Communications Theory Collection

Note: All items are in wrappers unless otherwise noted. Multiple items listed together in one row are housed together in a custom Solander (clamshell) box.

Document Title	Author	Explanation
The Sampling Theorem and Interpolation Formula. “Recent developments in multiplex-telephony” by W. M. Miner (Electrical World and Engineer 42 No. 23 p 920, December 1903); "On the functions which are represented by the expansion of the interpolation-theory" by E. T. Whittaker (Proceedings of the Royal Society of Edinburgh 35 Part 2 XVIII pp. 181–194, 1915); "Über die Dynamik der selbsttätigen Verstärkungsregler" (English: "On the dynamics of automatic gain controllers") by Karl Küpfmüller (Elektrische Nachrichtentechnik 5 No. 11 pp. 459-467, 1928); “Untersuchungen an der wechselzeitigen Mehrfachübertragung (Multiplexübertragung)” (English: “Studies of Multiplex Transmission”) by Herbert Raabe (Elektrische Nachrichtentechnik 16 pp. 213–228, 1939); "Communication in the presence of noise" by Claude Shannon (Proceedings of the Institute of Radio Engineers 37 pp. 10–21, 1949)	Various	The Sampling Theorem states that any signal of bandwidth “B” (e.g., 3,000 Hz) can be reproduced exactly if it is sampled 2*B (e.g., 6,000) times per second. The sampling issue first came up late in the nineteenth century with the advent of multiplexing in telephone systems. In the early stages of multiplexing, sampling frequency was determined experimentally rather than through mathematical theory. After a decade of experimentation, W. M. Miner (dates unknown) patented the first practical multiplexer in 1903, and he based his sampling decision on the fact that the telephone conversations sounded “remarkably better” at 3,600 times per second with “best results” being obtained at about 4,300 per second. In 1915, Edmund Taylor Whittaker (1873 – 1956) was the first to rigorously address the sampling issue, and he did so in a mathematical treatise dealing with the broader issue of interpolation in signal processing. He found that under certain conditions it is possible to interpolate samples such that all noise falls above a frequency equal to the sampling rate divided by 2. He called this the “cardinal function,” and proved that it is the only function that has this noise characteristic. Though stated a bit differently, Whittaker’s cardinal function is completely equivalent to the sampling theorem. In 1928, Karl Küpfmüller (1897 – 1977) also proposed the sampling theorem for telegraphy. Perhaps more important, Küpfmüller also discussed the addition of a band-limiting filter (an important tool in digital audio) that is still referred to as a “Küpfmüller filter.” In 1939, Herbert P. Raabe (1909-2004), one of Küpfmüller’s students, independently proved the sampling theorem for multiplexed telephone transmission in his doctoral dissertation. Finally, in 1948, Claude Shannon published a proof of both the sampling theorem and the interpolation formula as one part of his broader development of information theory.
"Certain factors affecting telegraph speed" (Bell System Technical Journal 3 No. 2 pp. 324–346, April 1924)	Harry Nyquist	Nyquist proposes that the number of independent pulses that could be put through a telegraph channel per unit time is limited to twice the bandwidth of the channel. This rule is a dual of what is now known as the Nyquist–Shannon sampling theorem. Cited by Shannon in "A Mathematical Theory of Communication" and "Communication in the Presence of Noise"
"Certain factors affecting telegraph speed" (Transactions of the American Institute of Electrical Engineers 43 pp. 412-422, 1924)	Harry Nyquist	Nyquist proposes that the number of independent pulses that could be put through a telegraph channel per unit time is limited to twice the bandwidth of the channel. This rule is a dual of what is now known as the Nyquist–Shannon sampling theorem. Cited by Shannon in "A Mathematical Theory of Communication" and "Communication in the Presence of Noise". Note: This is the longer version of the paper with the same title published earlier that year (just above). This final version includes a discussion of a submitted letter about the paper and commentary by Nyquist, not present in the earlier version.
