel percentage sheets.

Pre-Programmed Bonus Game Percentage Sheet					
Pay	Lower Limit	Upper Limit	Coin 1 Prob.	Coin 2 Prob.	Coin3 Prob.
5.	0	6	0.109%	0.109%	0.10938%
10.	7	32	0.406%	0.406%	0.40625%
15.	33	57	0.391%	0.391%	0.39063%
25.	58	77	0.313%	0.313%	0.31250%
40.	78	85	0.125%	0.125%	0.12500%
60.	86	88	0.047%	0.047%	0.04688%
80.	89	89	0.016%	0.016%	0.01563%
100.	90	90	0.016%	0.016%	0.01563%
<b>Bonus Pays</b>					
25.	91	99	0.141%	0.1287%	0.12797%
50.	91	99		0.013%	0.01152%
100.	91	99			0.00104%
500.	91	99			0.00009%
1000.	91	99			0.00001%
<b>Totals</b>			<b>1.563%</b>	<b>1.563%</b>	<b>1.563%</b>

Programmable machines have bonus features that are adjustable by the operator. These machines show the appropriate payback calculations fight on the machine in the setup mode. The operator can see the effect of the changes made and establish the percentage desired. Bonus calculator spreadsheets are also available to compare the effect of different settings on the payback percentage.

In the bonus calculator tables a comparison is shown between two of the eight bonus paytables (wintables) available for this particular bonus game. Notice that the base game payback percentage (base payback) remains the same. By changing the payable and the coin-in amounts, there is a change of

10% in the average payback between the two configurations.

The bonus game average payback table shows the differences between the two paytables with regard to projected hits for a specific amount.

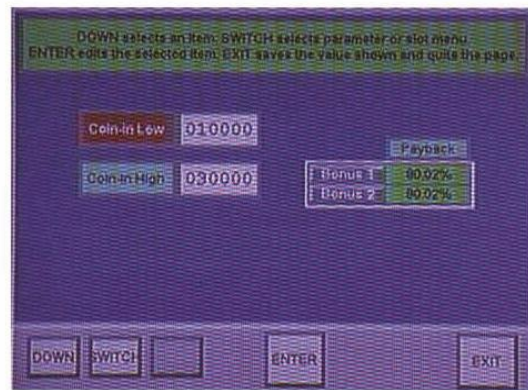
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Substantial success has been seen by many operators using bonus games to liven-up the traditional reel-slot and video poker game mix.

<b>Bonus Calculator</b>	
<b>Payback Percentage Wintable 2</b>	
<b>INPUTS:</b>	
Max Bets	2
Base Payback	75.000%
Coin-In Low	25
Coin-In High	75
Wintable (0-8)	2
Added Bonus	0
<b>OUTPUTS:</b>	
Average Door Prize	15
Base Payback %	75.000%
Bonus Payback %	30.000%
Total Payback %	105.000%
Games to Reach Bonus	25
<b>Payback Percentage Wintable 3</b>	
<b>INPUTS:</b>	
Max Bets	2
Base Payback	75.000%
Coin-In Low	75
Coin-In High	125
Wintable (0-8)	3
Added Bonus	0
<b>OUTPUTS:</b>	
Average Door Prize	20
Base Payback %	75.000%
Bonus Payback %	20.000%
Total Payback %	95.000%
Games to Reach Bonus	50

Programmable Bonus Game Setup Screen



**Combined Base Game and Bonus Game Summary Sheet**

	<i>Bonus</i>	<i>Base</i>	<i>Total</i>
Hit Frequency:	1.563%	+ 11.518%	= 13.018%
Payback % Coin 1:	32.422%	+ 59.030%	= 91.452%
Payback % Coin 2:	32.580%	+ 59.030%	= 91.610%
Payback % Coin 3:	55.240%	+ 39.760%	= 95.000%

<b>Bonus Game Average Payback</b>		
<b>Payback Percentage Wintable 2</b>		
<b>Pay Amount</b>	<b>Hits</b>	<b>Total Pays</b>
5	40	200
10	84	840
15	104	1560
40	25	1000
80	3	240
<b>Totals</b>	<b>256</b>	<b>3840</b>
<b>Average</b>		<b>15</b>
<b>Payback Percentage Wintable 3</b>		
<b>Pay Amount</b>	<b>Hits</b>	<b>Total Pays</b>
5	46	230
10	78	780
20	88	1760
50	41	2050
100	3	300
<b>Totals</b>	<b>256</b>	<b>5120</b>
<b>Average</b>		<b>20</b>