"Transmission of Information" (Bell System Technical Journal 7 No. 3 pp. 535-563, July 1928)	Ralph Hartley	This paper coined the word "information" (in a technical sense), making explicitly clear for the first time that information in this context was a measurable quantity. Cited by Shannon in "A Mathematical Theory of Communication."
"Certain topics in telegraph transmission theory" (Transactions of the American Institute of Electrical Engineers 47 No. 2 pp. 617-644, April 1928)	Harry Nyquist	Nyquist-Shannon sampling theorem. Nyquist uses Fourier analysis to demonstrate that the maximum signalling rate of a channel with bandwidth W is 2W and proposes three criteria for distortionless signal transmission. Cited by Shannon in "Communication in the Presence of Noise."
“Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter Wesen” by Leo Szilárd (Zeitschrift für Physik 53 pp. 840–856, 1929)	Leo Szilárd	Leo Szilárd describes a theoretical model that served both as a heat engine and an information engine, establishing the relationship between entropy and information.
Interpolatory Function Theory (1935) by J. M. Whittaker.	J. M. Whittaker	Contains a derivation of the "Shannon-Nyquist sampling theorem."
"Time Division Multiplex Systems" (Bell System Technical Journal 20 No. 2 pp. 199-221, April 1941)	W. R. Bennett	Cited by Shannon in "Communication in the Presence of Noise" as a basis for sampling theorem.
"Theory of Communication" (Journal of the Institute of Electrical Engineers 93 Part III. Radio and Communications Engineering pp. 429-457, 1946)	Dennis Gabor	Dennis Gabor (1900 – 1979) was a Hungarian-British electrical engineer and physicist. This work, which received almost 11,000 citations, describes Gabor's version of the Shannon-Nyquist Sampling Theorem. "Signals do not have arbitrarily precise time and frequency localization. It doesn’t matter how you compute a spectrum, if you want time information, you must pay for it with frequency information. Specifically, the product of time uncertainty and frequency uncertainty must be at least 1/4π." Cited by Shannon in "Communications in the Presence of Noise."

Cybernetics or Control and communication in the Animal and the Machine (1948) by Norbert Wiener	Norbert Wiener	Wiener's book on communications theory.
"The Philosophy of PCM" by B. M. Oliver, J. R. Pierce and C. E. Shannon [Bell Monograph, 1948]	Oliver, Pierce and Shannon	From Claude Shannon's files. This is a copy of the first (and only) separate printing of the concepts behind Pulse Coded Modulation (PCM) that was patented by the authors. **From Wikipedia with footnotes removed**: "Pulse-code modulation (PCM) is a method used to digitally represent sampled analog signals. It is the standard form of digital audio in computers, compact discs, digital telephony and other digital audio applications. In a PCM stream, the amplitude of the analog signal is sampled regularly at uniform intervals, and each sample is quantized to the nearest value within a range of digital steps ... In the United States, the National Inventors Hall of Fame has honored Bernard M. Oliver and Claude Shannon] as the inventors of PCM, as described in "Communication System Employing Pulse Code Modulation", U.S. Patent 2,801,281 filed in 1946 and 1952, granted in 1956. Another patent by the same title was filed by John R. Pierce in 1945, and issued in 1948: U.S. Patent 2,437,707. The three of them published "The Philosophy of PCM" in 1948."
Mathematical Theory of Communication. "A Mathematical Theory of Communication" by Claude Shannon (Bell System Technical Journal 27, Numbers 3 & 4 pp. 379-423 & 623-656, July and October 1948); "Communication Theory of Secrecy Systems" by Claude Shannon (*Bell System Technical Journal* 28 No. 4 pp. 656-715, October 1949); *A Mathematical Theory of Communication* (1949) by Claude Shannon and Warren Weaver; "The Mathematics of Communication" by Warren Weaver (July 1949 issue of *Scientific American*)	Claude Shannon and Warren Weaver	First editions of all of the publications leading up to, proposing and popularizing Shannon's Mathematical Theory of Communication.
"Theoretical Limitations on the Rate of Transmission of Information" by William G. Tuller (MIT Technical Report No. 114, April 23, 1949)	William G. Tuller	William G. Tuller was an employee at MIT's Research Laboratory for Electronics in the second half of the 1940s. In 1948 he defended a thesis at MIT on "Theoretical Limitations on the Rate of Transmission of Information". In his thesis Tuller states that under noise-free conditions an unlimited amount of information can be transmitted over such a channel. Taking noise into account, he delivers an argument partly based on intuitive reasoning, partly on formal mathematics, arriving at his main result that the information H transmitted over a transmission link of bandwidth B during a time interval T with carrier-to-noise-ratio C/N is limited by $H \leq 2BT \log(1 + C/N)$. This expression has a striking resemblance to Shannon's formula, and would by most readers be considered equivalent.
"The transmission of information" by Robert M. Fano (MIT Technical Report No. 65, March 17, 1949); and "The Transmission of Information Part II" by Robert M. Fano (MIT Technical Report No. 149, February 1950); and Fano's book - Transmission of Information: A Statistical Theory of Communication (1961).	Robert M. Fano	Roberto Mario "Robert" Fano (1917 – 2016) was an Italian-American computer scientist at the Massachusetts Institute of Technology. Fano was known principally for his work on information theory. He independently developed what is now called "Fano coding" or "Shannon-Fano coding," the transmission of discrete signals through a noiseless channel. Fano describes his development of that topic in the MIT technical reports included here). Fano's 1961 book is often referred to as "the bible of information theory."
"The Synthesis of Two-Terminal Switching Circuits" (Bell System Technical Journal 28 No. 1 pp. 59-98, January 1949)	Claude Shannon	In this paper, shannon applies the Boolean algebra circuit design methods he defined in his master's thesis to demonstrate that any circuit synthesis problem can be broken down into a combination of simpler problems according to their function to achieve the minimum number of switches for a given task.
Extrapolation, Interpolation, and Smoothing of Stationary Time Series with Engineering Applications (1949) by Norbert Wiener	Norbert Wiener	Wiener's book on time series analysis.
"Error Detecting and Error Correcting Codes" (Bell System Technical Journal 29 No. 2 pp. 147-160, April, 1950).	R. W. Hamming	Paper that introduced the Hamming code, a linear error-correcting code invented by Richard Hamming in 1950 that can detect up to two and correct up to one bit errors.
"Memory Requirements in a Telephone Exchange" (Bell System Technical Journal 29 No. 3 pp. 343-349, July 1950)	Claude Shannon	Shannon's influential paper on how to construct a telephone exchange network.
"Prediction and Entropy of Printed English" (Bell System Technical Journal 30 No. 1 pp. 50-64, January 1951)	Claude Shannon	Shannon's famous article in which he measures the entropy rate of English text to be between 1.0 and 1.5 bits per letter, or as low as 0.6 to 1.3 bits per letter. A new method of estimating the entropy and redundancy of a language is described
"The Information Theory" (Fortune Magazine 48 pp. 136-158 , December 1953)	Francis Bello	Popular article on information theory

"Communications Theory - Exposition of Fundamentals" and "General Treatment of the Problem of Coding" and "The Lattice Theory of Information" by Claude Shannon (Symposium on Information Theory: Report of Proceedings 1950. Transactions of the IRE Professional Group on Information Theory London, England September 1950 pp. 44-47 and 102-107, February 1953).	Claude Shannon	This proceedings includes three presentations by Claude Shannon and one by Dennis Gabor, plus two contributions to discussion by Alan Turing.
"Communication Theory and Physics" by Dennis Gabor (Symposium on Information Theory: Report of Proceedings 1950. Transactions of the IRE Professional Group on Information Theory London, England September 1950 pp. 48-59, February 1953).	Dennis Gabor	This proceedings includes three presentations by Claude Shannon and one by Dennis Gabor, plus two contributions to discussion by Alan Turing.
"A New basic theorem of information theory" by Amiel Feinstein (IEEE Transactions on Information Theory 4 No. 4 pp. 2-22, 1954)	Amiel Feinstein	Stated by Claude Shannon in 1948, the "Noisy Channel Coding Theorem" describes the maximum possible efficiency of error-correcting methods versus levels of noise interference and data corruption. Shannon's theorem has wide-ranging applications in both communications and data storage. This theorem is of foundational importance to the modern field of information theory. Shannon only gave an outline of the proof. The first rigorous proof for the discrete case is due to Amiel Feinstein in 1954.
"Zero error capacity of a noisy channel" by Claude Shannon (Separately-paginated reprint by Bell Telephone Laboratories)	Claude Shannon	Originally published in 1956 by I.R.E. Transactions on Information Theory, IT-2 No. 3. Shannon uses combinatorial graph theory to determint the zero error capacity (C0) of a noisy channel, defined as the least upper bound of rates at which it is possible to transmit information with zero probability of error.
"Certain results in coding theory for noisy channels" (Information and Control 1 No. 1 pp. 6- 25, January 1957).	Claude Shannon	Proves the "channel coding theorerm for memoryless channels" that he proposed in his *Mathematical Theory of Communication* based on "information density"
"Sampling theorems associated with Sturm-Liouville Systems" by Paul Weiss (Bulletin of the American Mathematical Society 63 No. 4 p. 242, 1957).	Paul Weiss	Proposes a generalization of Shannon's sampling theorem. Presented at the April meeting of the American Mathematical Society in New York.
"Coding Theorems for a Discrete Source With a Fidelity Criterion" (IRE National Convention Record 7 Part 4 pp. 142–163, 1959)	Claude Shannon	This paper lays out basic tenets of rate distortion theory (lossy data compression). In lossy data compression, the decompressed data does not have to be exactly the same as the original data. Instead, some amount of distortion, D, is tolerated. Shannon showed that for a given distortion (D) there is a function, R(D), called the rate-distortion function. If D is the tolerable amount of distortion, then R(D) is the best possible compression rate. This work helped spark compression techniques in audio, video and still images.
"Probability of Error for Optimal Codes in a Gaussian Channel" (Bell System Technical Journal 38 No. 3 pp. 611-656, May 1959)	Claude Shannon	Shannon's introduction of the "reliability function," the exponent of the minimum achievable probability of error as a function of signalling rate.
"On Measures of Entropy and Information" (Proceedings of the Fourth Berkeley Symposium on Mathematics, Statistics and Probability Volume 1 pp. 547-561, 1961)	Alfréd Rényi	Generalizes "Shannon entropy." Rényi entropy is also important in quantum information, where it can be used as a measure of entanglement.
"A New Model for the Clustering of Errors on Telephone Circuits" (IBM Journal of Research and Development 7 pp. 224-236, 1963)	J. M. Berger and Benoit Mandelbrot	Mandelbrot studied patterns in information transmission over telephone lines he concluded that on any scale the proportion of noise-containing periods to error-free periods was a constant – thus errors were inevitable and must be planned for by incorporating redundancy.
Low-Density Parity Check Codes 1963) by Robert G. Gallager	Robert G. Gallager	Gallagher's MIT doctoral thesis on "Gallager Codes," a technique for achieving high data tates and neglegible error probablities on noisy channels with a reasonable amount of equipment. This paper won an IEEE Information Theory Society Golden-Jubilee Paper Award in 1998 and its subject matter is a very active area of research today.
"The Shannon Sampling Theorem - Its Various Extensions and Applications" by A. J. Jerri (Proceedings of the IRE 65 No. 11 pp. 1565-1596, November 1977)	A. J. Jerri	In depth description of Shannon's sampling theorem and its extensions, followed by a discussion of its applications. Also includes a very extensive bibliography.